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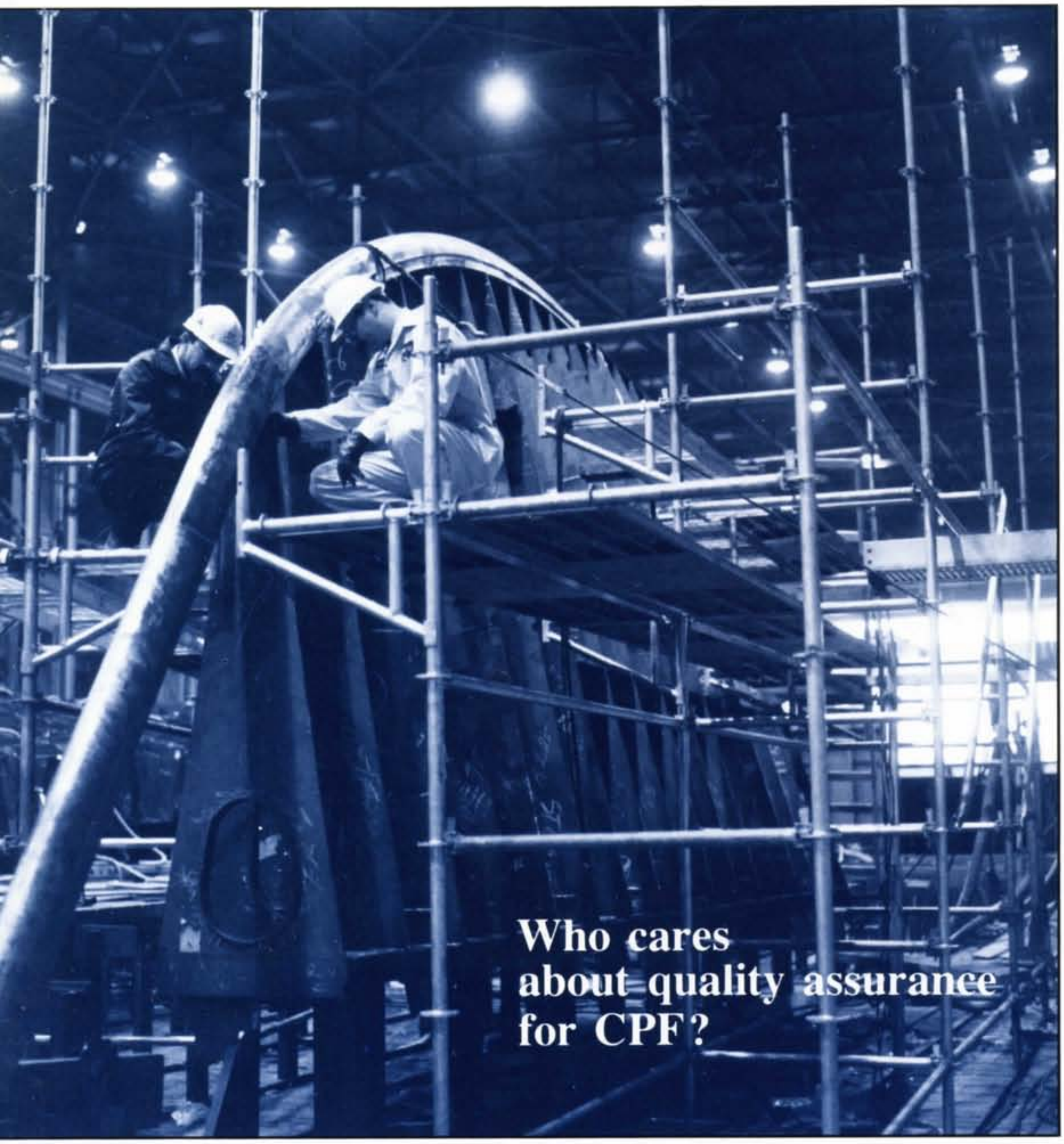
Maritime Engineering Journal

April 1989



Canada

They're back!

Naval Reserve
Maritime Engineers

...page 23

Maritime Engineering Journal

Director General
Maritime Engineering and
Maintenance
Commodore W.J. Broughton

OUR COVER

QA representatives from the navy and Saint John Shipbuilding Ltd. discuss a non-conformance in the stem of CPF-02. (*Photo by Danny Pond*)

APRIL 1989

DEPARTMENTS

FEATURES

The Maritime Engineering Journal (ISSN 0713-0058) is an authorized, unofficial publication of the maritime engineers of the Canadian Forces, published three times a year by the Director-General Maritime Engineering and Maintenance. 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

Problem-solving

Why you'll never see a "Newton" computer in the marketplace

Your response to our 1987 readership survey gave us quite a number of ideas to consider in terms of what we should be including in the *Journal*. Among the many suggestions was a call for articles highlighting "personnel initiative" relating to engineering incidents at sea; a how-they-solved-the-problem view of things. Happily we've been able to oblige, but only because people have taken the time to write about their experiences. They don't always portray engineering drama on the high seas, but then each article in some way offers a fresh perspective of the naval engineering profession through the kinds of problems we encounter and the ways in which we go about solving them.

Apart from the obvious benefit of profiting from lessons previously learned, following the trials and tribulations of other naval engineers tackling the problems at hand serves to strengthen our own ties to the profession. And let's face it, it would all be pretty cold fish if problem-solving were the exclusive bailiwick of computers. It's the people factor that counts.

To some extent computers share many of the human traits, if you will, that necessarily underly the problem-solving process. They are naturally tenacious and thorough, and can be programmed for engineering know-how, insight, inventiveness, logic, intuitiveness (of a sort) and even an eye for detail. But no matter what else you say about them, computers just aren't clever. To them inspiration is an eleven-letter word that doesn't compute. They can sit under the proverbial apple tree and get hit by a truckload of falling fruit, but they'll never make the connection and shout "Eureka!" — even figuratively. (Which might explain why nobody dares to introduce a "Newton" computer in the marketplace.)

If the problem-solving process were strictly a logical sequence of *IF-THEN* subroutines, much like those used to break the code of coloured pegs in a game of Mastermind, we could take down our shingles and turn the task of naval engineering over to the computers. There wouldn't be anything left for us to do. But of course the reality is much different. Problem-solving, as many of us know first-hand, is not always so ordered a process. Even with Expert Systems and smart machines able to search and integrate vast domains of knowledge faster and more efficiently than is humanly possible, no one has yet designed a computer that can give rise to an inspired, illogical solution based on a gut feeling. And sometimes that's what it takes.

Dent Harrison

Letter to the Editor

Dear Editor:

Congratulations on the continuing and, indeed, evolving excellence of the *Journal*. As I played a part in the *Journal*'s conception it is a pleasure to witness the obvious enthusiasm with which it is "consumed" by naval officers and others.

I say *naval* officers because it is obvious from published letters to the editor that MARS officers are enjoying the *Journal* as well. That is as it should be as, to my knowledge, there is no other professional Canadian naval journal where an unclassified dialogue can be carried out. That in large measure was why the *Journal* was commissioned in the first place. MARS officers at the time (1979/1980) were treating the Maritime Warfare Bulletin as their professional journal and were not interested in any other options. We, therefore, focused the *Journal* on MARE-related matters. Notwithstanding this, I consider it essential for the future professional health of the navy that MARS officers retain a close professional affinity with MAREs (and vice versa). Indeed, other than for our different sea-going operational roles the distinction between the two classifications is becoming far less pronounced than one might think, particularly on the CS side.

... Please continue your encouragement of naval dialogue with sequels to the excellent articles and papers appearing recently.

Captain(N) Dennis Reilley
Project Manager
Tribal Class Update and
Modernization Project

In his letter Captain Reilley had special praise for an article that appeared in our September 1988 issue — "ASW Frigate Electrical Propulsion — The Way Ahead," by DMEE engineers Wally Reinhardt and Ralph Storey. (Citing the paper as an important work, Captain Reilley said there are some very compelling reasons in favour of the electrical-propulsion concept, but expressed his concern over the possibility of our having to rely on indigenous industries if for some reason we cannot gain access to foreign propulsion gearing suppliers.) The paper, it is gratifying to add, was reprinted in the January 1989 issue of the Marine Engineering Digest. — Editor.

In Memoriam
Commodore Ernest C. Ball, CD
1932 – 1989

The naval community was saddened to learn of the death of Commodore Ernie Ball in early April. A former engineer-in-chief of the navy, Commodore Ball was known for his dedication to duty, his devotion to family and his regard for the people around him. He was an active member of the Salvation Army.

Commodore Ball joined the Royal Canadian Navy in 1951 while attending the University of Toronto, and graduated in 1956 with a Bachelor of Arts degree, majoring in physics and chemistry. He trained as a marine engineer in HMCS *Bonaventure* and at HMC Dockyard, Halifax, and attended the RNEC in Plymouth and the Royal Military College of Science at Shrivenham. In 1960 he was awarded the qualification of ordnance officer by the Royal Navy.

From 1960 to 1964 Commodore Ball served in a number of appointments in HMCS *Stadacona*, and as assistant squadron technical officer on board the destroyers *Gatineau* and *Restigouche*. He later attended the U.S. Naval Postgraduate School at Monterey, where in 1966 and 1967 he earned master's degrees in electrical engineering and physics and was awarded a Mewborn Student Prize for Research.

Commodore Ball served in headquarters as a systems engineer in the design of the DDH-280 Tribal-class destroyers, and

upon promotion to commander became section head in charge of design and procurement of naval tactical computer systems. In 1971 he organized the Fleet Maintenance Group Atlantic and became its first commanding officer.

He attended National Defence College from September 1972 until July 1973, then was promoted captain and appointed Director of Maritime Combat Systems at NDHQ. He later attended the federal Public Service bicultural development program at Laval University and in 1977 became a member of the directing staff of National Defence College.

Commodore Ball was promoted to flag rank in 1980 and appointed Director General, Maritime Engineering and Maintenance. Under his leadership a complete review of the maritime engineering occupation was undertaken, and he led the way for a new occupational structure, revitalized recruiting and revamped junior officer training to meet the requirements of a new era in engineering technology.

Following his retirement Ernie Ball became Director of Human Resources and Corporate Affairs with Burroughs Canada, then Director of Corporate Affairs and Communications with UNISYS Canada Inc. Shortly before his death he had taken up an appointment as deputy project manager for the CPF project with Paramax Electronics in Montreal.

News of the loss of Commodore Ball came as a shock to the entire naval community, and on its behalf our condolences go out to his family. For more than thirty years Ernie was a respected naval officer, professional engineer and friend of many. His devotion to the well-being of his colleagues and subordinates came to be a hallmark of his career. It is primarily for this that he will be remembered and sadly missed.

Commodore's Corner

By Commodore W.J. Broughton

The imminent addition of the first CPF and the first TRUMPed Tribal to the fleet have provided an impetus to re-examine fleet support. CPF and TRUMP represent major technological advances in the sophistication, complexity and capability of the majority of the systems and equipment fitted. We need to satisfy ourselves that we have the ability to continue to provide essential technical and logistics fleet support over the next two decades.

CPF and TRUMP also represent the first full-scale test of the new naval maintenance policy — a policy incorporating the concepts of reliability-centred maintenance analysis, condition-based maintenance, repair-by-replacement and progressive overhaul. Another important factor influencing the support issue is our reliance on Integrated Logistic Support (ILS) techniques during the design and acquisition phases. For the benefits of ILS to be fully exploited, however, there must be a mechanism for continuing the application of this concept into the in-service phase. Of further relevance is that all support for these new ships must be set up and maintained within the military and civilian staffs now available to ADM(Mat) and Maritime Command.

To grapple with the issue of fleet-support requirements, a multibranch exercise (MBX) was convened at the National Defence College in Kingston last November. Some thirty senior military and civilian personnel representing technical, logistics and operations staff from NDHQ, the major project offices and Maritime Command, deliberated for three days. The proceedings consisted of syndicate discussion groups in which specific support concerns were discussed, and plenary sessions at which the conclusions of each syndicate were presented for general discussion and consideration. The aim was to determine the best possible assignment of fleet-support responsibilities for our changing fleet.

Surprisingly, for some people at least, it became apparent that we do have, in our current management systems such as the Life-Cycle Management System (LCMS), the Canadian Forces Supply System (CFSS) and the Naval Maintenance Management System (NaMMS), a solid structure with the established procedures necessary to make it work. Additionally, it was the consensus of the group that the current responsibility split between NDHQ and Maritime Command as it applies to fleet support should remain as it is. It is the most satisfactory arrangement considering the requirements of technical control, financial allocations, operational responsibilities, departmental imperatives etc.

While these two major conclusions would indicate that we are headed in the right direction, we discovered that we cannot be complacent about the current situation:

- there is a general lack of understanding about the workings and established procedures of the LCMS, CFSS and NaMMS. Additional emphasis must be placed on training and education in the functioning of these systems and more discipline applied in adhering to the proper way of doing business.
- the full benefit of ILS techniques utilized in the design and acquisition phases of a major ship acquisition project may not be exploited during the in-service phase because of a lack of appreciation of the application of these techniques. Once again, training and education of relevant staffs must be pursued rigorously.
- there is sometimes conflicting or confusing direction contained in various in-service policy documents. These directives all must be examined, clarified, properly integrated and simplified such that they are consistent and more readily interpretable.
- there is a need to identify that minimum essential portion of the vast amount of technical data acquired by major project offices during the design and acquisition phases which must be retained to meet in-service requirements. This process must be carried out in order to develop a valid transition plan from the acquisition phase to the in-service phase. DGMEM, DG Proc S and Command Staffs will be working closely with the project offices to generate and execute the transition plans for CPF and TRUMP.
- an urgent requirement exists for increased emphasis on the development of an effective configuration management system. The complexity of the new ship classes demands greater attention be paid to configuration management, and efforts to improve it must be accelerated.

These points highlight the major issues raised during the Kingston discussions. A fuller appreciation can be gained from the written report which has now been widely distributed.

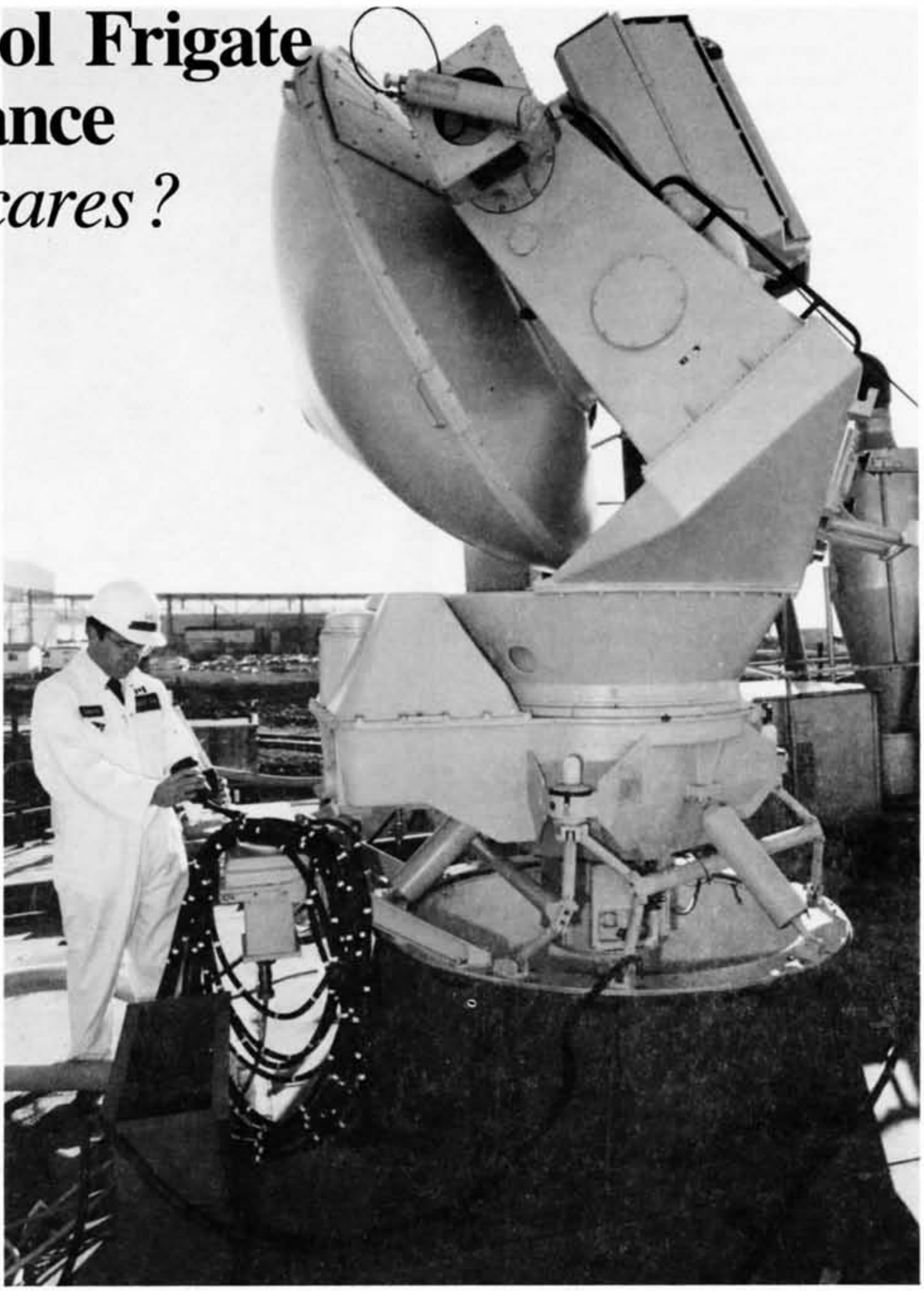
Where do we go from here? The next step is to follow through on the action plan which has been developed in DGMEM since the MBX. This plan identifies the OPIs and OCIs both in NDHQ and in Maritime Command for the implementation of the various recommendations. A further step will be the assessment of the resource requirements necessary to fulfil the task ahead of us.

The important things to keep in mind are these: we do have the solid foundation to build upon; and, we do know what the shortcomings are. From here it is a matter of applying ourselves to achieve the results we seek.

Only time will reveal the full value of the MBX, but I think it is fair to say that all participants left with the opinion that the future fleet-support challenge has been well defined and can be met. It will take dedicated effort by all concerned.

Canadian Patrol Frigate Quality Assurance
—Who cares?

By Cdr Darryl J. Hansen
Photos by Danny Pond



Introduction

Quality assurance? Boring! Bah humbug! Change the channel! If this is your reaction, you're probably in the navy and you're certainly not alone in your attitude. You are encouraged to read on: quality assurance doesn't have to be dull, and it certainly is important. This short article has been written to tell the story of how quality assurance (QA) is being practiced in the construction of the Canadian patrol frigates in Saint John, New Brunswick. It's a story which needs to be told, simply because it is working so well.

The CPF Situation

The Crown is in contract with Saint John Shipbuilding Limited (SJSL) to deliver 12 fully supported frigates between 1989 and 1996. At the present time, seven of the vessels are under construction (four of them in Saint John), with two of them well into the outfitting stage.

The contract with Saint John Shipbuilding, the first of its type in the Canadian shipbuilding industry, called for SJSL to exercise total system responsibility, including design, integration, construction and even preparation of the necessary shore facilities to support the new vessels.

QA was a vital part of the contract. In a perfect world the Crown could have signed the contract, turned its corporate back and returned years later to pick up the keys as the vessels rolled off the production line. The QA system put in place by the contractor would have guaranteed that the frigates were designed and built entirely in accordance with the contracted requirements. But we're not quite there yet; nor are we ever likely to be.

Saint John Shipbuilding Limited has been required to put a QA organization system into place which meets the intent of the Department of National Defence's specification DND-1015. This requires the company to have a quality assurance system functioning throughout the continuum of design, construction, trials and delivery.

The Navy Role

If SJSL does all of this quality assurance themselves, what then is the navy doing? The navy detachment in the shipyard is there to make sure that the QA system we paid for is functioning, and to provide the necessary course corrections to stay on track. Our rather lofty mission statement is: "to get the best ships possible for the navy under the terms of the CPF contract." This mission involves several roles, by far the most important of which is to provide a navy QA presence. SJSL's QA system in the shipyard is good, even very good, but it's that way only because the navy is knowledgeable, involved and concerned.

Before getting into the specifics of the QA function, it is worthwhile mentioning the other roles which the detachment performs. These include:

a. *Providing a technical interface*. The leadyard detachment is usually the first to detect construction-related problems. It is important to identify a problem and assess its urgency as quickly as possible. This allows a logical decision to be made on our level of involvement in the problem's resolution. We handle the urgent or simple matters, and staff the rest to other CPF offices or DGMEM. This isn't as easy as it sounds. Problems which arise are often exceptionally interesting, and there is a natural tendency to want to work them out ourselves. However, this process can be so labour-intensive that our primary role of providing QA suffers. It is a difficult (but necessary) decision to send problems outside of the leadyard for analysis.

b. *Status Reporting*. The leadyard detachment has to provide construction status against master project schedules, work-around schedules, certain major milestones associated with profit payments, and other schedule systems. Much of the information is not used by the leadyard, but must nonetheless be provided to other agencies. Experience has shown that the requirement for providing any particular type of status data should be reviewed on a regular basis.

c. *Special Taskings*. This role concerns everything from escorting senior officers on a "kick-the-tires" visit, to writing articles for the MARE *Journal*. It also includes documenting "lessons learned" for the benefit of followyard staff and other projects. Urgency ranges from "before you catch your next breath" to "this year." If you've ever been a sub-lieutenant, you will understand this type of tasking. Manpower devoted to this role can be significant.

In summary, then, the leadyard's primary role is quality assurance, but other roles — technical interface, status reporting and special taskings — also demand attention. A clear understanding of the roles is important, for without that understanding the primary role of providing quality assurance tends to be neglected in favour of more urgent or appealing arisings.

The Naval QA Function

The traditional naval way of doing QA has been to concentrate on mandatory in-process and final inspections of work. This was a necessary part of our progressive acceptance in repair contracts, but the approach was manpower-intensive. Further, the CPF contract is quite explicit that this role of hands-on QA is a contractor responsibility.

Remember as well that the essence of the navy QA role is to ensure that SJSL QA does its job. This is accomplished through a coherent series of activities which A-QA-193 (the QA bible) would group

under the subject headings of procedures evaluation, procedures compliance and product verification.

In brief, product verification is looking at the ship, procedures compliance is walking around with your hands in your pockets, and procedures evaluation is looking at the shipbuilder's published procedures in excruciating detail. Emphasis is placed on making sure that the contractor is following his written instructions: the theory being that if his written procedures are correct, and he is following them, then the final product (in this case the ship) will be specification compliant.

Our experience has shown that the theory is sound. Not surprisingly, we have also found that it has been a considerable challenge to apply the system to a shipbuilding project and make it work. QA activities in each of the areas of procedures evaluation, procedures compliance and product verification will be examined in turn.

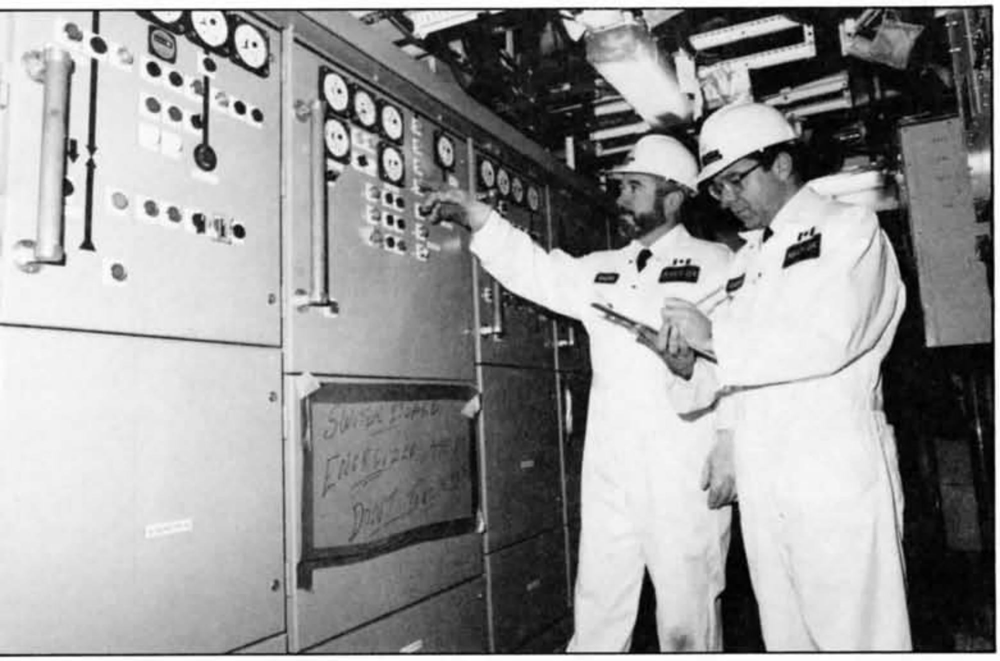
Procedures Evaluation

Procedures evaluation (PE) is a two-tiered process. First, the contractor's written procedures must be reviewed to ensure they are complete and correct. This is a major undertaking because of the multitude of procedures involved, and also because the review must be done by Crown personnel with the right skills and experience. After this review, the second step in procedures evaluation is to make sure that the contractor is faithfully following the written word. This requires that detailed checklists be prepared and that a thorough on-site audit be conducted.

The effort required to do a good procedure evaluation is typically quite significant, and it is for this reason that the leadyard detachment has not embarked on a dedicated PE program to date. However, yearly PEs of higher-level QA documentation are undertaken by Ottawa-based staffs, and SJSL conducts its own internal PE program: both of these activities are attended by leadyard personnel. Because of the up-front effort involved in PE, it is usually the hardest QA activity to perform. It is also the cornerstone. If the written procedures are being ignored, then the whole QA system will break down. After three years in the shipyard QA business, the leadyard detachment has decided to devote more resources to PE because of its importance to the QA system.

Procedures Compliance

In the shipyard, procedures compliance (PC) consists of observing in-process work. This surveillance activity does two things. First, it projects a navy presence. While this benefit cannot be quantified, we know



that the uniformed and readily identifiable navy QA presence is a key factor in the success of SJSL's own QA program. The second benefit of this activity is that it allows surveillance of the full range of construction activities on a regular basis. To ensure that the latter occurs, a disciplined approach based on simple checklists has been put in place. Without this discipline, human nature would tend to concentrate on the problems, concerns or interests of the day, largely ignoring other areas. These unmonitored areas would then grow into tomorrow's problems.

PC is a key component in the navy's QA program. It is carried on continually during normal working hours, and at night and on weekends on a random but frequent basis.

Product Verification

Product verification is the activity that most sailors conjure up when they think of quality assurance. While it is only part of the whole QA program, it is arguably the most important part.

ITP. SJSL has developed a master inspection and test plan (ITP) which details what type of inspections are to occur at any given stage of construction. For example, SJSL does in-process inspections at several points, and a final inspection and acceptance at the end of a production cycle. Some clarification is needed here: SJSL inspects and accepts, the navy *witnesses* that SJSL's inspection was complete and correct. In real terms this means that SJSL does the inspection of an item or system, and when they are completely finished and have accepted it the navy team does its own inspections. Any deficiencies found by the navy indicate a breakdown in the contractor's QA system which requires rectification.

There is a real danger of losing sight of the purpose of the DND witness-point inspection; the aim is to make sure that SJSL QA is doing its job. The urge to inspect the work as soon as it is finished, or to start the navy inspection while SJSL QA is doing their inspection, or of "helping" SJSL QA do the inspection *must* be resisted. Otherwise the navy team in essence becomes an auxiliary to the contractor's QA force, and not a higher-level check.

What to Inspect. Under the terms of the contract, DND has the right to witness any or all of SJSL's inspections on a non-interference basis. In practice the navy has chosen to look at the work (in a formal sense) at only a few points. These are not fixed, and witness points can be added or deleted as desired. We are currently looking at work which falls into one of two categories. First, there are those inspections which are of themselves considered to be important. For example, we witness structural welding/fit-up and paint inspections. In the second category are inspections classified in QA parlance as "last-point inspections." For example, we witness the surface preparation inspection of steel units just prior to paint application, and we inspect the finish of foundations before equipment is bolted down.

Test/Trials. Although the testing and trial of fitted equipment and systems is a whole discipline unto its own, the leadyard does witness a fair number of these events. They are akin to any other witness point and are handled in much the same way and generally by the same personnel. The leadyard staff has been augmented recently to cope with an increased level of test and trial activity.

Making It All Work

If you have managed to make it this far into the paper it is presumed that you are reasonably interested in the process of putting a QA system into a shipyard. For you QA aficionados, here are some hints (learned the hard way) about what's important in a navy QA system:

a. *Maintain your Focus*. (See also K. von Clausewitz: first principle of war.) QA is the primary role of the naval detachment. It is easy to get diverted by all sorts of sideshows, any of which can be exceedingly interesting and apparently important. To help keep our focus, we have published a set of standard operating procedures; we also have regular staff meetings to share concerns and problems with ship construction. We also sit back every few months and have a soul-searching session — are we doing things right to meet the mission; what's missing, what's wrong? This process has been very valuable.

b. *Dealing with the Contractor*. The contractor is **NOT** the enemy. The target is the *system* which allows (or

heaven forbid — condones) non-conforming work to occur. The contractor's own QA department should be the first line of defence. It is therefore very much in the navy's best interest that the contractor have a strong and credible QA department. To this end, the contractor's QA department must be supported and nurtured to turn it into a strong, viable force within the company.

c. *Doing Procedure Evaluation*. PE is difficult to do because it is time-consuming and is often perceived by the staff as drudgery. However, if you don't get a well-structured PE program established, your system will eventually bog down with excess product-related non-conformances. Ignore PE at your peril.

d. *Tame your Troops*. The naval animal wants desperately to put on coveralls, get a flashlight and go beat on the contractor. It is important to control this primeval urge: neither a QA organization nor a ship can function without discipline. This means that product verification takes place only after the contractor is finished his inspection. It means doing PE, and it means paperwork. (Contrary to naval folklore, CPOs can become accomplished writers.)

e. *Maintaining Morale*. Doing the navy QA job can be tough on morale. Long days and odd hours are required, without the welcome interruption of foreign ports. The detachment has lots of chiefs and no indians. The leadyard is in Saint John. (It's great once you get used to it.) The place thrives on paperwork. The whole concept of QA is negative: a perfect system would generate a "nil report." The list goes on.

It is important to realize that morale can suffer under these conditions. Hence, we try to make the place as unobjectionable as possible in terms of working conditions and hours. We strive to build team spirit. The philosophy of employment at the leadyard is based on the U.S. Marine Corps adage: everybody is a rifleman first. We train everybody in basic QA and inspection skills; hull technicians and naval electronic technicians often work side by side doing the same job. We try to do things as a team, and we try to have fun. This may run contrary to current defence thinking, but it is a firmly held conviction that you can be deadly serious about the job at hand, and still make it fun. Frigate — who cares? We do — and we're even enjoying it.

Cdr Hansen has been the CPF leadyard commander since December 1986.

Electrostatic Discharge and Field Effects on Electronics Systems

By L.R. Dicks and Gilles Morin

Abstract

This paper will introduce the effects of static electricity on modern electronics as well as a comprehensive system approach in considering electrostatic discharge (ESD) protection measures in all phases of the life cycle of an electronic system. Static electricity has become a potential source of damage to electronic systems used in most applications, including aircraft, ground and shipboard installations.

Introduction

Recent experiences within the Department of National Defence (DND) of Canada have shown that a number of electronic system malfunctions and damage have been caused by ESD effects. In most situations, problems have been identified in the course of a system's operation but could have been prevented or controlled with proper ESD considerations during the conception and acquisition stages of the life cycle of the system. ESD failures have been identified in aircraft and ground communication facilities, computer control centres, software development areas, cryptographic areas and in many electronic maintenance facilities.

The following case studies emphasize the importance of ESD awareness:

CASE A: A major military surveillance computer facility required daily operator action to correct system latch-up and processing errors. A study concluded that the system was susceptible to significant ESD events initiated by carts being moved within the facility. Dissipation of static charge from these carts eliminated system malfunctions and reduced servicing requirements considerably.

CASE B: A military communication facility experienced serious radio malfunctions which jeopardized ground-air-ground communications. A study indicated that the existing anti-static carpet did not have a low enough electrical surface resistivity to provide sufficient static charge dissipation.

Sources

Common sources of static electricity include moving parts, such as in processing equipment or robotics, rapid air flows, such as from moving vehicles, and also human bodies. Static electricity is generated because of the triboelectric effect of friction which enhances surface charge mobility between materials. The magnitude of charge is dependent upon the capability of a material to give or accept electrons, the speed of friction activity, the size and electrical conductivity of the material and the relative humidity (RH) of the environment. Low RH, below 40 percent, is a prime factor contributing to the build-up of static electricity. DND experience has shown that excessively dry conditions, near 20 percent or below, can overcome the effects of ESD protective materials.

Human Body Electrical Model

Because the human body is constantly in movement, it is a prime generator of static electricity. Daily routine activities such as walking on a carpet and handling common plastics can generate from a few volts to more than 40 000 volts. Studies have shown that human body capacitance may vary from 80 to 500 picofarads and skin contact resistance from 500 to 5000 ohms[1]. The trends to higher packaging densitites of microelectronics and faster speeds of operation have led to newer technologies susceptible to static potentials below 100 volts. Such voltages can be generated simply by changing body position. Often, human bodies cause ESD damage to electronic systems and associated components without any awareness of it, because the human threshold of perception of an ESD spark is approximately 3000 volts. Therefore, ESD control should be treated as part of the quality control system in manufacturing, maintaining and operating electronic equipment.

ESD Event

When two materials retain an electrostatic charge of a different magnitude (of the same or different polarity), an electrostatic field exists between the surfaces of these materials. If the electrostatic field strength exceeds the dielectric breakdown of air (12KV/cm), ionization of air molecules will occur and rapidly increase air conductivity. Consequently, a low resistive path is formed, enabling a current to flow and the two materials to equalize their charge. This process, called electrostatic discharge (ESD), normally takes place within a few nanoseconds. It is the speed and current characterizing ESD events which cause damage to modern electronics. Also of concern are the induced damages resulting from strong electrostatic fields which can rupture internal structures of microelectronics.

ESD events are characterized by fast rise and fall times of approximately 1-5 nS and 30-100 nS respectively. As shown in *Figure 1*, such short electrical transients cover a wide frequency spectrum up to 1 GHz in some cases. Consequently, an ESD current radiates strong electromagnetic energy which can couple into nearby electronic circuitry by conduction through power and interconnecting leads and by radiation through openings in the equipment chassis. The process is called *electrostatic discharge-electromagnetic interference* (ESD-EMI) coupling. *Figure 1* represents a typical ESD event initiated from human bodies, in both the time and frequency domain.

ESD Effects

The requirement for faster speed of operation, shorter propagation delays and lower power of modern electronics implicitly led to the mininaturization of electronic devices. Consequently, modern designs require higher packaging densities, thinner oxide layers, smaller and shorter traces and an extreme space reduction between components dopped on integrated

Using basic Fourier transform analysis, the frequency spectrum of an ESD event can be calculated from the following equations[2]:

$$F1 = \frac{1}{\pi Tf} \quad F2 = \frac{1}{\pi Tr} \quad A = 2*I*Tw \quad (1)$$

where F1 and F2 are the 20dB and 40dB cutoff points respectively, Tr and Tf are rise and fall times respectively, A the spectral amplitude in Amp/Hertz, I the maximum ESD current and Tw the 50-percent time width of the ESD pulse.

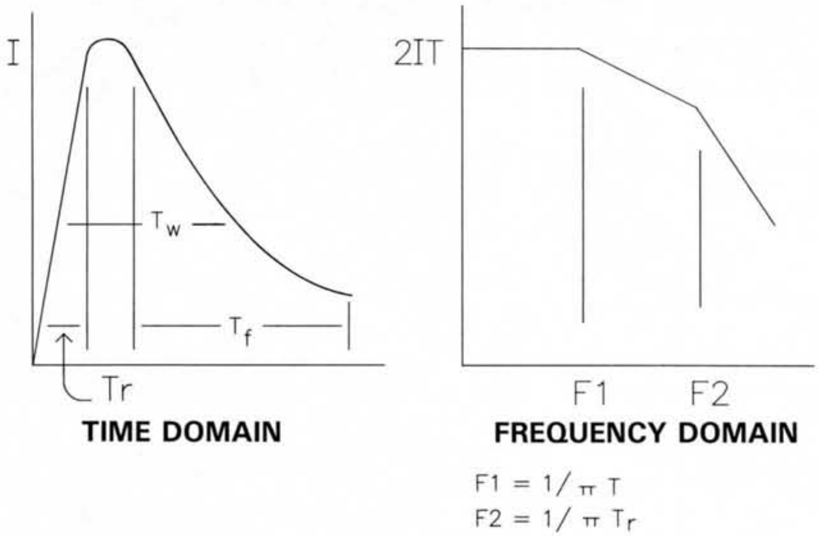


Fig. 1. Time and Frequency Domain of an ESD Event

circuit wafers, leading to microelectronics with growing susceptibility to the ESD direct, indirect and field effects. These effects can result in catastrophic failures and soft failures. ESD can cause electrical overstress (EOS) which may not affect system operation. However, it will affect the system performance characteristics, minimize reliability, reduce mean-time-between-failure (MTBF) and lifetime expectancies, and therefore increase costs of operation. Repeated ESD events will gradually deteriorate system capabilities, eventually resulting in catastrophic failures. Such time-dependent breakdowns are called latent failures.

Direct Effects

Direct effects result from damages caused by direct current injection initiated from an ESD source. Severe peak ESD currents can exist because of the short duration (typically nanoseconds) in which static charge (typically microcoulombs) is dissipated:

$$I = dQ(uC)dT(nS) \quad (2)$$

Relatively high current of several amperes flowing directly through ESD-sensitive electronic devices will cause permanent damage which can result in sudden or latent failures. The permanent damage generally occurs by breaking dielectric material such as silicon dioxide or by the metallization of junctions and traces.

Indirect Effects

Indirect effects normally do not cause catastrophic failures, but will disrupt the operation of electronics (soft failures). For instance, electronic system operators often face unusual and unexplained operational malfunctions which they can easily correct themselves. These failures are often the result of ESD-EMI coupling and are not given any attention to prevent future occurrences because of the simple corrections required.

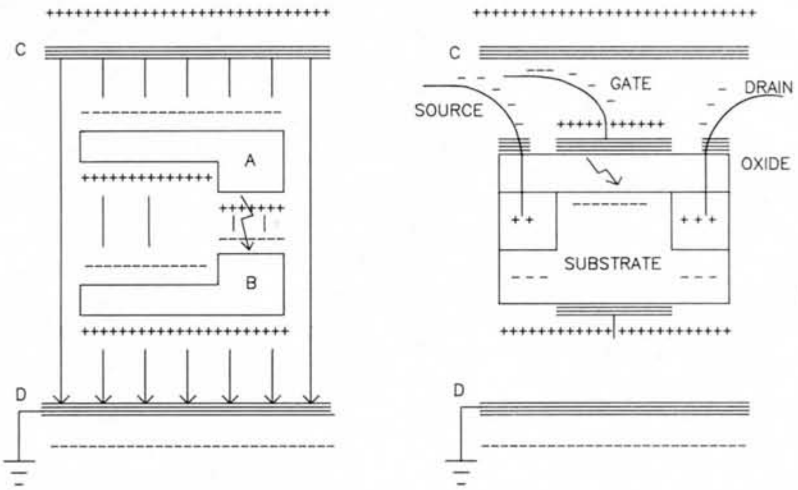


Fig. 2 Electrostatic Field Induced Damages

Field Effects

When an object retains a static charge, an electrostatic field exists. Such a field can cause catastrophic damage to electronic devices without having an ESD event initiated from the charged object. As shown in *Figure 2a*, consider two charged parallel plates, C and D. The electrostatic field lines-of-force are perpendicular to the plates and uniform. If two conductive objects A and B were placed within this field, both A and B would be polarized by the induced charge and a constant potential would exist between A and B. However, the electrostatic field strength between A and B will vary upon the distance separating these two objects. If this field strength exceeds the dielectric breakdown field strength of air (12 KV/cm), an ESD event will occur between objects A and B to neutralize their charge. This mechanism can rupture the oxide layer of MOS microelectronic devices due to the polarization of conductive areas such as drain, gate, source and substrate (*Figure 2b*)[3]. Since newer technologies use thinner oxide layers, electronic devices are susceptible to electrostatic field damages due to low internal dielectric voltage breakdowns.

ESD Protection

In general there are three thrusts to implementing an ESD protection program. First, a level of protection against the effects of an ESD event can be designed into the equipment or system. Second, the generation of static charge can be minimized where there is a measure of control over the appropriate factors. Thirdly, the elements to maximize a fast and safe dissipation of charge can be put in place. A comprehensive system approach, including an assessment of the impact of the protective measures on the operator, is needed to ensure complete protection against the effects of ESD.

ESD Awareness

First and foremost in ESD protection is proper ESD awareness. Personnel must have a basic knowledge of ESD and then the specific knowledge to enable them to effectively carry out the activities at each stage of the life cycle. Ideally, ESD education should involve a coordinated effort in order that the protection be continuous. Some agencies are more concerned, informed, and implement the necessary precautions better than others, and while there are continuing efforts at education, there are gaps in the protection provided. Unfortunately, sometimes it is only after a catastrophic experience that proper ESD protective measures are implemented.

Life-Cycle Management

The Department of National Defence has adopted the concept of life-cycle management for the management of materiel within the Canadian Forces. Life-cycle management provides for the management of all activities from the time a requirement for an equipment item or system is conceived until the disposal of the equipment or system from inventory. The life-cycle management system provides a convenient framework from which to view ESD protective measures.

The Conception Stage

During the conception stage specific performance parameters are defined, along with the operational environment, which includes the natural and induced (climatic, shock, and vibration conditions) and the electromagnetic environment. These environmental conditions will also define the level of ESD protection required and, hence, the design effort.

The radars and electronic equipment for the North Warning System will operate in ideal conditions for the generation of static charge by moving parts, or by humans during periods of maintenance; hence the potential for damage or malfunction. In another environment, such as found at a communications site where the temperature and relative humidity are well controlled, there is a lesser need for ESD protection to be designed into the system. For communications equipment used in the field, the most probable source of ESD is the human, and this must be a factor in the design of the system.

It is during this stage that the factors which will influence the requirement for ESD protection must be defined.

The Acquisition Stage

During the acquisition stage the objective is to take into inventory an equipment item or system which will meet the performance parameters defined in the conception stage. The quality assurance authority has the responsibility to ensure ESD is taken into consideration by the contractor during the design phase.

It is important from the quality assurance perspective to ensure that the contractor has an effective ESD control program within his manufacturing facility. Failure to implement an effective control program by the contractor can result in degraded performance in the field, latent failures, and a low MTBF.

ESD Susceptibility Testing

An integrated test program must be undertaken to ensure the equipment or system will meet performance parameters under the defined operational environment. Degradation or damage of component parts by ESD during manufacture or assembly could be a factor in passing or failing the test program. This program should also include specific tests to ensure that the protection built into the equipment or system is effective against ESD.

Presently, the International Electrotechnical Commission is the only organization which has ratified an ESD test standard for electronic equipment, assemblies and systems: IEC-801-2 "Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, Part 2-Electrostatic Discharge Requirements". DND is presently working on the development of a standardized agreement (STANAG) with other NATO countries for the ratification of EMC test methods which will incorporate ESD test requirements. Also, the Electrical Overstress/Electrostatic Discharge American Association is working on the development of various standards on ESD protective equipment and material requirements and testing.

Storage, Handling, Packaging and Shipping

The contractor must institute the correct storage, handling, packaging, and shipping procedures at his facility. Again it is the quality assurance function to ensure that the contractor has these aspects under control. Guidelines for handling ESD-sensitive items are provided in detail in reference 8.

The In-service Stage

The measures implemented for ESD protection should be transparent to the operators. It is important to allow them to concentrate on their tasks without the hindrance of wriststraps or other ESD-preventive devices.

If an equipment item or system were designed to be used in a controlled environment, such as would be found in a communications site or computer facility, then the particular environment must be documented and maintained. Changes should not be made which might affect the controlled environment without appropriate study and documentation. Important factors include not only temperature and relative humidity, but also flooring or carpeting, the grounding system, and static-dissipative mats if used (although not ideal for an operational situation). Maintenance practices must be insitituted such that the controls remain intact and effective.

The supply system must impose obligations on suppliers of assemblies, devices and components to ensure these parts are not ESD-damaged before being received. The parts should be packaged and shipped in the proper ESD-protective materials. Within the "system," materials made available for the packaging of assemblies, devices and components must meet ESD protection requirements. Handling procedures need to be well defined, understood and practiced by personnel, and the parts stored in an ESD-protective environment.

Assemblies such as circuit cards or electronic modules that contain ESD-sensitive electronic parts should be catalogued, packaged, labeled and handled as ESD-sensitive items. It is not always possible to determine the component technology that is used in circuit-card assemblies and electronic modules. Therefore, all such items should be packaged and handled as ESD-sensitive unless it has been established that they are not susceptible to ESD.

The in-service repair and overhaul facilities must implement rigid ESD control procedures. The expense incurred in troubleshooting and repairing a circuit board necessitates reducing the risk of returning a damaged board or assembly to inventory. The same degree of caution must be exercised as when handling unmounted ESD-sensitive components.

Common plastic bags or containers (often used to hold work instructions and test procedures) and styrofoam must be banished from the workshop. Personnel should wear ESD-protective clothing. Synthetic clothing is regarded as a static hazard and the wearing of cotton-based smocks is encouraged when handling ESD-sensitive items.

Static-free workstations are required. These workstations have static-dissipative table and floor mats grounded through a one-megohm resistor to dissipate static charge to ground. Static-dissipative wriststraps are also used. In cases where an environmental control system is not installed, low humidity will result in an increase in ESD damage. A small humidifier can be used to maintain the relative humidity to a safe level (40 to 50 percent). Proper ESD protection tools and equipment must complement the other elements of the workstation. An ionizer should be used to neutralize the charge on ESD-protective materials.

All containers, tools, test equipment and fixtures should be grounded before and during use, either directly or by contact with a grounded surface. Grounding of electrical equipment should be via grounded plug and not through the conductive surface of the grounded ESD workstation. Handtools with insulating handles capable of generating static electricity should not be used unless treated with topical antistat.

Continuity and resistivity checks of wriststraps, grounded workbench surfaces, conductive floor mats and other connections to ground must be performed periodically, and a log kept of dates that the tests were conducted. Containers and tote boxes should be electrically connected together before transferring ESD-sensitive parts from one to another.

Conclusion

The increasing malfunctions and damages to modern electronic equipment and systems clearly indicate that ESD should be a major concern. ESD effects can be controlled and minimized if proper precautions are taken in all phases of the life cycle of a system. ESD control requires thorough application of protective measures, since the failure to implement simple practices such as the wearing of ESD wristraps can jeopardize the overall protection program. ESD is part of the life-cycle system and must be considered along with all other requirements.

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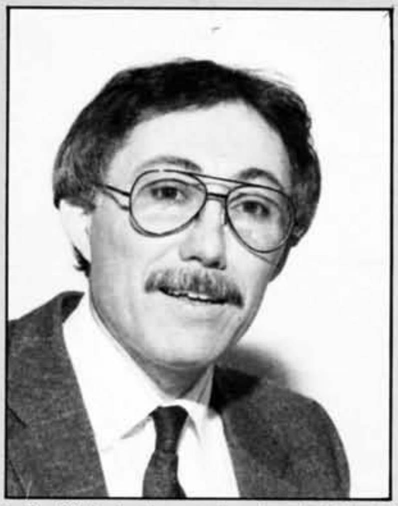

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A Proposed Gas Turbine/Electric Propulsion System Retrofit for the *Annapolis* Class

By L.T. Taylor

The *Annapolis* class is having a major role change with the fitting of CANTASS. The following "pie-in-the-sky" conversion of this class is the result of a "what if" question after reading the summary of a study of an electrically propelled frigate. A proposed design is presented with some supporting argument, but without a full design-spiral approach.

The Proposed Propulsion Plant

An AC-to-AC cycloconverter electric transmission system is used with variable frequency electric generation and frequency change with cycloconverters to vary propeller speed. Ship's service electrical power is obtained from the propulsion power bus with its own cycloconverters and motor-generator sets. *Figure 1* is a schematic of the proposed plant. Two Allison 571K gas turbines drive the propulsion alternators, producing up to six megawatts of 3-phase, 3,300-volt power at frequencies between 100 and 200 hertz. Each shaft is driven by a 6-MW, 24-pole 3-phase 1200-volt AC motor at speeds of 0 to 150 rpm, corresponding to frequen-

HMCS *Annapolis*

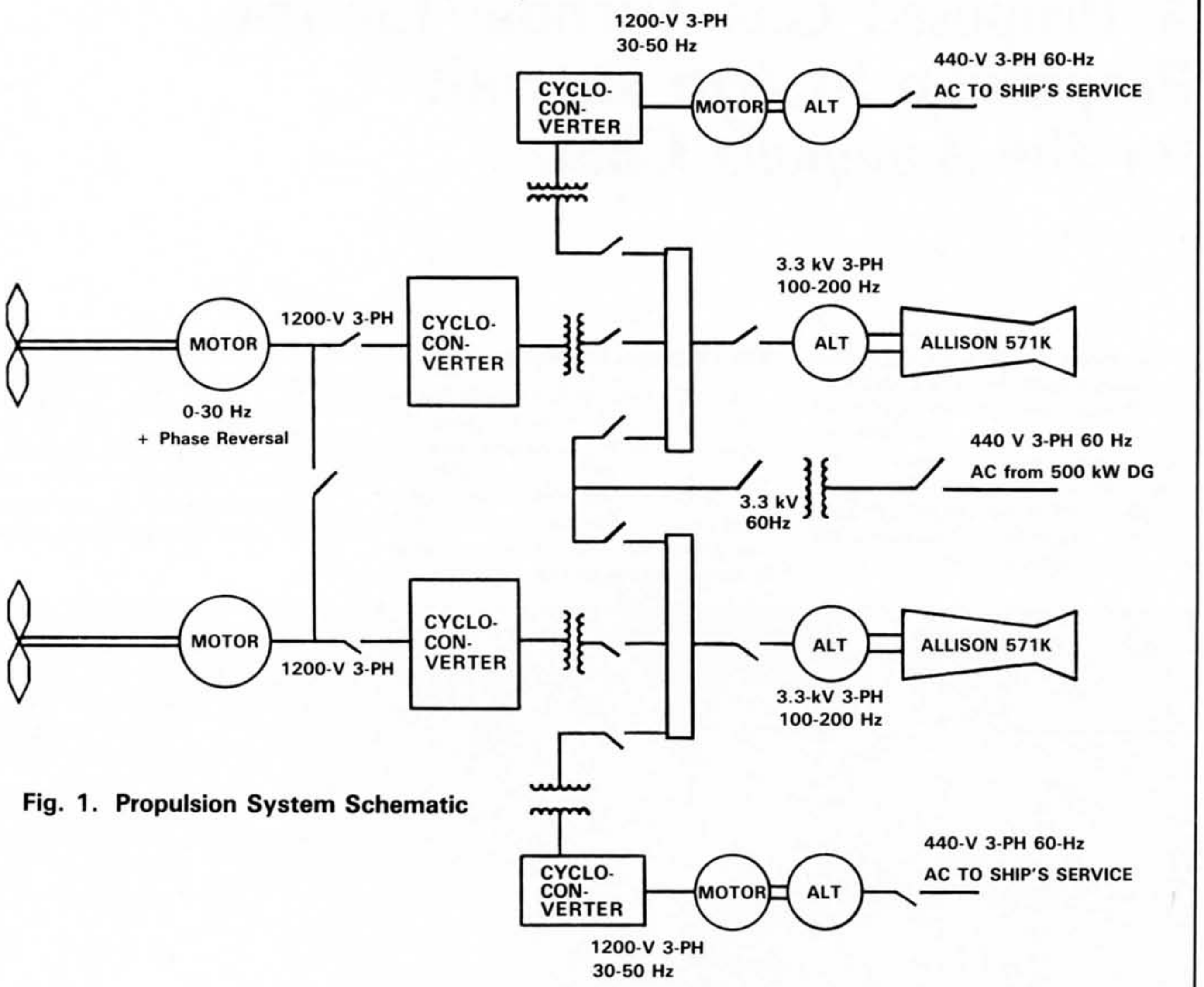

Fig. 1. Propulsion System Schematic

cies of 0 to 30 hertz output from the cycloconverters.

Two nominally 1-MW motor-generator sets provide 440-volt, 3-phase 60-hertz ship's service electrical power. There is a separate cycloconverter for each MG set. Control of the cycloconverter output frequency is driven by the 60-Hz ship's service requirement. The actual cycloconverter frequency output will be a few percent above 30 Hz to account for the induction-drive-motor slip. Only one of the two MG sets can be connected to the main switchboard at any one time. *Figure 2* is a basic machinery layout sketch for the proposed plant. *Figure 3* is a section and elevation of the propulsion motors connecting to the existing shaftlines in the engine-room.

Modes of Operation

The following four modes of operation are available with this propulsion system:

a. Normal Cruise — one 571K alternator set driving both propulsion motors, and one motor-generator set for ship's service power. (Speeds up to 19.5 knots);

b. High Speed — two 571K alternator sets, one driving just its propulsion motor and fully isolated from the other which supplies its propulsion motor and one motor-generator set for ship's service power. (Speeds up to 23.25 knots);

c. Full Power — two 571K alternator sets, each driving just its propulsion motor with the ship's service electrical power supplied by the 500-kW diesel supplemented by 200-kW diesels if required. (Maximum speed of 24.00 knots); and

d. Emergency "Get Home" Capability — the 500-kW diesel, driving one or both propulsion motors through either cycloconverter with 200-kW emergency diesels providing ship's service power.

Some Justification

Electric propulsion is quiet, and a towed-array ship has its effectiveness improved by reducing its self-noise. For a retrofit such as this, the installation problems are greatly reduced by the flexibility of arrangement possible with electric propulsion. Only the motors need to be mechanically aligned with the shafting. The engines can be sited conveniently around existing air intakes and funnels. This type of AC/AC electric propulsion provides very easy reversing compared with

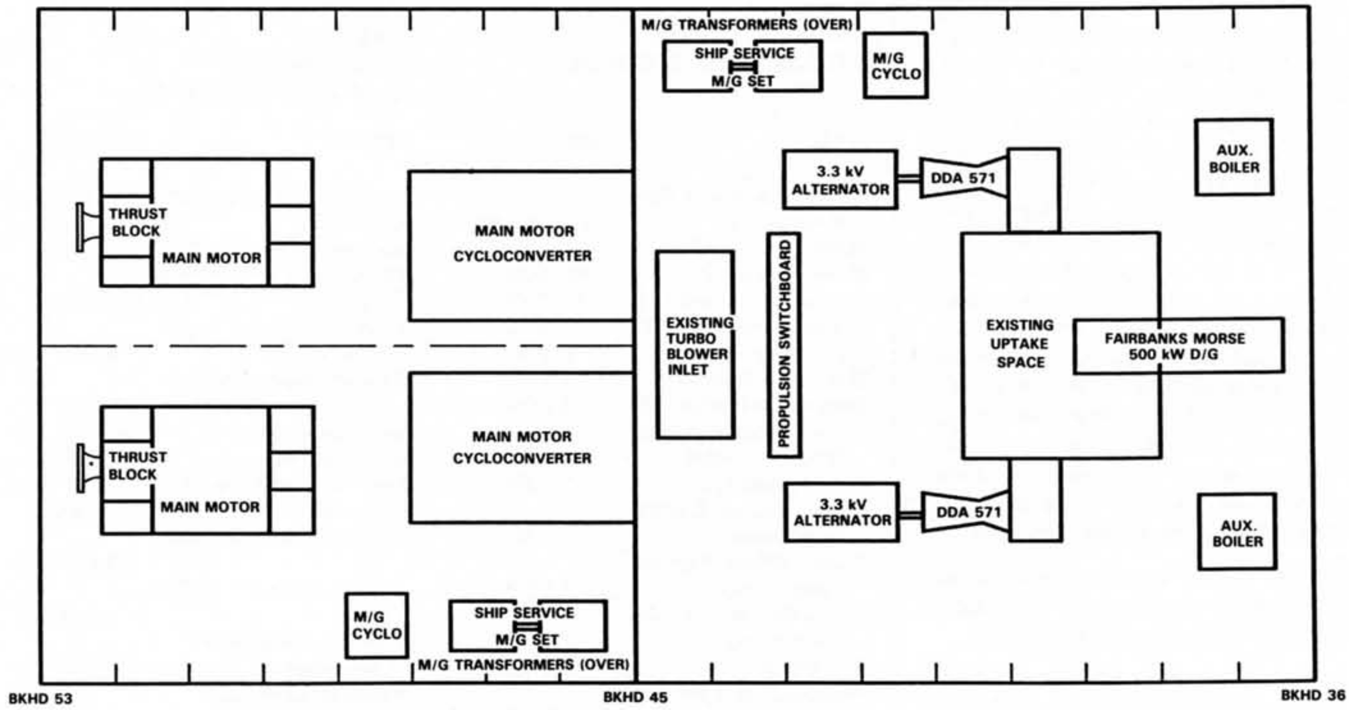

Fig. 2. Machinery Layout

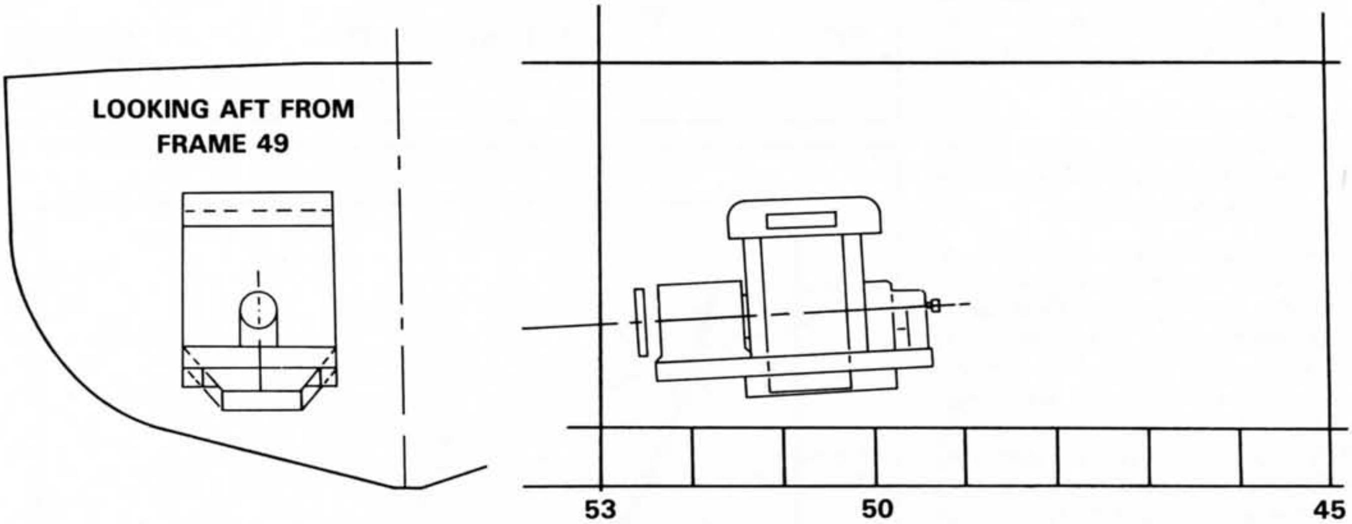

Fig. 3. Section and Elevation at Motors

unidirectional prime movers connected to mechanical transmission systems. The inherent cross-connect capability of electrical propulsion can provide for more efficient part-load operation as well as redundancy at part power and get-you-home operating modes for survivability. Gains in part-load efficiency, particularly at low powers, are important in a towed-array ship since they convert to increased endurance and thus increased time on station.

The Allison 571K gas turbine is used in this proposed package because it differs only from the Allison 570K used in TRUMPed DDH-280s in the free-power turbine. Training and support will be common for the most part with that for the TRUMPed 280s. It is a second-generation gas turbine with a good part-power specific fuel consumption which, as stated already, is important in a towed-array ship. The 571K air requirement is 43.3 lb/sec (compared with over 60 lb/sec per turboblower) so the existing ducting areas available in the *Annapolis* class should be adequate. The 571K at its intermittent rating has an output of only 8288 h.p., so that the total installed power will be significantly reduced over the original Y-100 steam plant. Here again the role change of the ship assists in justifying a reduced maximum speed.

Six-MW motors and cycloconverters manufactured by GE Canada are presently at sea in the Canadian Coast Guard Type 1200 icebreaker and thus can be considered proven technology. Increasing the size of the motors is not seen to impose serious technical problems. The proposed Polar 8 icebreaker will be powered by six 12.5-MW motors. To increase the propulsion power level, more gas turbine alternator sets or sets of higher power output would be required along with the higher power motors. A full design-spiral approach would be required to do option trade-offs, but as stated at the outset this is a single-point design. Some supporting argument has been made up using open sources, predicated on changes within the machinery spaces alone without impact on ship structure/arrangement elsewhere.

The use of the propulsion prime mover to also provide the ship's service electric power does three things for this ship:

a. It reduces the number of prime movers fitted and required to be run compared with the number if separate diesel or gas turbine generators were to be run continuously at sea.

b. It improves the ability to quieten the ship since motor-generators are quieter than diesel or gas turbine generators.

c. The incremental load it adds to the propulsion load on the gas turbine at very low speeds has a significant effect on fuel efficiency.

To demonstrate this third advantage consider the case of 1000 h.p. for propulsion and another 1000 h.p. for 650-kW ship's service electrical load. The improved sfc at 2000 h.p. over 1000 h.p. in *Figure 4* is indicative of improved efficiency. Looked at another way, it was costing 900 lb/hour fuel to propel the ship; now for 1250 lb/hour we get both. The delta of 350 lb/hour or .35 lb/h.p. sfc is difficult to beat for a separate generator set.

Table 1 lists the major equipment to be removed from the engine- and boiler-rooms, complete with weight. Essentially the only equipment left after the strip-out is:

a. Engine-Room — 75-ton A/C unit
— HP air compressors
— LP air compressor
— hull and fire pump

b. Boiler-Room — aux. boiler
— 500-kW diesel generator
— LP air compressor
— hull and fire pump

TABLE 1
STEAMPLANT STRIP-OUT

ITEM	WEIGHT
Main Engine and Condenser (2)	84,000 lbs
Main Gearing (2)	68,600
Main Boilers (2)	192,400
Turbo-alternators (2)	33,800
Turboblowers (2)	8,560
Main Feed Pump	6,630
Main Circ Pumps	7,760
Extraction Pumps (2)	4,200
Lube Oil Coolers and Filters (2 sets)	5,000
Air-ejectors (2)	2,170
Gland Vapour Ejector Condenser	1,250
Steam-Driven Forced Lube Pump	1,550
Motor-Driven Forced Lube Pump	1,760
Deaerator	6,050
Deaerator Extraction Pump	1,210
Pacific Feed Pump	1,500
Recip Feed Pump	2,830
Fuel Pumps (2)	3,440
Evaporators (2)	12,700
TOTAL	445,410 lbs

TABLE 2
GAS TURBINE/ ELECTRIC WEIGHTS

ITEM	WEIGHT
Propulsion Motors (2)	82,500 kgs
Oil Pumps	175
Seawater Pumps (4)	800
Oil Coolers and Filters (2)	300
Cycloconverters (main) (2)	7,000
Transformers (main) (2)	50,000
Main Generators (2)	20,500
Gas Turbines	800
Gas Turbine Lube Oil Modules (2)	325
Motor-Generator Sets (2)	22,000
Cycloconverters (MG) (2)	1,500
Transformers (ss to Propulsion)	2,500
Reverse Osmosis Desalinator (2)	6,000
Second Aux Boiler	2,800
TOTAL	197,200 kgs (433,840 lbs)

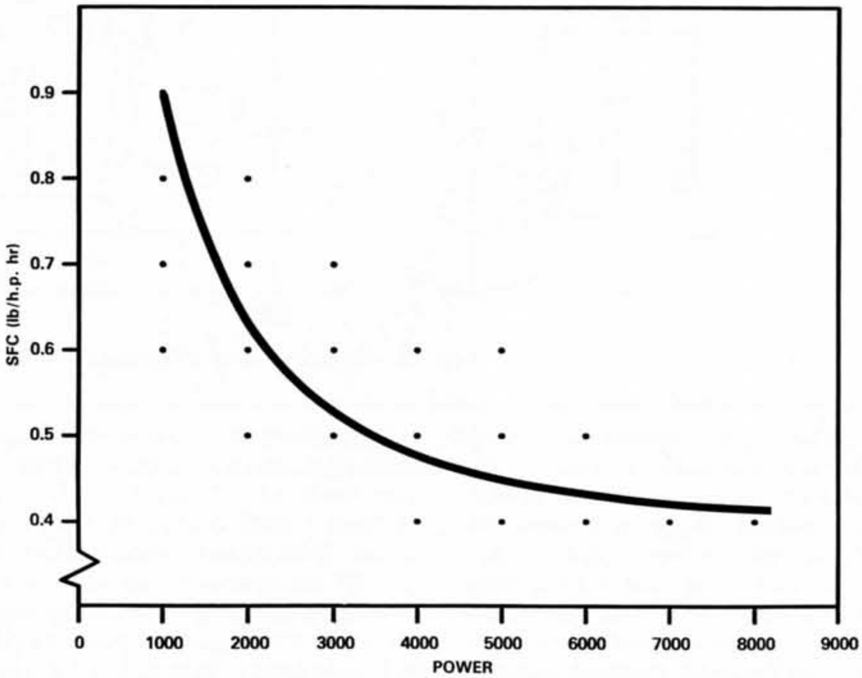

Fig. 4. Allison 571K SFC Curve

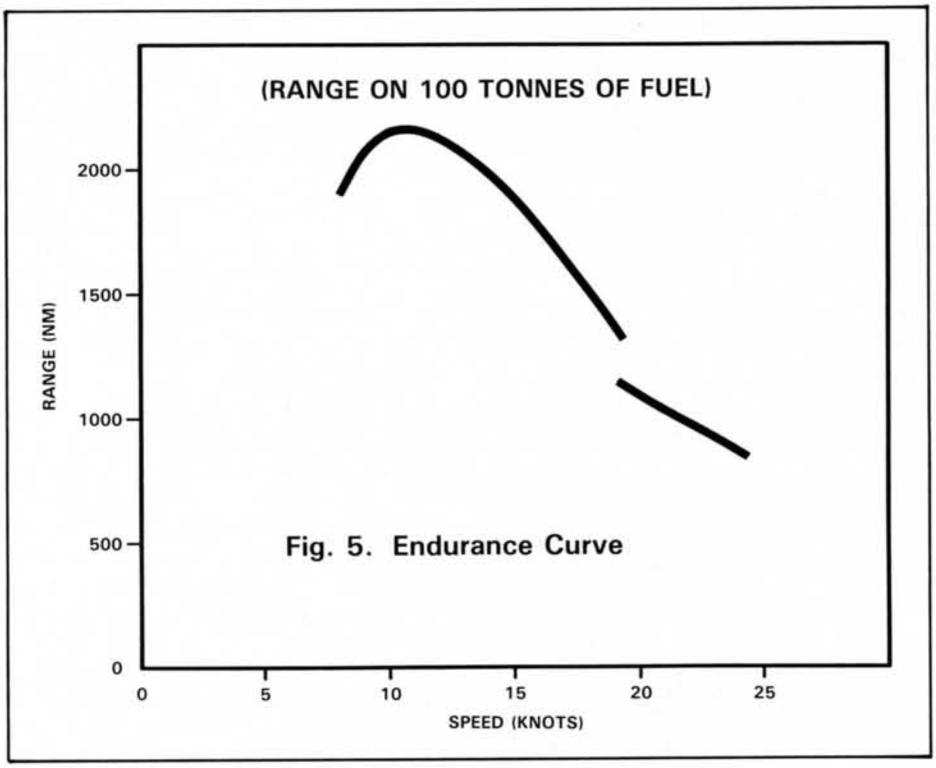

Fig. 5. Endurance Curve

The weight of seatings and piping has not been estimated for the strip-out and none will be made for the new installation. *Table 2* lists the major equipment to be installed, with weight estimate. The weights are comparable.

Propeller

A propeller designed to put less power into the water in the same stern area as before can be designed for quieter operation at an efficiency improvement. A lower power propeller can have a smaller tip-to-hull clearance than one of higher power without a noise penalty. This in turn allows a larger propeller disc area and reduced specific loading with an improved propeller efficiency. Another element in this is the shaft rpm. Propellers designed with noise in mind tend to rotate at lower shaft speeds at equivalent powers and ship's speeds compared with a propeller designed to get the most speed out of the ship. With the new power level, at equal maximum torque on the shafting, the ratio of new to old rpm equals the ratio of new to old power, giving approximately 120 rpm as the new maximum shaft rpm. The 150 maximum shaft rpm called up earlier provides a torque margin while using a motor with a similar number of poles to that used by the Type 1200 icebreaker. Again, a full design approach would look at trade-offs between numbers of motor poles and the cycloconverter output frequency to give a low maximum shaft rpm considering noise, efficiency and torque transients.

Economy

The economy associated with using the propulsion prime mover to provide ship's service electrical power has already been demonstrated. The rationale for the use of a variable frequency propulsion alternator is to operate the gas turbine at the turbine rpm requiring the least fuel for the power output required. Again this is important at low power. Using 2000 h.p. as before, the difference between operating at constant power turbine rpm (constant frequency) and at least-fuel rpm is approximately 30 lb/hr in 1250; almost 2 1/2 percent.

Endurance

Figure 5 is the endurance curve expressed as miles steamed per 100 long tons of fuel, including a ship's service electrical load of 450 kW and full fuel (360 lb/hr) for one auxiliary boiler. This curve takes into account an increased propeller efficiency over the *Annapolis* class present propeller, and uses the effective power-versus-speed curve based on the class as determined by a concept exploration computer model. The conversion efficiency of the electrical plant was varied from 90 percent at low power to 93 percent at high power.

A direct comparison of this endurance curve with that for the *Annapolis* class with Y-100 steam machinery is not possible here. Despite this it is possible to say that at economical speed, at 19 knots with two 571K gas turbines driving, and at maximum speed on just gas turbines, the range of the electrically propelled ship is more than one and a half times that of the steamship.

Conclusion

A gas turbine/electrical propulsion retrofit into the *Annapolis* class would produce a more capable CANTASS platform by virtue of both economy and noise. Economy improves the platform by extending its time on task. Noise reduction improves the platform by increasing the sensor capability. The gas turbines used in this paper have significant commonality with the Allison 570K gas turbines being fitted into the TRUMPed DDH-280 class, with benefits in support and training. Having chosen this gas turbine there is a penalty in maximum speed available. Maximum speed should be slightly less important in the *Annapolis* class as CANTASS platforms than in their original design role. The electrical plant used in this retrofit is available now from Canadian manufacturers.

As stated at the opening, this is a "pie-in-the-sky" retrofit; however, it would serve as a very useful demonstration platform for electrical propulsion while providing an operational capability improvement at the expense of maximum speed.

Acknowledgment

Without the assistance of Mr. Phil Malone of Allison Gas Turbines and LCdr A. Smith of DMEM 2, the comparisons determined for presentation in this paper would have been merely estimates.

L.T. Taylor is a civilian engineer with the Naval Engineering Unit (Atlantic). He retired from the navy in 1983, following a 22-year career.

Expert Systems and their Application in Marine Engineering

By Dr. Pierre Roberge and
LCdr Serge Lamirande

Abstract

With the introduction of the CPF and the upcoming development projects such as the new submarine program, we can expect that the training of marine engineering technicians to a level of technology never attained before will become a critical factor of these programs. Looking at past figures, of the 333 sailors recruited for the Mar Eng trade in 1978, only 26 achieved Certificate Level 2 by 1985. We would suggest that these figures will not improve as the complexity of the training increases in the future. Thus, the development of Expert Systems could have significant benefits for the marine engineer by making important engineering data readily available at sea and ashore.

Introduction

The aim of this paper is to introduce a subfield of Artificial Intelligence called Expert Systems, demonstrate what they can do, and finally display the advantages they could provide to the navy.

What is an Expert System?

An Expert System is a computer system comprising both hardware and software that encodes human expertise. An Expert System contains human knowledge, from a specific and limited field (called the domain of the system), stored in a computer in such a way that even someone who is not an expert can access and apply the knowledge.

What makes Expert Systems unique is the way they approach and solve problems. Expert Systems not only function with conventional mathematical and Boolean operators, but also incorporate typical human reasoning processes such as rules of thumb and shortcuts used by experts in solving problems.[1] Expert Systems can also handle vast amounts of information, from one or several experts in a particular field (which could represent dozens of years of corporate knowledge), in order to solve a specific problem.

How does an Expert System work?

There are two kinds of information a person needs to solve a particular problem — knowledge or expertise in the domain of the problem, and knowledge of the specifics of the problem, which can be called data.[2] The Expert System works by applying expertise to data. The data are supplied by the user, while the expertise (contributed beforehand by any number of human experts) is supplied by the encoded domain of the system.

Conventional programming vs Expert System languages

In conventional programming, knowledge about a problem and procedures for manipulating that knowledge to solve the problem are mixed together. A non-programmer looking at the code would not understand its application. This means that the human expert must depend on a programmer to express that knowledge correctly.

Artificial Intelligence researchers have developed a number of techniques to separate the knowledge in a program from the procedures to manipulate that knowledge. In effect, any expert can examine the knowledge in an Expert System and determine if the knowledge is correct. Moreover when knowledge about the problem changes, the expert can point out the exact rules or assumptions that need to be changed. Separation of knowledge from inference and control is probably the most important concept to come out of Artificial Intelligence (AI) research.[3] *This powerful property allows nonprogramming managers and technical professionals to develop their own Expert Systems.* (The programming language can be in plain English.)

Another basic difference between conventional programming and intelligent software such as an Expert System is that AI focuses on verbal and graphic aspects of knowledge (*Figure 1*) rather than on its mathematical aspects. For example, multiple images can be displayed on the screen simultaneously to visually represent clusters of output instrumentation. The user selects the temperature on the gauges as he sees it on the machinery (*Fig. 1a*) and the Expert System "fires" the appropriate rule. Systems could also be displayed to help the user comprehend the situation (*Fig. 1b*). In addition, Expert Systems rely on rules of thumb (heuristics knowledge) rather than on mathematical certainty; therefore, it becomes possible for managers to look for solutions to problems even with incomplete information.[4]

What can Expert Systems do?

An exemplary industrial application

A major food-packing company (Campbell Soup), with help from a computer company (Texas Instruments), built an Expert System to help run its soup-canning cookers. The cookers (multi-storey, building-sized installations), handle tens of thousands of cans of product at a time, and as with many complex processes there are many interacting factors to be monitored and controlled. When things go awry there is a great loss in production combined with a lot of waste and clean-up.

As these processing installations evolved over several decades, the company came to depend heavily on a single veteran employee who was expert at diagnosing the subtle causes of problems and determining corrective action before they became crises. As he was approaching retirement, his supervisors realized that his absence could create a lot of trouble. The solution was to transfer his expertise into an Expert System. The computer company developed the knowledge engineering and inference engine (software programmation) by working with the human expert for many months, modifying their system, and reconsulting whenever unsatisfactory results were encountered.[2]

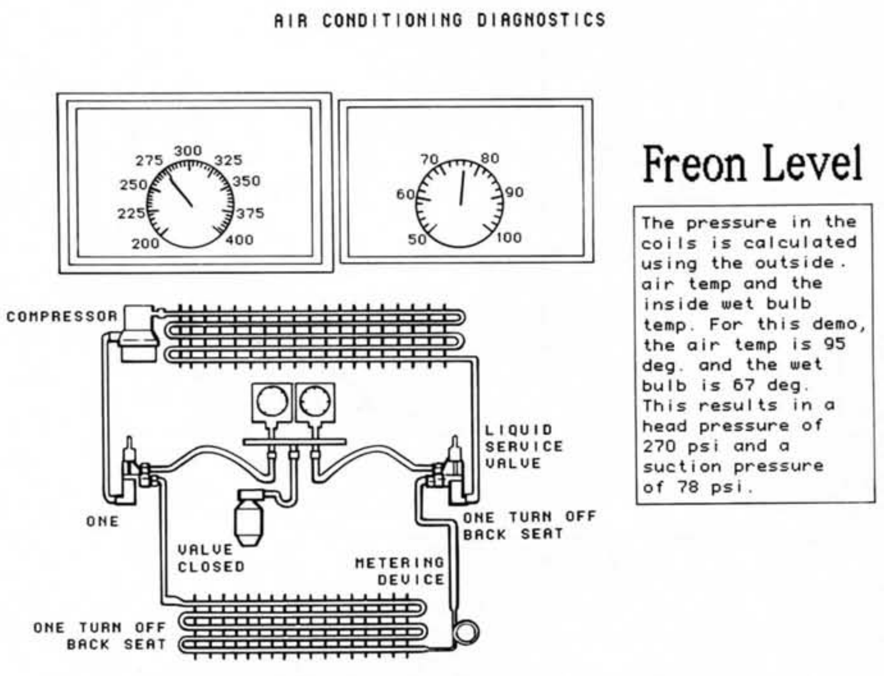

Figure 1A

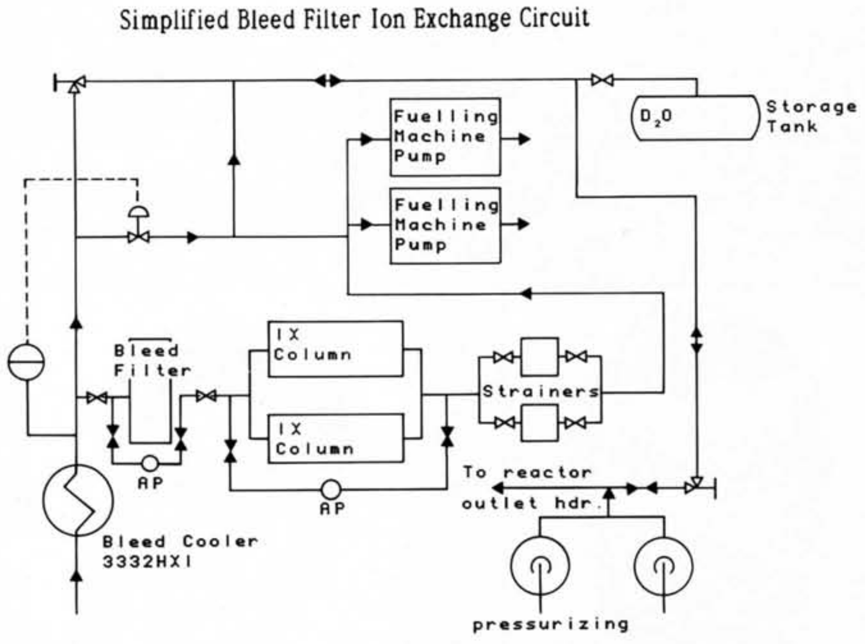

Figure 1B

Figure 1. Knowledge can be graphically represented using "interactive images". Fig. 1a shows gauges for a compressor on an air-conditioning system, and Fig. 1b shows how a system (bleed filter ion-exchange circuit) can be displayed.

The major benefits of this Expert System were:

a. The expertise was distributed across all plants simultaneously, providing quicker malfunction diagnosis.

b. The expertise would be retained as corporate knowledge, even after the local expert retired.

c. Campbell Soup paid for this development in less than six months, just from savings in down-time alone.

d. Their Expert System could also be used as a training tool for less knowledgeable maintenance personnel.

Expert Systems in marine engineering

At sea: It is not difficult to think of situations for which analogous skills captured from key civilian and military experts would be valuable to the marine engineer. Being able to clone the abilities of the best technicians of different engineering systems, and transferring that knowledge aboard every ship carrying these systems, would be like going to sea with a group of engineering experts (*Figure* 2). If there were a modification to the system, or if new problems arose, the Expert System could be improved, revised and then redistributed to the concerned ships from a central controlling agency. Practical examples of where specific Expert Systems could be used at sea are as follows:

- Vibration analysis
- Lube-oil analysis (SOAP)
- Diesel health monitoring
- Gas turbine health monitoring
- Health monitoring of ancillary systems (fridges, air conditioning, beartrap, etc)
- Ship's stability
- Damage control

These systems could not only provide a quicker way to solve a problem, but would also improve the safe and efficient operation of the machinery, thus improving the ship's readiness.

Ashore: How often has the efficiency of a unit been disrupted by the transfer or retirement of civilian and military experts? Expert Systems would provide the corporate memory to the affected unit in the particular field of interest. Practical examples of Expert Systems which could be used ashore are:

- Coating selection
- Hull inspection
- Maintenance history
- System specification
- Refit scheduling

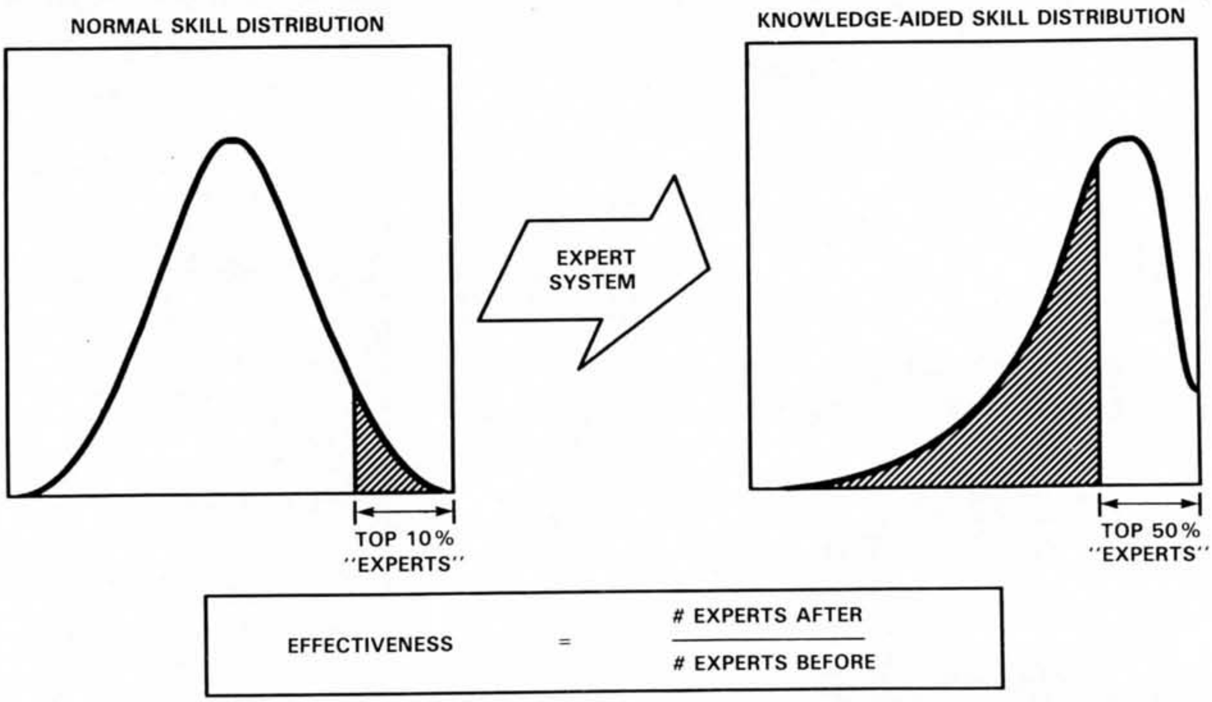

Figure 2. Through the application of Expert System technology, the performance distribution of a population can be improved for certain problem domains.

Why are Expert Systems suddenly so attractive?

The recent industrial interest and growth usage of Expert Systems are due to the combined development of powerful personal-computer technologies (improvement in speed, memory capacity), and of transparent Expert System shells. Fifteen years ago no such thing as an Expert System existed. Ten years ago, developing a decent Expert System would have cost approximately half a million dollars. Today, some excellent Expert System shells are available for less than $500.[2]

Conclusion

Expert Systems are here to stay. Since 1986 there has been a push in industry to develop and integrate Expert Systems because of the immediate benefits they can provide. Moreover, as the technology is mature enough and the navy possesses the technical expertise on specific systems, now would seem to be an opportune time to introduce this engineering tool in the navy. The development of Expert Systems could drastically reduce the size of an engineering department, thus reducing the hotel requirement on board warships and submarines. It could also change our training effort since the training budget and number of training personnel could be reduced in proportion to manning.

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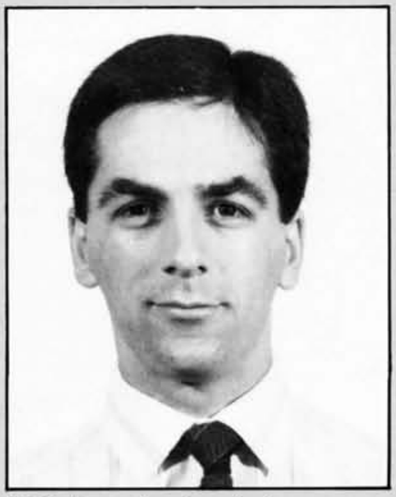

LCdr Serge Lamirande is a postgraduate student at RMC. He is currently involved in developing an Expert System in collaboration with Ontario Hydro on the heavy water chemistry of a CANDU nuclear reactor.

Naval Officers as Programmers *A Wasted Resource*

By Cdr Roger Cyr

Introduction

Ever since the Tribal-class destroyers were commissioned in the 1970s, naval officers have been employed as programmers maintaining the tactical software for the command and control system of these ships. These officers virtually opted out of the normal career stream to be employed in software, even though this choice severely limited their career advancement and employment opportunities. They took a short basic programming course and were then employed as tactical programmers. As a consequence, the software maintenance effort has been relegated to officers who, even though they have been designated software subspecialists, lack the requisite engineering skills or tactical experience to adequately produce or manage software.

With the introduction of the Canadian patrol frigate and the Tribal Class Update and Modernization Project the navy will face a major increase in the amount of software that must be maintained. The sheer volume of this software inventory dictates that a significant amount of the navy's limited personnel resources will have to be dedicated to maintaining software. And, given the labour-intensive nature of software production, relegating this task to officers may not be cost-effective.

Programming — A Technical Skill

The employment of naval officers in software stems from the perception held by many that software is at worst black magic and at best an art-form which requires specially developed high priests possessing specialized talents which must be preserved at all costs. In fact, software development has remained very much in an archaic state and has not kept pace with the immense technological advances which have burgeoned in the computer industry.

Software along with hardware is but a component of a global system, and the maintenance process for any system requires management, engineering and technical skills and disciplines. There are four basic tasks normally associated with software production and maintenance, and they require different types of skills. The basic tasks are:

Requirements Analysis — the process of validating the requirement for the function to be performed by the software. It entails the generation and application of software requirement specifications and produces a structured system-functional specification. This task is considered to be a user function which should be performed by someone experienced in the subject matter. In the case of shipboard software the subject matter is tactics.

Software Design — the process by which validated software requirement specifications are converted to a design specification. This is an engineering process which entails employing design methodologies to produce developed system structures. This task requires engineering skills and should be performed by a combat systems engineer.

Coding — the production function in software development where the design is converted to code by the use of a programming language. This task requires technical skills and should be performed by a technician who is skilled in the applicable programming language.

Testing — the process of validating the written program against the requirement. This task is also a user function which should be performed by someone with knowledge of the subject of tactics; namely, a combat control officer.

Software is analogous to hardware in the varying levels and areas of expertise which are required to effect maintenance of the total product, and both processes should be parallelled. The Fleet Software Support Centre is to software what the Fleet Maintenance Group is to hardware, and in both organizations engineering functions should be carried out by engineers; production functions by technicians and technologists. Having combat or engineering officers performing basic programming functions at the FSSC would be analogous to having combat system engineering officers at the FMG repairing electronic printed-circuit boards. Undoubtedly many CSEs would enjoy working with a soldering iron, fixing PCBs, but such employment would not optimize the navy's manpower resources. CCOs and CSEs as the tactical users and system engineers of combat systems should be involved with the requirements and design aspects of software maintenance, whereas software production (as it is for hardware production) should be the purview of technicians.

Employing officers as programmers is often justified on the basis that in order to be able to design or manage software there is a need to first be a programmer. Such a requirement would be analogous to requiring hardware engineers to first be hardware technicians. Since programming is not an engineering function, but a technical skill, it should be performed by a technician; a non-commissioned member (NCM), as is the case for hardware. A naval tactical programmer NCM trade should be created, with entry at the petty officer second-class level from either the naval operator and naval technician trades, or from outside the navy through a lateral entry program. The entrant programmer would undertake a programmer analyst course and a year of on-the-job training before being classified as a naval tactical programmer.

Canada appears to be the only NATO country employing naval combat officers as programmers. In other navies combat officers are involved in the software maintenance process as expert users, defining and validating the requirements of the combat systems. It is a more cost-effective approach to software maintenance as the actual design and production phases are contracted out.

Conclusion

Even though there has been a colossal increase in the use of software by combat systems, there has been little or no change in our approach to software development and maintenance. In a sense, software maintenance is still very much treated as a cottage industry in which we have been employing a handful of MARS officers in a rather haphazard fashion. If indeed we are to conquer the software crisis which plagues combat systems today, we must approach software maintenance in the same way we do hardware maintenance and devote our limited personnel resources to this effort in a logical and labour-effective manner.

Commander Cyr is the DMCS 8 section head for naval computer technology at NDHQ.

Naval Reserve Maritime Engineers
They're back!

By Cdr J.R. Pirquet

The MARE(R) component of the naval reserve is back. There is an establishment of 70 reserve MAREs, and already the first UNTD entry of eleven men and two women has graduated from the first summer's training in 1988.

The aim of this article is to make you, the MARE community, aware of this new breed in your midst, touch on the rationale behind its reintroduction and, yes, do a bit of a sell-job so that when the majority of the first class start their OJT in the summer of 1989 they will be greeted with recognition and some degree of enthusiasm.

Why, though, you might ask, when we have large numbers of regular force MARE trainees filling up our schools and ships is the navy introducing a new breed of maritime engineer who, on the surface at least, will not be nearly as qualified? The answer lies in recognizing that even if the navy were to fill *all* its peacetime establishment billets (and there is still a way to go) the advent of an emergency would require going beyond the regular force for enough engineers to support the operational fleet. The time needed to train these inductees to function usefully must be kept to the absolute minimum, so it is logical that most, if not all of them, should have some background in marine engineering systems and procedures.

While, ideally, any shortfall would be filled by ex-regular force engineers of the supplementary reserve, there are simply not enough out there to fill the bill that has already been identified. The situation, therefore, is that there would still be a shortfall at a critical time and it is this shortfall that the MARE(R) occupation is designed to fill. As closely as can be established at the moment, this amounts to about 70 engineers in various disciplines. In addition to filling war-establishment billets in an emergency, the MARE(R) will provide technical leadership for the reserves in peacetime.

The 1987 White Paper recognized the need for an effective reserve component of Canada's "total force" and MARCOM responded to direction to revitalize the naval reserve by instituting the Naval Reserve Policy Steering Committee (NRPSC).

Commodore Lawder, who as COS MAT was a member of the NRPSC, recognized the need to revive the MARE(R). To gauge the profession's opinion, he circulated a straw-man proposal on how to "make it so." He received very positive feedback to his proposals and in September 1987 the NRPSC authorized COND to proceed with recruitment and training of University Naval Training Division (UNTD) entry MAREs starting in the summer of 1988.

In the decision to go ahead it was recognized that the MARE(R) could not be trained as extensively as a regular force colleague and some specialization would be required. Since the requirement was mainly in the area of technical support, specialization was also in that field and MARE(R) training performance objectives clearly reflect this. The principal difference between MARE and MARE(R) is that the latter will not be trained in operational aspects and the area of naval technical expertise will be narrower. The individual UNTD MARE(R), from the total force perspective, is therefore a specialist in some aspect of marine engineering support. The list of the principal sub-occupations open to the reserve MARE (*Fig. 1*) illustrates the scope of specialization.

While entry to the MARE(R) through a direct-entry officer (DEO), post-university scheme will be permitted in particular cases, the primary route will be the university entry scheme (UNTD) as this allows for the maximum, reasonably assured, naval training time. A minimum of three, fourteen-week work periods while in a recognized engineering program of studies is required to remain in the MARE(R) program. Two types of university/college student are eligible for UNTD entry:

a. those on a four-year regular program, with a fourteen-week holiday each summer; and

b. those on a six-year co-op program where, after the first summer, academic periods alternate with work (training) periods.

While these two-programs-in-one, so to speak, may appear to complicate the training task, they in fact improve matters as they allow a steadier and numerically smaller flow of on-the-job trainees through the technical support units (TSUs) after basic training the first summer. This can be seen at *Figure 2*. The co-op students also have two extra work terms in which to continue with naval reserve training if they so wish, but as universities usually like them to gain work experience with at least one

MARE(R) Occupational Structure-UNTD entry

	F	Technical Support
	G	Systems Overseer
	H	Systems Design
	J	Control Systems
MS R44 -	K	Electrical Systems
	M	Support Systems
	N	Propulsion Systems
	P	Fluid Systems
	Q	Mechanical Systems
	R	Acoustics
CS R44 -	S	Engineer – Software
	T	Electronics Control
	V	Weapons Mechanical
NC R44 -	D	Naval Construction
NA R44 -	E	Naval Architecture

Figure 1

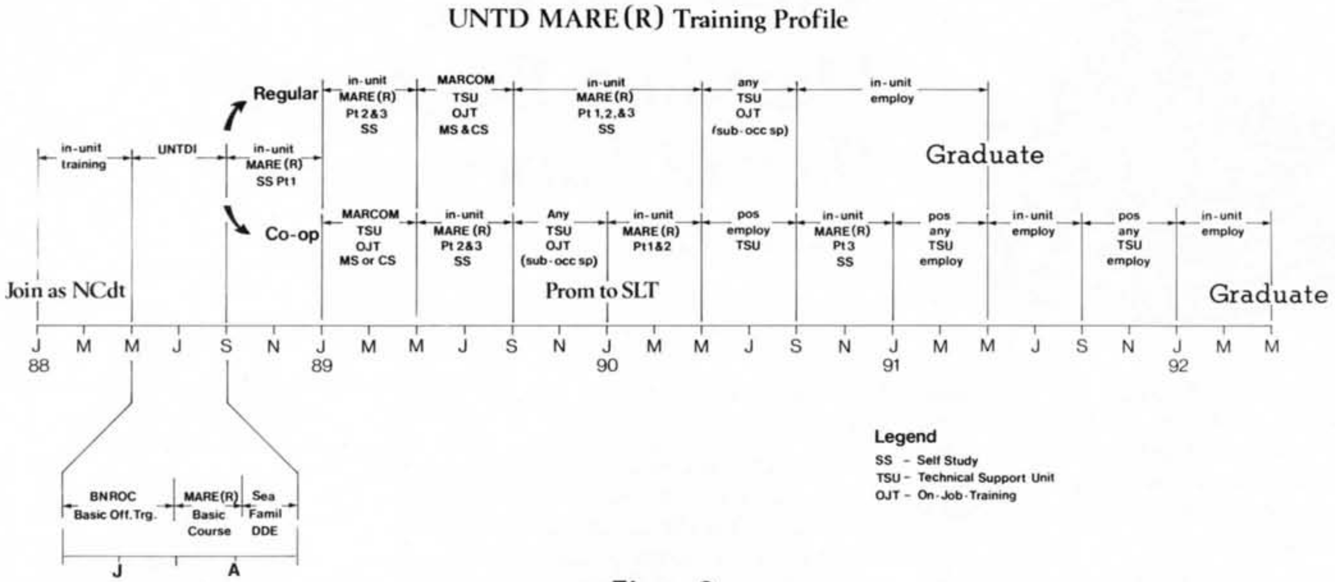
UNTD MARE(R) Training Profile
Regular
in-unit MARE(R) Pt 2&3 SS
MARCOM TSU OJT MS & CS
in-unit MARE(R) Pt 1,2,&3 SS
any TSU OJT (sub-occ sp)
in-unit employ
Graduate
in-unit training
UNTDI
in-unit MARE(R) SS Pt1
Co-op
MARCOM TSU OJT MS or CS
in-unit MARE(R) Pt 2&3 SS
Any TSU OJT (sub-occ sp)
in-unit MARE(R) Pt1&2
pos employ TSU
in-unit MARE(R) Pt3 SS
pos any TSU employ
in-unit employ
pos any TSU employ
in-unit employ
Join as NCdt
Prom to SLT
Graduate
J M M J S N J M M J S N J M M J S N J M M J S N J M M
88 89 90 91 92
BNROC Basic Off. Trg.
MARE(R) Basic Course
Sea Famil DDE
J
A
Legend
SS - Self Study
TSU - Technical Support Unit
OJT - On-Job-Training

Figure 2


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other employer it is unlikely that an individual will do more than three or perhaps four work terms with the navy.

On being recruited toward the end of the first semester in university, the individual MARE(R) attends a naval reserve unit on weekly parade nights and so is introduced to the navy. In late May each year the MARE(R) hopefuls join their MARS and LOG counterparts at the Basic Naval Reserve Officers' Course (BNROC) at Albert Head. This nine-week course is run along the lines of regular force officer basic training in Chilliwack, with a somewhat more nautical flavour. Following graduation from BNROC, naval reserve engineers complete a three-week course at NOTC giving them a general introduction to naval engineering systems and administration. To round out their first exposure to the world of naval engineering, they go to sea on a destroyer for two weeks' familiarization.

The trainee's next two fourteen-week training periods are spent on the job with technical support units. There they complete performance objectives that gradually build up their knowledge and skill to the point where they will be useful junior members of a unit on graduation from university/college.

As *Figure 1* shows, there is a considerable degree of sub-occupational specialization permitted in the MARE(R). The training reflects this in the second OJT phase where the individuals are sent to the TSU of their specialty selection. Ideally, they will return to this unit for all subsequent periods of continuous naval duty during their careers as reservists. At some point, usually following graduation, the trainees will sit an oral board and perhaps write an examination for sub-occupation qualification (R44F, G, etc), after which formal training will be completed. It is expected that the qualified MARE(R)s will remain active with the naval reserve, returning to "their" technical support units for the mandatory periods of continuous naval duty. This amounts to a minimum of two weeks every three years.

In my efforts to find OJT training billets for MARE(R) training, I have often been asked "What can they really do for me?" by hard-pressed, understaffed commanding officers. My answer is that they should not be an administrative burden. I am convinced that as long as MARE(R)s are given the minimum amount of guidance they will work hard, and even though their time on continuous naval duty may be limited they will make significant contributions to their units. Certainly from my experience with the "raw material" so far, the individuals are bright and eager to learn. If we don't take advantage of this opportunity we will lose a potentially valuable source of talent, civilian engineers, which in the past we have been reluctant to exploit to the full.

For those interested in statistics, the cost (pay and allowances) to train a MARE(R) to do a useful job is about $25,000 compared to $90,000 for regular force MARE training to 44B. The penalty is that a MARE(R) will be considerably job-constrained without further specialty packages. I believe this is a small price to pay for the rich resource a pool of peacetime MARE(R)s will give the regular force, and the considerable saving in training time they will allow in war or emergency.

By the time you read this all of the first thirteen UNTD MARE(R) trainees will have started their first OJT phase. Please let me know how you found them, where their strengths and weaknesses lie. In this way coursing, self-study documentation and the MARE(R) product can be improved to meet your needs.

Commander Pirquet retired from the regular force in 1987 and has since been responsible for the reintroduction of the maritime engineering element of the naval reserve. His MARE(R) special project office is collocated with NOTC on the West Coast and he can be reached at (604) 380-5811.

MARE

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 may be controversial.
- To present practical maritime engineering articles.
- To present historical perspectives on current programs, situations and events.
- To provide announcements of programs concerning maritime engineering personnel.
- To provide personnel news not covered by official publications.

WRITER'S GUIDE

We are interested in receiving unclassified submissions, in English or French, on subjects that meet any of the stated objectives. Final selection of articles for publication is made by the Journal's editorial committee.

Article submissions must be typed, double spaced, on 8 1/2 × 11" paper and should as a rule not exceed 4,000 words (about 17 pages). The first page must include the author's name, address and telephone number. Photographs or illustrations accompanying the manuscript must have complete captions. We prefer to run author photographs alongside articles, but this is not a must. In any event, a short biographical note on the author should be included with the manuscript.

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

Looking Back
Engineering Incident at Sea — *A Lesson*

Introduction

During an exercise a DDH-205 was ordered to regain station which required a speed of 25 knots for five hours. Four hours later the machinery was performing well so it was decided to attempt a periodic full-power trial. Full power was achieved, then the water level in the starboard boiler began dropping dramatically. The EOOW was informed immediately and emergency procedures were carried out. The ship was stopped and the water level was returned to normal. There were no apparent boiler problems and the ship rejoined the exercise.

Events

Soon after getting under way again the EOOW noticed that the port engine required about 40 psi more steam pressure at the first-stage nozzle than did the starboard engine. With the recent boiler emergency in mind, he investigated and discovered by torsionmeter readings that the port

engine was developing substantially more power than the starboard engine. Although there had been no abnormal noise or vibration, it was suspected that the port shaft was fouled so the ship was stopped and the MSEO and CERA were called to the scene.

Under MSEO's direction, engine revolutions were increased incrementally on both shafts up to 70 rpm. At each indicated shaft speed the port engine required a higher steam pressure and was developing proportionately higher power than the starboard engine. A graph of these results was plotted which suggested full power would be achieved on the port shaft well before the maximum 230 rpm. The trial was then terminated and the ship was restricted to single-shaft operation. Consideration was given to withdrawing from the exercise.

During the trial all bearing temperatures and readings at the wear and expansion indicators were normal. Despite its high readings, the port torsionmeter seemed to be functioning properly since the curve was smooth and followed the same pattern as the starboard side. A fouled stern tube was discounted as there was no unusual noise or vibration in the gland space. The possibility of a fouled turbine rotor on the port main engine was discounted for the same reason. A fish net or other obstruction of the propeller was ruled out after investigation by ship's divers. The mystery persisted.

Undaunted, the MSEO decided to try another approach. Both shafts were brought to 70 rpm as indicated on the tachometers and a strobe light was used to validate these readings. The starboard side checked out but the port shaft was actually rotating at 92 rpm! The problem was a faulty tachometer. The ship was able to rejoin the exercise with no restrictions.

Machinery Damage

Nil. The faulty reading was caused by slippage in the tachometer.

Lesson Learned

Always consider the possibility of an instrumentation error. A minor deficiency can sometimes exhibit the same symptoms as a major malfunction.

This article was taken from a collection of real incident descriptions originally prepared by Cmdre E. Murray in 1979-1980 while he was Engineering Division Commander of Fleet School Halifax. The purpose was to increase awareness in the marine engineering community of past mistakes so that similar mishaps might be avoided in the future. The details were drawn from Maritime Command Headquarters records of Boards of Inquiry and Summary Investigations.

Attention to detail in maritime engineering is as important today as it was ten years ago, so the publication of incident details and the lessons learned should be an ongoing effort. Readers are encouraged to submit more recent accounts of incidents for future issues of this journal.

News Briefs

Cdr Bell retires

After 24 years in the Canadian navy, Commander Don Bell is retiring as the senior refits officer in NDHQ to take up a position with Canadian Commercial Corporation (CCC) in Ottawa. CCC is the Crown corporation which conducts international government-to-government sales for Canada.

An ROTP engineering graduate of CMR and RMC, Cdr Bell was awarded an Athlone Fellowship by the British Board of Trade in 1969 and spent the next two years in the U.K., working first as an engineering research assistant and, in the second year, reading for his masters degree in administrative sciences at The City University, London. He later obtained a masters degree in business administration from St. Mary's University, Halifax.

Among his career appointments Cdr Bell served as engineer officer in HMCS *Margaree*, squadron technical officer for Desron One, MSEO at NEU(A) and production operations officer at SRU(A) where he was awarded the Maritime Commander's Commendation "for support provided to the operational fleet."

In his new employment as a contracts officer with Canadian Commercial Corporation, Don Bell will be responsible for defence sales to the U.S. Navy under the terms of the Canada-U.S. Defence Production Sharing Agreement.

Commodore Ball dies at 56

Commodore Ernest C. Ball, CD (RCN, CF Ret.) passed away in hospital in Toronto on April 3, 1989. He is survived by his wife Joyce, daughters Lynne and Kathryn, and sons Gordon and David.

Commodore Ball served in the RCN, RCNR and Canadian Forces from 1951 until his retirement in 1984. A former naval ordnance officer, his last service appointment was as Director General Maritime Engineering and Maintenance in Ottawa.

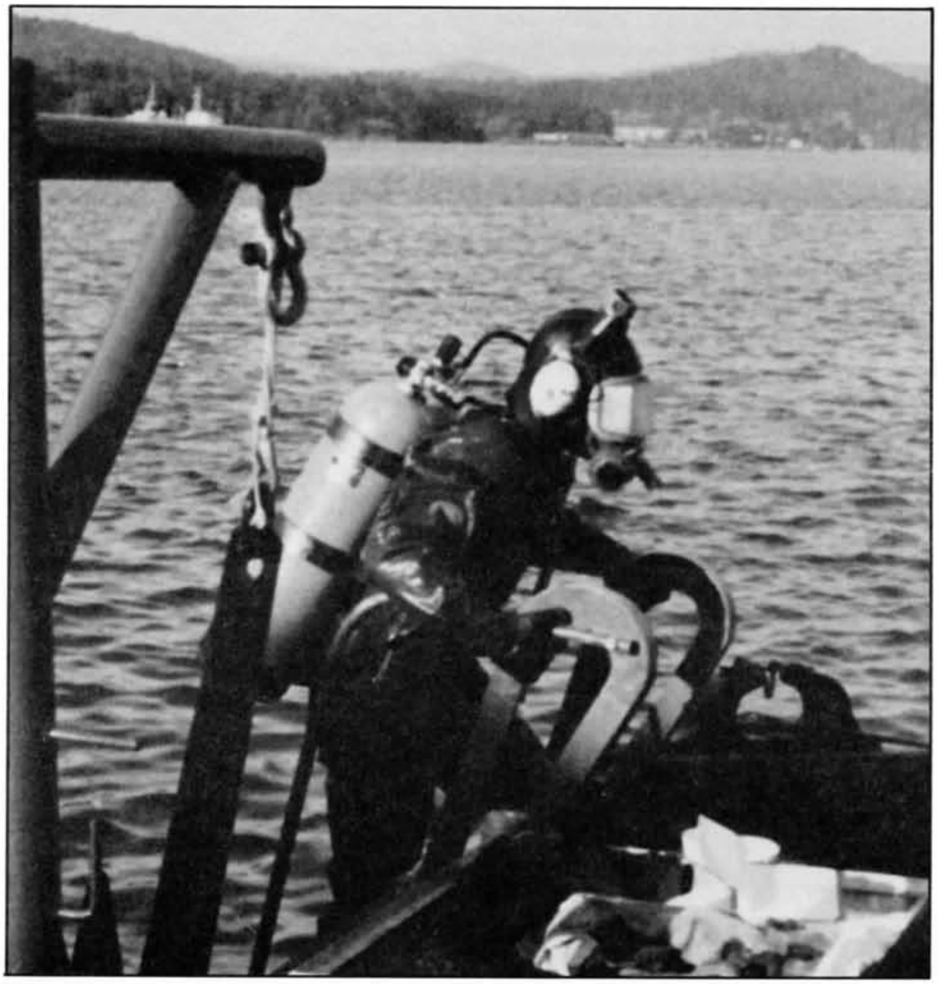
Following his retirement Commodore Ball became Director of Human Resources and Corporate Affairs with Burroughs Canada, then Director of Corporate Affairs and Communications with UNISYS Canada Inc. Two months prior to his death he had transferred to Montreal to take up an appointment as deputy project manager for the CPF project with Paramax Electronics Incorporated.

Funeral services for Commodore Ball were held at the Salvation Army North York Temple on Friday, April 7th.

See also page 3

Hank Baker retires

Henry Baker, one of DND's recognized experts on shipborne electronic equipment, has retired from DMCS 3 after more than 45 years of naval and civilian service. During his career Baker pioneered numerous advances in radio, radar and sonar technology. In the 1950s he invented a radio DF trainer and also developed a new method for measuring radio antenna radiation patterns in ships. In 1965 Baker received a merit award for his work in modifying the AN/SQA-501 VDS handling gear, and in 1986 received international praise for his technical assistance to the Italian navy's VDS program. His last project with DND was overseeing the development of a ring-laser gyroscope which provides a stable element for the SQS-505 variable-depth sonar.



An underwater propeller change for *Huron*

— Coming up in our September issue