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Maritime Engineering Journal

October 1996

Hull Structures: The CF Ship Structural Integrity Program

Also:

- *Wisdom and morality in the age of information*
- *Looking Back: The engineering heroes of* **Titanic**

Canada

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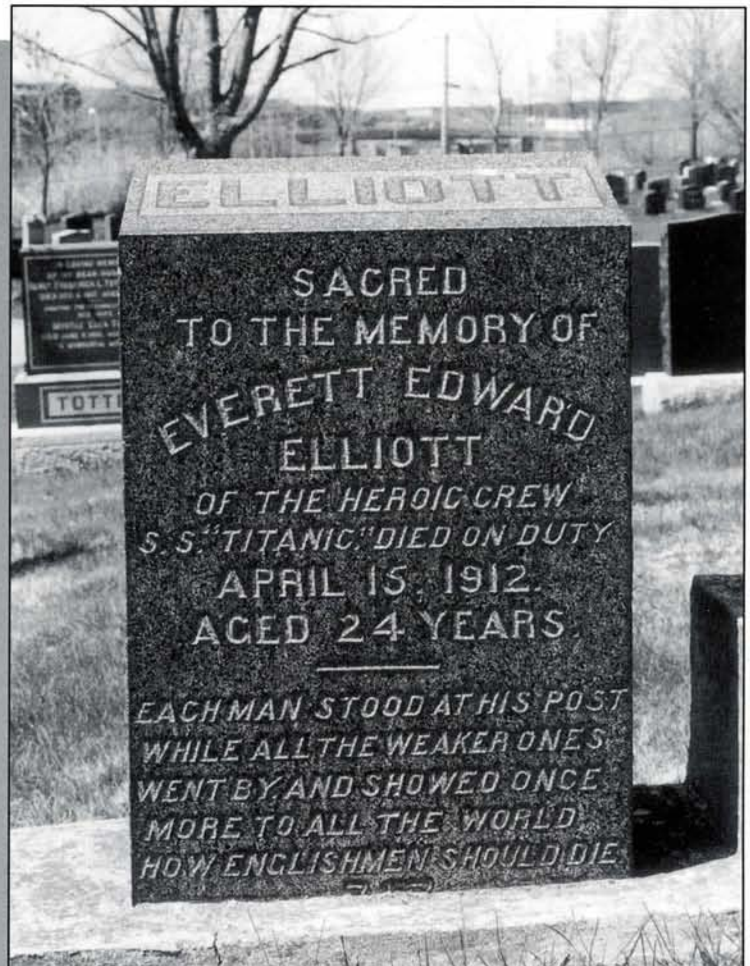

(Photo by Brian McCullough)

The sentiment on this grave marker for Everett Edward Elliott "of the heroic crew, S.S. Titanic" was typical for all those who died on duty. It reads: "Each man stood at his post while all the weaker ones went by, and showed once more to all the world how Englishmen should die."

See "Looking Back"

Maritime Engineering Journal

Established 1982

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Maritime Equipment Program
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OCTOBER 1996

OUR COVER
HMCS *Iroquois*: Part of the new CF Ship Structural Integrity Program.
(Formation Halifax Photo)

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

Editor's Notes

Piecing together our technical history

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

There is an exciting project under way, these days, in the not-so-musty halls of Canadian naval history. An association of serving and retired engineers and historians is hard at work piecing together the official post-1945 story of Canada's naval technical history (CNTH). Led by former Assistant Deputy Minister for Engineering and Maintenance RAdm M.T. Saker (ret.), the all-volunteer group is working in support of the Directorate of History and Heritage (DHH) in Ottawa. DHH has been mandated to produce a three-volume official history of Canadian naval activities.

The immediate priority is to collect and verify data on the many aspects of our naval technical history with an eye toward producing subject monographs. It is a sizeable task. The CNTH team has set its sights on capturing the accurate and complete stories surrounding the significant achievements of the navy's Engineering, Electrical, Ordnance, Constructor and Supply branches from the end of the Second World War to the present. From the inspired beginnings of the *St. Laurent*-class destroyer escorts, through the heady years of the hydrofoil project, to the design and construction of today's Canadian patrol frigates, it is a fascinating history replete with examples of pioneering technological advances and a desire to "do it at home."

Some facets of our post-war activity, particularly with respect to Canadian naval aviation, have already been published. Still, a great deal of information on a wide range of subjects remains to be collected, verified and produced. One of the top priorities of the CNTH Association is to review its database of material and contributors and identify shortfall areas. RAdm Saker is ably supported in this task by a nucleus of motivated experts, including the former Director of History, Dr. W.A.B. Douglas, and the former Director General Ships, RAdm S.M. Davis (ret.).

The enterprise is a worthy one and has received the endorsement of the Maritime Engineering branch. At a recent meeting of the CNTHA's project committee Cmdre F.W. Gibson (DGMEPM) pledged his support for the project, offering to promote the activities and findings of the naval technical history project through the pages of the *Maritime Engineering Journal*. At the same time, beginning with the February 1997 issue, the *Journal*'s mailing list will be opened up to include the CNTHA's growing network of contributors.

A synergistic partnership between DGMEPM and the CNTH Association offers direct benefits to the Maritime Engineering community, not the least of which is a wider readership for the *Journal*. The main benefit, of course, is that we will gain access to a wealth of fresh perspectives on the navy's technical history — our technical heritage, as it were, warts and all. By studying what worked and occasionally what didn't work for our predecessors, we stand to make a better contribution to the navy through our own day-to-day engineering activities. Who knows, we may even develop a stronger sense of identity with our technical roots at the same time.

Properly documented, the story of Canada's naval technical record of the last fifty years will make a valuable, lasting legacy for generations of engineers and technicians to come. In this task we wish the Canadian Naval Technical History Association well, and look forward to a long and happy association with them.

If you would like to get in touch with someone from the CNTHA to offer information, make a suggestion for a research topic, or contribute in any other way, please contact: Dr. Roger Sarty, Senior Historian, Directorate of History and Heritage, NDHQ Ottawa, K1A 0K2, tel. (613) 998-7045, fax 990-8579. Your assistance would certainly be welcome.

Are you receiving enough copies of the *Journal*?

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

Correction

The photograph of HMCS *Ontario*'s Electrical Department that appeared in our February issue was, in fact, a portrait of the ship's Supply Department taken between August 1954 and June 1956. The photo was misidentified in the DND archives.

Commodore's Corner
MOS Review Update

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

Since my last Commodore's Corner on this topic in the February 1996 issue, the Military Occupation Structure (MOS) Review of the MARE occupation has been completed. The results have been briefed to the VCDS and the final report has been provided to ADM(Per) staff for detailed consideration by a subcommittee of the Personnel Planning Working Group (PPWG).

The bottom line of the review is that the minimum requirement for MAREs was determined to be marginally higher than the current establishment. Therefore, there was no requirement to recommend changes to recruiting, training or occupation structure. A relatively small number of MARE billets were identified as possible candidates for alternate service delivery, but because of the requirement to satisfy a "peacetime planning factor" it was recommended that these positions be maintained as MARE billets.

One important characteristic of our occupation that was confirmed by the review is that the MARE establishment is largely driven by a requirement to support the fleet from ashore. We go to sea to perform an important role as members of a ship's combat team, but also to add to the knowledge and experience needed to support the fleet from ashore. This, among other aspects of a MARE's expertise, is not available in the private marketplace and must be developed within the service if the fleet is to receive the support it needs.

The PPWG has begun its review of the various occupation reports. When it will complete this task or what the likely outcome will be is unknown. It is noted that the PPWG recommended to the VCDS that preparations commence to allow MOS review of the operator trades. Whether this will have an impact on when the support trade review will be completed is also unknown.

An executive summary of the review has been mailed to all MAREs. If you have not received it, or if you have any questions, contact Cdr D. Flemming, DGMEPM SPO at (819) 994-8720.

The data gathering and initial analysis are now complete, but the process continues. The review must still be placed in the broader perspective of which support classifications are required to meet the commitment of the 1994 White Paper on Defence and what size they should be.

Letters

Roger Cyr's look back to 1959 and "The Great Impostor" (June 96 issue) brought back some long-forgotten memories.

As a young AB electrician's mate I was drafted to *Athabaskan* in 1959. If my memory serves me correctly it was a hot day, my kit bag weighed a ton and I was having trouble finding my ship. I could not find hull number 219, but there were two tribals numbered 218! I forget the details, but I did locate my ship and was victualled on board in time for my tot. I no sooner found my slinging spot than we sailed to film the gunnery sequences and record some stormy weather shots for the Hollywood production of "The Great Impostor." The film crew was on board *Micmac* (I think) and for four days we sailed up and down the Nova Scotia coast filming our gun's crew and looking for stormy weather. We successfully obtained the gunnery scenes but failed to find a storm. We eventually rang on 30 knots and got the desired effect in simulating stormy conditions.

The *Athabaskan* and *Micmac* crews did all the work, but *Cayuga* ship's company got the free tickets to the premier showing of "The Great Impostor!" – **Bill Edison, DMSS 5-9-3, Ottawa.**

Life aboard ship

Reading your article on HMCS *Ontario* (February 1996 issue) reminded me of two aspects of "life on a cruiser" that are indelibly etched in my mind.

The first concerns the messing. Who could forget the aroma of freshly baked bread and rolls that permeated the ship throughout the middle and morning watches? The second was an "abandon ship" exercise during Operation Big Hello when all the Carley floats released for the exercise sank like stones. Too much shipside grey paint on their exterior surfaces, I suspect.

So much nostalgia for such a great period in the Canadian Navy. – **Mike McQuillen, former crew member of *Ontario*'s sister ship, HMCS *Quebec* (1955-56).**

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.

In Memoriam

Captain(N) Keith Patrick Farrell, RCN (ret.)

1919-1996

The maritime engineering community was saddened to learn of the death of Constructor Captain Keith Farrell, RCN (ret.) on May 28 in Ottawa. Captain Farrell was well known for his naval design work on the *St. Laurent* and *Iroquois* classes, and later through his innovative design work on commercial ferries. A graduate of London University and the Royal Naval College, Greenwich, he was honoured with fellowships in the Royal Institution of Naval Architects (RINA) and the Society of Naval Architects and Marine Engineers (SNAME). He was also a member of the Royal Corps of Naval Constructors (RCNC), a Professional Engineer of Ontario and a member of the St. Lawrence College Marine Engineering Advisory Council. Above all, Keith Farrell was a devoted husband, father and grandfather. He is survived by his wife Doreen and their children John, Elaine, Marilyn and Mark, and seven grandchildren.

Captain Farrell came to Canada in 1949 as an RCNC constructor officer on loan to the RCN. Under the tutelage of Cmdre Baker, he was tasked with reviewing and developing the preliminary design for Canada's new *St. Laurent*-class destroyer escort. Responsible for the general arrangement, strength and stability of the class, it fell to him to determine the principal characteristics of all ship systems, including their routing and weight limitations for operability and damage control. The result was an anti-submarine escort of great effectiveness, beauty and stability (said to have been "designed to sink upright") that served the navy well for four decades.

In 1956 he joined the RCN as a commander and was posted to Halifax as manager of the Constructor Department. On one memorable occasion just before Christmas 1958, he was called out at midnight to go to sea in HMCS *Saguenay* to render assistance to *Huron* which had lost her lower bow section in a storm. "I transferred by jackstay in rough seas off Bermuda," he wrote, "surveyed the damage, advised on shoring the structure and kept watch as we made our way slowly ahead. The merits of proceeding astern were debated, but some speed was desirable to avoid another storm and we made port late on Christmas Eve. We then made temporary repairs and devised permanent repairs carried out subsequently in Saint John, New Brunswick."

As Director of Ship Design and Construction in 1964, Captain Farrell set up a program to co-ordinate and expedite development work on the aviation facilities for the DDH conversion project. There were a number of problems, but within a year the navy was able to announce a flying capability in the trial ship, HMCS *Annapolis*. In 1965 he began design work on the new DDH-280 class, and in 1966 was posted to Montreal as principal naval overseer to co-ordinate production of the class drawings and the eventual construction of the ships themselves. In 1972 he moved on to broader management responsibilities as Director of Quality Assurance, Quebec Region, leaving that appointment on his retirement in 1974.

Captain Farrell went on to enjoy an extremely successful civilian career, first with CEL Ltd. in Victoria, and later with German & Milne in Montreal and Ottawa. He established his own consulting agency in 1984 and later volunteered his engineering expertise in Latvia and Ukraine.

Throughout his engineering career Captain Farrell brought to his work a tremendous degree of skill, innovation and resourcefulness, along with an unimpeachable work ethic. And while he left a lasting, positive mark in the field of ship refits and new vessel design, perhaps the greatest accolade to be bestowed upon him was the respect he received throughout his life from his family, friends and professional colleagues. This was demonstrated most eloquently by the presence of the 200 family members and friends who came to pay their last respects to him on May 31. Fair winds and calm seas, Keith.

And then, when you must come this way alone,
I'll greet you with a smile and say, welcome home.
— Author Unknown

Of Buzzwords and Specs

Article by LCdr S.K. Dewar

It seems that we are destined to live in a buzzword culture. Everywhere we look the latest trend in thinking has been encapsulated in trite, simplistic words and phrases: *empowerment*, *total quality management*, *synergy* (a personal favourite), *paradigm shifting*, *alternate service delivery*, *decentralization*, *delayering* — we are surrounded by these New Age shibboleths. The urge to distill newfound wisdom into bite-sized packages seems irresistible.

More often than not the buzzword represents an untested hypothesis whose limits of applicability have not been clearly defined. The chief appeal of most buzzwords seems to be that their disadvantages are not yet readily apparent, whereas the failings of the status quo are there for all to see. The great danger, of course, lies in the uncritical acceptance of a buzzword (and the system it represents). Discussion of important ideas often seems to be limited to an enumeration of the flaws of the existing system, presented in contrast to the presumed benefits of the new way of doing business. Scant attention is paid to developing an understanding of how we got to where we are in the first place, or to the obvious fact that the new way of doing business will have its own flaws. Somehow it is just "known" that the new way will be good. Hardly a good basis upon which to make decisions.

There are issues of critical importance to the engineering profession in general, and to the DND engineering community in particular, that are right now being elevated to buzzword status. One issue that causes me a great deal of concern is the move in many quarters toward using *performance* contractual specifications instead of *technical* specifications. (The mil. spec. vs. commercial spec. debate is an important subset of this issue.) Although I've seen enough presentations where performance specs have been touted as the way ahead (usually as a few bullets on an OHP) it seems that no proof of their supposed superiority is necessary. Are there not advantages to technical specs too? I wonder if the people pushing the performance specs really understand the full engineering implications, or if their opinions are being biased by managerial, contractual and legal considerations.

The aim of this letter is not to provide an opinion with respect to the primacy of either method. There are valid reasons for selecting either one (or both to some degree). What I do maintain, however, is that the dogmatic views of the issue are not particularly helpful.

When we choose to go with performance specs, we are in effect spelling out what we want the contractor to do in terms of some measurable *outcome*. How he achieves the outcome is presumed to be unimportant, because we will rely on a test later to ensure the contractor has met his end of the bargain. What counts is that we tell the contractor *what* we want, not *how* to do it. With technical specs, on the other hand, we are prescriptive with the contractor. We place importance on *how* he goes about achieving the desired results. We insist that codes of practice be obeyed and we demand to see the inner workings of his organization. In the vernacular, we are telling the contractor "how to suck eggs."

How do you ensure that long-term performance requirements are satisfied?

The use of measurable, quantifiable standards in determining contractual performance is of great and obvious value to engineers, and for that reason alone I think most of us can see the utility of performance specs. They are also beneficial from a managerial/legal standpoint because they are presumed to shift the risk to the contractor, whereas when we are prescriptive we shoulder some of the risk. The push to performance specs has a lot to do with recognized problems inherent to the prescriptive approach. Errors in "tech" specs, contradictions across large numbers of specifications quoted in a contract, our own unfamiliarity with certain technical specifications — these can be (and have been) disadvantageous to the Crown.

Unfortunately, performance specs have their drawbacks. System performance can sometimes be subjective or difficult to test, and we must infer through other methods that the system can perform as intended. Weapon systems are a case in point, where the only true testing ground (combat) is notoriously difficult to simulate. For many types of systems it is equally impractical to test for extreme, degraded, or unusual performance conditions. Since we can't test for every conceivable situation, the designers and end-users must understand the limits and assumptions that are used in design and manufacture...which certainly does not point in favour of a "hands-off" approach to contracting.

This is particularly true when it comes to dealing with the growing complexity of software systems. In the nuclear industry, for example, great efforts are made to regulate the computer codes being used in designing nuclear reactors. These codes must be carefully validated by experiment before being used to design actual systems. It is the certain knowledge that a discipline was used to develop these new tools or methods that makes them useful. In many cases it is the assurance that sound methods were used during design and manufacture that allows us to infer that the end product is fit for the purpose intended.

A key question in the prescription-versus-performance debate is: How do you ensure that long-term performance requirements are satisfied? A test or trial, which is a snapshot of system performance early in life, may not measure long-term performance. Can contractors realistically be held accountable for problems that show up years after the contract has closed and the warranty has expired? The promise of collecting "liquidated damages" from a contractor after the fact may reassure the lawyers and accountants, but I doubt it offers much comfort to the operational commanders and men and women who have to depend on the equipment or system for many years.

This relates directly to one of the greatest motivations behind the prescriptive approach. The bugbear of engineering is still, in many respects, the strength of materials. Despite years of scientific progress our knowledge of material behaviour is still very incomplete. Precise theoretical predictions of corrosion, cyclic thermal and stress fatigue failure mechanisms remain elusive. Yet these types of failures may not manifest themselves until many years after a system or ship is delivered by the contractors, with potentially disastrous consequences.

The use of technical specs to prevent material failure has had a very long genesis in engineering practice. The failures of steam boilers in the 19th century, the frequent failures of bridges in both the last and the present century, and the failure of the welded "Liberty ships" are all examples of failures which have given significant impetus to the development of specifications and codes of practice for engineering, such as the ASME pressure vessel code.

One would hope that boilers, bridges and even ships and submarines are designed on sound, well-proven methods. Tried and true methods may be staid and boring, but they save lives. Insisting on these methods will limit the latitude of contractors and may stifle innovation to some extent, but engineers should rely on objective evidence before allowing safety margins to be reduced by design. The prescription of technical specs is in effect our assurance that we are not the unwitting subjects of an experiment in innovation (or 'bottom-line' management). It is a very odd and ahistorical view to suggest that the onus must rest squarely on the customer to prove that innovation is justified.

The only sensible, rational approach to DND equipment procurement is to understand that both the *how* and the *outcome* of engineering activities are important. We can not trust in some buzzword to guide us in how we do our business. We must understand the limitations of both approaches, and guide our actions by the knowledge that there are no "silver bullet" solutions to problems. In short, a dogmatic view of contracting and systems/equipment procurement must be avoided.

Perhaps I am preaching to the choir, but silence is often taken as consent. We have an obligation to challenge these new ways of doing business, whether they originate within the profession or without, to ensure that they are sound.

LCdr Dewar is the DMSS 4 project manager for the Maritime Environmental Protection Project.

Truth Versus Loyalty

Article by CPO1 Bob Steeb, CD, CET, CIMarE

As Formation MOC Adviser for the Mar Eng Occupations I was invited to attend the 1996 Eastern Region MARE Seminar held in Halifax in early May. The keynote speaker, Brigadier General Colin Curleigh (Ret.), delivered an impressive presentation which addressed the evolving relationship between the military profession and Canadian society, with emphasis on its possible future implications for the naval engineering community.

BGen Curleigh's address underlined many of the dilemmas facing today's leaders in government, the Canadian Forces and society in general. He referred in particular to the decline and decay of ethics and morality, and what to do when truth and loyalty are at odds with each other. As we have seen over the past few years, this is indeed a concept that faces many in the military when the question arises: Do I remain truthful, or do I bend the truth and remain loyal?

After reflecting on this, I offer the following thoughts. If a conflict arises between truth and loyalty I submit that the truth has already been defiled. Truth can be defined as the state or character of being true in relation to being, knowledge, or speech; it implies steadfastness, honesty and sincerity. Leaders *must* be true. When a subordinate is put into a position of weighing truth versus loyalty because of the actions of a leader or superior, I believe that the unwritten (and unspoken) oath between the two parties has been broken by the leader or superior. While loyalty is noble and absolutely necessary, I postulate that when truth and loyalty clash the leader has broken his or her part of the contract and that there is no dilemma to wrestle with. Truth clearly must win out.

So what does this mean? We as leaders must be unequivocally honest and true when dealing with subordinates. This is a most basic fundamental leadership principle, but judging by recent events I believe it must be stressed, re-stressed and *lived* in the Canadian Forces, the navy and in the engineering community at large. Without truth on the part of the leader we cannot expect and certainly do not deserve loyalty.

CPO1 Steeb is the Halifax Class Chief ERA at Fleet Maintenance Facility Cape Scott, and Formation Mar Eng MOC Adviser.

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.

The Canadian Forces Ship Structural Integrity Program

Article by LCdr Ken Holt

Ships, like aircraft, are designed, constructed and maintained to exacting standards. Despite these similarities, naval ship hull structures are managed in a distinctly different manner, and for good reason. Product applications are unique, resource levels are not the same, and the consequences of failure are different. In addition, the design and manufacturing processes and the production runs differ significantly.

In the context of the Canadian navy there is a continuing requirement to maintain safe ships at high availability rates, all within tight budgetary constraints. This paper discusses the Ship Structural Integrity Program (SSIP), a through-life management approach tailored specifically to meeting Canadian naval requirements. Input has been derived from commercial practice, the CF Aircraft Structural Integrity Program, past experience and good fundamental engineering principles.

Background

The Canadian navy has always had the satisfaction of operating safe warships. To the credit of our designers, builders and maintainers, structural failures have been uncommon, and when they have occurred they have been "graceful"enough to allow the ship time to abort its mission and proceed safely to a shore facility for assistance. Only on the rarest of occasions have Canadian naval ships operating in peacetime been required to take damage control measures due to structural problems.

Despite the success of our naval ships, we are regularly reminded of the need for due diligence. Just last December HMCS *Calgary* was called upon to effect a dramatic rescue of the crew of the bulk carrier *Mount Olympus* when their ship broke up at sea. Between 1991 and 1992 forty-four ships were lost worldwide, while more than 200 ships reported major structural failures. One principal reason for these alarming numbers is the lack of maintenance.

Today, hull design, construction and maintenance practices for Canadian naval ships face unprecedented challenges, not the least of which are conflicting requirements and policies. The various approaches to structural management that have evolved over the years are ill-suited to today's requirements and constraints — safety, availability and resource expenditures. To make matters worse, specialists independently address different areas of responsibility, and system requirements are not always clearly defined or even adequately reported. Now more than ever it is necessary to define an integrated management system in which everyone speaks a common language. If the Ship Structural Integrity Program is to succeed, it will have to offer satisfactory answers to such valid questions as:

HMCS Halifax in drydock *(DND photo)*

• Should traditional levels of safety be maintained (if yes, then how so), or should increased risk of structural failures be accepted in the interest of reducing expenditures?

• How can availability requirements ranging from 70-90 percent be met?

• Since there is no requirement to conduct 100-percent survey and repair procedures at refits every four years for the *Halifax* class and perhaps in future for other classes, can hull structures be adequately maintained by progressive upkeep?

• How will the introduction of the Ship Structural Integrity Program affect the workload of ships' staffs already heavily burdened with PM routines?

• Is life-cycle material management the right approach for through-life management of ship hull systems?

• Can an acceptable balance be reached between opposing requirements such as reduced cost and high availability rates?

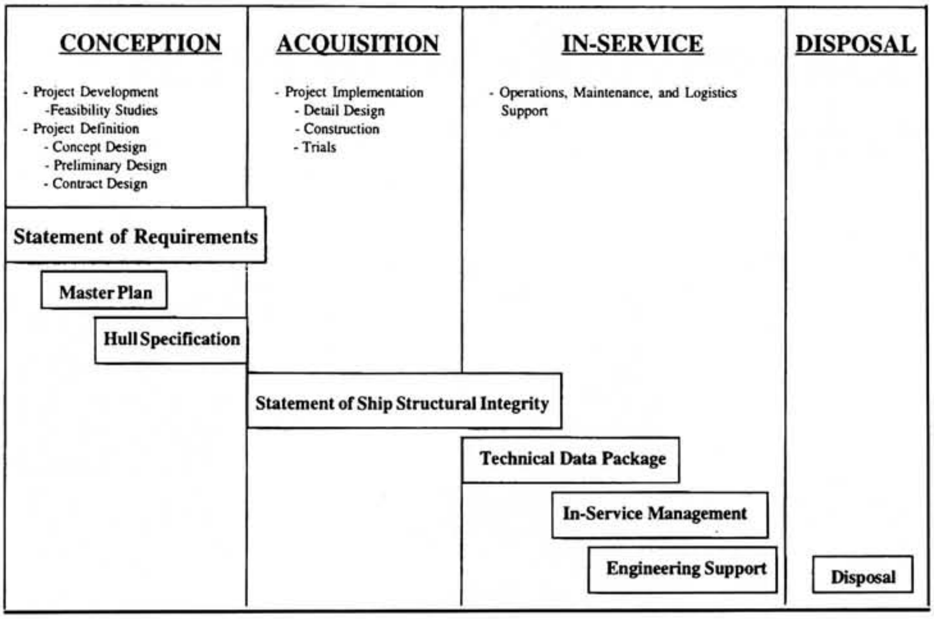


Fig. 1. SSIP Life Cycle Tasks

• To what extent should ship structural integrity management be contracted-out?

The Ship Structural Integrity Program

SSIP has its roots in a number of similar programs, including the air force's ASIP (developed by the USAF in response to aircraft structural failures experienced in the late 1950s) and the American MSIP developed primarily for commercial marine vessels. SSIP has been developed to be consistent with the commonly understood LCMM phases of *conception* (project definition), *acquisition* (project implementation), *in-service* and *disposal.* It is convenient to define SSIP in this fashion since the LCMM role is distinctly different in each phase (*Fig. 1*).

SSIP[1] articulates project and engineering management policy as:

• documentation management (design standards and specifications);

• quality control and quality assurance;

• configuration management (CM);

• effectiveness analysis (e.g. RAM , reliability, availability and maintainability analysis; life-cycle cost analysis; in the future by operational load monitoring); and

• management information systems.

SSIP policy requires that structural standards be written to state the essential and minimum acceptable requirements. To do otherwise would pave the way for excessive safety margins. Under these circumstances the design authority has the continual task of clarifying requirements and confirming ship safety when "soft" limits are exceeded through weight or configuration changes. With minimum safety standards management decisions become simplified, design and acquisition costs become more controllable. The structural LCMM requirements are communicated to allow designers and project managers as much flexibility as can be safely exercised.

Quality control and quality assurance are essential in ensuring the final product resembles the intended design. This applies to construction, configuration changes and repairs to ship structure. SSIP policy requires that these processes be firmly established. Actual process is defined at the contractor's shipyard, or at the fleet maintenance facility (FMF), to best match unique work methods to DND or industry standards. Through rational application, safety and economy are balanced; in other words, full quality control/assurance procedures apply to critical structure only, and sampling techniques are employed for secondary and tertiary structural work.

Structural integrity cannot be confirmed without firmly entrenched CM practices. Change is welcomed since Canadian naval ships can only be effective fighting machines if their equipment and systems remain current. The structural LCMM needs to know details of changes to ensure that applied loads do not exceed hull structural capacity. This is accomplished using mathematical models which form the basis for ship hull safety decisions. For this reason, configuration management of these models and supporting engineering data are given prominence in the SSIP. Economy of effort is assured by rational application of configuration management. For example, document changes are kept to a minimum as CM will be required only for changes affecting important structure. It is intended that a record of changes will be maintained on a master structural drawing, thus limiting the number of drawing updates.

The success of SSIP will be gauged by the lack of unplanned operational disruptions, safety related problems and cost to maintain the hull. This is accomplished by monitoring trends in survey and repair data, by performing RAM analyses (in future by operational load monitoring systems), and in future by monitoring life-cycle cost parameters.

Current data is necessary for all manner of management decision-making such as deciding whether to effect repairs now, or to wait until the next scheduled repair period. Since SSIP relies heavily on information feedback, data is subjected to effectiveness analyses and the results are used to make periodic seaworthiness assessments. Thus, a foundation is laid for improving future designs. In short, management information systems allow an LCMM to know the current structural condition of a ship so that timely action can be taken to ensure minor structural problems do not become significant. Management information systems also enable continual improvement of all aspects of the Ship Structural Integrity Program.

Conception and Acquisition

Each ship class is meant to have its own structural integrity program that recognizes its unique design assumptions and maintenance requirements. A ship's program consists of a series of tasks relevant to the ship's particular life-cycle phase. At conception, an SSIP statement of requirement is developed which includes statements of requirement for capability and availability. An SSIP master plan used primarily for in-house planning clearly defines the specific tasks. The hull specification developed during conception becomes the structural section of the acquisition contract. The structural LCMM, despite being remote from the project management office, is thus able to ensure that essential structural requirements become part of the contract.

Detailed design and construction are generally conducted through contract with industry. As the informed customer, DND provides a check on contractor quality assurance and is responsible for work acceptance against the hull specification. The SSIP requires that the design

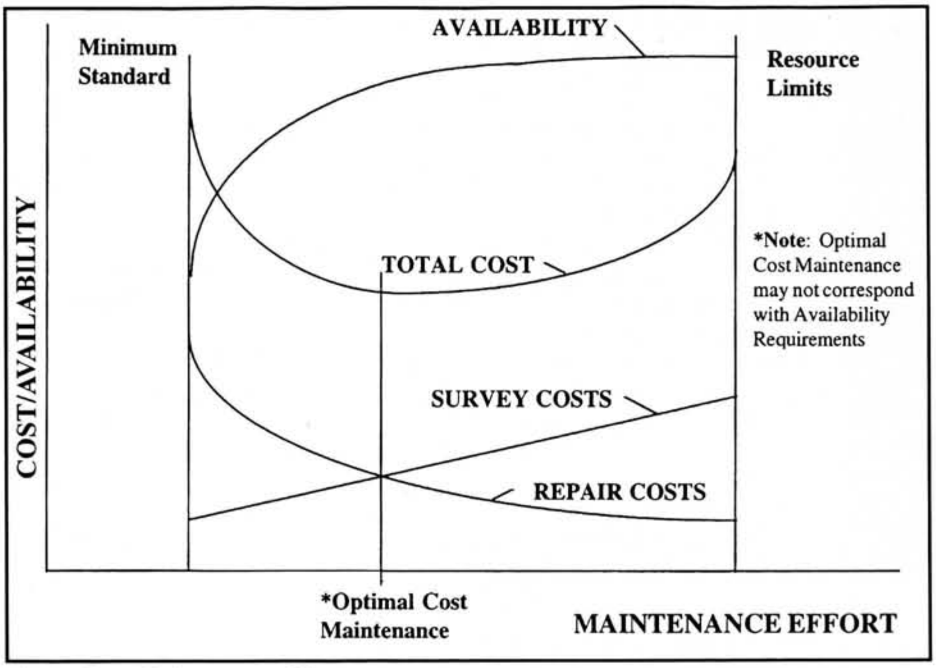


Fig. 2. Cost/Maintenance Effort

team employ well-developed design and analysis procedures, incorporating commercial design practices where it is economical to do so. This is important since the first of class is effectively the prototype; flexibility for change diminishes rapidly as the design progresses. The hull specification, consistent with SSIP policy, provides a basis for clear requirements to be communicated very early in the project.

During the acquisition phase, a streamlined in-service technical data package is assembled to define the ship's structural baseline configuration. This will include key drawings, including a master structural drawing (the focus of in-service configuration management), a structural design disclosure document which highlights important structural design assumptions and parameters, and the structural maintenance plan (i.e. PM routines, including fleet maintenance facility surveyor inspection plans). These ensure accurate post-construction analyses and decision-making.

Two obstacles in the path of design and construction are the lack of performance-based specifications for hull structures, and the lack of ability to conduct full-scale test and trials. With the exception of shock trials, there are no trials which can be performed to prove overall structural capability. Potential risk to the Crown is reduced by SSIP policy which contains guidelines for writing the hull specification.

Striking the correct balance between contractor and in-house effort[1] is an issue which is well beyond the control of the structural LCMM. The decisions that are made have a large impact on the eventual hull structure design and fabrication, although as previously discussed the LCMM ensures that relevant technical input makes its way into the hull specification through the SSIP policy document and design standards.

In-Service Management (Engineering Support) and Disposal

Plans made during the acquisition phase provide initial guidance for in-service management. Technical data packages fully describe the baseline class vessel. Maintenance is scheduled so that ship structures, while under the control of the operational commander, retain a baseline capability within acceptable tolerances. In this manner the requirements for availability and safety can be met within budget. This is the theory; how is it accomplished in practice?

Preventive maintenance routines, judiciously applied, ensure early recognition and rectification of significant defects before they begin to inhibit operations and become excessively costly to repair. The periodicity of maintenance is based on expected degradation rates and on the consequences of failure, and is established such that the baseline hull condition is economically maintained.

SSIP recognizes the delicate balance between the demands placed on ships' crews and fleet maintenance facilities, and those for the surveys and repairs that are essential for achieving minimum safety standards.[2, 3] As it stands, ships' staffs conduct six-monthly rounds (visual observations) of accessible important structure, while the FMFs perform in-depth inspections on a less frequent basis.

A structural inspection database (SID) developed by DMSS 2 and MIL Systems Inc.[4] for storing, summarizing and highlighting significant defects and trends has been in use for three years. SID's ability to store and display sketches means maintainers are better able to match inspections of problem areas to criticality of structural elements. In addition, RAM analyses (or availability centred maintenance analyses) provide a basis for making adjustments to PM routines (e.g. periodicity of surveys). In this manner, the switch to a progressive maintenance approach is manageable.

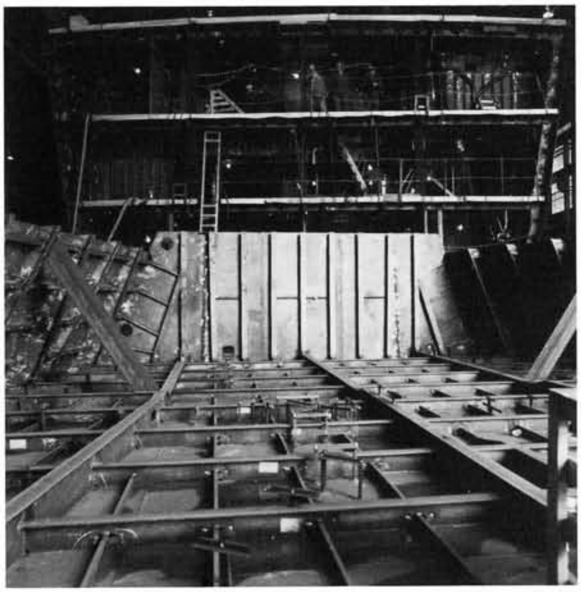
Although life-cycle cost data is not currently available, it is expected that this useful tool for gauging maintenance effectiveness will become available for input to SID in the not-too-distant future. As can be seen from *Fig. 2*, maintenance cost optimization and availability rely heavily upon making correct decisions with regard to inspection scheduling. MSEI (now MIL Systems) has estimated that structural maintenance costs can be reduced by as much as 40-50 percent through better maintenance management.

A Statement of Structural Integrity (SSI) is the culmination of the maintenance effort. When a ship enters service, and every five years after that, an SSI is issued to communicate to ship and operational authorities that the ship has been constructed/restored to a condition consistent with its design structural capability. A copy of the SSI is kept in the Captain's Ship Book.

Throughout a ship's life, the results of lessons learned, technical consultations and configuration changes are all fed back into the SSIP to fine-tune the PM routines. At the end of a ship's operational service the SSIP is closed and its records are archived for the benefit of future ship designers.

Technology Improvement

Continual improvement of the state of the art in the design, analysis and in-service management of ship structures is a general objective. The effort is not class-specific and draws information from all areas of expertise. An Improved Ship Structural Maintenance Management initiative being pursued through the office of the Chief of Research and Development aims to better define loads and the effects



CPF construction

of degradation and damage. It also aims to improve maintenance management of hull structures. Traditional structural approaches rely heavily upon empirical load formulations simply because, without sufficient analytical tools, there has been no alternative. Today, constraints such as limited computing capacity are no longer a significant factor. The CRAD initiative will involve software development, tests of degraded and damaged structures, and full-scale load trials. Hard quantitative evidence on structural degradation rates will be input to ships' maintenance routines so that, in future, fleet maintenance facilities and ships' staffs will be able to assess the operational risks of short-term repairs and "go, no-go" operational decisions.

Conclusions

The Ship Structural Integrity Program covers all LCMM ship hull structural requirements, integrating the management process. To meet availability and cost requirements in an atmosphere of "maintenance by progressive upkeep," SSIP has been tailor-made to meet the structural integrity requirements of Canadian naval ships. This has been necessary since traditional methods do not lend themselves well to today's requirements, and because there are no structural integrity programs on the open market that are relevant to Canadian naval requirements.

Ship hull structural integrity is economically assured through the application of minimum standards, quality assurance and quality control, configuration management, effectiveness analysis and management information systems. The entire process culminates in the issuance of a Statement of Structural Integrity for each ship in the fleet.

The Ship Structural Integrity Program (SSIP) is still in its infancy and will take a number of years to fully implement. Although the in-service maintenance management phase is taking priority at the moment, there still remains much to be done to firmly establish standards at the minimum acceptable levels. In this respect, an internal SSIP steering committee has already made many useful contributions through its own meetings and through reviews conducted across industry.

[If you have constructive criticism regarding the Ship Structural Integrity Program, please contact LCdr Ken Holt, DGMEPM/DMSS 2-3; Tel. (819) 997-5798. Your comments are encouraged and welcome.]

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[1] D-03-002-008/SG-007, Canadian Forces Ship Structural Integrity Programme (SSIP), Draft CFTO, June 30, 1995.

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Notes

[1]Total ship responsibility (TSR), where the contractor assumes responsibility for complete ship design and construction, has been applied in both the CPF and MCDV projects. In his paper, "Reflections on Warship Acquisition Strategies and Total System Responsibility,[2]" Cdr R.Greenwood makes the point that in the Canadian naval context TSR is at one end of the spectrum and is not the most cost-effective approach. He argues that cost benefit in design results from the correct balance of contractual (procurement) and technical (design) aspects. The crown assumes high risk and loses design visibility under TSR; design vs. requirements issues tend to become contractual issues. Greenwood suggests that a partnership with industry, including producibility input from credible shipyards early in the design process, should be considered in future acquisitions. In this way, limited Canadian resources will be best utilized with the greatest probability of success.

[2]PM routines are the central focus of structural maintenance. The survey and repair standard defines minimum acceptable defect characteristics beyond which repairs are required.

[3]Through weight monitoring, ship loads are managed within acceptable limits. This relies on maintenance of ships to a fixed condition baseline (modified only through the configuration change process).

[4]The Royal Navy and the USN have purchased copies of SID. Australia and the Netherlands have expressed keen interest in possible future applications.

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A proposal to improve the protection and control of a warship's electric plant

Article by LCdr M. Tinney

This article is based on a paper originally published in the proceedings of the IMarE conference entitled, "Electric Propulsion, The Effective Solution?" held in London, England, Oct. 5-6, 1995.

Warship distribution systems are becoming more complex, with transient inducing loads connected to the same network as sensitive loads. In modern warships all major systems including weapons, command and control, propulsion control and damage control have become very reliant on, and very sensitive to, a supply of stable electrical power. Enhancing the survivability of these systems therefore depends to a great degree on the survivability of the electric plant. While efforts have been expended toward designing protection and control systems to provide adequate levels of reliability and survivability, it is suggested that there is still a need for improvement in:

- power, load and distribution system management;
- fault detection and isolation; and
- equipment health monitoring.

Power, Load, and Distribution System Management

Power management: Ideally a generator should be operated in the range of 65 percent to 90 percent of peak power to provide optimum operating conditions for the prime mover. However, it is not unusual to see generators operated at very low loads for long periods of time. Typically, when the load reaches 80 percent of the generation capacity, another generator is automatically brought on line. As a result, if one generator is running at 79 percent load when a large intermittent load is started, a second generator will automatically start. When the load is removed, the second generator will remain on line even if the load drops well below the 80 percent level. It is then left to the ship's electricians to monitor the load and return the system to single-generator operation. However, as this might not occur for several hours, there results inefficient usage of power and undesirable operation of generator prime movers. Hence there is a need for an automated control system to ensure that generator prime movers are operated within their optimum operating range.

Load management: There is currently no control over the start-up of loads in existing networks. As a result, a variety of low-priority loads such as compressors and pumps can be brought on line ran-

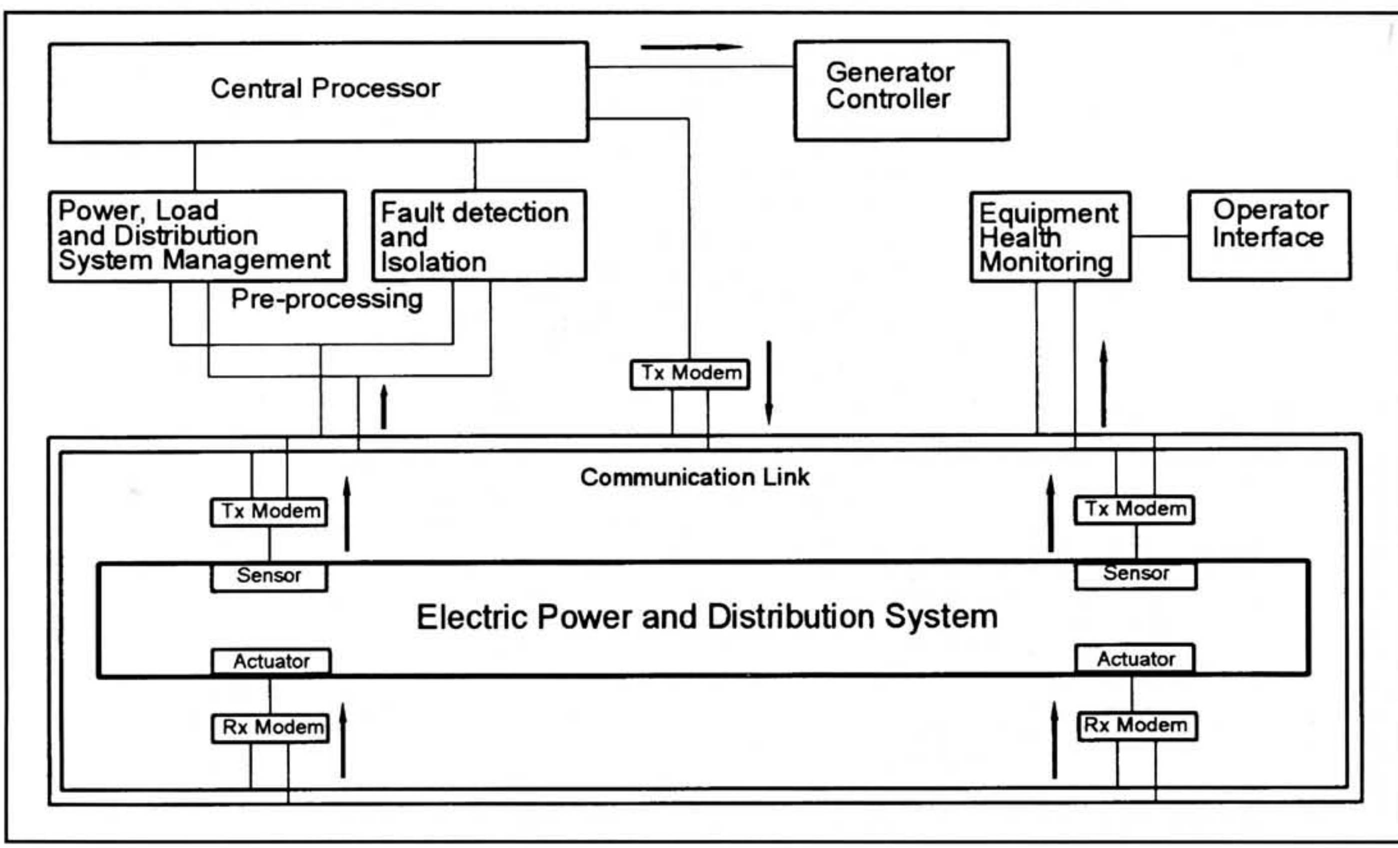

Fig.1. IPS General Layout

domly by either manual or automatic means. The problem is that they may be brought on line at a time when the system is not ideally set up to absorb the new load. The random nature of loads being added to the system also opens the door to situations where two or more large loads attempt to start at the same instant. Since unpredictable events such as these can cause load shedding or generators to trip, there is a need for a system that can ensure loads are brought on line in a controlled fashion when the supply system is ready.

Distribution system management: Given that warships by their very nature are intended to go in harm's way, it follows that the reliability of the power supply to connected loads under all conditions, and the survivability of the power plant under battle conditions are two key aspects of a naval power and distribution system. The commonly used radial distribution system is not the best design when maximum ship survivability is the aim. In a conventional distribution network it usually takes about half a minute to bring up emergency power following a complete power loss — a potentially disastrous delay for a ship in a battle situation.

Fault Detection and Isolation

The control philosophy which governs the action of conventional protection systems is designed to protect the connected cable and loads with little or no co-ordinated control between breakers. For example, in a short-circuit situation, if the breaker closest to the faulted circuit does not react fast enough, the next breaker in line will trip and other components will be taken off line unnecessarily. This action may protect the circuit well, but it does not take into account the safety or operational requirements of the vessel. In addition, an incorrect trip sequence can lead to even greater problems such as network instability, unnecessary loss of generators and even further loss of power to loads which should not have been affected. Also worth noting is that some types of faults can go undetected and unrepaired for long periods of time simply because the protection system has no way of monitoring for them. Typical examples include high-resistance-to-ground faults, broken insulation and crushed or damaged cable.

Equipment Health Monitoring

Conventional distribution systems have no capability to automatically detect and analyze problems in any of the driven loads. Instead it is common to rely on preventive maintenance and EHM techniques to detect equipment problems, both of which are manpower intensive. A solution would be to develop an automated system which could evaluate and advise on the condition of large loads throughout the system.

The Solution:
An Integrated Protection and Control System

A proposed solution to the deficiencies just described is an integrated protection and control system (IPCS) as illustrated in *Fig 1*. The system would consist of a centralized intelligent process controller which can monitor and control all the major elements in the power and distribution system, including the generators, distribution components and major loads. The central processor would get its information from numerous sensors distributed around the power plant and connected through a ring communication link. For maximum benefit the system would need to be designed around a zonal distribution system that would allow power to be rerouted around damaged areas, or areas under maintenance whenever necessary. The centralized processor utilizing an expert controller would employ a degree of intelligence in handling the system's fault protection, power management, load management, distribution system management and equipment health monitoring.

The IPCS concept of power management involves keeping track of the load on separate or parallelled buses, and controlling the starting and stopping of gen-

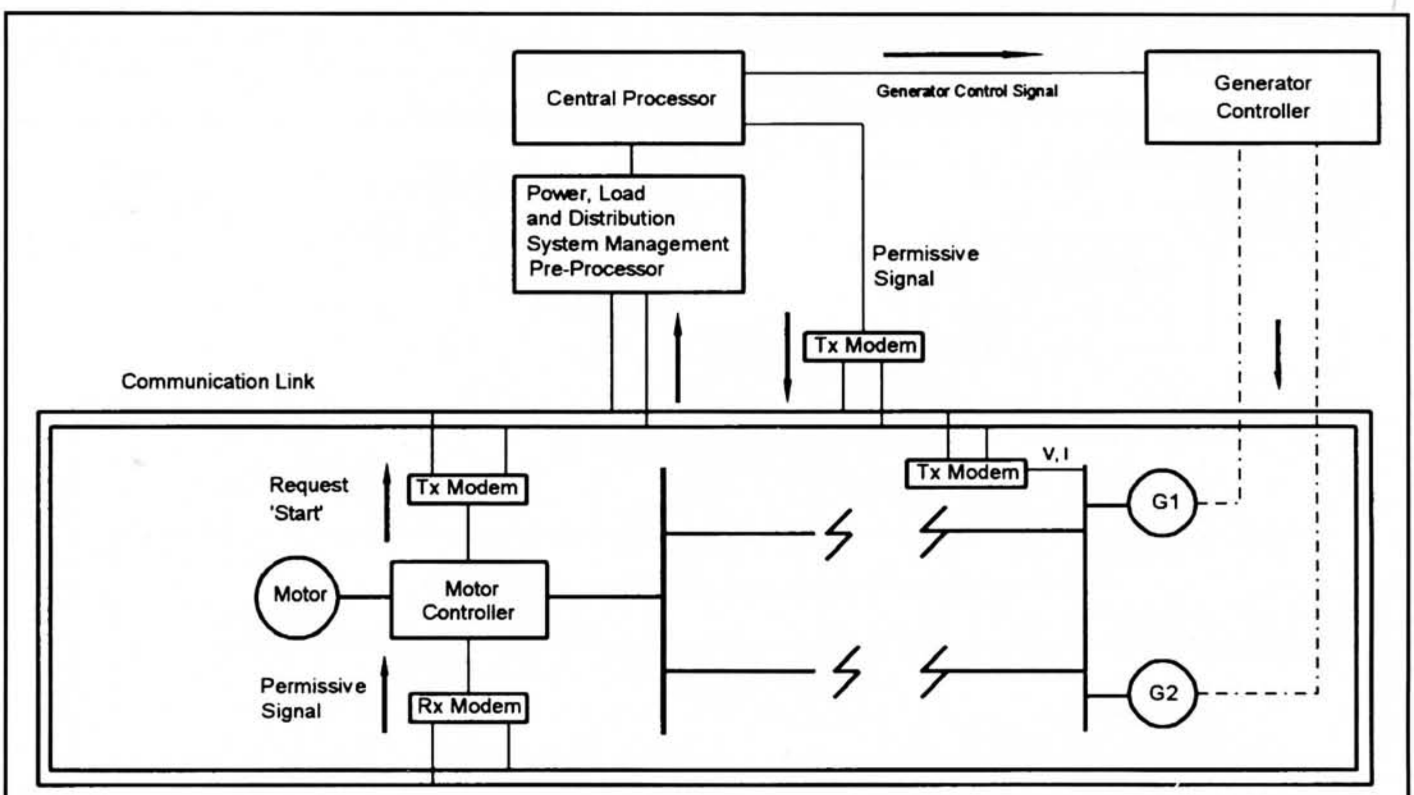

Fig. 2. Power and Load Management

erators in accordance with preset upper and lower limits. The aim is to keep all generators operating at optimum power levels for the prime movers.

The IPCS concept of load management illustrated in *Fig. 2* would entail the control of all large loads such that they would not be allowed to start until the IPCS had first ensured the generation system was ready to absorb the new load. The definition of a large load would depend on the generation capacity of the installed generators. To achieve this, each load controller would transmit a REQUEST START signal to the IPCS over a communication link. In response, the IPCS would ensure the generation system was properly set up to absorb the new load, then transmit a "permissive" signal over the same communication link. This signal would control an auxiliary contactor in the load controller which would then allow the load to start.

For high-priority loads the IPCS would check to see if the generators could absorb the increased load. If yes, the IPCS would immediately send a permissive signal to allow the load to start. If the system determined, however, that the generator could handle the new load in the steady state, but that the in-rush current might cause a generator to trip, the IPCS would automatically shed preselected low-priority loads. The IPCS would then send a permissive signal to allow the new load to start, and bring another generator on line. Finally it would pick up the low-priority loads that had been shed.

The response to the start of a lower priority load would be basically the same, except that the IPCS would try to avoid starting a second generator if possible. With the IPCS constantly monitoring installed loads, the load on the generators could rise to 90 percent without the danger of a generator tripping on overload. Conversely, as power demand dropped, the IPCS would reduce the number of generator sets on line. Examples of systems that might be identified as low-priority loads include electric heaters, some galley and laundry equipment, and certain fans and pumps.

In an IPCS system, reliability and survivability would be enhanced through the use of a zonal distribution system as shown in *Fig. 3*. The zonal system would have two constantly energized buses connecting the loads through a load distribution panel. The IPCS would be programmed to ensure that the port and starboard buses were powered from separate sources of supply, whenever possible, and that the buses were synchronized and ready to be parallelled in an instant. It would also automatically transfer power with a no-break static transfer switch in the event of power loss on one bus, or reroute power around damaged areas. Aside from providing a more reliable and survivable supply network, the zonal system would actually be cheaper to procure and install than a radial network. It would require fewer components and less cable than a radial network and would fit in nicely with modular ship construction; both of which would provide cost benefits.[1]

The IPCS approach to fault identification and isolation would recognize that the continuous availability of electric power is of paramount importance in preserving the ship's operability, integrity and safety. A purpose-designed IPCS would consist of programmed microprocessors housing all control functions for the switching apparatus. Since the system would receive input from many of the distribution components, the IPCS would be constantly updated with the status of the instantaneous current and voltage in the feeders. It would then transmit appropriate control commands to the breaker relays. The breakers and switches themselves would retain many of their existing capabilities as a form of back-up. Under normal operating conditions the microprocessor would control the system at such speeds that the fault detection components in the breakers would be rendered redundant. But if the IPCS should fail for any reason, the breakers would still provide a degree of protection to the system.

An IPCS could clear overloads, short-circuit faults and other types of single- and multiple-phase faults faster than a conventional system, while controlling breaker co-ordination better. Any faults that occurred would be detected and isolated automatically, with power being rerouted to the loads whenever possible. Reverse power protection would also be dramatically improved since the IPCS

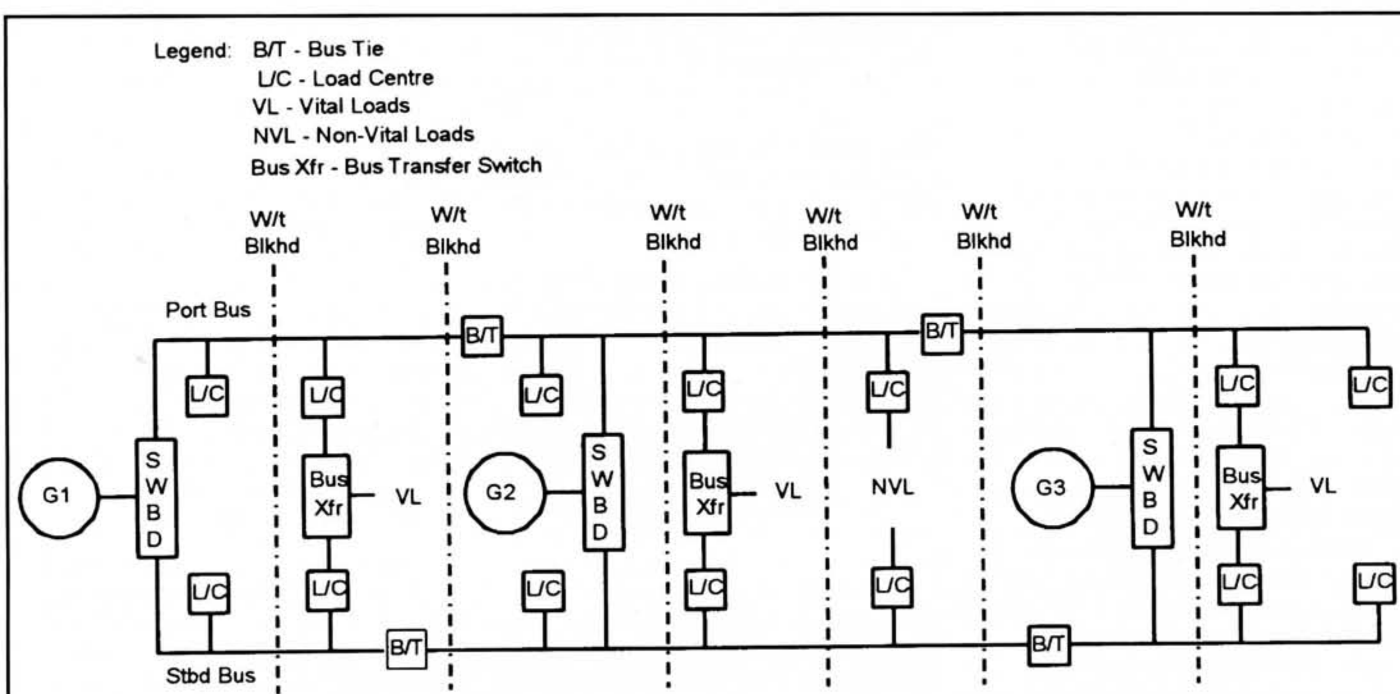

Fig. 3. Zonal Distribution System

would be able to discriminate between generator internal faults and generator parallelling operations. Overloads on the network would be rare since the IPCS would be designed to prevent such occurrences through the use of the power and load management system. Should an overload occur, the IPCS would be faster and much more accurate in identifying the problem, and much smarter in its response.

An IPCS could be programmed to monitor all circuits for high-resistance-to-ground faults, broken insulation and damaged cables, and alert the ship's electricians to the existence and location of these types of faults. High-frequency pulsing techniques currently used by telephone cable repair crews could be used to locate the exact position of faults. Identification of the specific problem could be accomplished by measuring the energy content of high-frequency components in the power supply lines. This procedure relies on the fact that damaged cables generate arcing current with significant levels of broadband current. The energy content is obtained by filtering out the 60-Hz component of phase current to obtain signals in the 2-10-kHz band, and then summing the squares of digitized samples averaged over the period of a 60-Hz cycle. This procedure is already in use in land-based power system monitors.[2]

The EHM aspect of the system would be designed to focus on large motors and their driven loads throughout the distribution system. This would be accomplished by carrying out signal analysis of the power supply lines feeding the motors. We can utilize the fact that induction motors are effectively two-directional transducers to monitor the state of the pump end of a motor/pump arrangement by monitoring the input power. Problems in either the motor or the driven component create vibrations which materialize as torque pulsations which are in turn reflected in the electrical waveforms at the input to the motor.[3] This aspect of the system will fit in nicely with the rest of the IPCS system since the existing communication link can be used to transmit the measured signals to a centralized processor tapped onto the link. This processor will use signal analysis techniques to identify problems such as phase imbalance, open circuits, or internal shorting in motors, and worn impellers or bearings in pumps. All that would be required to perform this analysis is a few seconds of signal analysis of the input waveform to the motor and a set of baseline readings for comparison. The output of this processor would be system status messages relayed to the watchkeeping consoles.

IPCS Equipment

Sensors: For fault protection and power management purposes, voltage transducers in the form of potential transformers, and current transducers in the form of either current transformers or Hall Effect probes would be employed. In circuits fed from small breakers with an instantaneous trip coil, but no relaying, a small Hall Effect probe would be used to detect the field in the trip coil. The breaker trip would then be set to maximum so that it would only operate if the IPCS were to fail for any reason. Signals from the sensors would then be fed onto the communication link through modems such that all signals would be available to the host computer in real time. In this system, the term "modem" refers to analogue modulator/demodulators as opposed to digital modems.

Data transmission method: Since the IPCS would demand that a multitude of sensors and actuators be controlled simultaneously, analogue communications rather than digital would be employed. Amplitude-modulated (AM) single-sideband (SSB) frequency division multiplexing (FDM) would be used to transmit the numerous signals over a communication link simultaneously. Coaxial cable would be used for the communication link since it has a broad bandwidth and is more suitable to analogue communications than fibre optics. For survivability, the link would be triple-redundant, with one communication link in the keel, a second to port and a third to starboard. Since SSB modulation requires only 3-kHz bandwidth per channel, a coaxial cable could provide thousands of channels, thus allowing sensor and control signals to be transmitted simultaneously.

Transmit modems: Sensor signals would be fed onto the communication link using inductively coupled oscillators fed by a stable carrier frequency. These devices would modulate the carrier with the sensor signal and then convert it to single-sideband prior to transmission.

Preprocessing: At the central processor the complex input signal from the communication link would be fed through a series of filters, tuned resonators and demodulators to separate the original sensor signal from the envelope of the carrier wave; one such circuit would be required for each signal. The signals would then be fed through a signal verification process and analogue-to-digital converters prior to being processed by the main processor.

Main processing: The backbone of the IPCS would be a central processor, continuously updated with signals from the system sensors. For a patrol-frigate-sized plant it is estimated that the central processor would actually consist of five processors running in parallel in order to monitor all of the sensor data. The logic forming the basis of the central processor would be derived from a powerplant simulator. Mathematical models of all generators, loads and interconnected equipment would be translated into independent software modules with separate input and output files. These modules would be tied together to form a powerplant simulator which would be operated under all normal and adverse conditions to identify the most predictable fault characteristics. Based on this an expert control system would be designed to recognize the normal and abnormal operating characteristics of the distribution system and control the system as required. This expert controller would be modelled, simulated and run against the powerplant simulator to ensure that it performed as desired. A hardware model of the control system would be verified by running it with the powerplant simulator. From this any problems in the control algorithms or the fault-identification capabilities of the system could be identified and, hence, rectified early.

Running in parallel with the central processor would be a separate processor containing the system simulator software which forms a reference knowledge base for the main processor. Under normal operation, the central processor would monitor the system parameters and compare the system's status with that of the powerplant simulator. Abnormal operations requiring fast response, such as during a fault, would be accomplished by matching fault signatures against look-up tables stored in memory. Responses to overlapping areas would require a combination of these two procedures. Such responses would have to be established via the simulator and then moved into a rule-based expert module for real-time discrimination between faults and operational disturbances.

An important aspect of the expert controller would be its adaptive capabilities. Consider a scenario where a drive motor is replaced by a motor of a different design, perhaps as an emergency measure or as a result of a design change. The time response and electrical parameters of the new unit would replace the data file for the old motor in the system simulator, and the simulator would be run to derive new set-points and ramping functions for the control system to ensure stable operation. Based on this, new control algorithms would be implemented and the control system could quickly be ready to operate with the new motor in the system. Similarly the system could be adapted to account for changes in the system parameters due to aging. The simulator could also be used to spot failure trends and provide predictions if similar incidents start to develop in the future.

Postprocessing: Post-processing involves the transmission of appropriate command signals to the actuators through the common communication loop. It is estimated that the time between the occurrence of a high-priority fault and the issuance of a control command would be in the order of five microseconds. Normal monitoring and control sequences and lower priority faults could be handled within 50 milliseconds. The actuators would receive their control signals through modems that demodulate the transmitted control signal from the carrier.

Postprocessing would also include administrative functions such as sending information to a printer or display screen, or storing data in a computer memory bank. Information in the data bank might be useful for post-fault analysis in an attempt to avoid fault recurrences, or simply to keep track of the number and type of faults which occur in the system.

Actuators: For fault protection, the command signals from the CPU would be fed to the trip relay of conventional breakers. For load management purposes, the signals would be fed to a solid-state switch upstream of the breaker controlling the unit to be controlled. Thus a unit could be started or stopped without operating the breaker. For power management, command signals would also be fed to an interface with a generator's control system to start and stop the unit as required.

Summary

Although most of the technology and hardware that would be required for such an IPCS is well proven and readily available, the system described here remains largely at the conceptual stage. A couple of studies sponsored by DMSS 5 have indicated that the concept has good potential and numerous benefits. For example, the increased speed of response in identifying and isolating faults could allow generators to be designed with lower short-circuit tolerance, offering weight, size and cost benefits to a warship. The most notable benefits, however, would be improved reliability in the delivery of electric power and improved survivability for the warship as a whole.

The concept is modular in nature in that either some or all of its functions could be employed as deemed necessary. For example, the mere application of power management would be of enormous benefit for any warship and would not require that load management also be provided. One aspect of the IPCS concept currently being developed by DMSS 5 and the Naval Engineering Test Establishment is the ability to monitor the condition of large motors and their driven loads using motor-current signature analysis. This would form the backbone of the EHM system.

Warships by their very nature must be designed to go in harm's way. Therefore, the survivability of each system in the ship is a significant characteristic which must be carefully considered during the design stage. Each system must be designed to resist damage and, should it occur, to tolerate damage. The integrated protection and control system was conceived to improve the survivability of the electric power and distribution system through the use of redundant controls, separated systems, automated systems and smart controllers. The IPCS would improve the protection system's ability to identify and respond to both normal and abnormal operating conditions in the distribution system. It would also provide automated power and load management which would minimize the potential for overload situations and improve the operating conditions of the generators and their prime movers. The envisaged system would improve equipment maintenance through the use of an on-line, real-time automated EHM system to monitor the condition of electric motors and their driven loads in a pro-active manner. Redundancy of the power supply would be provided through the use of a zonal type distribution system able to reroute power around damaged areas while maintaining power to essential services.

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LCdr Tinney is the DMSS 5 project manager for power generation and conversion equipment. His article, "Electric Propulsion — The Way of the Future," appeared in the October 1995 issue of the Maritime Engineering Journal.

CF Surface Ship Stability Management

Article by LCdr Garry Pettipas

Most readers will recognize the essential capabilities of a warship as, "float, fight, move." So key are these capabilities that functional robustness is specified as a system requirement. Cross-connectivity, alternate supply and emergency power sources are "designed into" most systems to ensure that, should a primary system fail, a back-up system will provide that essential capability on demand. Significant effort is directed toward maintaining basic system functions as well as back-up sources.

These concepts, as they apply to the "fight" and "move" capabilities, are well understood. The same cannot be said of the "float" capability. Too often the ship is viewed as an immutable platform possessing infinite strength and stability. While it is true that the hull system is highly reliable and requires comparatively little maintenance, this must not be used as rationale to discount the importance of hull maintenance. Consider the impact on the "fight" and "move" capabilities should the ship cease to float.

The "float" capability refers to ship stability — ships must float (buoyancy) and they must float upright (stability). Stability capability is quantified using the hull's buoyancy and a calculated righting arm. The capability must be sufficient to withstand high seas, strong winds, upper-deck ice accumulation and high-speed turns in times of peace and war.

Stability robustness is addressed by specifying a damaged stability capability. As with all battle essential systems, a portion of the fitted capability is held in reserve to enhance overall availability. A ship's hull is divided into watertight sections which collectively contribute to the total buoyancy and stability of the ship. Damaged stability specifications identify a number of these "buoyancy components" as inactive (i.e. flooded) and require the remainder of the hull system to keep the ship afloat with a specified minimum freeboard and righting arm. Damaged stability capability is a critical factor in hull design. It comes at a price in terms of ship size and trade-offs with other fitted systems.

Like any other ship system, the hull system's performance diminishes over time. Stability degradation results from weight growth and the upward migration of the ship's vertical centre of gravity. Typically the damaged stability capability is the first to be compromised. Since this capability is seldom required during normal peacetime operation, its erosion is transparent to the ship's operators and draws little attention.

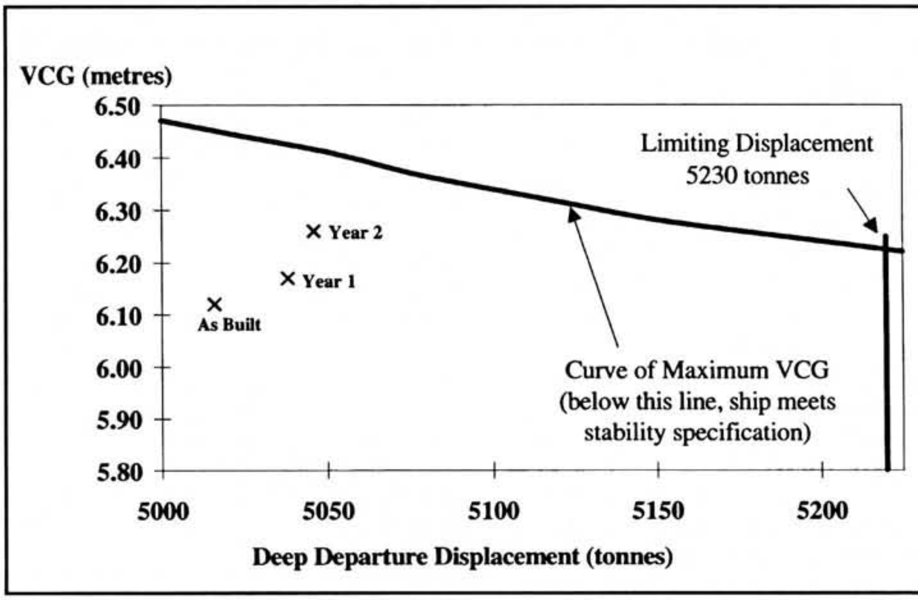

Fig. 1. Sample of a weight management envelope for a ship class, showing displacements and vertical centres of gravity as built, and after the first and second years of service.

Hull Stability Capacity

There is a physical limit to what can be safely carried by any hull. Consider a sailing dinghy: excess weight will sink it, or if someone were to shinny up the mast the dinghy would become much less stable and could even capsize. These two basic mechanisms are used to define a hull's stability capacity.

Stability capacity may be represented using a weight management envelope (WME) which identifies limiting values of ship displacement and vertical centre of gravity (VCG) beyond which the stability requirements are not met. Typically the WME is defined by a worst-case damage scenario derived from the stability specification. The WME takes the form of a Displacement vs. VCG graph as shown in *Fig. 1*. Although the WME is developed to address stability management issues, the interrelationship between ship weight and longitudinal strength is also considered. Where the vessel's limiting displacement is defined by longitudinal strength rather than reserve of buoyancy, this fact is indicated on the WME.

Stability Management

Stability management refers to activities which monitor, assess and control the degradation of the a ship's "float" capability. Its purpose is to ensure that the hull system remains capable of performing as designed throughout the vessel's service life. The basic requirements for stability management are the same as those for any other system:

- develop a specification describing what the system is expected to do and how well it must do it;
- identify a method for verifying performance;
- document the system's performance over time to track degradation; and
- take corrective action when the system no longer complies with the specification.

Warship stability capability is specified by defining both the *intact stability* criteria and the *damaged stability* criteria which are derived from the operational requirements of the ship. The achieved stability capacity depends on the shape of the hull, the internal watertight subdivision, the ship's weight and the distribu-

Stage	Task	Agent
Concept	Develop stability specification	Naval Requirements Staff
Acquisition	Define class stability requirements	Project Manager
Acquisition	Track design and build weights	Contractor
Acquisition	Develop class stability mgt. plan	Contractor
Acquisition	Demonstrate stability performance	Contractor
Acquisition	Develop technical data package	Contractor
In-Service	Manage stability capability	Class Manager
Disposal	Summarize through-life growth	Class Manager

Table 1. Summary of SSMP Tasks

tion of the ship's weight. It is important to specify stability requirements early in the design so that the required capability is designed into the vessel. It is impractical, often impossible, to reengineer an existing ship to meet an enhanced stability capability.

Verifying the stability capability requires an inclining experiment to determine the ship's weight and centre of mass. The data collected is used to numerically assess the vessel's capability according to the specified stability criteria. The results of a stability assessment are documented in the Captain's Ship's Book (via the Statement of Metacentric Height) and in the ship's Manual of Trim and Stability. The information in these documents is used to adjust the ship's heel and trim and to estimate the ship's response to various cases of hull damage.

Once a ship enters service the stability capability will begin to degrade as a result of inevitable weight growth. In some cases it is possible to minimize the adverse effects of weight growth by moving existing weight lower into the ship, or by adding ballast to lower the ship's centre of gravity. What must be realized, however, is that once a hull's physical weight limit has been reached, additional weight growth (intentional or otherwise) will lead to degraded stability capability. At this point the only way to restore the damaged stability capability is to remove weight from the ship, usually at the expense of some operational capability. For example, a reduction from two embarked helicopters to only one would restore the stability capability, but at the expense of helicopter availbility. An alternative approach would be to accept some degree of degraded damaged stability capability, thus exchanging wartime survivability for peacetime operability.

Ship Stability Management Program (SSMP)

To address the need for managing the through-life degradation of ship stability, the Canadian Forces is implementing a formal ship stability management program consisting of eight tasks (*Table 1*). The level of additional effort beyond that currently being expended is minimal as, for the most part, the identified tasks are things that we have done in the past. The SSMP draws these tasks together and identifies them as requirements of the "float" capability of CF warships. Each task is associated with a particular stage in a ship's life and is assigned to one of the key agents of that life-cycle stage.

A detailed explanation of the requirements of each task may be found in the SSMP document and is not repeated here. The impact of the program on the fleet will come mainly from the weight monitoring and weight status reporting portions of a document known as the Class Stability Management Plan (CSMP). The CSMP is produced during the acquisition project and delivered to the in-service class manager along with the ship's technical data. The CSMP details:

- the stability specification defined by the acquisition contract;
- the in-service procedures for monitoring a ship's physical weight, recording authorized weight changes and tracking the migration of the centre of gravity;
- the weight management envelope; and
- the requirements for in-service weight reports, weight surveys, inclining experiments and updates to the stability documentation.

The objective of the CSMP is to ensure that weight growth due to engineering changes, involuntary weight growth and mid-life upgrades is well managed and does not compromise a vessel's stability capability beyond the stated stability specification. In real terms, weight monitoring is accomplished by the ship's staff reporting draft readings and liquid loads to the class desk. While the details of individual class stability management plans will vary between classes, the intent is to collect between ten and twenty estimates of the ship's actual displacement per year. This data will be augmented by an annual displacement assessment conducted by the fleet maintenance facility and will be used to plot the ship's physical weight on the weight management envelope.

For stability management to be effective it is vital that the agent managing engineering change and ship configuration also be the authority for weight control. Without weight feedback to the desk managing the ship configuration, the weight growth process is open-ended and cannot be controlled. It is the responsibility of the in-service class manager to ensure that the weight change summary sheets of all approved engineering changes (ECs) are retained. By adding these documented weight changes to the known ship weight at the time of the latest inclining experiment, the ship's current weight can be estimated. The vertical centre of gravity information in the ECs can be used to estimate overall migration of the vertical centre of gravity in a ship.

Generally, in-service weight reporting will occur annually (depending on the CSMP) so that ship modification authorities, operators and engineering support staff can observe a ship's weight growth and compare the vessel's current weight against the weight management envelope. Thus, the remaining capacity of the ship to incur additional weight growth without compromising its stability capability will become known.

A Closing Note Regarding Weight Growth

A weight allowance is included during ship design to account for in-service growth and mid-life upgrade. The allowance is based on the experience of previous designs, tempered by the fiscal and political realities of the day. Regardless of how the number is decided, that growth when added to the forecasted "as delivered" displacement becomes the "worst case, end-of-life" displacement used to design the ship's stability and strength capacities.

In-service ship weight may be broken down into several broad groups:

- light-ship weight (structure and fitted equipment);

• liquid load (fuels, ballast water, fresh water);
• solid weight (provisions, stores, spares, etc.);
• bilge water; and
• crew and personal gear.

Since the light-ship weight may be altered only by authorized engineering changes, such controlled weight growth becomes the responsibility of the in-service class manager. Liquid loads normally do not "grow" because the volume of the structural tanks is fixed. Some minor weight deviations will occur due to changes in fluid densities, but monitoring ship weight to that level of precision is not necessary. Solid weight and bilge-water weights are promulgated by design documentation and are managed by ship's staff. Crew weight, of course, is determined by the established crew size for the vessel.

Ideally a ship's weight derived from engineering change data can be reconciled with the weight derived from draft readings, but in practice this is rarely the case. The difference lies in the uncontrolled weight growth resulting both from the way the ship is loaded for operations and employed, and from the amount of "unofficial" gear and fittings added by the crew (bicycle racks, exercise equipment, etc.).

The point to note is that all weight change will affect the strength and stability of the vessel. Stability is eroded by the cumulative effect of *all* weight added to the ship. In this sense it becomes everyone's responsibility to help manage their ship's stability capability prudently by not embarking unneeded or undocumented items.It doesn't matter whether the added weight is an authorized engineering change, a temporary mission fit, foreign port souvenirs, extra groceries or bilge water. If it pushes the ship beyond the weight management envelope, the stability capability designed into the ship will be compromised.

LCdr Pettipas is with the DMSS 2 ship stability design authority in Ottawa.

1996 Eastern Region Maritime Engineering Seminar

Article by Lt(N) Jacques Brochu

The Eastern region MARE seminar was convened at the Canadian Forces Maritime Warfare Centre in Halifax, Nova Scotia, May 8-9, 1996. RAdm Gary Garnett, Commander of Maritime Forces Atlantic (MARLANT), provided the opening address to an audience of approximately 100 military and civilian engineers and technologists. At the end of the seminar BGen Colin Curleigh (Ret.) delivered a well-received keynote address on the importance of ethics in the military profession and in Canadian society as a whole (see "Wisdom and Morality in the Age of Information").

A total of 13 presentations were made, covering different fields of the Maritime Engineering profession. Technical issues included: "Combat Systems Data Acquisition and Analysis," by Lt(N) Grant Sullivan (FMF *Cape Scott*); "Marine Data Acquisition System (MDAS)," by Mr. Steve Dauphinee (FMF *Cape Scott*); "Submarine 2000," by LCdr Earl Gosse (DREA); and "Reengineering our Maintenance Concepts," by Mr. Ahmed Abdelrazik (NETE). The delegates produced informative presentations which underscored the importance of accurate data gathering and efficient maintenance procedures in providing timely, efficient and cost-effective support to the fleet.

The training aspect was covered by Capt(N) I.D. Mack (N12 Training) and LCdr Jeff Whalen (CFNES) with their respective presentations on "CFNES 44A Training" and "CFNES Computer Based Training." They clarified some of our more immediate training priorities and the likely nature of the navy's future training missions and techniques. LCdr Derek Davis and LCdr Joe Murphy addressed career management issues in a realistic and positive manner. It is fair to say that in spite of the significant challenge facing the effective management of the naval officer MOCs, the Maritime Engineering occupation is in good health. The objectives of the Force Reduction Program have been reached, and IE/IPS terms of service are not affecting us adversely. Equally, professional advancement opportunities such as staff college, postgraduate training and second-language instruction seem to be available in reasonable numbers.

Organizational and operational requirements were also extensively discussed. Cmdre F.W. Gibson presented the DGMEPM perspective on the way ahead for the MARE community, Capt(N) D.J. Marshall discussed the results of the Naval Engineering and Maintenance Functional Review and Cdr Don Flemming (SPO/DGMEPM) addressed the impact of the MARE OA recommendations. These senior officers, together with Capt(N) MacKay, Capt(N) McMillan and Cdr André Langlois who discussed Maritime Operations Groups commitments and DNR procedures, provided honest opinions which significantly contributed to the overall success of the seminar.

Certainly one of the most appreciated parts of the seminar was the senior officer open forum. Several interesting and important issues were addressed, with a strong emphasis on the perceived lack of leadership within MARE senior management. Cmdre D.G. Faulkner (N4 Materiel) closed the proceedings, thanking the presenters for their time and congratulating them on their professionalism. Cmdre Faulkner said that their timely and positive contribution had made the seminar viable. He also emphasized the essential need for strong leadership from within the MARE community to provide direction and definition in this time of transition. The objectives of the seminar were met, and for those who participated, it was clearly a success.

Lt(N) Brochu is the staff officer to the engineering manager at FMF Cape Scott.

Keynote Address* to the 1996 Eastern Region Maritime Engineering Seminar [*abridged]

Wisdom and Morality in the Age of Information

By BGen Colin Curleigh, CMM, CD (Ret.)

My task today was set by Commodore Faulkner when he asked me to address the matter of the evolving relationship between the military profession and Canadian society, with emphasis on its possible future implications for the naval engineering community. I will respond to his direction in this address, but perhaps in a way that he did not anticipate or intend!

As many of you know, Captain Tom Brown (Ret.) is with the Continuing Education department of the Technical University of Nova Scotia. At lunch a few months ago he asked me if I was interested in helping him set up and run a course on "Ethics in the Workplace." He caught my attention and we have been working together on this project ever since.

Although I had touched on ethics in my philosophy studies, I have been away from management and organizational theory and practices for several years. In my subsequent research of current thinking on these matters I reviewed books with such titles as "Business Ethics in Canada," "Leadership and Integrity," and "Ethics and Excellence." In this survey of recent literature I came across a recurring theme that stands out so boldly that it will very likely become the dominant concern not only of business, but of our civilization during the next decades.

Barbara Tuchman, the well known historian, has characterized our century as an "Age of Disruption," citing such familiar concerns as environmental degradation, the population explosion, and the North-South economic gap. However, she makes the startling declaration that her major concern lies in what she sees as a "real disruption in public morality." And she is not alone. Other world thinkers from many countries and professions have also, in one way or another, voiced their concern over the widely based breakdown of morality. They are saying in effect: "If we don't get a handle on the ethical collapse going on around us, we will be doomed as surely as we would be by a nuclear disaster or an environmental catastrophe." Ethics, they are saying, are no mere luxury — they are central to our survival.

I think we all sense this breakdown of morality in nearly all aspects of the world and our society, but I am not sure we realize either its cancerous growth, or its devastating consequences to our very survival if we do not take concerted and wise action to rectify the situation. Another reason why I am grateful to be invited as your keynote speaker today is that, in preparing for this address, I have been forced to zero in on this matter of a general moral crisis much more quickly and thoroughly than I would have otherwise.

"The message out there for those who are willing to listen is that morality and wisdom are no longer matters we can just pay lip service to."

Wisdom, like morality, is another one of those words we take for granted. In this age of technology, quantification, bottom lines, hard data, and hard-nosed management, we tend to look on notions of wisdom and morality as being soft — nice to have, but not critical to our busy preoccupations. But the message out there for those who are willing to listen is that morality and wisdom are no longer matters we can just pay lip service to. When properly understood and applied they are absolutely essential if we hope to exist very long into the next century.

One recently published book that has attracted my attention stresses the importance of wisdom — wisdom in which morality is central — as the ultimate value in business today. In "Working Wisdom — the Ultimate Value in the New Economy," Canadian businessman and management consultant John Dalla Costa claims that even though the shift to a knowledge economy is clearly taking place, many company executives remain oblivious to the need for a more fundamental transformation than just reengineering their organization.

Dalla Costa has run his own company, serves on boards of several companies and has been a consultant working with a wide range of multinational and Canadian companies. His observations in the first chapter are illuminating. His experience with companies and businesses that have undergone severe change recently is that the reengineering metaphor is entirely inappropriate. As he says, "Organizations that derive their models for change from machinery, computers and systems will inevitably miss the importance of human comprehension, self-reflection and insight. Revitalization hinges on rehumanizing the practice of business, not reengineering it."

Like many experts involved in planning or managing change he had assumed that the principal barrier to effective change was resistance. What he found, however, was that the problem in many instances was not change-resistance, but change-fatigue. As he says, change-fatigue is more than the organizational equivalent of yuppie flu. It occurs when employees are expected to absorb new stimulus and direction before they have fully understood a previous wave of change. Some of the symptoms of change-fatigue he says can be seen in people who are convinced there is another "shoe to drop." They divert their energy to speculation on what is coming next and how it will affect them personally. Beneath the anxiety of change is the greater anxiety of dispensability. Will I survive the next cut? In many cases change initiatives were viewed by management as "total solution" efforts, and rather than sort out why any current or previous initiatives failed, they simply went on to the next model of renewal and restructuring. Change-fatigue is not the result of too much change, but of too much mismanagement of change.

Now that flux is the norm (continuous whitewater rafting), obligations are in perpetual suspension and employees never have time to settle down to recreate the needed network or trust. Confidence is continuously shaken. It is not change itself that is so draining, but the fact that so much of it is proceeding without support, reciprocity, or context. Even as they adopt new structures and roles many employees have withdrawn their commitment and can barely conceal their skepticism. From his interviews of people in change situations, Dalla Costa concludes that:

• people's self-confidence takes a severe beating in even the most methodical, well-planned change;

• trust between employee and company, as well as between employees themselves, becomes dangerously frayed or broken; and

• confidence in the whole company, but especially in senior management, is destroyed.

Can you relate this to your own experience? How does it relate to the recent Phillips Group survey of the Canadian Forces that indicates that fewer than 20 percent of members have confidence in the most senior levels of the Department to lead us through these difficult times?

There has been a lot said recently about the Information Age, and you may find it refreshing to hear what Dalla Costa has to say about this notion and how it relates to the value of wisdom in the business world. Restructuring and reengineering may provide a more efficient movement of products and information, he says, but in today's world the creation of value depends more on managing knowledge and interconnecting new understanding than on the flow of information. In a reversal of conventional thinking it seems that the more we know, the more uncertain things become. Rather than enriching our possibilities, the amount of data spewed out by technology has produced more "information pollution" than understanding. An unfortunate side effect is that when people presume themselves to be informed, they assume themselves to be experts. This impedes deeper learning and undermines companies that are trying to establish themselves as learning organizations.

Wisdom, Dalla Costa says, in essence "grows through the learning of more knowledge, and the practical experience of day-to-day life — both filtered through a code of moral conviction." Wisdom through knowledge, experience and morality. It is this code of moral conviction that he considers crucial in the development of wisdom that I would like to bring into sharper focus. According to Dalla Costa, morality in an effective organization today "is not an add-on, but an integral aspect of operations. It is not a burden or a constraint, but a context for dealing with unpredictability and chaos."

An ability to handle ethical issues is not natural, but must be developed. Having been brought up in a sound moral environment of family, community or military organization helps, but it is no guarantee that one can deal intelligently when confronted with a moral issue. There are many cynics who say that you can't teach practical ethics, and they are right if they mean a sure-fire method to handle moral issues and resolve them correctly. But as a start, we should try to help them understand clearly the nature of moral issues and at least examine some well-tested principles for dealing with them.

One of the best books I have come across on the subject is Rushworth Kidder's "How Good People Make Tough Choices — Resolving the Dilemmas of Ethical Living." Kidder is an experienced researcher and teacher of real-world ethics and I believe it may be instructive for us to gain some insight into what he has to say. I cannot do his book justice in five minutes, but I will give you a brief outline of its main points and I am sure you can put them in the context of your own experience.

When faced with a tough choice we often either avoid it, or bull our way through to a conclusion with more concern about getting it resolved than getting it right. However, people with sound basic values are not satisfied with this approach and will often agonize over the choice. It is sound values that raise tough choices, and tough choices are never easy. Tough choices don't always involve laws, regulations, or codes, nor are they always big headline issues. Tough choices typically pit one moral "right" against another. Right-versus-right is at the heart of the toughest moral choices.

It is not that there aren't plenty of right-versus-*wrong* choices out there, too, but they are very different from the difficult right-versus-right choices which strike at the very heart of our most deeply held values and present us with "ethical dilemmas." Right-versus-wrong issues do not have the same depth. The closer you examine them the more they begin to "smell." They become issues of moral temptation, and the anguish we experience is often just the product of our attempt to justify or rationalize a wrongdoing.

It is the ethical dilemmas that give us the really tough choices, and we must understand what is involved if we hope to have any success in dealing with them. From his experience and research, Kidder suggests that there are fundamentally only four moral dilemmas which are so common that they stand as models against which we can examine all moral dilemmas. They are:

• the *individual vs. the community* (us vs. them, self vs. others, the smaller group vs. the larger group);

• the *short term vs. the long term* (now vs. later);

• *truth vs. loyalty* (honesty vs. promise-keeping); and

• *justice vs. mercy* (fairness vs. compassion).

Merely to fit a particular dilemma into one or more of the paradigms and to analyze it is not to resolve it. Resolution requires us to choose which side is the "nearest moral right" for the circumstances, and that requires some principles for decision-making. The author suggests that of the many theories that have been put forward for ethical decision-making, three which are drawn from the traditions of moral philosophy are particularly useful for helping us think through right-versus-right moral issues. You are probably familiar with them:

• ends-based thinking (do whatever produces the greatest good for the greatest number);

• rule-based thinking (a universal standard; follow only that principle that you want everyone to follow); and

• care-based thinking (the Golden Rule; put yourself in the other person's shoes).

There are problems with each of these ways of thinking, but they are useful because they give us a way to exercise our moral rationality. They will not deliver a sure answer to our dilemmas, but they should provide different lenses through which we can see our dilemmas and assess them.

I hope this brief outline convinces you that it is possible to develop practical learning methods for helping people to better understand and deal with moral issues. These issues will never become easy, but at least with moral courage you can do what you believe is right because it is based on an understanding that comes from energetic self-reflection.

Kidder also stresses what he calls "ethical fitness." If our society is adrift from its moral anchors, how, he asks, can we hope to survive in the next century?

He claims that what is needed is ethical fitness, which he defines as a capacity to recognize the nature of moral challenges and to respond with:

- a well-tuned conscience;
- a lively perception of the difference between right and wrong;
- an ability to choose what is right; and
- the moral courage to live by it.

Let me try to pull all this together. I have touched on several important contemporary issues under the general themes of morality and wisdom. First, the indicators are clearly there that we must now shift our emphasis and efforts from reengineering our organizations to rehumanizing them. We must deal with change-fatigue and we must re-earn the trust and confidence of our people.

Second, we must recognize that the promises of the Information Age are being negated by information pollution and information overload. We must advance beyond just information flow and start internalizing selective information into useable knowledge and learning to apply that knowledge in context so that it becomes understanding. Ultimately, we must learn to combine new knowledge with our experience, with the important injection of morality, as the recipe for wisdom. It is the application of wisdom that is becoming crucial to our work and to our lives.

Third, morality is no longer just a goody-goody word. It is becoming increasingly recognized that a massive breakdown in morality is pushing us into a national and global crisis situation. Deliberate and courageous application of sound moral principles will be essential to successful business, to good government and to our very survival.

Finally, helping people learn the importance of morality and how to deal with moral issues will become increasingly important. We have had a quick view of a possible approach for gaining a better understanding of the essentials of morality and for developing moral fitness.

Let me finish my address by bringing all this back to those of us here in this room. Despite the problems the Canadian Forces are facing at the present time with the fallout from the Somalia Inquiry, and as reflected in the stark message of the recent survey I mentioned earlier, I believe that at the core Canada's military is a principled institution. I also believe that with determined effort we can once again demonstrate our dedication to morality and integrity, and perhaps even to wisdom.

If we are successful with our efforts in revitalizing our core values and in living up to them, I believe the Canadian military could become an inspiration to the country as a whole to face up to the moral renaissance that we as individuals, and as a society, need to survive as we enter the next century. If we in our military can regain trust, confidence and the moral high-ground, why could it not then happen at the national and global level? All of you sitting here today can surely play a significant role in that moral revitalization process.

Thank you.

BGen Curleigh retired from the Canadian Forces in 1992 after 40 years of service. He joined the Forces as a MARS officer and was a naval Sea King pilot before Unification brought him into the air force for the duration of his career. His last operational position was Commander, Maritime Air Group (1986-1989).

We're *still* looking for a motto

Remember our call for motto suggestions in the February 1996 issue? Well, we weren't exactly inundated with entries, so we are extending the deadline to January 15, 1997.

To refresh your memory: We are looking for a slogan in English or French that describes the *Journal*'s purpose. We plan to use it as a subtitle for the magazine, so it should be simple, yet elegant, and should incorporate some sense of the magazine's objectives (see page 6). The editorial committee is even putting up a book prize for the winning entry.

Of course the *Journal* reserves the right to modify the winning entry, or create its own motto if no suitable entry can be found (but don't make us do it, *please....*)

Send as many entries as you like:

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Update:
Ozone-depleting Substances

Article by LCdr Tom Shirriff

As many readers are aware, current environmental laws and regulations have placed severe restrictions on the production and use of ozone-depleting substances (ODS). The driving force behind these changes is the Montreal Protocol of 1987 which took steps to reduce depletion of the ozone layer (see *MEJ*: October 1992, p.21). The navy is affected by this in numerous ways: in fire protection systems, in refrigeration and air-conditioning systems, and even in the solvents and degreasers used for maintenance. There is no question that this issue is of major importance, and significant efforts are being applied to ensure the navy is ahead of the ODS power curve.

Of greatest consequence to the navy is the end of production of fire suppressants Halon 1211, Halon 1301, and refrigerants Freon R11 and Freon R12. The Protocol does not ban the use of these gases, but has prohibited production of them as of Jan. 1, 1994. In effect, what stocks we have now are all there are. We cannot produce more. The cost of Freon and Halon will rise, if you can still buy it, to the point where we will have to find alternatives.

Federal and provincial regulations have also changed. All Freon is now recovered routinely (including Freon from ships being decommissioned) and releases of Freon and Halon must be reported. All personnel working with Freon or Halon require training and certification. The CF has created a stockpile of R11 and R12. Stocks are still available commercially, but these are not projected to last much longer. The life of our stockpile depends on how careful we are in reducing releases and how quickly we convert to a non-ozone-depleting refrigerant.

Halon has also been stockpiled. Halon removed from shore facilities is being banked to supply essential military platforms (i.e. armoured vehicles, aircraft and ships), but it won't last indefinitely. A significant quantity of Halon is lost through leaks and accidental releases, which is an active concern with the Canadian Forces.

Halon Replacement

There is no replacement for Halon that could be considered completely equivalent to Halon. The search for a drop-in replacement has shown that all current replacement agents have problems of one form or another. Some are still ozone-depleting, but not nearly to the same extent as Halon. Some agents are considered greenhouse gases, which would contribute to global warming. Others are toxic, corrosive, too heavy or too unproven.

To replace Halon 1301 in fire-suppression systems on board ships, the replacement agent must meet a demanding set of criteria in addition to an ability to put fires out. It must not be a risk to personnel, it must fit in the ship without great increase in weight or modification costs, and it must not require replacement after the next round of environmental regulation. Among the agents short-list for consideration are FM 200, NAF S III, and fine-water spray. We may not be able to find one agent that will work for us in all spaces. We may not even be able to eliminate the use of Halon. There is also a question as to whether we can safely reduce the level of fire protection on board our ships.

A number of problems have occurred with accidental Halon releases from several classes of vessels. The *Halifax* class has had the greatest problems and steps are being taken to reduce the possibility of accidental releases. Most releases have been due to software, wiring and maintenance practices. Wiring problems have been corrected, software is being changed and personnel are being trained in the correct procedures for handling Halon.

Replacing the Halon 1211 in portable extinguishers poses far less of a problem than finding a replacement agent for fitted systems. Anyone who tries to get a portable Halon extinguisher refilled will find that the Halon 1211 extinguishers are being replaced by 20-lb ABC units (15-lb CO2 units for electrical and electronic spaces). Adequate supplies of new extinguishers have been purchased and it is expected that portable Halon extinguishers will be replaced by the end of fiscal year 96/97.

Freon Replacement

The approved replacement for Freon R11 and R12 is Freon R134a. Freon R134a is not as efficient a refrigerant as current types, generally offering a reduction in capacity of approximately 25 per cent. Since a number of our shipboard refrigeration and air-conditioning systems do not have sufficient reserve capacity to absorb this loss of capacity, the compressors in some systems will have to be replaced. Moreover, Freon R134a is not compatible with our current refrigeration lubricating oil. It requires a polyester-based oil which, unfortunately, tends to dissolve rubber gaskets and hoses. All non-compatible materials will therefore also have to be replaced. The plan is to convert/replace compressors based on length of service remaining. *Halifax*-class compressors will be converted first, and vessels scheduled to be paid off prior to 2005 will not be converted.

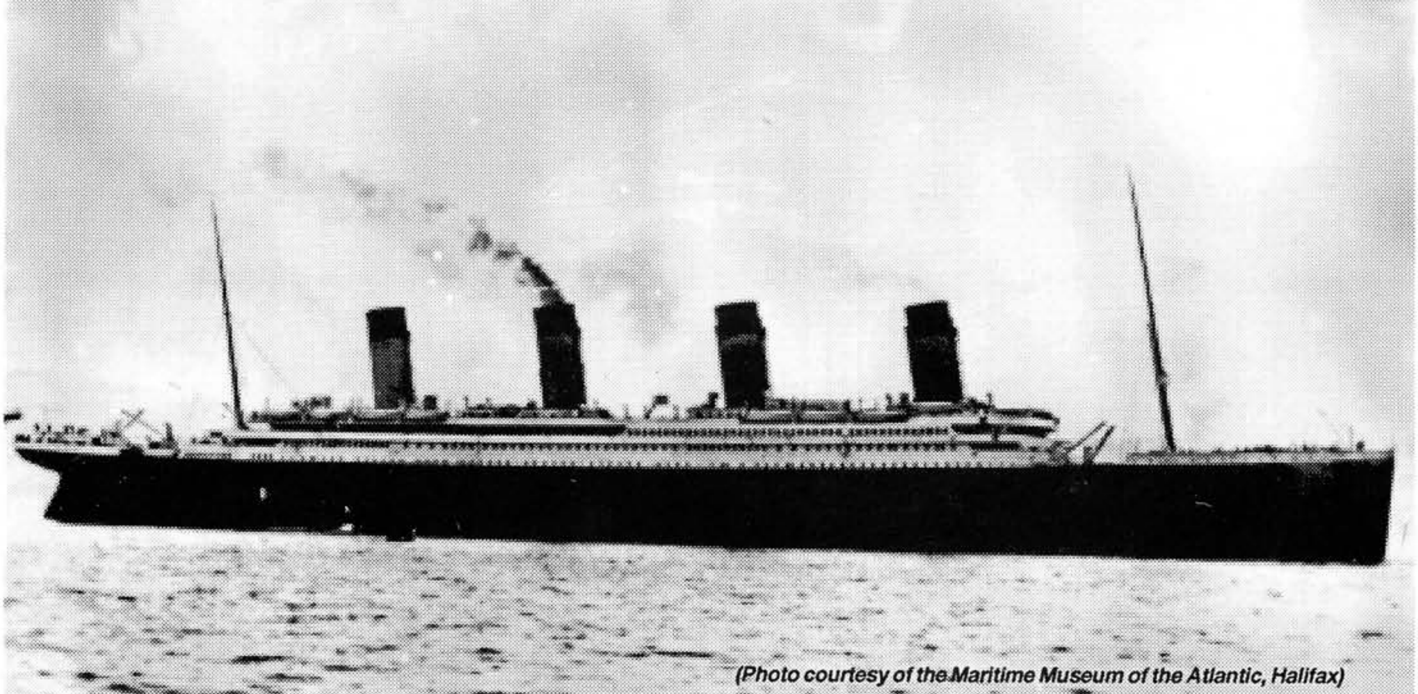
Releases of Freon R22 must be controlled. Purge units on R22 systems must be of higher efficiency than those currently fitted to reduce the amount of R22 released along with the purged air. New purge units have been purchased and will be fitted in ships as an interim measure prior to converting their air-conditioning compressors to operate with a non-ozone-depleting refrigerant.

LCdr Shirriff is the DMSS 4 project manager for maritime ozone-depleting substances replacement.

Titanic's Engineers — Heroes of a Disaster

Article by LCdr Robert Jones

"Greater love hath no man than this, that a man lay down his life for his friends."—John 15:13 (KJV)



(Photo courtesy of the Maritime Museum of the Atlantic, Halifax)

Next spring marks the 85th anniversary of the greatest maritime disaster ever on the North Atlantic — the loss of the Royal Mail Steamer *Titanic*. Just before midnight on April 14, 1912 the ill-fated White Star liner was midway on her maiden voyage from Southampton to New York when she struck an iceberg 640 kilometres southeast of Newfoundland. During the early morning hours of April 15 the great ship struggled and died, along with 1,523 of her passengers and crew. Although the story of the disaster is well enough known and remains one of the most traumatic events in the world's maritime history, there is a lesser known aspect to the sinking that has secured its place of honour in the annals of seafaring heroism.

It concerns the heroic actions of *Titanic*'s engineers who, along with the members of the Harland & Wolff shipbuilders team on board at the time of the tragedy, sacrificed themselves in their efforts to keep their vessel afloat with systems intact for as long as possible. The story of their courage and attention to duty may be little more than a footnote to history today, but it is largely because of the engineers that as many as 705 people actually did manage to survive the sinking. The engineers and builders personnel perished to a man on board *Titanic* during those middle watch hours of April 15, leaving behind 18 widows, 27 children and 1 fiancée. The memory of their heroic efforts, and ultimately their sacrifice, deserves to be kept alive by seagoing engineers everywhere.

Titanic was the second of three giant luxury ocean liners built just before the First World War for the White Star Line by Harland & Wolff Ltd. of Belfast, Northern Ireland. At 46,328 gross tonnes (52,310 tonnes displacement), she was 269 metres feet in length and 28 metres in beam. When *Titanic* entered service in April 1912, less than a year after her sister ship

Olympic, accommodation improvements had increased her tonnage by 1,000 gross tonnes over the first of class, making her the largest ship afloat. *Titanic* was certified for a complement of just over 3,500 passengers and crew, and represented the latest in marine technology, propulsion systems, marine safety and passenger comfort. The third vessel was to be named *Gigantic*, but because of the disaster was named *Britannic* when she was launched in 1914.

Olympic served as a troop transport during World War I, receiving the nickname "Old Reliable." She eventually retired from commercial transatlantic passenger service in 1935 and was scrapped. *Britannic*, the youngest of the three sisters, had a career that was nearly as short as *Titanic*'s. Called into service as a hospital ship in 1915 while she was still fitting out, she struck a mine and sank in the Aegean Sea in November 1916. She remains the largest liner on the ocean floor. Her wreckage was explored by Jacques Cousteau in 1976.

Titanic's main propulsion system consisted of 24 double-ended and five single-ended coal-fired boilers located in six boiler-rooms. The fire tube "Scotch" boiler units, working at 215 psig, required 12 hours to cool down from rated steaming conditions to cold. The ship's 159 furnaces were hand-fed 650 tonnes of coal per day, with the ash being ejected over the side. On the day she sailed from Southampton, *Titanic*'s 11 bunkers contained 6,000 tonnes of coal and there was even a coal fire burning in No. 10 bunker, the after bunker in boiler-room No. 6. (Coal handling brought a myriad of hazards to sea, and slow-burning fires in a ship's bunkers were not uncommon.) Fuel consumption depended a great deal on the grade of coal being burned as there were considerable differences in calorific values depending on where the coal was mined. Welsh steaming coal was considered to be of very good quality. The coal trimmers toiling in the enclosed bunkers at the bottom of the ship worked in an oppressive environment, shovelling coal in temperatures approaching 38°C.

Although *Titanic* carried four funnels, the aftermost stack was a dummy fitted mainly to balance the ship's appearance. Main propulsion machinery was comprised of two sets of four-cylinder, triple-expansion steam reciprocating engines, each driving outboard shafts at 75 r.p.m. at full power. These engines in turn exhausted into a low-pressure unidirectional Parsons turbine (with an inlet-to-exhaust ratio of 9:1 psia) driving a centreline shaft. The 50,000 shaft horsepower developed at full power was capable of driving the triple-screwed *Titanic* at 24 knots. By comparison, by 1907 Cunard with Admiralty backing had developed the 30,000-tonne steam-turbine liners *Lusitania* and *Mauretania*, each capable of speeds in excess of 27 knots at 70,000 shaft horsepower. *Mauretania* held the title of fastest transatlantic liner up until the late twenties.

Electrical power generation on board *Titanic* was provided by four steam-reciprocating dynamo sets, each producing 400 kW on a 100-volt DC bus. There were also two smaller emergency reciprocating 30-kW steam dynamo sets located on D level, six metres above the waterline in deep draft condition. The ship was fitted with the latest refrigeration and evaporation machinery (three distilling units produced 180 tonnes of fresh water per day) as well as numerous types of electrical machinery, including eight cargo cranes, four passenger elevators and a 50-phone switchboard.

Titanic also carried a powerful five-kW Marconi wireless station (with a guaranteed daytime range of 560 km) which played a pivotal role in alerting surrounding ships to her plight. In 1912 approximately 1,000 of the 23,200 registered power-driven ships were equipped with wireless from one of three rival manufacturers — British Marconi, German Telefunken, or American DeForest — who provided wireless operators on contract to the various shipping lines. Vessels usually carried only one operator, which precluded a continuous wireless watch (a practice that would change after the sinking). *Titanic* had the luxury of carrying two Marconi operators who spent the majority of their time clearing

The Ottawa Connection

The grand opening of Ottawa's Chateau Laurier Hotel in April 1912 was cancelled due to the sinking of the RMS *Titanic*. The hotel and the train station across the street had a profound influence on the character of the nation's capital, bringing a world class look and feel to the centre of Ottawa. In large part the creation of the complex was due to the energy and drive of the president of the Grand Trunk Railway, Charles M. Hays.

Hays and his wife Clara were first-class passengers on board *Titanic*, travelling with their two daughters and son-in- law. Hays was returning from a series of business meetings with the railway's financial backers in England. Mrs. Hays, her daughters Margaret and Orian and her maid Anne Perreault survived the sinking, but Charles Hays, his private secretary Vivian Payne and his son-in-law Thornton Davidson refused to take places in a lifeboat while there were still women and children on board. These men were counted among those who perished in the disaster and Hays' body was one of those recovered by *Mackay-Bennett*'s relief ship, *Minia*. Hays was buried in Mount Royal Cemetery in Montreal. The period of mourning delayed the hotel's opening until June 1 of that year.

(Photo courtesy of Sandi Digras, Director of Public Relations, Chateau Laurier Hotel, Ottawa)

Roll Call

Among the heroes of the tragedy stand *Titanic*'s engineers. Numerous memorials were raised in their memory throughout the United Kingdom and the United States. The most famous of these is located in Southampton, and at its unveiling ceremony on April 22, 1914 more than 100,000 people stood in memory of these brave men:

Joseph Bell - Chief Engineer
W.E. Farquharson - 2nd Chief Eng.
Norman Harrison - Jr. 2nd Eng.
J.H. Hesketh - Jr. 2nd Eng.
Bertie Wilson - Snr. Asst. 2nd Eng.
Herbert Harvey - Jr. Asst. 2nd Eng.
Jonathan Shepherd - Jr. Asst. 2nd Eng.
George Fox Hosking - Snr. 3rd Eng.
Edward C. Dodd - Jr. 3rd Eng.
Charles Hodge - Snr. Asst. 3rd Eng.
Francis Coy - Jr. Asst. 3rd Eng.
James Fraser - Jr. Asst. 3rd Eng.
Leonard Hodgkinson - Snr. 4th Eng.
James M. Smith - Jr. 4th Eng.
Henry Dyer - Snr. Asst. 4th Eng.
Renney Dodds - Jr. Asst. 4th Eng.
Arthur Ward - Junior Asst. 4th Eng.
Thomas Hulman Kemp - Extra Asst. 4th Eng. (Refrigeration)
Frank Alfred Parsons - Snr. 5th Eng.
W.D. Mackie - Jr. 5th Eng.
Robert Millar - Extra 5th Eng.
William Young Moyes - Snr. 6th Eng.
William McReynolds - Jr. 6th Eng.
Henry Philip Creese - Deck Eng.
Thomas Millar - Asst. Deck Eng.
Peter Sloan - Chief Electrician
Alfred Samuel Allsop - Jr. Elect.
Herbert Jupe - Asst. Elect.
Alfred Pirrie Middleton - Asst. Elect.
Albert George Ervine - Asst. Elect.
William Kelly - Asst. Elect.
George Chisnall - Snr. Boilermaker
Hugh Fitzpatrick - Asst. Boilermaker
Arthur J. Rous - Plumber
William Duffy - Chief Eng. Writer
Thomas Andrews - Ship Designer Harland & Wolff
William Parr - Harland & Wolff
Roderick Chisholm - Harland & Wolff
Anthony Frost - Harland & Wolff
Robert Knight - Harland & Wolff
William Campbell - Harland & Wolff
Frank Parkes - Harland & Wolff
Ennis Watson - Harland & Wolff

commercial traffic for the first-class passengers. Messages relating to navigation were supposed to take precedence over all other traffic.

The crew of *Titanic* totalled 915, of whom 397 belonged to the engineering and deck departments. The remaining 518 were responsible for running the vast hotel services for the first-, second-, and third-class passengers. The engineering department consisted of a chief engineer, 34 engineers, 176 firemen, 30 greasers and 72 coal trimmers, ranging in age from 19 years to 51 years, the average age being 32 years. A large number of the engineering department including the chief engineer had seen service in the sister ship *Olympic* and so were familiar with *Titanic*'s engineering arrangement. Thirty-three-year-old Junior Second Engineer Hesketh had even put his experience from *Olympic* to use early on by making improvements to *Titanic*'s machinery arrangement while the ship was building. *Titanic*'s official sea trials were conducted during a seven-hour period on her transit from the builder's yard in Belfast to Southampton in early April 1912.

Many facts associated with the sinking are recorded in the historical record as a result of eye-witness testimony given during separate investigations conducted by the American Senate and the British Board of Trade. A number of firemen, trimmers and greasers were registered among the survivors. Dr. Robert Ballard's 1985 discovery of the *Titanic* wreckage more than three kilometres down on the ocean floor has also shed new light on the sinking, especially by providing a more precise estimate of the ship's position at the time of the collision.

Titanic departed Southampton on her maiden voyage to New York on Wednesday, April 10, 1912, making calls for additional passengers at Cherbourg, France and Queenstown, Ireland. She was scheduled to arrive in New York on Wednesday, April 17. On Sunday night, April 14, *Titanic* was steaming at 22 knots — her fastest speed during the voyage, with 24 of her 29 boilers fired up and on-line — steering a course of 266°, approximately 640 km southeast of Cape Race, Newfoundland. The ship had received numerous ice warnings throughout the day and the lookouts of the first watch were ordered to keep a sharp watch for ice. (Many items had been forgotten or overlooked on the maiden voyage, including sufficient binoculars to equip the lookouts in the crow's nest.) The winter of 1912 had been particularly mild, resulting in a great deal of ice drifting farther south than normal into the shipping lanes. It was a cold clear night and the sea was uncharacteristically calm. The sea temperature had been dropping throughout the day and by the end of

"He was... ...the Love of our Hearts"

This portion of a letter written by the Belfast parents of *Titanic* Asst. Electrician Herbert Jupe was taken from "Titanic – An Illustrated History." Original misspellings and grammar errors have been left intact.

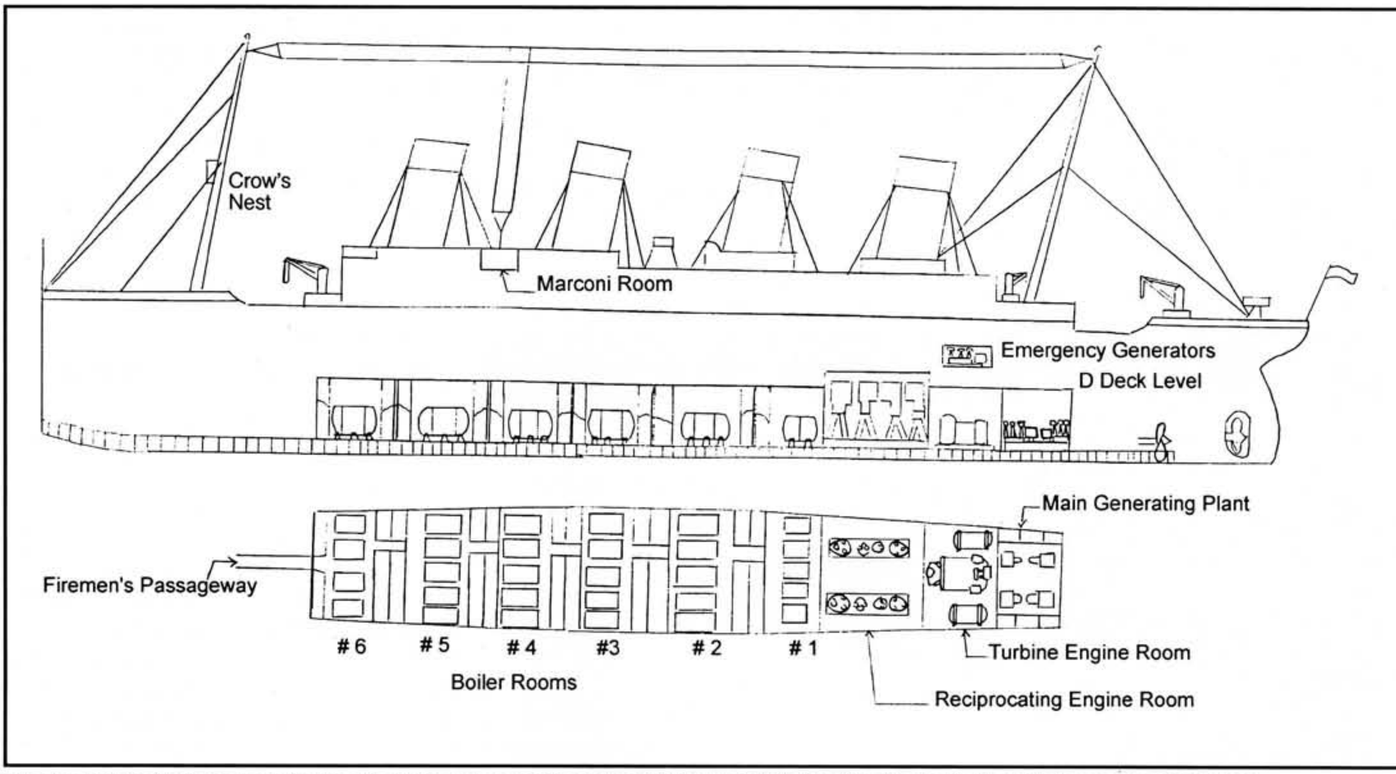
"Dear Sir,

I have been inform...that the body of my Beloved Son Herbert Jupe, which was Electrical Engineer No. 3 on the Ill Fatted Titanic has been recovered and Buried at Sea by the Cable Steamer 'Mackay-Bennett'....We are obliged for all your kindness to my Precious Boy. He was not Married and was the Love of our Hearts and he Loved his Home. But God gave and God has taken him. Blessed be the name of the Lord. He has left an aceing (aching) Void in our Home which cannot be filled. Please send along the Watche and Handkerchief marked H.J.

Yours Truly,

C. Jupe

His mother is 72 last April 4th. His father is 68 Last Feb. 9th."



The Royal Mail Steamer *Titanic*. To a man, the engineers of this great White Star liner died so that others might live.

the first watch it was recorded as -1°C. The ship's carpenter and deck engineer were ordered to take cold-weather precautions.

The iceberg was first sighted by Frederick Fleet, one of the two lookouts posted in the crow's nest. He immediately rang the bell warning the bridge of an obstruction dead ahead and then reported the hazard by telephone. The officer of the watch, First Officer Murdock, issued helm and engine orders in an attempt to manoeuvre the vessel to port around the iceberg. Unfortunately the speed and time equation worked against him and *Titanic* struck the berg a glancing blow at 23:40. For ten seconds the iceberg scraped down the starboard side, depositing ice on the foredeck and either punctured holes or fractured shell-plating below the waterline in the first six watertight compartments. The damage extended into the forward-most boiler-room (No. 6) and just into the coal bunker in boiler-room No. 5. Most of the passengers were in their beds sleeping and unaware that a collision had even taken place.

Down below in the forward spaces it was a different story. One trimmer found himself briefly trapped in a bunker when the coal shifted down on him. For those on watch in boiler-room No. 6 the noise of the iceberg grinding down the ship's side (reported as sounding like a thunder clap) was followed by a wave of seawater foaming into the space. With warning bells ringing, the firemen, trimmers and engineers of No. 6 managed to evacuate into the adjoining boiler-room either through the watertight door before it slammed shut, or up the escape ladders. A number of watchmen stayed behind in No. 6 to draw the fires from the boilers and vent the pressure to atmosphere before evacuating the space. This action was critical as it prevented the boilers from exploding from the thermal shock of cold sea water making contact with the pressurized drums. On the upper decks, the noise of the steam venting from the exhaust pipes on the forward stacks was ear-shattering. Within minutes there was nearly three metres of water in the forward boiler-room. The minor bulkheads of the coal bunker in boiler-room No. 5 initially stemmed the flooding in that compartment for a brief period.

Titanic was a double-bottomed vessel, subdivided into 16 transverse watertight compartments with most of the bulkheads running up to E deck approximately three metres above the waterline. Although she could remain afloat with up to four compartments lost to the sea (no one could imagine a grounding or collision extensive enough to open up more than four watertight compartments at any one time), *Titanic*'s builders did not claim she was unsinkable. That fateful tag arose from the publicity surrounding her modern design and immense size.

Titanic was soon stopped dead in the water. Her position has since been estimated as 41° 47'N 49° 55' W, approximately 22 km east-southeast of the position reported in the ship's distress signals. Within minutes of striking the iceberg the master, Captain E.J. Smith, requested that the ship's builder, Mr. Thomas Andrews, accompany him on a damage survey. The flooding forward was already extensive (16,000 tonnes of water in the first 40 minutes) and Andrew's assessment was very grim — he gave the ship, at most, one and a half hours to live.

At 00:05 on April 15 Captain Smith issued orders to uncover the lifeboats. *Titanic* carried two emergency boats with a design capacity of 40 adults each, 14 wooden lifeboats (65 adults each) and four collapsible boats (47 adults each). Two of the collapsibles were stowed awkwardly on the roof of the officer's quarters abreast the forward funnel. The seven ship's officers, six quartermasters and forty-four boatswain's mates, look-

Eighty-two-year-old *Titanic* survivor Louise Pope of Milwaukee, Wisconsin visited Halifax for a remembrance ceremony in September 1991. Pope was four years old at the time of the disaster and remembers nothing of the *Titanic* voyage. She lost an aunt and uncle in the tragedy, but was rescued along with her parents. *(Photo by Roy Flemming, Halifax)*

outs and seamen had the task of launching and coxswaining the boats. *Titanic*'s boat list actually exceeded the British Board of Trade requirement of 16 lifeboats in vessels larger than 15,000 tonnes. Still, Captain Smith knew full well that at capacity there was space in his boats for only half the complement on board. Smith also knew that the only hope for survival for the majority of the people in his charge would be the timely arrival of a rescue vessel.

In fact a vessel was visible on the horizon. Smith attempted to raise its attention by firing rockets and signalling with flashing light, but to no avail. Before the discovery of the wreck it was generally believed that this vessel was the cargo steamer *Californian*, under the command of Captain Stanley Lord, stopped for the night and drifting in pack ice about 30 km north of *Titanic*. Her sole wireless operator had turned in at 23:35 after a 16-hour day. The controversy over the role of *Californian* will continue to be debated, but the most recent investigations lend credence to the possibility that there was another ship between *Titanic* and *Californian*. Still, atmospheric conditions were unusual that night and it is accepted fact that the crew of *Californian* observed *Titanic*'s rockets firing well down on the horizon. It is unfortunate that the watch officers did not wake their wireless operator at the first report of rockets. The role of *Californian* is fascinating and whole books have been written on the topic. As recently as 1990-1992, the British Marine Accident Investigation Branch conducted a reappraisal of the situation in light of the discovery of the wreck of *Titanic* and at the request of Captain Lord's supporters.

Efforts to minimize panic were so successful that many of the passengers and crew were not fully aware of the gravity of the situation. Some of the first lifeboats were lowered at half their capacity or less. This action is somewhat understandable in light of the fact that very early in the crisis passengers were reluctant to leave the bright, warm, slightly listing ship and allow themselves to be lowered 21 metres from the boat deck in creaking boats onto a cold black sea. Some passengers had been told that rescue ships would be on scene within an hour or two. There was also a fear by some of the ship's officers that the davits would fail with a fully loaded lifeboat and there was a plan to complete loading the lifeboats via the gangway doors. The boatswain and his team sent below to open the doors for this purpose were never seen again.

Immediately after the collision the Marconi operators were ordered to send out a wireless distress message. At first they transmitted "CQD" (CQ-stop transmitting, D-distress) and then the new "SOS" code. (*Titanic*'s wireless operators had the distinction of becoming the first to use the new distress code "SOS" adopted in 1909.) At times the operators had difficulty hearing their signals due to the noise of the steam unloading through the exhaust ports on the stacks. The Marconi room was located on the boat deck between the first and second funnels.

Down in the engineering spaces efforts were focused on pumping out sea water and conducting an orderly shutdown of the forward boiler-rooms. Chief Engineer Bell is recorded as saying very early in the incident that he was confident the pumps would keep *Titanic* afloat. *Titanic*'s bilge pumping arrangement consisted of reciprocating steam bilge pumps located in the reciprocating propulsion engine-room. Bilge suction lines ran to all lower-level compartments through three-inch and five-inch-diameter suction lines. Valves in the compartments were fitted with lazy rods, allowing operation from the deck above a flooded compartment. (Having just come out of build, it would be interesting to know just how effective *Titanic*'s system operated that night under the emergency conditions. How many times during our own sea training work-ups have we discovered problems with lazy rods and bilge suction valves?)

The Cunard liner *Carpathia*, bound from New York to Gibraltar, heard *Titanic*'s distress call at 00:35 and responded immediately. She was approximately 93 km southeast of *Titanic* and with a top registered speed of 14 knots was a good four hours away through the ice-congested waters. It is a tribute to Captain Arthur H. Rostron and his engineering staff that *Carpathia* managed to make good a speed of 16 knots on her run to scene. Rostron was seen silently praying, raising his hat as he did so, as he conned his ship through the icebergs toward *Titanic*'s reported position. The situation had developed into a race between the arrival of rescue ships and the rate of flooding in *Titanic*'s compartments.

Each of the forward boiler-rooms contained five double-ended boilers (No. 6 boiler-room had only four) with six furnaces each. As each boiler-room was evacuated in turn, the fires in the furnaces were overhauled and the steam pressure was vented off. Anyone familiar with steam systems can only begin to imagine the co-ordination of effort it required to maintain water levels and steam pressure in those boiler-rooms while conducting an orderly evacuation of the flooding forward spaces. As the ship's trim increased by the bow it became more and more difficult to stoke coal "uphill" into the boiler furnaces that faced forward. In the end, none of the boilers exploded throughout the entire period the lifeboats were being loaded and launched. According to eyewitnesses, it was only later that a series of explosions occurred deep within *Titanic* as the ship was in her death throes. Perhaps some of the abandoned hot boilers exploded.

Fireman Fred Barrett lived to recount how a group of engineers and firemen under the direction of Engineer Herbert Harvey were conducting pumping operations in boiler-room No. 5. Engineer Jonathan Shepherd had just broken his leg by stepping into an open manhole and was lying off to the side in the space. Without warning, the forward bulkhead gave way. Harvey ordered everyone topside while he attempted to help Shepherd out of the space. Tragically, every man, save Barrett, drowned before they could reach the escape ladders.

The engineers were released from their places of duty just prior to 02:10. Second Officer Lightoller's testimony at the Mersey Inquiry indicated that a large group of engineers arrived on the upper deck just before the final death throes of the ship. With all the lifeboats gone they and the 1,500 people still on board had little chance of surviving in the -1°C water. A handful of passengers and crew did manage to survive by seeking refuge on the two swamped collapsible boats which floated off the wreck, and by being picked up by two lifeboats that were attempting to retrieve swimmers.

Steam pressure for the dynamo sets was maintained until 02:17, by which point more than half of *Titanic* was submerged and the stern portion was climbing out of the water toward a steep 45-degree angle. Eyewitnesses in the lifeboats standing off several hundred metres from the doomed ship found the experience surreal, with *Titanic* well down by the head, lights still blazing even in portions of her submerged hull. It is now known that *Titanic* broke in two before plunging to the bottom, but it is interesting to note that the leading naval architects of the day believed the ship went down with her hull intact. They believed her material and construction technique were sufficient to withstand the tremendous shearing stress imposed on her longitudinal structure during her final headstand. From the time of collision (23:40) to the time of her sinking (02:20) *Titanic* remained afloat for two hours and forty minutes, well beyond the original estimate given by Mr. Andrews.

Unfortunately, the sea temperature condemned the majority of the victims to a slow death by exposure in the freezing waters. More scandalous was the fact that only two of the ship's boats made any effort to row into the periphery of the mass of humanity and retrieve swimmers. Ships that arrived on the scene after *Carpathia* throughout the 15th found no bodies and very little floating debris due to the presence of pack ice which had drifted into the area in the early morning hours. The majority of the victims were wearing cork life jackets and for weeks after the sinking transatlantic liners reported sighting bodies caught up by the North Atlantic drift, floating miles from the scene of the disaster. One partially swamped lifeboat containing three corpses was found by the White Star liner *Oceanic* almost a month afterward.

This deck chair and other *Titanic* artifacts are on display in the Maritime Museum of the Atlantic in Halifax. *(Photo by Brian McCullough)*

Looking Back

Heart-wrenching tales: Halifax's cemeteries hold the remains of 150 *Titanic* victims, including the body of an unnamed two-year-old boy recovered from the sea by the cable steamer *Mackay-Bennett* whose crew paid to have this monument erected in Fairview Cemetery. In the background to the right is the headstone marking the grave of 29-year-old Alma Paulson and her four children aged eight, six, four and two years. *(Photo by Brian McCullough)*

From April 21 to 25 the Halifax-based cable steamer *Mackay-Bennett* hired by the White Star Line to search for bodies recovered 306 corpses, returning with 190 after burying 116 at sea. Among those committed to the deep was the body of Electrical Engineer Herbert Jupe (see "He was the Love of our Hearts"). More than one hundred victims including a blond-haired two-year-old boy were eventually laid to rest in the Fairview cemetery in Halifax. Deeply moved by their heart-wrenching duty, the crew of *Mackay-Bennett* commissioned a specially carved headstone in memory of the boy (see photo).

Responsibility for the *Titanic* disaster lay with her master. A brave, experienced seaman with more than forty years of service, including service as the master of *Olympic*, Captain Smith possessed a misplaced confidence in the technology embodied in his command. A product of his age, he displayed an arrogance before the forces of nature that was in keeping with the general attitude of masters of the fast transatlantic mail liners of that era. The drive to remain on schedule caused many shipmasters to take undue risks in conditions of fog or ice. *Titanic* was making her fastest speed at the time of the collision in an area which had been reported as containing ice hazards. Had *Titanic* avoided the berg, she would have ultimately slowed down and altered course as her track was leading her directly into a huge ice field which in some areas projected ice as much as five metres out of the water.

More than two generations have passed since the sinking of the Royal Mail Steamer *Titanic*. In today's era of re-engineering and downsizing the concepts of sacrifice and devotion to duty are often lost in the rhetoric of cost-effectiveness. The engineers of *Titanic* performed their duty until the end. The 705 survivors in large part owed their lives to the efforts of those who did their duty below, unseen on the deck plates. Let us uphold their example of selfless courage as we strive to do our own duty in these turbulent times.

Acknowledgments

I would like to thank the following people for providing advice, support and/ or information in the writing of this article: **LCdr Derek W. Davis**, MARE Career Manager, Ottawa; **Sandi Digras**, Director of Public Relations, Chateau Laurier Hotel, Ottawa; **Roy Flemming**, Halifax; **Cdr D.B. Flemming**, SPO/ DGMEPM, Ottawa; **William A. Hilts**, Ottawa; **Brian McCullough**, Production Editor, *Maritime Engineering Journal*, Ottawa; and **Lynn-Marie Richard**, curatorial assistant of the Maritime Museum of the Atlantic, Halifax. They helped me answer some of the questions outstanding from the time when, as a small boy, I first heard the story of the great ship *Titanic* from my father.

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LCdr Jones is a Marine Systems Engineer with DQA in Ottawa, and has been a Titanic *historical buff since childhood.*

DCIS (Damage Control Information System)

A warship's capacity to fight, float and move can sometimes be compromised by the inability to combat damage, fire or flood rapidly and effectively. Correct training in firefighting and damage repair are obviously essential in minimizing the effects of fire and flood, but having improved decision-making aids is also very significant.

The era of grease-pencil plotting is fast fading. With the modern damage control arrangements in *Halifax*- and *Iroquois*-class ships the use of information transfer technology is paramount. A ship's DC organization requires that the damage control system maintain an accurate picture of a situation, allow effective communication and offer advice on possible corrective procedures. Clearly, there is potential to improve the acquisition, communication, processing and presentation of DC information to ensure the survival and continued combat effectiveness of the ship.

DMSS 4-2 has been pursuing the development of an automated damage control system for the Canadian patrol frigate and the next generation of ships, linking in real time the key decision-making stations of the combat system and DC organization. The original concept calls for a system possessing stateboard drawings in a plan view, with control marking displays and overlays in accordance with navy policy.

This initiative led to a decision to evaluate a U.S.-designed Damage Control Information System (DCIS) currently installed in several American destroyers. The DCIS is based on the premise that it will duplicate and eventually replace the current handwritten plots with computer-generated, real-time, dynamic damage control decision aids to increase plotting accuracy and relay the same damage plot to every connected system on the LAN. These aids will consist of full-ship, interlaced, colour stateboard diagrams, and be able to annotate these diagrams with specific damage control symbology.

As an installed shipboard system linking all ship-survivability personnel, the DCIS will provide a ship's DC organization with decision aids for fighting major battle damage, reducing cascading damage, limiting and dealing with personnel casualties, and reconfiguring ship systems to bring offensive and defensive capabilities on line in a timely manner. The easily expandable DCIS is configured to use commercial hardware, act as a stand-alone system or be linked to a survivable database and network. The system will substantially reduce voice traffic and act as an embedded trainer, and can be installed in new ships or retrofitted into existing combatants at low cost.

The DCIS is presently being updated to incorporate Canadian naval DC policy and to reflect Canadian Halifax-class stateboard drawings with overlays and markings. The update will take several months to complete, after which the finished product will be installed in a designated CPF for a one-year operational evaluation and trial. DMSS 4-2 and the Naval Engineering Test Establishment will conduct several design reviews and qualification tests on the system. Upon successful completion of a feasibility study conducted by DMSS 4-2 and NETE, the DCIS will also be integrated with the ICEMaN LAN in the designated CPF. — **LCdr Tony Lafreniere, DMSS 4-2 and Peter Michetti, NETE.**

Firefighting in compartments containing live electrical equipment

Sending firefighters into shipboard spaces where live electrical equipment cannot be isolated has always presented a dilemma for people involved in managing firefighting teams. DMSS 4 therefore tasked NETE to investigate the potential dangers to personnel who enter a compartment with charged hoses from the ship's fire-main and attempt to fight a fire with the power still on to some equipment.

The problem is particularly relevant to uninterruptable power supplies. Although it may be possible to isolate the mains supply, the battery back-up might also be hazardous to personnel in terms of electric shock, electrolyte burns and toxic gases.

Testing involved directing a stream of salt water onto a 440-volt power source and measuring any current a firefighter might be subjected to. The stream was varied for distance, pressure and water flow, and account was made for body resistance and the effectiveness of any shock-protection equipment worn by the firefighter. Batteries were subjected to similar saltwater conditions in an effort to establish the potential hazards from explosion, electric shock, acid burns and toxic gases.

Testing has now been completed and a report is being drafted for DMSS 4 that will provide conclusions and recommendations to help in the decision-making process for future firefighting directives and procedures. — **Peter Lawton, Section Head, Combat and Control Systems Section, NETE and LCdr A.J. Lafreniere, DMSS 4-2.**

Planning Effective Long-Range Support to Fleet Operation

A constant in the present environment of continuous change has been the objective of ensuring that support to fleet operations is delivered in the most effective manner possible. In this regard there seems to be no end to the conceptual initiatives in motion, but precious few "real" initiatives in terms of the navy's day-to-day activities. One initiative that aims to bridge this concept-to-reality gap is the newly formed Ship Management Working Group (SMWG).

The SMWG operates in conjunction with the Ship Management Committee sponsored by DGMEPM and DGMD, and is co-chaired by DMMS and MARCOM N3. SMWG membership is made up of operational, engineering and logistic staffs from DGMEPM, DNR, MARCOM, MARLANT, MARPAC and both FMFs.

The group met on May 28 at NDHQ for the first of what are intended to be semi-annual meetings. The SMWG's objective is to develop a fleet support plan consistent with MARCOM's operational program, thus ensuring concurrent development of DGMEPM and MARCOM business plans. In less general terms the group is striving to reflect not just refits and processes, but fleet capability as well. To this end the SMWG will combine the mandates and functions of a number of other committees and groups, and make use of the recently developed Class Plans — guides for developing, maintaining and supporting various ship classes consistent with operational, cost and schedule requirements.

The multidisciplinary composition of the SMWG will ensure that all aspects of fleet support are identified and examined in a regular, interactive forum. Moreover, granting direct liaison authority between representative staffs will minimize bureaucracy and optimize the flow of information and ideas. A projected benefit of direct liaison will be an assurance that resources are being committed in the most effective manner consistent with the current policy or "rule sets" imposed by higher authority. Through feedback, the SMWG will be able to identify troublesome areas and facilitate changes to correct policies which are frustrating efforts to optimize fleet support.

By ensuring that fleet support is established, maintained, reviewed and forecasted on a regular basis for previous, current and forecasted years, the SMWG can provide senior leadership with progressive advice and recommendations in support of maritime operations. Even at this early stage the SMWG is showing great potential in providing the vital bridge of information and ideas between fleet support concept and reality. — **LCdr N. Leak, MARLANT N37, Halifax.**

IMLA conference on maritime education (Sept. 7-9, 1997)

The International Maritime Lecturers' Association (IMLA) will be holding its conference, "*The New World of Maritime Education: Meeting Challenges, Seizing Opportunities, Managing Change,*" Sept. 7-9, 1997 in St. John's, Newfoundland.

The conference is being hosted by the Marine Institute of Memorial University and is one of several "Summit of the Sea" conferences marking the 500th anniversary of John Cabot's landfall in Newfoundland. The colloquium will address the challenges and opportunities facing maritime education and training in the next millenium.

For more information, contact: **Captain Wayne Norman, Secretary of the Papers Committee, School of Maritime Studies, Fisheries and Marine Institute, Memorial University of Newfoundland, P.O. Box 4920, St. John's, Nfld., A1C 5R3. (Telephone: 709-778-0450/Fax: 709-778-0659/E-mail: imla97@gill.ifmt.nf.ca)**

Submission Formats

As a general rule, article submissions should not exceed 12 double-spaced pages of text. The preferred format is MS Word, or WordPerfect, on 3.5" diskette, accompanied by one copy of the typescript. The author's name, title, address and telephone number should appear on the first page. The last page should contain complete figure captions for all photographs and illustrations accompanying the article.

Photos and other artwork should not be incorporated with the typescript, but should be protected and inserted loose in the mailing envelope. If at all possible, electronic photographs and drawings should be in TIFF format. A photograph of the author would be appreciated.