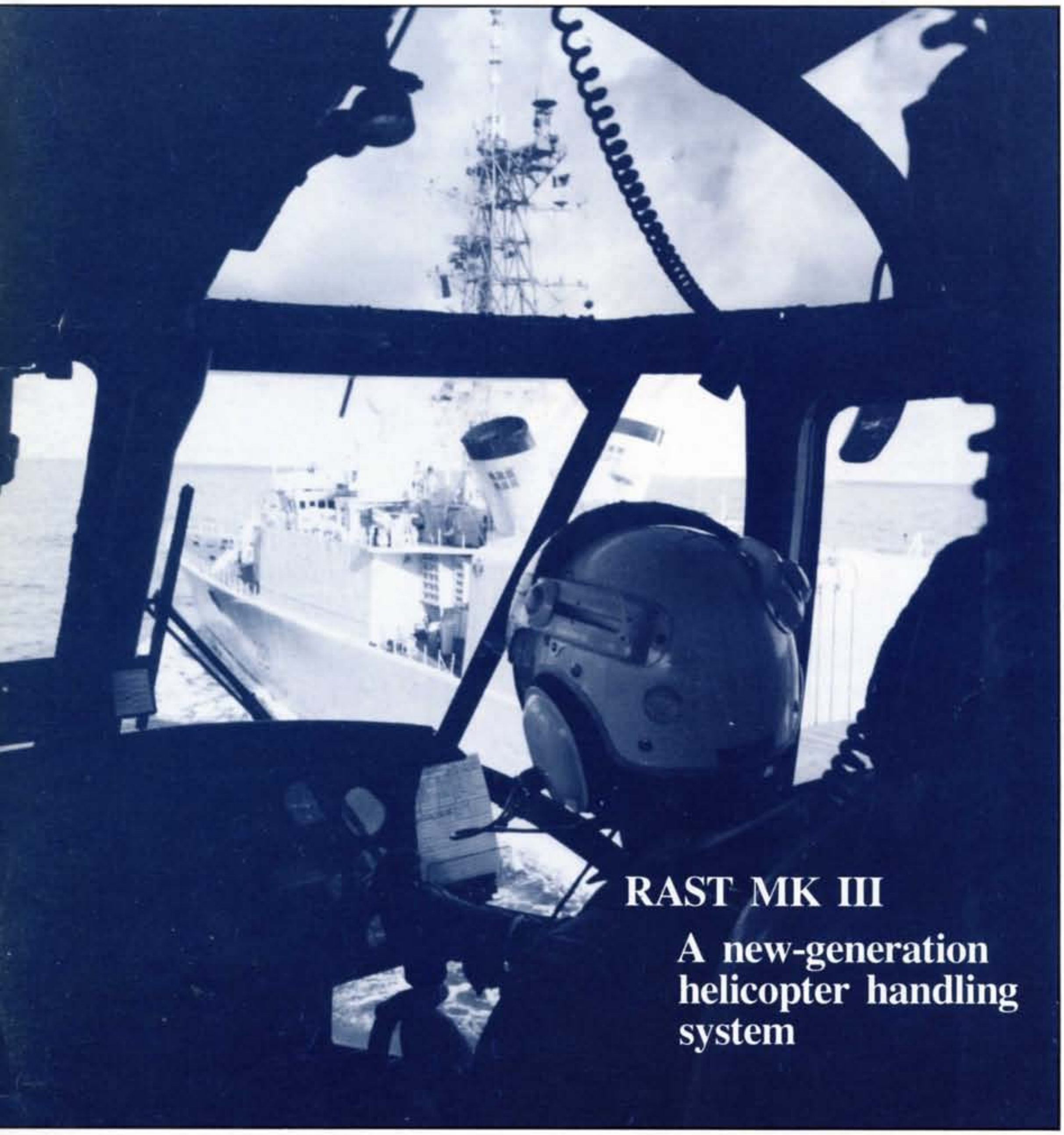
National Defence / Défense nationale

Maritime Engineering Journal

September 1989



RAST MK III

A new-generation helicopter handling system

Canada

Huron propeller change
...page 11

Maritime Engineering Journal

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

OUR COVER

View from the cockpit of a CH-124 Sea King helicopter preparing to land on the flight-deck of HMCS *Huron*. *(Canadian Forces photo by WO Vic Johnson.)*

SEPTEMBER 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

"Feeding the beast"

Our contributors could write the book on it

The question invariably arises: "So, are you getting enough articles?"

We've learned that as often as not the people who ask that question already have an article idea in mind. What they really want to know is whether or not we would be interested in looking at a submission from them. It's called testing the waters.

The short answer is Yes, we've been managing to keep the "hopper" full and Yes, we are always interested in new submissions.

Support for the *Journal* has been wonderful, but our magazine has an alarming propensity for gobbling up editorial material like it was paper. Not only do we have to keep the beast fed, we have to know four or five months ahead of time exactly what we are going to serve it for dinner. Last-minute menu changes are what send editors running to the pharmacy for take-out orders of Milk of Magnesia. And that's when it's nice to have an extra article in hand to replace a late scratch — which has happened more than once.

We publish a brief writer's guide in every issue, but it is worthwhile taking a moment here to explain how a manuscript should be prepared for submission. Following these simple guidelines will make our job easier when it comes time to edit your article and mark it up for typesetting and layout.

Manuscripts should be typed (*double* spaced, please), leaving one-inch margins on all sides. If you are working on a PC with a dot-matrix printer, check the ribbon before printing. A faint page impression makes a manuscript extremely difficult to work with. We realize not everyone types or has access to typing facilities, so — if you are adrift in an open boat somewhere in the South Pacific, and the batteries in the coxswain's laptop have corroded, then by all means consider a "handraulic" submission.

Take a look at the articles in this issue to see how we handle upper and lower case and italics for titles, section headings, references, etc. In your manuscript you should indicate italics (say for a subsection heading) by underlining the heading. It is not necessary to number paragraphs.

As far as length is concerned, our best advice is to practice a degree of word economy. Don't overwrite, but at the same time don't underwrite. Make every word, sentence and paragraph count in getting your message across.

Judging from our conversations with prospective writers, the most baffling aspect of the submission process has to do with photographs and illustrations. Here is what works best for us:

Since we size artwork to fit the space available in a layout, you should not cut and paste photographs or illustrations into your manuscript. We do all of this photographically — nothing actually gets snipped or defaced.

Instead, number each piece of artwork (including tables) and where you refer to them in the text just write the number in brackets and underline like so: (Fig. 2), (Table 6), etc. If you aren't making direct reference to a particular photo or sketch but still want it to appear at a specific place in the text, tell us so in a marginal note. We will do our best to work it that way in the layout.

Be sure each photo, drawing and table is fully identified, including a caption if there is one. If you are supplying a photograph of something that is indistinct or viewed from a confusing angle, give us a break — tell us which way is up. Remember to include the photographer's name and organization for the credit note. With drawings a good rule of thumb is to provide us with the clearest possible copy. Rough sketches are perfectly acceptable as long as they are clearly labelled. They don't have to be Rembrandts.

When it comes time to mail your article in to us, enclose the artwork *loose* with the manuscript (no staples or paper clips) and use a cardboard stiffener to keep the package flat. And that's it. We'll take it from there.

If you have any concerns, or would like to query us about an article idea, give us a call at (819) 997-9355. We will be happy to talk with you.

Remember that the *Journal* welcomes article submissions from anyone interested in writing for our readership. We are always on the lookout for new material and new writers. In the last five issues alone we published articles from more than 20 first-time contributors. Of course, some of your bylines are now appearing for the second or more time (we like to think of you as repeat offenders) and it is always nice to see the interest being maintained.

We have an editorial staff here that is ready and willing to help you get your article into print — so please keep the submissions coming. We will be relying on your continued, excellent support when we move the *Journal* up to quarterly publication starting next July.

Dent Harrison

Letters to the Editor

Dear Sir,

I read the January 1989 *Journal* with interest, especially the article by Cdr Roger Cyr (*Evolution of the Man/Machine Boundary in Combat Systems*). While his point is quite well taken, I feel that an operator's perspective would not be out of place.

Cdr Cyr concludes his article by citing man's reluctance to accept machine-based decision-making processes. I submit that this reluctance is perhaps the single-most important safety check in the evolution and acceptance of today's high-technology automated systems and the intelligent systems of tomorrow.

The criteria for identifying an unknown contact as hostile, for example, require careful consideration of all data and intelligence pertinent to a particular theatre of war. The criteria used in the North Atlantic could be vastly different than those required in the South Atlantic. How do intelligent systems tell friendly Exocet from hostile Exocet? It would be no less than foolhardy to rely on the pre-programming, by one (or several) individuals, of a combat system that overrides the collective years of experience and front-line exposure retained by the at-sea commander and his staff.

Errors caused by perceptual bias are much better known as errors caused by the fog of war. Although not planned for by naval commanders, they are, not unlike a fumble in football, always expected to play some part in battle.

The problems and difficulties facing the future engineers of intelligent systems will not be unlike those faced by today's architects of automated systems. A good example could be automated ESM systems. These systems receive raw RF signals, measure certain parameters and, like the old-fashioned operator, compare these parameters with those stored in a file or threat library. What must be remembered is that the automated system's output is only as good as the sensor accuracy and the heuristic rules coded in the software. Needless to say, the RF signals received by our ESM sensors will not always be a perfect match with the parameters listed in the threat library. What then? The automated system, in this case, selects any number of possible threat emitters that come close to a match. Then depending on how threats are listed, it picks one. That the chosen emitter might not be the one that is being intercepted by the sensor cannot be determined and the operator, trained to trust his equipment, blindly accepts the wrong answer.

The old-fashioned and suspicious operator, using whatever perceptual bias is handy, will not blindly accept something that doesn't "seem right." Is that standing in the way of progress? Or is it fulfilling a critical safety step in the threat evaluation process?

The operator will compare the RF signal parameters received with what he expects to see. And he will do that with the worst case (threat) in mind. Today's automated systems face the same problems that tomorrow's Expert Systems are going to face; what do you do when a situation for which it has not been programmed occurs? A trained naval tactician using his experience and the latest intelligence cannot help but do better than a machine that can supply the right answer only if the correct "ones and zeroes" are present.

The simple truth is that the rules and variables of naval combat are ever-changing and that an automated or intelligent system could never be designed to deal with every situation.

A difficulty that has been faced by navies in recent times is that of operating in a high-tension as opposed to a general war scenario. In a general war scenario the accidental or incidental attack on neutral/non-combatant targets is less likely to happen and less likely to result in increased pressure on the offending nation. In short, warships are designed, and their crews are trained, to cope with the most likely threat. In the case of NATO navies that threat is the Soviet Union. When navies are required to do their business during periods of tension in areas such as the Persian Gulf where neutral air and shipping traffic continues in spite of the dangers, the risk of misidentifying and engaging neutrals/non-combatants remains; regrettable, but unavoidable.

Cdr Cyr makes reference to the USS *Stark* incident in his article. While the tragic lessons learned from the ill-fated frigate should be applied to our understanding of maritime warfare, all aspects and details of the incident must undergo critical analysis to avoid drawing incomplete conclusions. From my own reading of the albeit unofficial and unclassified versions of the incident, the USS *Stark* was unable to counter the Mirage-launched Exocet missile because (a) the SLQ-32 ESM set did not detect the missile seeker head; and (b) the 20 mm close-in weapon system had been switched off as it was unserviceable.

Perhaps some errors in procedure were committed in not bringing the ship to general quarters (action stations) sooner, or by steaming in the third degree of readiness as opposed to the second. The critical, and in this case deadly, shortcomings, however, are more accurately attributed to the failure of certain equipment and not, as suggested by Cdr Cyr, to human error on the part of the tactical operators.

The USS *Stark* was disabled and men were killed because the high-tech sensors and weapons designed to counter such threats failed. Human error may have played a part, but it was not the error of an incorrect perceptual bias by operators. It was more likely the improper design, testing and maintenance of those systems.

The loss of HMS *Sheffield* during the Falklands conflict is similarly misrepresented by Cdr Cyr. *Sheffield* was unable to react to an incoming missile beccause her ESM suite was unable to operate simultaneously with her SHF SATCOM transmitter. The question that naturally follows asks, Was this evidence that automated systems should be the sole basis for tactical decisions? or Should more careful engineering take place to ensure that the various elements of integrated combat systems are actually capable of operating in a modern threat environment?

To stand in the way of progress is to become extinct. To prematurely place complete faith in high technology is to become another *Stark* or *Sheffield.*

Cdr Cyr's article makes sense in that it recognizes the need for greater emphasis in research and development in the areas of high-tech combat systems. The part that needs a second look is that which implies the human mind, biased or not, can or should be replaced by a silicon chip.

The way ahead in the design and use of high technology in a naval application requires an evolutionary thought process not only by the operator, but by the engineer as well.

The naval combat systems operator cannot be considered the weak link, intruding upon and thus inhibiting an otherwise foolproof, artificially intelligent system (designed of course by foolproof engineers). The operator must, instead, be considered the central and final controlling point around which automated systems and tactical decision aids are designed.

W.P. Stiff

Lieutenant Commander

CPF Detachment Montreal

(Paramax Electronics Inc.)

Dear Sir,

I was pleased to see that LCdr Stiff took the time to respond to my article.

He makes the point that *today's* systems, for example ESM systems, require an operator's perspective in the evaluation of parameters. Today's systems, because of their limited technology, indeed require human intervention. But what about systems of the future? In the '50s, automatic detection and tracking was inconceivable. Yet, it is reality today.

What can be achieved today with the present technology is a greater level of automation, especially where there is a need to evaluate a large collection of data against an equally large set of parameters. Track management, track correlation and situations where response time is critical are particularly good, applied examples of the benefits of automation.

The article did not mean to imply that all human element should be removed. Far from it. The requirement for a controlling point remains, and any knowledge-based ship would still require a commanding officer to act as the controlling point of the combat system — at least for the next few decades.

Cdr R. Cyr

NDHQ/DMCS 8

Dear Sir,

Crow's Nest Reunion

The Crow's Nest (Officers' Club) in St. John's, Newfoundland was founded on January 27, 1942, and in 1992 will be celebrating its fiftieth year of existence.

The brass plaque commemorating the founding of the club bears the words: *"Here the officers of His Majesty's navies and the navies of our allies engaged in the Battle of the North Atlantic sought and found a secure haven from the perils of the sea; from hence they went forth again to resume the fight."*

To commemorate this golden anniversary, the club is planning a reunion, during the summer of 1992, of naval officers who used the Crow's Nest during the Second World War, as well as all other members and their *"wives and sweethearts."*

In order to determine the scope of this reunion we are looking for expressions of interest from all who might be able to come to St. John's for this three- or four-day planned event.

It is our intention to keep travel costs to an absolute minimum, so we would ask anyone who might be able to attend to disregard travel expenses at this time.

Anyone interested in attending should write to: Crow's Nest Reunion, P.O. Box 5094, Queen's Beach, St. John's, Newfoundland, A1C 1A4.

Yours sincerely,

David H. Winter

Crow's Nest Officers' Club

Reunion Committee

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.

Commodore's Corner

Challenging future in store for maritime engineers

By Commodore W.J. Broughton

In many ways 1989 has turned into a year of change. I really thought the "year of change" would be next year, when the fleet will see the arrival of the first Canadian patrol frigate and the first of the TRUMPED Tribal-class destroyers. But I feel I should personally address this year's events at this time.

Clearly the major event for the Department as a whole has been the impact of the Budget. For us, the cancellation of the SSN project means that we in the maritime engineering discipline of the navy will not be developing nuclear technology with our members to the full. There are bound to be some feelings of disappointment and "loss of future" among us. Even though fruition of the SSN project would have been beyond my time in service, I was personally very much committed to the concept. However, I also believe there remains a very challenging future for the navy and maritime engineering.

Branch members should be aware that those of you who are pursuing nuclear engineering degrees will complete them. The broadening objective of a master's program will allow you to apply your enhanced effectiveness in important work, including keeping abreast of the application of nuclear power to marine propulsion. We will retain ongoing expertise in this discipline as we do in other technologies. Technological currency is an essential element of our overall technical capability.

As I pen these thoughts in early August, we are in the early days of restructuring the Defence Services Program. It is clear, however, that the navy places a high priority on the Canadian Submarine Acquisition Project (CASAP) and is looking to a future fleet of SSKs.

An objective of such a program, in my view, must be the development of full design authority capability within the maritime engineering community. This objective, of course, will affect both officers and non-commissioned members, be they employed at first, second or third level of operations and maintenance. We have much still to learn in all systems areas and in ship-level technology such as noise reduction, structures and dynamic control. And we will have to expand the numbers of our people who have submarine knowledge and experience.

In terms of important new projects for the future, it is opportune to note the recent selection by cabinet of the two contractors for the Project Definition phase of the Naval Reserve Minesweeper Project. Here again, we see a "new" vista in our technical expertise that we must develop. And, of course, we have recently acquired the two minesweeper training auxiliaries, HMC Ships *Anticosti* and *Moresby*.

The loss of the SSN project has been a disappointment. But the future remains full of many challenges that continue to deserve our commitment.

RAST MK III
A New-Generation Helicopter Handling System

By Cdr Ron Johnson

Figure 1. "Flying the wire," necessary with the HHRSD, RAST MK I and CPF RAST systems, will become a thing of the past with the "wireless" RAST MK III. (*DND photo*)

Introduction

In the early 1960s the Royal Canadian Navy had a requirement to conduct ASW operations using relatively large helicopters operating from small ships during virtually any condition of weather and visibility. The navy needed a system which would enable it to safely deploy and recover its main weapon/sensor system, day or night, in conditions up to sea-state five (30 degrees of roll and 9 degrees of pitch) and in relative winds up to 50 knots.

Thus, the Helicopter Hauldown and Rapid Securing Device (HHRSD), or what was more commonly referred to as the beartrap, was specifically developed for the RCN, much to the envy of other navies. The HHRSD immediately became an essential and important part of Canadian warship ASW operations. However, as well as this system has served the navy, it possesses some fundamental shortfalls which can now be addressed through state-of-the-art technology and RAST MK III.

Background

The HHRSD provided a means of mechanically securing the helicopter after landing, and then straightening and traversing it using a minimum of flight-deck personnel. As an interesting aside, the original beartrap was a wireless system, calling for a free-deck landing. It was only during initial trials that the capture area of the trap was considered to be too small and that some form of recovery assistance would be required. The addition of the hauldown cable was not totally welcomed by the pilots, and it was some time before the idea of being "tied to a wire" (*Figure 1*) gained general acceptance.

As the Canadian navy's experience in shipborne helicopter operations grew, so did the evolvement of HHRSD. Through some modification and redesign, HHRSD became the Recovery Assist Securing and Traversing (RAST) system. Indal Technologies Incorporated of Mississauga, Ontario has already produced some 200 shipsets of the RAST MK I version for the USN. RAST MK II, yet another version, was intended for the Royal Australian Navy, but, unfortunately, did not come to fruition. A modified version of RAST MK I, designated CPF RAST, is currently being installed in our new patrol frigates.

Although much-improved versions of HHRSD, the new RAST systems still suffer from certain disadvantages, particularly in the areas of life-cycle costs, weight, space, complexity, reliability, maintainability and manpower requirements. RAST MK III is a major capital development project which will address the disadvantages of the current RAST systems and provide the Canadian navy with its next generation of shipboard helicopter recovery and handling system.

The Genesis

Having worked with the HHRSD and been the developer of the USN RAST MK I and CPF RAST systems, Indal was well aware of the deficieneies asociated with the RAST-type systems. Within the company, a careful analysis of RAST operations led to the conclusion that the recovery assist function was a drawback to the system and that its elimination could result in significant gains without prejudicing the existing operating envelope. In February 1985, Indal captured the interest of DND (DMEE 5) through the submission of an unsolicited proposal for a significantly modified recovery system designated ASIST, an acronym for Aircraft Ship Integrated Secure and Traverse system.

In the interim, weight was becoming a critical concern with both TRUMP and CPF. The decision to procure the European Helicopter Industries EH-101, a new medium-ASW helicopter to replace the in-service Sea Kings, was also causing concern. Because the EH-101 is a much heavier aircraft than the Sea King and incorporates a nose-wheel instead of a tail-wheel, it appeared that extensive modifications to the current in-service HHRSD system might be necessary. Thus, the ASIST proposal became even more attractive and Indal was contracted to produce a concept feasibility study. The subsequent production and in-house testing of a full-scale engineering model (*Figure 2*) further convinced DND of the merits of the concept and a follow-on contract was awarded to Indal for the design, development and evaluation of an advanced development model (ADM). This system, although still referred to as ASIST by Indal, was designated by DND as RAST MK III.

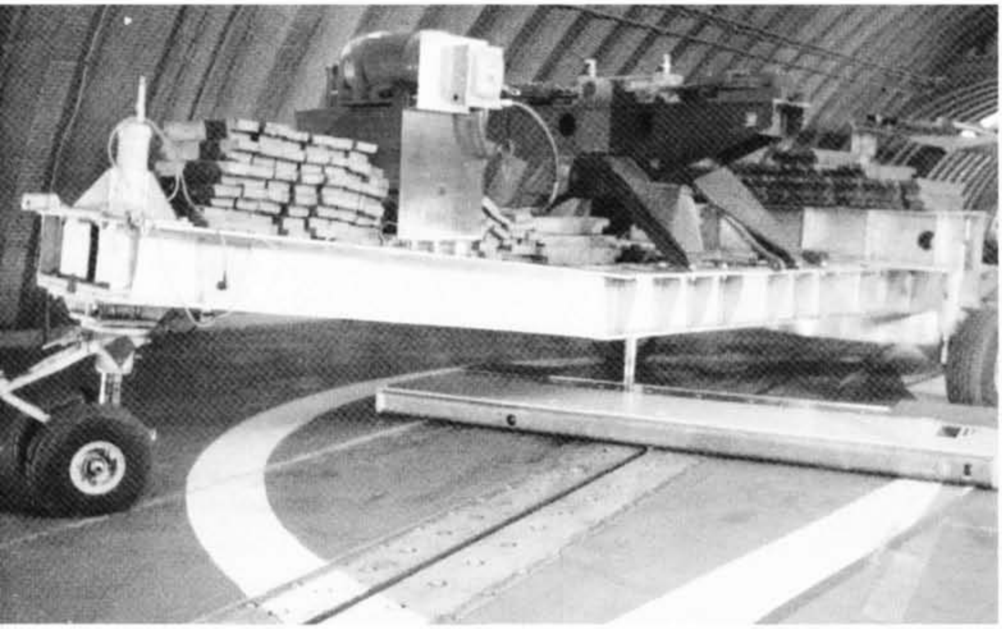


Figure 2. The RAST MK III full-scale engineering model under test at Indal Technologies.

Design Considerations

In developing RAST MK III, the major design considerations centred around the known deficiencies and disadvantages of the current systems. Specifically, RAST MK III had to:

a. provide for an integrated secure-and-traverse system;

b. allow day-and-night helicopter operations in up to sea-state five conditions;

c. eliminate the requirement for the recovery assist cable and yaw restraint system, including tail-guide winches;

d. eliminate the requirement for any personnel to be on deck during hover, landing, recovery or traverse stages;

e. decrease the existing time required for landing, straightening and traversing, thus promoting operational flexibility;

f. eliminate the requirement for below-deck equipment, and decrease system weight and space;

g. reduce system complexity, thereby reducing life-cycle cost and ILS requirements and improving reliability and maintainability;

h. be compatible with all RAST-configured naval helicopters with minimal aircraft-fitted equipment, and be applicable to all sizes of naval ships; and

j. operate with surface- or flush-mounted tracks and be compatible with current track installations.

The Concept

RAST MK III is significantly different from previous systems. To wit, the haul-down cable and tail-guide winches have been eliminated through an integrated system, while improving upon the present operational envelope for flight operations.

RAST MK III (*Figure 3*) is fundamentally composed of three major subsystems: the *Rapid Securing Device* (RSD), which is a much redesigned trap that provides for the securing and manoeuvring of the aircraft; a *variable-speed traverse winch*, which moves the RSD fore and aft along the flight-deck; and a separate *Position Sensing System* (*Figure 3a*) which allows the RSD to automatically track the hovering helicopter and position itself underneath the recovery probe. Also included is a new and improved *Pilot Visual Cues* (PVC) system incorporated in the horizon bar to provide a more accurate indication of aircraft position relative to the flight-deck and recovery zone, and a *Ship Motion Prediction* (SMP) system to assist in determining suitable quiescent periods in ship motion.

Although the recovery procedure has in essence reverted to being a free-deck landing, it is a free-deck landing with a difference!

Six Simple Steps *(Figure 4)*

Step One: The Landing — Having executed a normal approach in accordance with standard procedures, the helicopter hovers in the vicinity of the flight-deck until cleared to land by the Landing Safety Officer (LSO). On being cleared the pilot moves to the high-hover position over the flight-deck where two upward-looking infra-red sensors acquire and track permanently fitted beacon arrays located on each side of the helicopter. The sensors provide an output signal proportional to the displacement of the beacon from the centre of the sensor field of view in the lateral and fore-and-aft axes. This signal is used to control a self-contained, variable speed, electrically driven traverse winch which maintains the position of the RSD within 500 mm (1.5 ft), plus or minus 150 mm (6''), of the computed helo probe touchdown position.

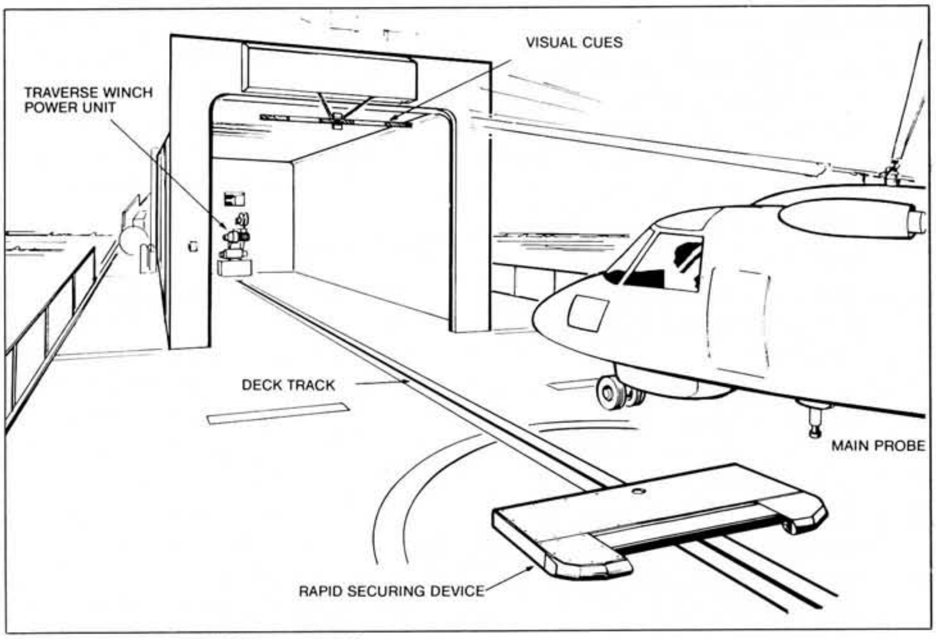


Figure 3. RAST MK III system elements.

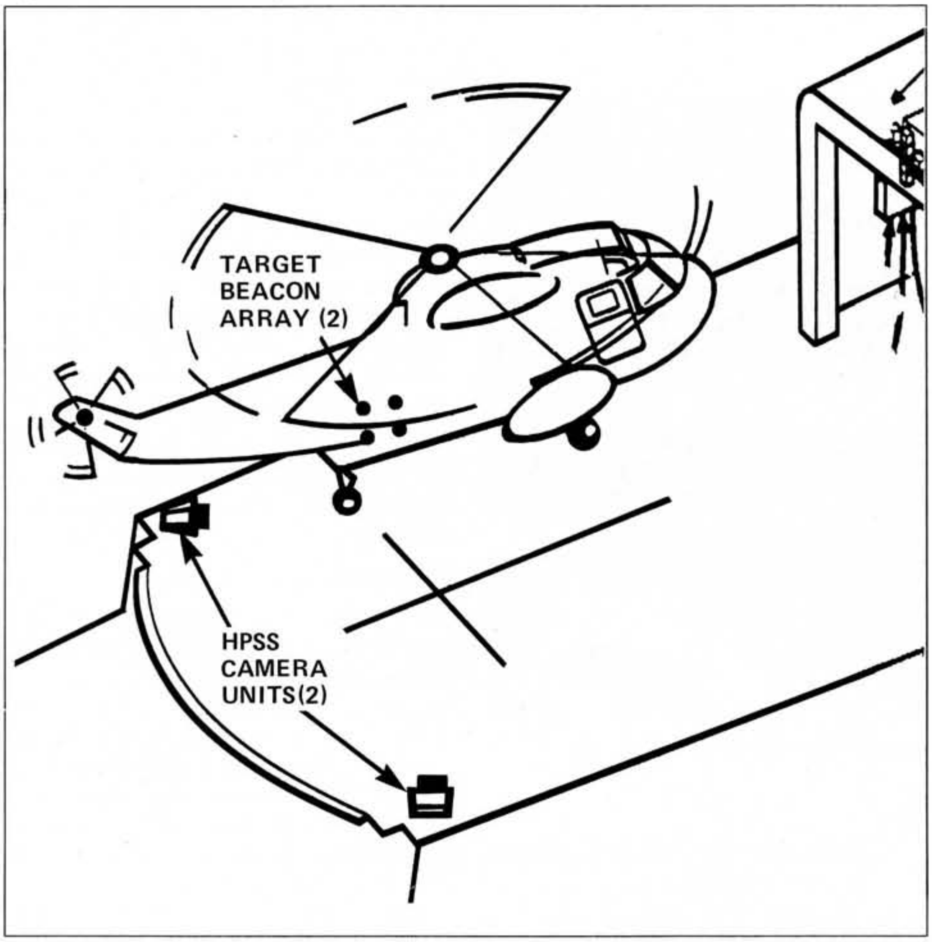


Figure 3a. Helicopter Position Sensing System.

With the elimination of the hauldown cable, significantly larger landing dispersions are now possible. To compensate for this the RSD, which is approximately six feet wide, provides for a much enlarged capture area. While the HHRSD wire-recovery system provided a recovery or designated landing area of 12.6 sq m (15.2 sq ft), the RSD can now track the helo fore and aft, providing an effective capture width of 1.83m (6 ft) centred on the deck-track, and an effective capture length limited only by rotor/hangar clearance and touchdown clearance. This is an effective increase in the overall capture area of well over 400 percent compared to HHRSD.

Step Two: The Capture — The lateral and fore-and-aft signals from the IR sensors also provide the pilot with information regarding the hover position in relation to the safe-recovery zone. When the position is correct and the Ship Motion Prediction system indicates a quiescent period in ship motion, the pilot can drop to the low hover, adjust position if necessary, and then safely land. At the moment of touchdown an electro-optical sensor (incorporated in the front of the RSD) causes the RSD, which has been tracking the helo at speeds of up to 1.5 m/sec (5 ft/sec), to slow down to 0.3 m/sec (1 ft/sec) just prior to its contact with the probe. Upon contact with the probe, the leading edge of the RSD is depressed which in turn stops the RSD.

Step Three: The Secure — When the shock bar or leading edge of the RSD is depressed and the RSD has stopped, the capture claw is immediately driven across the RSD by a hydraulically activated chain drive at 1.83 m/sec (6 ft/sec). Under all conditions when the system is operating in its normal mode, the claw will contact the probe and secure the helicopter firmly to the flight-deck in two seconds or less anywhere within the designated landing area. When the RSD claw sensors indicate capture of the probe, the RSD and mechanical traverse winch-brakes are applied, a capture signal is sent to the controller and the system reverts to standby. Although normally automatic, the RSD claw can be activated manually by the LSO if desired, but once captured by the RSD claw the helicopter is never disconnected until the moment of the next launch.

Step Four: The Castor — Now that the helicopter has been safely secured to the ship, it must be aligned for the traverse into the hangar. (Up to this point in the process no one other than the pilot has been required. The operation of castoring or aligning the helo currently utilizes the Landing Safety Officer, but if desired it would be possible to automate this process as well.) To align the helicopter the LSO, who has a clear and unobstructed view of the process, merely toggles a joystick to apply a lateral force to the aircraft probe by the RSD claw. This will cause either the tail- or nose-wheel to castor.

Step Five: Straightening — Once castored, the LSO can align the helicopter fore and aft by the further application of

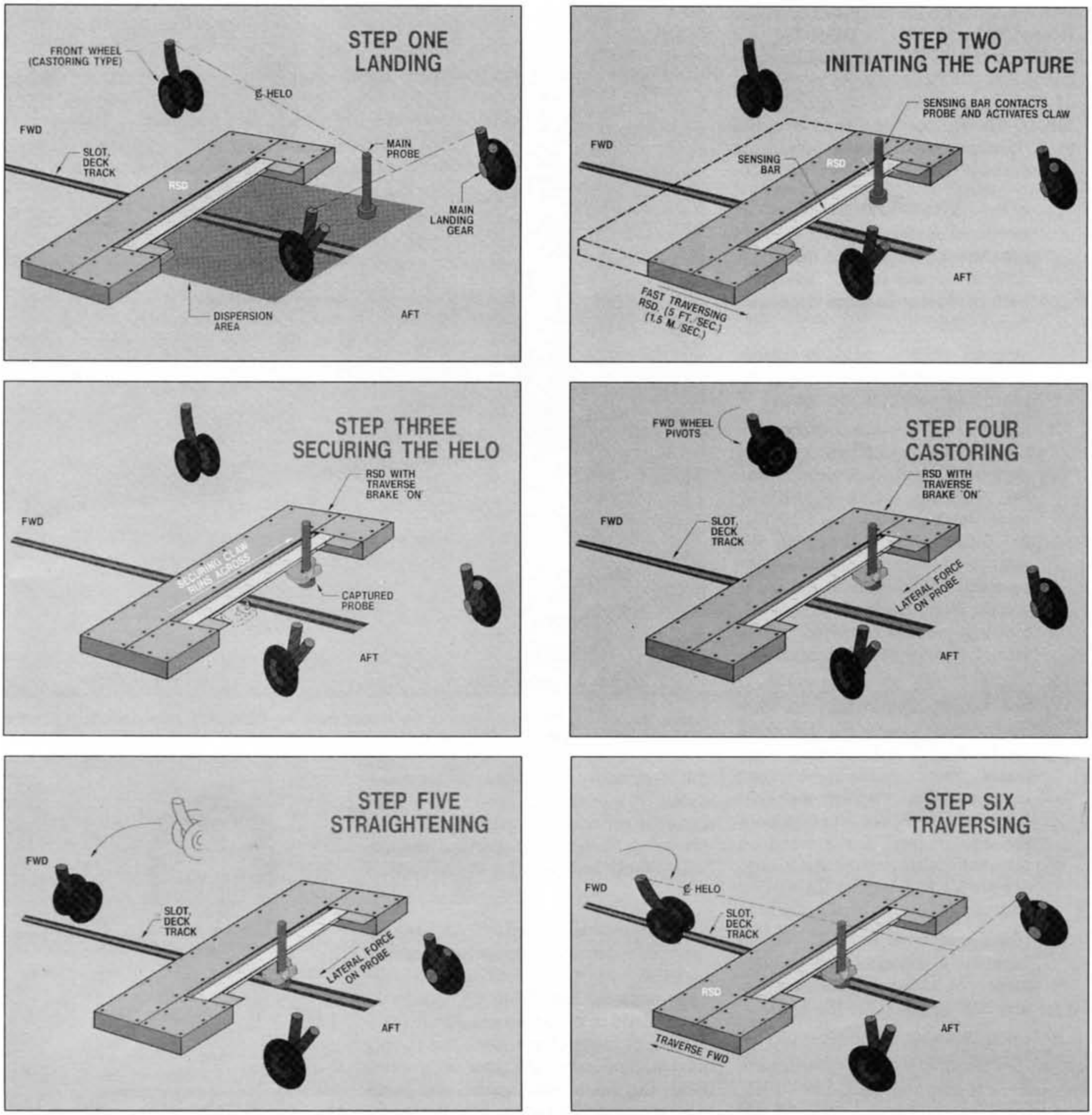


Figure 4. The six simple steps in the RAST MK III system.

lateral force to the probe in the appropriate direction.

Step Six: The Traverse — Having easily and quickly aligned the helicopter, the LSO need only manipulate the same joystick controller to traverse the aircraft to the hangar. Minor corrections to alignment can still be made while traversing and (if fitted) a nose- or tail-probe can be lowered into the deck-track slot.

It is important to re-emphasize the fact that the entire recovery and securing process is accomplished using only two people: the pilot and the LSO; and that there is no requirement for additional tail-guide winches or cables. All operations for launch and recovery are completely automated and pose no risk to flight-deck personnel. Even the requirement for a special procedure to statically ground the aircraft (*Figure 5*) has been eliminated with RAST MK III.

Advantages

To the Canadian navy, RAST MK III offers the greatest potential benefit through the reduction in top-weight. Because of the minimum amount of associated equipment and the elimination of the current requirement for a separate helo hauldown compartment, RAST MK III will offer an overall reduction in weight high up in the ship of up to five tonnes over the HHRSD and CPF RAST systems. With the current effort to reduce top-weight in the TRUMP DDH-280s and with the potential for the thirty-thousand-pound EH-101 to increase to as much as 33,000 pounds during its life span, RAST MK III has obvious benefits as a retrofit to the current systems. Other significant advantages of RAST MK III are:

a. **cost** — RAST MK III offers an estimated savings of up to 60 percent when compared to the initial acquisition and overall life-cycle costs of the current in-service Canadian system;

b. **volume** — the reduction in volume of system components will free up much additional internal space;

c. **safety** — no personnel other than the LSO are required on the flight-deck while the helicopter is hovering, landing, being aligned or traversed. In addition, the Pilot Visual Cues system will provide the pilot with a better indication of position with respect to the deck, and the Ship Motion Prediction system will provide improved indication of periods of deck stability;

d. **speed** — with the aid of the Position Sensing System and the Pilot Visual Cues system the helicopter can be quickly and accurately positioned, thereby reducing the time required in both the high- and low-hover positions. The elimination of the requirement for a hook-up procedure also reduces the recovery time, which implies less time is required on the recovery course;

e. **communications** — RAST MK III completely eliminates the requirement for voice communication between the pilot and the LSO;

f. **reliability and maintainability** — because the system is integrated and there is less associated equipment, reliability and maintainability are significantly improved; and

g. **complexity** — although RAST MK III contains state-of-the-art technology, it is actually a mechanically simpler system to understand and operate. Training LSO operators and equipment maintainers will likely be accomplished more quickly and with less difficulty than with previous systems.

Figure 5. RAST MK III eliminates the requirement for flight-deck personnel during recovery/launching operations. (*DND photo*)

Conclusion

RAST MK III is a mature R&D development project which will carry shipborne helicopter operations well into the next century. It is seen as the ideal candidate for retrofit on in-service ships (during refits or mid-life updates), new ship programs (including frigate and corvette sized ships) and the NFR-90, to name a few.

Considerable interest in RAST MK III has been expressed by a number of navies, including the USN. One authority has even rated the RAST MK III concept 15 years ahead of the newly designed French SAMAHE traversing system, and equally advanced over the only other competition from the UK's MacTaggart and Scott. This is high praise indeed, considering the evaluation of the RAST MK III Advanced Development Model is not scheduled until May 1990.

Acknowledgment

The author gratefully acknowledges the cooperation of Indal Technologies Incorporated in supplying the RAST-system photographs and illustrations for this article.

Commander Johnson is the DMEE 5 section head for naval auxiliary machinery at NDHQ.

Huron Underwater Propeller Change

By LCdr Larry White

Due to the unavailability of underwater still photographs, the photos accompanying this article come from an earlier Huron *propeller operation performed in drydock in Halifax. A videotape of the underwater operation in Esquimalt was successfully produced.* Editor

In the midst of preparations for HMCS *Huron*'s upcoming change of home port from Halifax to Esquimalt in the summer of 1987, the possibility of doing an underwater propeller change on a DDH-280 was considered. The coastal waterways of British Columbia are notorious for their navigational hazard of deadheads. These rogue logs, drifting upright within feet or inches of the surface, have accounted for a considerable number of damaged propellers over the years. Although more than eighty underwater propeller changes have been made on DDE steam destroyers during the past twenty years, it had never been attempted on a DDH-280.

The Fleet Diving Units are responsible for changing damaged propellers, and they are well-practised in the procedure where a steamship is concerned. The fixed-pitch propeller on a DDE is similar to that on an outboard motor; remove the holding-on nut and the entire prop can be pulled off the shaft. But the controllable-pitch propeller on the DDH-280 is much different in that the blades rotate individually within a fixed hub, much like the propeller blades on an airplane. This makes changing them more difficult since a complete set of individual blades must be removed and replaced.

After some discussion it was decided to task the Diving Units to carry out a feasibility study and develop an SOP for a DDH-280 underwater blade replacement. (About this time I was posted from NEU(A) to Fleet Diving Unit (Atlantic) as the Engineer Officer. When my new CO greeted me with a certain tasking letter from NEU(A), I realized I had more or less tasked myself with the study.) The rest of the study team would consist of CPO1CD Gerd Mantel of FDU(P), CPO2CD John DeJong of FDU(A), and Ted Heap, Main Propulsion Technical Officer at NEU(P).

Luckily for us, *Huron* was required to undergo a drydocking in May 1987 for a blade change. With notebook in hand and video camera to the shoulder, we converged on Halifax Shipyards to witness the dry-land procedure. LIPS Canada, manufacturer of the propeller system, had advised against doing the change underwater. They said the job had never been attempted anywhere in the world. There was no problem exposing the internal components to seawater, they just felt that with the very fine clearances involved, divers would not be able to cope. This caused us some apprehension, but it also made us more determined to succeed if the opportunity presented itself. After five days on the drydock floor we concluded that the job could be done under water and we set to work putting together an SOP.

We did not have long to wait to have our ideas transferred from paper to practice. In August 1987 off Vancouver Island *Huron* started experiencing abnormal vibrations. A survey of the port propeller showed two, possibly three blades with slight bends at their tips. Even such small bends produce vibrations that will cause major damage to the shaft bearings and gearbox.

We received full support to give the underwater change a try. If successful, and a blade change could be done without the need of a drydock, this could provide MARCOM more operational flexibility if needed. We even hoped to show that a blade change in a remote, secluded bay might be possible.

To be on the safe side we required that a drydock be on stand-by and that *Huron*

Figure 1. Divers PO1 Frew and LS Brewka change tanks as they prepare to make another dive on Huron. Underwater communication sets and hull-mounted video equipment made the blade-replacement job easier for divers and supervisor.

be alongside for at least three weeks. It was decided to attempt the change in December of 1987. There was a lull in *Huron's* operational commitments then, and this would also allow enough time to manufacture some of the tools we felt would assist the divers. It was estimated the job would take between 24 and 30 hours of in-water time, which would mean about a week on site. There was no pressure from MARPAC to hurry, so it was decided not to work overtime or weekends. Everything was to be done in slow time.

The job started on the first Monday in December, a typically beautiful West Coast day that boosted our confidence. Work began by securing a crane barge alongside *Huron*. An underwater video camera was mounted on the hull of the ship, and the divers were equipped with communication headsets (*Figure 1*) that later proved to be worth their weight in gold. Problems could be discussed and solved on the spot.

The ship was trimmed by the bows as much as possible to bring the propeller shafts (and the mating surface between the blades and the yoke) close to the horizontal. This would make it easier for the divers to slide the blades on and off the yoke. The first piece of equipment to be installed was an oil boom. The propeller hub itself contains about 700 lbs. of lubricating grease and the void space between the fairing cone and hub is filled with tallow. It was thought that when these components were removed, the water would be filled with oil and grease, covering the divers and the chain blocks and producing an oil slick that could put an early stop to the job.

After rigging the eye-bolts and chain blocks the fairing cone was removed (*Figure 2*). There was much speculation whether the half-ton cone would float or sink as it was filled with foam and sealed by fiberglass. Since there was more danger to the divers if it floated out of control, it was decided to suspend a weight from the cone. Several bolts securing the cone to the hub were removed and tapered pins inserted in their place. They would act as guides as the cone was pulled back from the hub and would also prevent the cone from floating away if it were improperly weighted.

Here we ran into our first problem. The weight for the cone was sufficient; however, it was placed off-centre and the cone twisted, tail-end floating upwards. The cone bent the guide pins and jammed, and it took most of the afternoon to free it. When the cone was ready to be replaced, it was weighted to be neutrally buoyant. After that it was just a matter of swimming it into place. Incidentally, the tallow which came away during the removal of the cone proved not to be a problem. As it floated to the surface the sea-gulls quickly did our clean-up for us.

The grease in the hub cavity was a major headache. It had previously been decided to try to remove most of the grease before the hub was separated. A steam lance, to soften the grease, was inserted through an eye-bolt hole in the hub and a suction hose was fixed to another hole. The fittings which had been manufactured were quite elaborate and the theory seemed sound, but in practice it was quite different. The hose plugged easily and the containers which were used to collect the grease rapidly became filled with oily water and we soon ran out of them.

Most of the second day was taken up by this problem. With the visions still

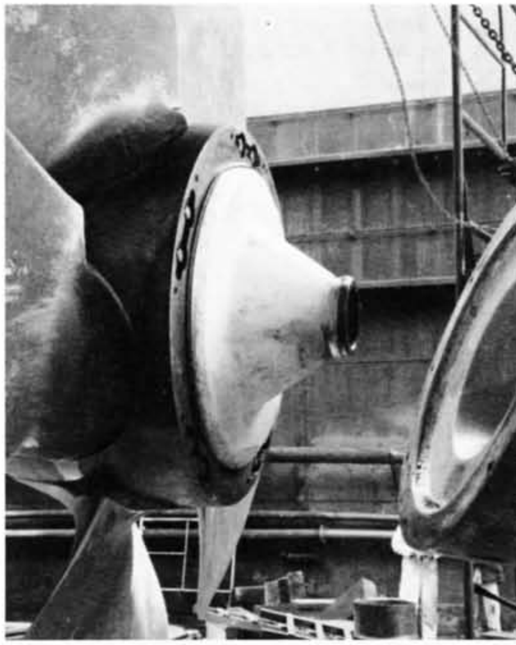


Figure 2. With the foam-filled fairing cone pulled away (right), the white tallow pressed against the hub is revealed. This part of the underwater operation required careful planning to prevent the buoyant cone from floating away out of control.

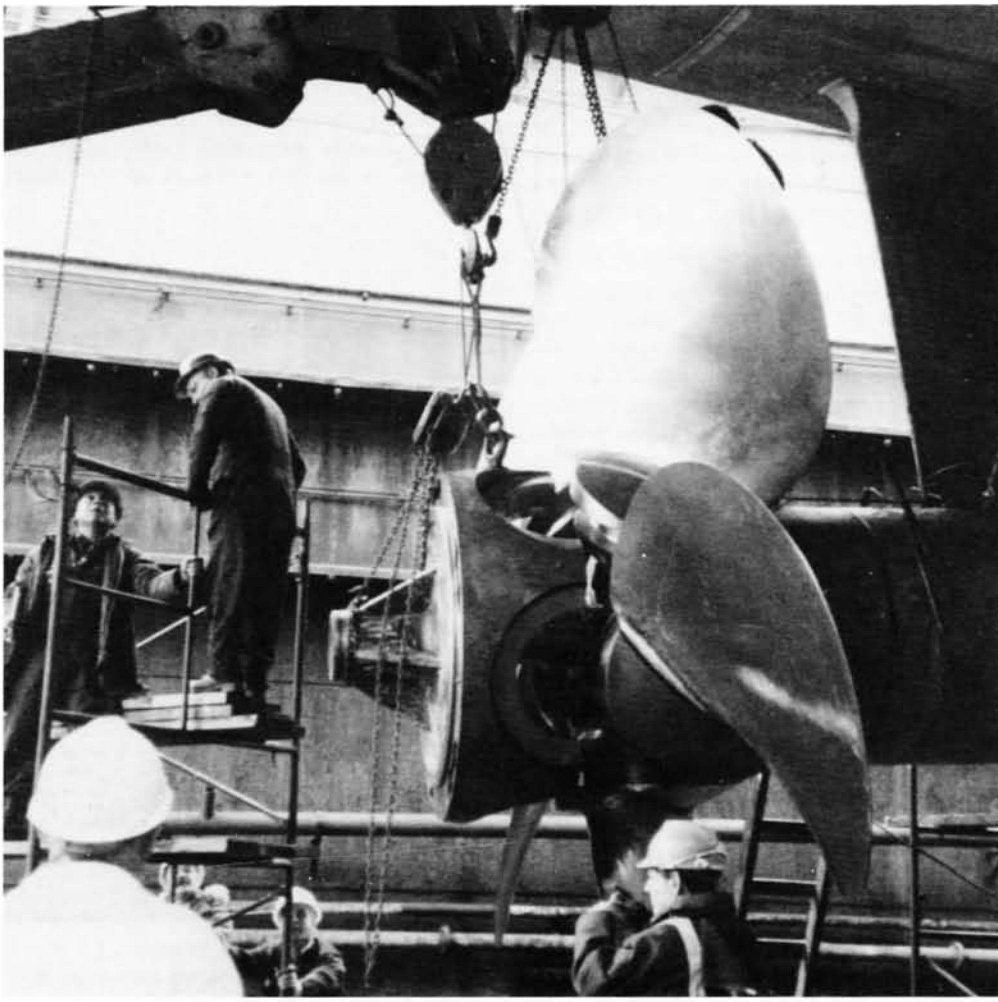


Figure 3. The hub is separated to expose the yoke and blade roots.

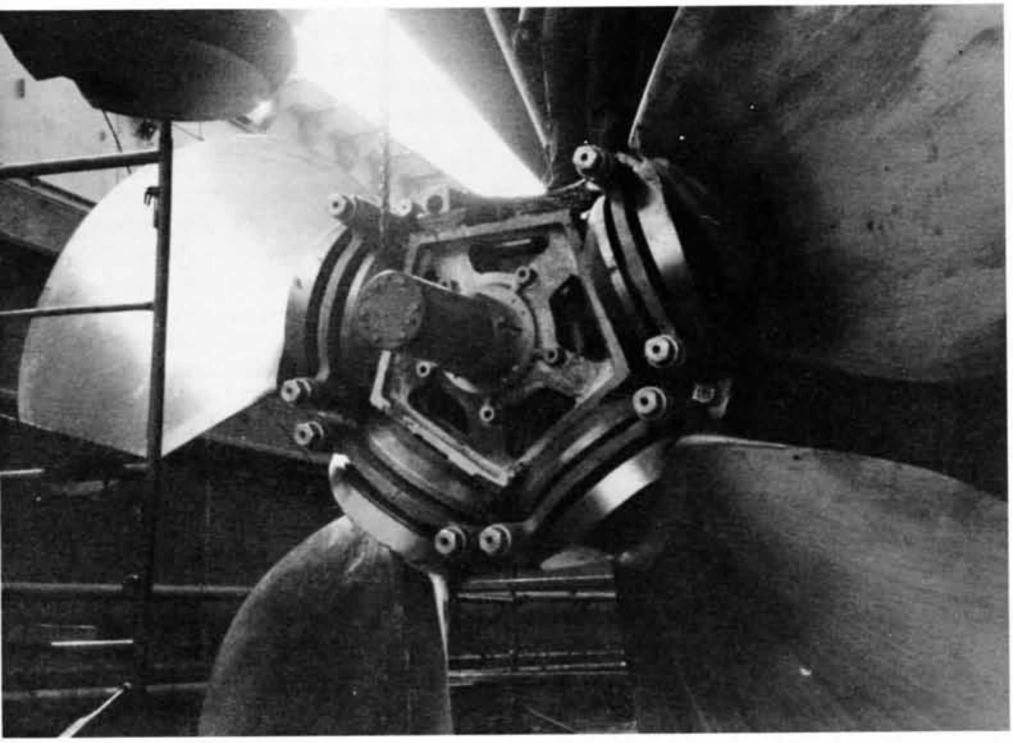


Figure 5. The first blade is removed. It was especially important that the yoke table be as level as possible during the underwater operation.

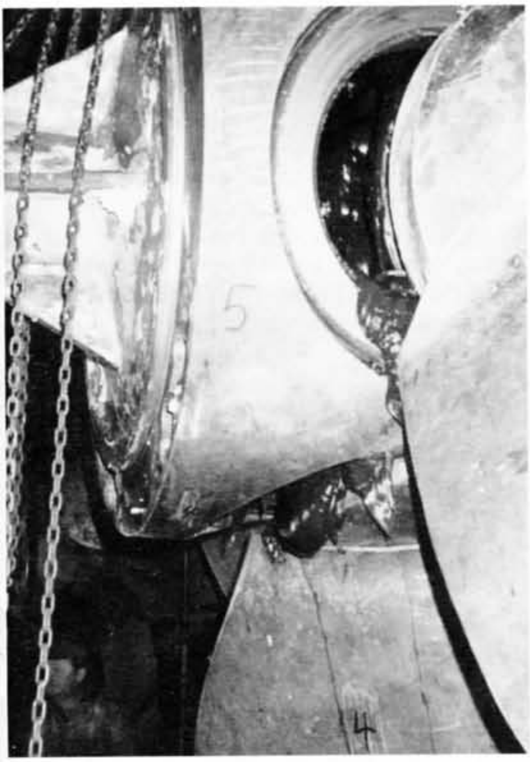


Figure 4. The hub grease, which oozed freely from the cavity during the drydock procedure, proved not to be a problem later when the hub was opened up under water.

fresh in mind of the hub removal in the drydock, when the grease ended up everywhere (*Figures 3,4*), there was concern that we might not be able to continue. Finally, it was decided to make a bold move and remove the hub and see what would happen. A second oil boom was rigged as a precaution and the coupling bolts were removed. As the hub was separated, the suction hose was positioned to remove the grease as it oozed from the split. We could have saved ourselves the trouble. The cool water, consistency of the grease and the buoyancy helped confine the grease to the hub. Only a fine film of oil formed on the surface.

It seems perfectly logical now, but even though we were relieved there was a feeling of embarrassment that so much time and effort had been spent on this point. We were beginning to feel that we had over-planned for this job by trying to foresee every possible problem. We felt differently the next day when we ran into a problem which we had completely failed to foresee.

Day three started with the blade removal (*Figure 5*). The cradle was secured to the first blade to be removed and the chain block hooked into the strop. All the rigging had been set up as for a steamship propeller change, but it was discovered that the distance between the tip of the blade and the hull on the 280 was less than that on a DDE. The rigging for the two classes of ship, therefore, was not the same and the chain block bottomed out before enough lift could be attained.

It was a frustrating oversight. It seemed that no matter what was attempted, it didn't work. Lifting strops were shortened and the chain block was rigged and re-rigged to the point where all that was needed was a lift of less than half an inch. It was hard to believe that the job would have to be delayed until we obtained different equipment—maybe even cancelled altogether—but then someone noticed that two small washers on the chain block's hook prevented the hook from travelling too far into the block. When they were removed, it was just enough.

The 280 propeller blades come as a complete set, balanced by the manufacturer in the factory; therefore, even though only three blades were damaged, all five had to be replaced. They also had to be positioned in the hub in the correct order to ensure proper weight distribution. But we came up against a snag. The numbers on the blades did not match; apparently an odd blade had been shipped. Thanks to many hard-working individuals we were able to obtain the correct blade the next day.

With the removal of the hub and the grease cleaned away, the yoke and blade roots were exposed. The very fine clearances (*Figures 6,7*) would not present a problem when blades were removed, but there was concern for their replacement. Clearances between the blade keyway and block, and the blade and hub bearings are measured in the thousandths of an inch. Water movement against the large blade surface would make it extremely difficult to handle, and damage to any part of the bearing surfaces had to be avoided.

Water traffic around *Huron* was strictly controlled by QHM, and wooden blocks and wedges were used wherever possible to steady the work. The elation of the first blade removal was only surpassed by its replacement. The first blade took 75 minutes to replace, the fifth took thirty minutes. By Friday the divers had replaced all blades, and on Monday the hub was ready to be installed.

This proved to be more difficult than originally thought. The guide pins that had been made for the job helped to steady the hub, but they allowed too much play and were of no assistance in aligning the hub halves together. The hub had to be

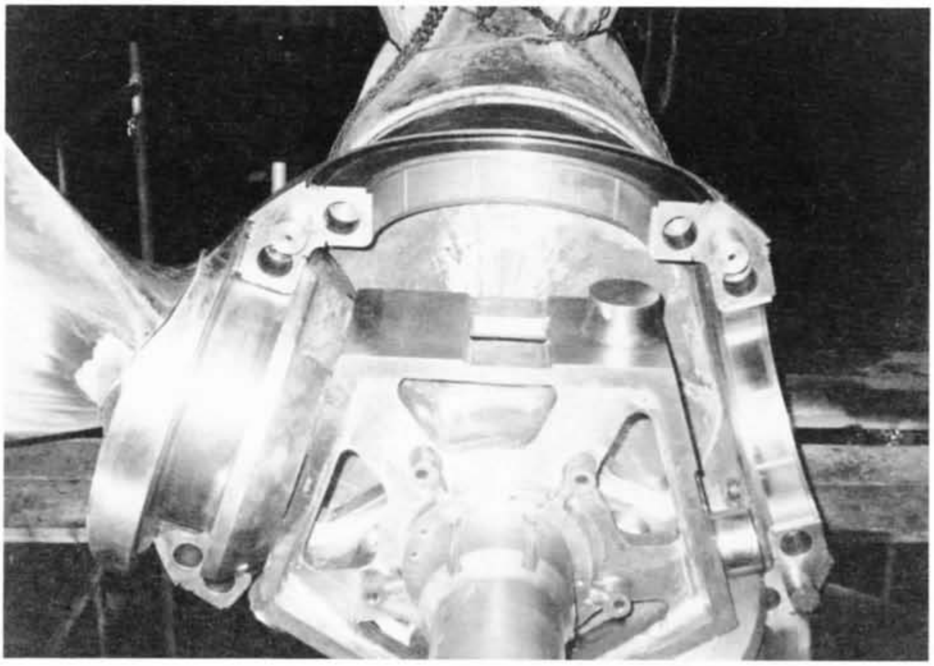


Figure 6. A close-up view of the yoke pin and bearing of the forward half of the hub. Note the precision fit of the blade.

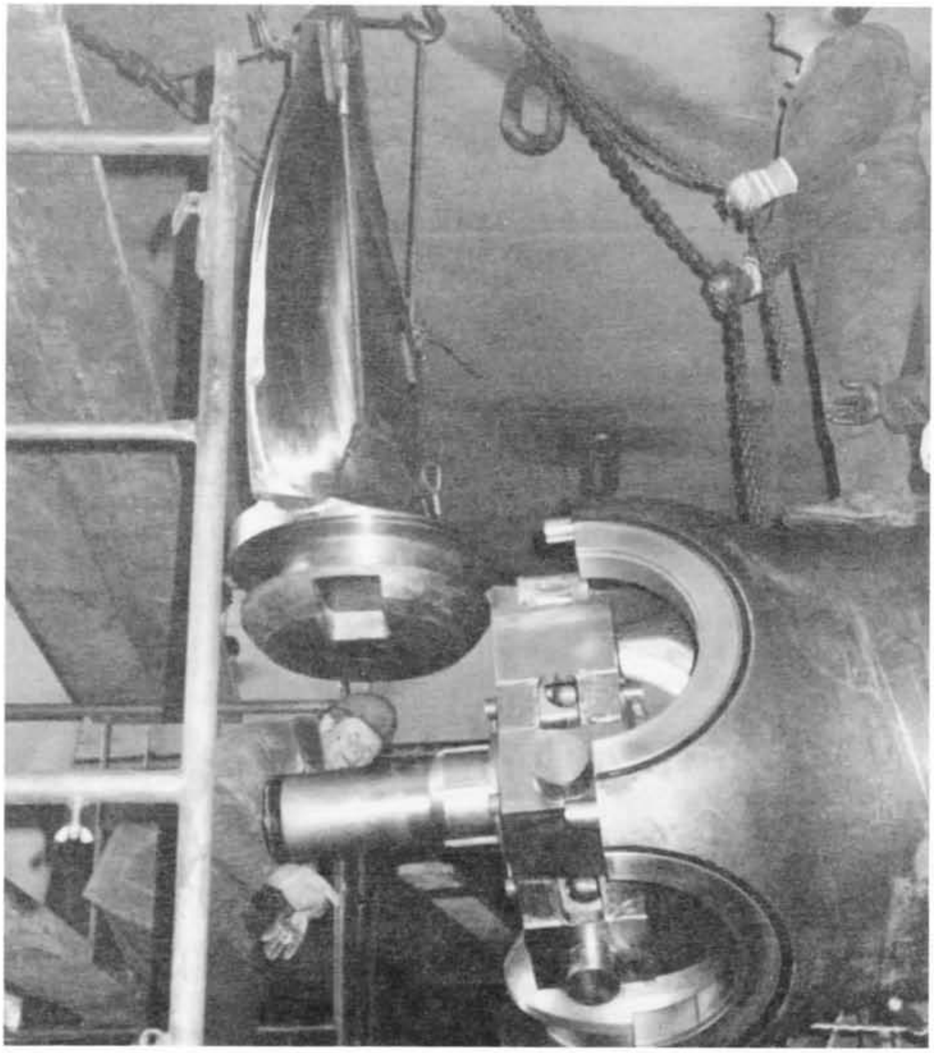


Figure 7. A new blade is swung into position. The fine clearances between the blade keyways and block, and the blades and hub bearings, made blade-replacement a tricky operation.

aligned at ten points simultaneously and it is a credit to the divers who showed perseverance and extreme patience to achieve this under difficult circumstances.

The hub halves are secured by fine-threaded coupling bolts which are torqued to 3400 ft-lbs. There is a procedure for torquing bolts underwater — torque, then retorque after a period to allow trapped water to escape around the threads. This method would result in a delay of several days. It was recommended, and approved by DMEE, that a 3/8'' hole be drilled through the centre of the bolt so that a true torque could be achieved immediately.

The remainder of the job went well and was uneventful. Altogether it lasted eight days, with a dive time of 38 hours (about 150 person-hours in the water). Despite the difficulties that had to be overcome, the job went much more smoothly than anyone anticipated. The success of the operation was a result of the efforts of many, but particular recognition goes to CPO Mantel and his dive team and to Mr. Al Hudson and his crew of the crane barge.

In the final analysis, the DDH-280 underwater blade-replacement procedure — developed and proven in surprisingly short order — gives the Maritime Commander one more viable option in managing fleet-maintenance operations. The procedure might well be destined to remain as a backup for a time when nothing else will do, but at least it is a wild card that can be played with confidence whenever circumstances call for it.

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Determination of Post-Overhaul Acceptance Criteria for Improvement of Electric-Motor Reliability

By *Italo Giangrande, P. Eng. and W.A. Reinhardt, P. Eng.*

Abstract

The quality of scheduled overhaul and subsequent installation on board ships is indicative of the in-service reliability of electric motors. It follows that the overhaul quality is to a certain extent a reflection of the post-overhaul motor test (POMT) specification. However, in the past, some naval refit contractors have been unable to meet, at a reasonable cost, the POMT specification (CFTO C-03-010-111/TR-000 dated 8 July 1980) which was suspected to be too stringent. In order to develop suitable POMT vibration analysis (VA) and rundown time acceptance criteria, it was necessary to establish the relationship between post-installation test (PIT) and corresponding in-service motor reliability.

NETE conducted a reliability study on a number of overhauled electric motors on the Multiship IV, V, and other subsequent refits to determine suitable POMT and PIT acceptance criteria. This study involved a statistical analysis of the POMT and PIT data collected from these refits. The conclusions are as follows:

a. The NETE 'D' and 'D -3' curves for Category B and A motors, respectively, are suitable POMT VA acceptance criteria,

b. The POMT rundown time should comply with an amended version of the acceptance criteria which is more discriminative, and

c. All electrically driven auxiliary equipment overhauled during refit should be subjected to PIT.

Introduction and Background

The implementation of preventive maintenance tasks is designed to achieve the inherent reliability of the equipment. As such the navy employs periodic overhauls of shipboard machinery, which includes electric motors. In effect, the quality of overhaul and subsequent installation on board ships are the main factors to be considered in determining the in-service reliability of electric motors.

One of the principal problems associated with overhauling, is determining the degree to which the motor should be overhauled. In general, reliability is enhanced with the refinement of overhaul control specifications, but at the expense of higher overhaul cost. In fact it has happened that some naval refit contractors were unable to meet electric motor POMT specifications (defined in the CFTO) at a reasonable cost. It was realized that the existing concept of common POMT vibration analysis (VA) acceptance criteria developed from certain overhauled critical motors was too stringent and impractical for all shipboard motors. On the other hand, to use dedicated POMT VA acceptance limits for each type of motor could prove to be complicated and probably economically unjustifiable. Alternatively, to devise more cost-effective acceptance standards, motors were grouped with respect to size and importance (criticality) on board ship; i.e:

a. *Category A.* Motors (military and commercial specification) greater than 5 h.p. and critical to shipboard operation and safety, and when overhauled must meet the upper levels of the proposed POMT VA acceptance criteria.

b. *Category B.* All remaining integral-horsepower motors (military and commercial spec.); when overhauled must meet a relaxed POMT VA acceptance criteria.

c. *Category C.* All fractional-horsepower motors (military and commercial) and some low horsepower commercial motors (non-critical); when overhauled are subject to a more relaxed POMT VA acceptance criteria. The commercial motors in this Category are normally not overhauled, but replaced.

Relaxed POMT VA acceptance criteria for Category B motors were proposed based on a number of factors. These included acceptable motor rotor balancing limits, reasonable motor assembly allowances, maximum vibration levels of motors considered to be satisfactorily overhauled and the IRD Mechanalysis vibration envelope for machines in good condition (Refs 1, 2). This was referred to as the Category B curve shown in *Figure 1.* The Category A curve is represented as 6 Vdb below the Category B curve (Refs 3, 4).

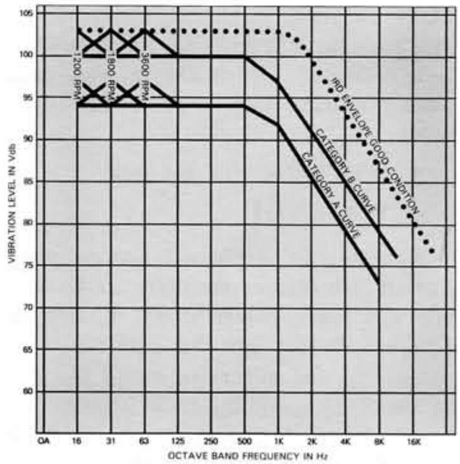

Figure 1. POMT VA NETE Acceptance Curves for Category A and B Motors (as per Ref. 3)

To refine the POMT acceptance criteria and improve motor reliability, NETE conducted a reliability study on several electric motors which were overhauled during the Multiship IV and V refits.

Reliability Study Objectives

The objectives underlying this study were to:

a. Monitor the effectiveness of POMT specification by correlating the POMT results with motor reliability,

b. Validate or modify the existing POMT VA and RDT acceptance criteria by reviewing the POMT VA from ship refits,

c. Determine the post-installation test (PIT) VA effectiveness, and

d. Define the acceptance limits accordingly.

Method of Statistical Survey

In order to determine representative acceptance criteria, the selected multiship refits included a number of overhaul contractors. It was also considered that cost-effective POMT VA acceptance criteria would allow for a 20 percent rework condition. With the cooperation of the Canadian Forces technical services detachments, naval engineering units, ship staffs, and NETE field service representatives, copies of the POMT results in the form of Completion Certificates and subsequent motor-failure reports of in-service failures were prepared. The Completion Certificates included both the POMT VA levels and bearing wear-in (run) rundown time (RDT) for motors only. Similarly, wherever possible, PIT and post- refit trial data were collected. Essentially, the raw data were compiled into two separate data bases:

a. POMT VA, PIT VA, and

b. POMT RDT

For analysis purposes it was assumed that all information pertaining to the survey was exact. Nevertheless, an area of concern was with the difficulty in associating the in-service motor failures to the corresponding fault source. To overcome this problem, an intuitive assessment was employed to determine the relevance of the failure. For instance, all electrical failures attributed to environmental factors such as defective switches, water ingress, etc. and/or reported failures which were not subjected to POMT and PIT VA were excluded from the statistics. Computer programs were developed to compare motor POMT VA and RDT to their respective acceptance criteria, and to calculate and list the statistical results.

Improved POMT Acceptance Criteria

A review of the proposed acceptance criteria was performed with the POMT and PIT data collected from the Multiship IV, HMCS *Nipigon*, and HMCS *Assiniboine* refits. The results are highlighted as follows:

a. The NETE 'D -3' and NETE 'D' curves, depicted in *Figures 2a* and *2b*, are more appropriate POMT VA acceptance criteria than the Category A and B curves. These curves account for speed variations.

b. The motor bearing run-in test of 1, 5, 10, 20 and 30 minutes is cost-effective and sufficient to establish the RDT trend. Although a very short RDT is a reliable indicator of deteriorating bearing life, the recurrence of one reduction in the RDT trend is misleading. On the other hand, a relationship exists between deteriorating bearing life and the RDTs after the 30-minute bearing run-ins that are less than one third the average values established for the motors.

c. The application of PIT on all overhauled electrically driven auxiliary equipment in the refit program would substantially reduce the number of in-service failures, and thus improve motor reliability (Ref. 5).

Based in part on these results, a new and improved electric motor overhaul specification, D-03-002-006/SG-000 (issued by DMEE 6 in 1984 and subsequently updated in 1986) included the following:

a. For Category A motors, the POMT VA levels must be within the NETE 'D -3' curve,

b. For Category B motors, the POMT VA levels must be within the NETE 'D' curve, and

c. The bearing RDT should be increasing with each separate bearing run-in period of increasing time duration of 1, 5, 10, 20, 30 minutes (Refs 6, 7).

Determination of POMT and PIT Acceptance Criteria

The analysis on the revised POMT and PIT acceptance criteria was conducted with the data collected from the remainder of the selected Multiship V refits and other overhauls. These included HMCS *Saguenay* (1985), HMCS *Preserver* (1985), HMCS *Gatineau* (1986), HMCS *Mackenzie* (1987), HMCS *Provider* (1987), and overhaul work conducted by Peacock Inc.

POMT VA Category A and B Motors Acceptance Criteria

A summary of the POMT VA statistics for both Category A and B motors of each ship individually and collectively is shown in *Table 1*. Overall, a total of 594 motors were subjected to POMT VA with the following results:

a. For Category A motors, the POMT VA data were compared to NETE 'D -3' as shown in *Figure 2a*. In addition, limits denoting 3 Vdb lower than the NETE 'D -3' curve, referred to as the NETE 'D-6' curve, were used as the respective comparator. As indicated in *Table*

SHIP	REFIT YEAR	MOTOR CATEGORY	# UNITS	# PASSED			% PASSED		
				ACCEPTANCE CRITERIA			ACCEPTANCE CRITERIA		
				D	D-3	D-6	D	D-3	D-6
SAGUENAY	1985	A	13	N/A	9	1	N/A	69.2	7.7
		B	15	12	11	N/A	80	73.3	N/A
GATINEAU	1986	A	19	N/A	16	10	N/A	84.2	52.6
		B	49	45	35	N/A	91.8	71.4	N/A
PRESERVER	1986	A	37	N/A	23	12	N/A	62.2	32.4
		B	54	49	31	N/A	90.7	57.4	N/A
PROVIDER	1987	A	47	N/A	32	23	N/A	68.1	48.9
		B	56	45	40	N/A	80.4	71.4	N/A
MACKENZIE	1987	A	12	N/A	11	10	N/A	91.7	83.3
		B	54	54	52	N/A	0	96.3	N/A
PEACOCK	1986-87	A	238	N/A	217	201	N/A	91.2	84.5
TOTAL		A	368	N/A	311	261	N/A	84.5	70.9
		B	226	203	168	N/A	89.8	74.3	N/A

Table 1. Summary of POMT VA Statistics

1, of the 368 Category A motors, 311 (86 %) units passed the NETE 'D -3' curve.

b. For Category B motors, the POMT VA data were compared to the NETE 'D' curve as shown in *Figure 2b*. Similarly to Category A motors, limits representing 3 Vdb lower than the NETE 'D' curve, referred as NETE 'D -3' curve, were used as the comparator. *Table 1* shows that 226 motors were Category B, of which 203 (90 %) units passed the NETE 'D' curve.

c. On the other hand, the designated comparators just described proved to be too stringent and uncalled for. As a result, it is expected that with acceptable overall quality as per CFTO D-03-002-006/SG-000 and an allowable 20 percent rework requirement, the NETE 'D -3 and 'D' curves for categories A and B, respectively, will make valid, cost-effective POMT VA acceptance criteria.

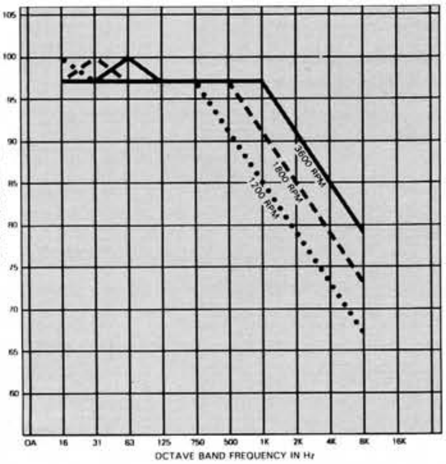

Figure 2a. POMT VA NETE "D -3" Acceptance Criteria for Resiliently Mounted Cat. A Motors Only.

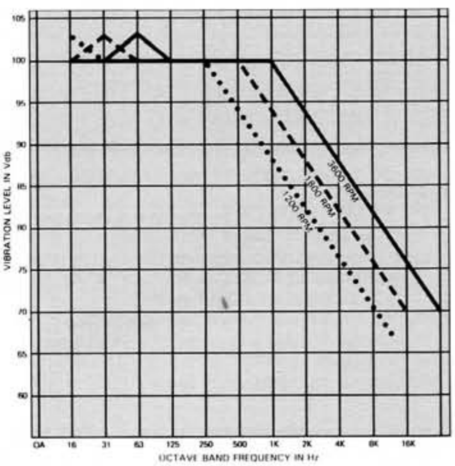

Figure 2b. POMT VA NETE "D" Acceptance Criteria for Resiliently Mounted Cat. B Motors

PIT VA Effectiveness for Refit Programs

Table 2 summarizes the results obtained for the PIT VA data collected on HMCS *Saguenay*. Motors were considered unsatisfactory in PIT if they failed to meet, wherever available, the relaxed shipboard VA norms. These consisted of up to ten percent of the vibration readings randomly scattered in the 'moderate' range of the norms or the NETE 'D' curve for units which are not included in the VA program. Of the 23 units subjected to both POMT and PIT, 14 units passed the POMT VA, but not the PIT VA.

This reinforces the importance of PIT in the refit program to increase reliability by ensuring correct installations and alignments. In addition, a correlation of 89 percent existed when the motors passed the PIT VA and the corresponding POMT VA, as opposed to not passing the POMT VA. Even though it was deemed essential to include PIT in the refit program, it was not possible to confirm definite PIT VA acceptance criteria for motors without shipboard norms due to the difficulties encountered in gathering the PIT VA raw data.

Correlation of POMT VA, PIT VA, and In-Service Motor Failures

Table 3 lists in-service motor failures subsequent to the refits. It includes the corresponding POMT and PIT results by indicating pass or fail. The correlation is determined according to the relevancy of the fault (see Method) and/or if subjected to POMT or PIT.

From 27 indicated correlations, 24 (90 %) in-service failures correlated with the corresponding POMT or PIT. Of these, three were attributed to installation faults. It is presumed the correlation would have been even greater if the corresponding PIT VA data had been available. Inevitably, it can be seen that with the existing POMT VA acceptance criteria and proper installation, at least 90 percent of the in-service failures would be eliminated.

POMT RDT Acceptance Criteria

A summary of the statistical results for the POMT RDT data is shown in *Table 4*. *Table 5* shows the relationship between one decrease in the RDT trend during the intermediate bearing run-in periods of 1, 5, 10 and 20 minutes, and the corresponding in-service motor failures.

From a total of 63 units with one decrease in RDT, eight units failed during service, but only one was related to a bearing fault (more likely the bearing seating itself). For this reason, one decrease in RDT during the intermediate bearing run-in should be permitted since it is not representative of a bearing fault. In effect, this should increase its effectiveness to about 98 percent in terms of avoiding unnecessary rejections. This is calculated from the results obtained in *Table 4* where motors attaining an increasing RDT trend during the intermediate bearing run-in period is 89 percent, with an additional nine percent having one decrease in the RDT trend.

The POMT RDTs after the 30-minute bearing run-in period were compared to one third the average RDT values (30-minute 1/3 RDT average) and one half the average RDT values (30-minute 1/2 RDT average) established for the overhauled motors. The number of failures for each motor to attain at least either control limit is indicated in *Table 6*.

The effectiveness of the 30-minute 1/2 RDT average compared to the 30-minute 1/3 RDT average is measured for cases where there is an increase in failures from the 30-minute 1/3 RDT average. The effectiveness of the 30-minute 1/2 RDT average is indicated with a Y(Yes) if failure to the 30-minute 1/2 RDT average conformed with either a reported in-service motor failure or failure to meet the

MOTOR CATEGORY	UNITS SUBJECTED TO POMT AND PIT	UNITS FAILED PIT AND PASSED POMT	UNITS PASSED PIT AND PASSED POMT	UNITS PASSED PIT AND FAILED POMT	CORRELATION* %
A	14	7	6	1	86
B	9	7	2	0	100
TOTAL	23	14	8	1	89

* Correlation exists when motors passed the PIT VA and the corresponding POMT VA as opposed to not passing the POMT VA.

Table 2. HMCS *Saguenay* PIT VA Results

POMT VA control limits; otherwise, it was denoted with an N(No).

The 30-minute ½ RDT average control limit rejected five percent more units than the 30-minute ⅓ RDT average, as indicated in *Table 4*, but with a noticeable 67 percent increase in effectiveness (*see Table 6*).

Although for the 30-minute bearing run-in the 30-minute ½ RDT average is an effective control limit, it is difficult to implement because the data containing the computed RDT averages for all the overhauled motors are not readily available to the overhaul contractors. Alternatively, it was considered that a short RDT after the 30-minute bearing run-in could be a reliable indicator of deteriorating bearing life. For purposes of analysis, the RDT after the 30-minute bearing run-in was defined as *short* if it did not exceed the RDT after the 20-minute bearing run-in period by more than three seconds. This is designated as the "short 30-minute RDT."

The methodology consisted of identifying all motors with RDTs after the 30 minute bearing run-in that failed to attain at least the 30-minute ½ RDT average. It was assumed that the 30-minute average control limit was 100 percent effective; that is, failure to adhere to the control limit corresponded to faulty motor bearings. The RDTs of the 30-minute bearing run-ins for each of these motors were then compared to the short 30-minute RDT. From a total of 56 units identified as failing to attain at least the 30-minute ½ RDT average, 46 units indicated a short 30-minute RDT; an 82 percent correlation. Given that an 80 percent correlation is more than sufficient, it is determined that after the 30-minute bearing run-in the RDT must be greater by three seconds than the RDT of the corresponding 20-minute bearing run-in.

UNIT	NEI NUMBER	MOTOR	FAULT	POMT	PIT	RELEVANCY	CORRELATION
1	E28116	AFTER CAPSTAN MTR.	DRUM SWITCH	P	P	N/A	Y
2	E27793B	WATER SERVAC PUMP	BEARINGS	P	F	A	Y
3	E27415-03	#3 HULL FIRE PUMP	BEARING	P	P	A	N
4	E28116-0	AFTER CAPSTAN MTR.	WINDING	F	–	A	Y
5	E28116-B	AFTER CAPSTAN MTR.	HIGH CURRENT READING	–	–	A	Y
6	E27414	BILGE PUMP	PUMP CEASED	P	–	N/A	Y
7	E29244B	FAN 45-1	BEARING	F	–	A	Y
8	E27992B	SW PUMP	PUMP CEASED	P	–	N/A	Y
9	E27334B	#4 H&F PUMP	BEARING	F	–	A	Y
10	E29233A	FAN 3J1	WATER INGRESS	P	–	N/A	Y
11	E29243A	FAN 2&3	BEARINGS	F	–	A	Y
12	E29244A	FAN 2D2	BEARINGS	F	–	A	Y
13	E28235-0	HOIST/LVFRMG SET	CUMMUTATOR	F	–	A	Y
14	E29225	RADIO CODING ROOM MTR	WINDINGS	F	–	A	Y
15	E24230B	ASTERN GUARD VALUE MTR	WINDING	F	–	A	Y
16	E29227-0	HW CIRC PUMP MTR	WINDING	P	–	A	N
17	E27137-2	75T CHILTO UNIT MTR	WINDING	F	–	A	Y
18	E25335-1	#1 FORCED DRAFT FAN MTR	INSULATION	P	–	N/A	Y
19	E27279-1	FAN CFWT 490FL	BURNT MTR	P	–	A	N
20	E25454-1	MAIN EXTRACTION PUMP PORT	BEARINGS/MISALIGNMENT	P	–	A	Y *
21	E25454-2	MAIN EXTRACTION PUMP STBD	BEARINGS/MISALIGNMENT	P	–	A	Y *
22	E28290-1	AMMO HOIST DOOR	WINDING	P	–	A	Y
23	E29236-2	GALLEY EXHAUST FAN	BEARINGS	F	–	A	Y
24	E29236-7	GALLEY FAN	WINDING	F	–	A	Y
25	E29266	VANE AXIAL FAN	BROKEN LEAD	P	–	N/A	Y
26	E29236-2	VANE AXIAL FAN A3	WINDING	F	–	A	Y
27	E28290-2	AMMO ELEVATOR	WINDING	F	–	A	Y

NUMBER OF NO CORRELATION (N) =	3
NUMBER OF YES CORRELATION (Y) =	24
TOTAL INDICATED CORRELATION =	27
% CORRELATION WITH POMT VA =	88.8%

REMARKS

1. The POMT and PIT VA results are denoted by:
   P: passed F: failed – not tested
2. Relevancy indicates whether the motor was subjected to POMT or PIT and if the fault is associated to POMT or PIT.
3. The correlation is determined according to the relevancy of the fault and/or if subjected to POMT or PIT.

* Attributed to installation fault.

Table 3. Correlation of In-service Motor Failures with POMT VA and PIT VA.

'30 MINUTE % RDT AVG.'	MTRS. PASSED '30 MIN % RDT AVG.'	
	#	%
33	718	97
50	686	92
67	639	86
75	596	80
85	543	73
90	498	67
100	401	54

MTRS. ATTAINING AN INCEASING RDT TREND		MTRS ATTAINING 1 DECREASE IN RDT TREND		MTRS ATTAINING MORE THAN 1 DECREASE IN RDT TREND	
#	%	#	%	#	%
659	89	68	9	15	2

(1) TOTAL NUMBER OF MOTORS = 742

(2) RDT TREND FOR INTERMEDIATE BEARING RUN-IN PERIODS OF 1, 5, 10, AND 20 MINUTES

Table 4. POMT RDT Overall Statistical Results

NEI CODE	# UNIT	RUN TIME(min)	IN-SERVICE FAILURES	RELEVANCY
E25326	1	5	1	–
E25333	1	5	–	–
E25339	1	10	–	–
E25344	1	10	–	–
E25350	1	20	–	–
E25352	1	20	–	–
E25407	1	20	–	–
E25432	1	20	–	–
E25441	1	10	–	N
E25454	1	20	(INSTALLATION FAULT)	–
E27269	1	10	1	–
E27371	1	10	–	–
E27376	1	5	–	–
E27378	1	5	–	–
E27400	1	10	–	–
E27415	1	5	1 (BEARING FAILURE)	Y
E27477	1	20	–	–
E27497	2	10, 5	–	–
E27515	3	20, 5, 10	1 (PUMP)	N
E27522	2	20, 5	–	–
E27615	1	10	–	–
E27628	2	20, 10	1	–
E27692	1	20	–	–
E27742	1	20	–	–
E27743	2	20, 20	–	–
E27825	1	10	–	–
E28109	1	5	–	–
E28116	1	10	1 (POMT)	N
E28235B	1	20	1 (POMT)	N
E28235C	1	20	–	–
E28290	2	20, 5	2 (POMT)	N
E28376	4	20,20,20,20	–	–
E29206B	1	5	–	–
E29232	1	5	–	–
E29234	1	10	–	–
E29238	1	5	–	–
E29245	2	20, 20	–	–
E29247	1	10	–	–
E29255	1	20	–	–
E29266	2	20, 20	1 (BROKEN LEAD)	N
E29292	2	20, 20	–	–
E29334	1	20	2 (POMT)	N
E38111	1	5	–	–
E38140A	2	20, 10	–	–
E39116	1	10	–	–
E70913F	1	10	–	–
E94139	1	20	–	–
E38139	2	20	–	–
E39117	1	20	–	–

Table 5. RDT with One Decreasing Time During Intermediate Bearing Run-in (1, 5, 10, 20 minutes) and Corresponding In-Service Failures.

	FAILURES TO '30 MIN.% RDT AVERAGE'				
NEI	33%	50%	POMT	FAILURE REPORT	EFFECTIVENESS
E25339	0	1	F	N	Y
E25350	1	6	F (6)	N	Y
E25518	0	2	P	N	N
E27374	3	3	F (2)	N	
E27414	1	2	P	Y (2)	Y
E27497	0	1	P	N	N
E27511	0	2	F (1)	N	Y
E27513	1	1	P	N	
E27749	0	2	P	N	N
E28109	0	1	P	N	N
E28290	2	2	F (1)	Y	
E28291	2	2	P	N	
E29231	1	1	P	Y (3)	
E29233	0	1	P	Y (1)	Y
E29234	0	1	P	N	N
E29235	1	3	P	Y (3)	Y
E29236	1	2	F (2)	Y (2)	Y
E29239	2	3	P	N/A	
E29255	0	1	P	N/A	
E29263	2	2	P	N	
E29265	0	1	P	Y (1)	Y
E29279	0	1	P	Y (1)	Y
E29302	0	1	F (1)	N	Y
E29306	1	2	P	N/A	
E38139	1	2	P	Y (1)	Y
E38140A	0	2	P	N/A	
E39117	0	1	P	N	N
E94107	1	1	P	N	
E94139	1	1	P	N	
E38111	1	1	F (1)	N	
E27515	1	1	P		
E27522	0	2	F (2)	Y	Y
E27641	1	1	P		

- Numbers in brackets denote reported failures.
- N/A – not available, failure reports were not received from HMCS MACKENZIE
- Y – yes, received failure report, N–no
- P – pass POMT VA, F – failed POMT VA
- % effectiveness = $\frac{\text{\# of effectiveness indicated with Y (yes)}}{\text{total indicated effectiveness}} = \frac{12}{18} = 0.67 = 67\%$

Table 6. Comparison between 30-minute 1/3 RDT Average and 30-minute 1/2 RDT Average.

Conclusion

Evidently, the reliability of electric motors is a function of both the POMT and PIT acceptance criteria which determine the quality of overhaul and subsequent installation. As established in the reliability study, the acceptance criteria for a satisfactorily overhauled motor are as follows:

a. For Category A motors, the POMT VA levels must not exceed the NETE 'D -3' curve.

b. For Category B motors, the POMT VA levels must not exceed the NETE 'D' curve.

c. For all Category A and Category B motors, the RDTs shall increase with each separate bearing run-in period with one decrease during the intermediate bearing run-in of 1, 5, 10 and 20 minutes permitted, and

d. The RDT after 30 minutes of motor run-in must be more than three seconds longer than the RDT after 20 minutes of motor run-in.

e. Units considered failed under the criterion described in (d) shall be retested for POMT RDT. If a unit fails again, further investigation is required with consideration to both the POMT VA and RDT acceptance criteria.

Although it was not possible to define global PIT VA acceptance criteria, PIT should be included for overhauled electric-driven auxiliaries in the refit program and adhere to:

a. Wherever available, the relaxed shipboard norms. That is, the maximum levels must not exceed the shipboard averages +12 Vdb, with a maximum of ten percent of the vibration readings randomly scattered in the "moderate" range of the shipboard norms, and

b. For motors without shipboard norms, the NETE 'D' curve which is a representative guideline for acceptance.

Acknowledgment

The authors are indebted to the different organizations, CFTSDs, NEUs and ships for their assistance and cooperation.

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Engineering Incident:

DDH-280 Solar Gas Turbine Generator

Introduction

During an exercise a DDH-280 Solar gas turbine seized, apparently due to a bearing problem. Upon the ship's return to Halifax one week later, the engine was scheduled for replacement.

Subsequent Events

The ship went to Extended Notice on arrival and was not scheduled to sail for a number of weeks. This permitted the ship's staff to carry out the Solar engine change methodically and without undue haste.

On the first workday the enclosure was removed, the connections were broken and the engine was unbolted from its mounts. The next day, the engine was removed to the hangar and a new engine set in its place. The necessary ancillary equipment was then taken off the old engine and reinstalled on the new one. This included the old compressor bleed valve.

Concurrent to this activity, dockyard personnel undertook in-situ work on the enclosure for the same Solar engine. As an appropriate precaution to avoid foreign object damage, ship's staff left the protective packaging blanket around the compressor inlet while the work was under way. The engine change-out was completed without incident and the dockyard finished the enclosure work a couple of days later.

The generator, then ready for testing, was run up but achieved only 60 percent speed before tripping out on the start-cycle time limit. The engine-start was attempted several more times with the same result.

The bleed valve, which is designed to prevent compressor stall during start-up, was suspected as being the cause of the problem. It had been taken from the expired engine and the symptom seemed indicative of a faulty compressor bleed valve. A new bleed valve was installed and the engine was run up. Again it failed to achieve more than 60 percent speed before tripping out. The peculiar problem was discussed at length and the Solar engine manuals were raked for clues.

Finally, the Auxiliary Machinery Room chief decided to check the compressor inlet to see if the protective blanket had been removed. (Everyone present had assumed someone else had already taken this obvious step.) The enclosure panel was withdrawn and, sure enough — the blanket was still securely in place barring unwanted objects (and adequate air) from entering the compressor. The blanket was removed and the engine was run up successfully.

Machinery Damage

Damage was minimal, consisting only of a deformed compressor inlet screen.

Lesson Learned

A careful check-off procedure would have prevented this (fortunately) minor incident.

CPF Main Engine Removal Trial

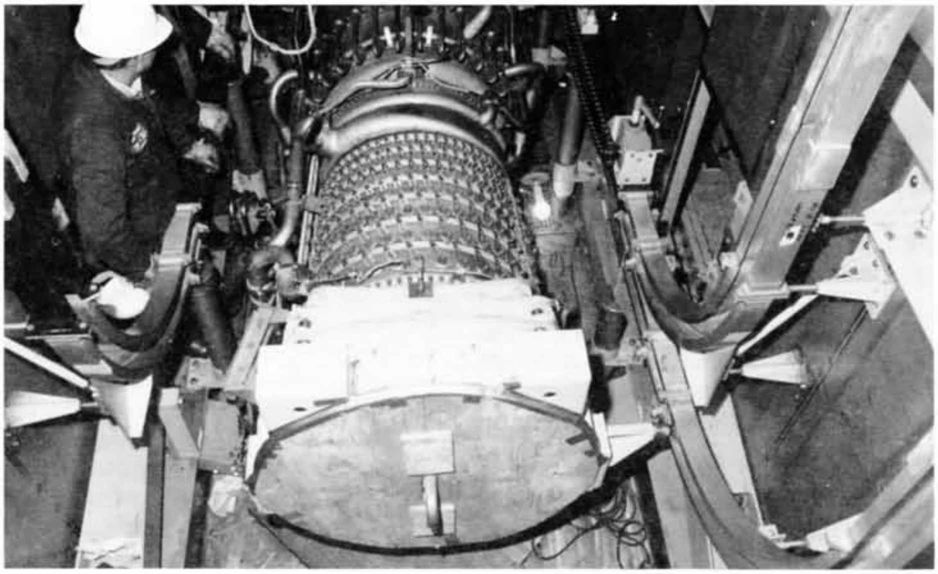


Fig. 1 The gas generator resting in the enclosure plenum. The junctions of the transition and enclosure rails just above the upcurve are clearly visible.

By Lt(N) Cliff Wardle
DMEE 2 Gas Turbine Section, NDHQ

Photography by Danny Pond,
Courtesy of Saint John Shipbuilding Ltd.

Last December, personnel from Saint John Shipbuilding Ltd. and General Electric completed a CPF engine-removal trial on board *Halifax*. After a week of preparations, the team successfully removed an LM-2500 gas generator through the ship's gas-turbine inlet ducting.

The design of the air intake makes the LM-2500 relatively easy to remove from the ship (much easier than taking an FT-4 engine out of a DDH-280). The top of the inlet housing removes with little trouble, allowing the engine to be pulled straight out through the top of the ship.

Fig. 2 A good view of the turbine end of the gas generator, now clear of the enclosure plenum. The #6 bearing has been protected by a sheet of plastic as it is the most vulnerable part of the gas generator when it is exposed like this.

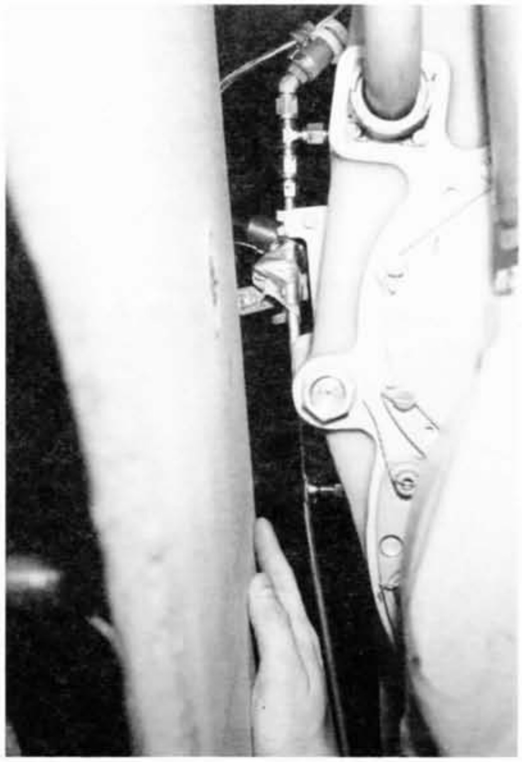


Fig. 3 Minimal clearances like this can be easily checked prior to removal with a representative-sized jig.

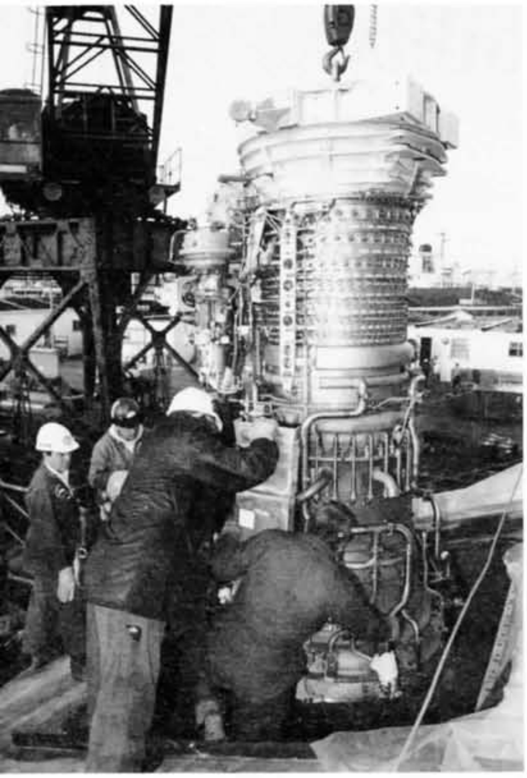


Fig. 6 As it lifts clear of the top of the inlet housing, the gas generator is guided by the port-side rail extensions visible in the centre of the photograph.

Fig. 5 An overhead view of the gas generator on the chain hoist as it clears the critical region.

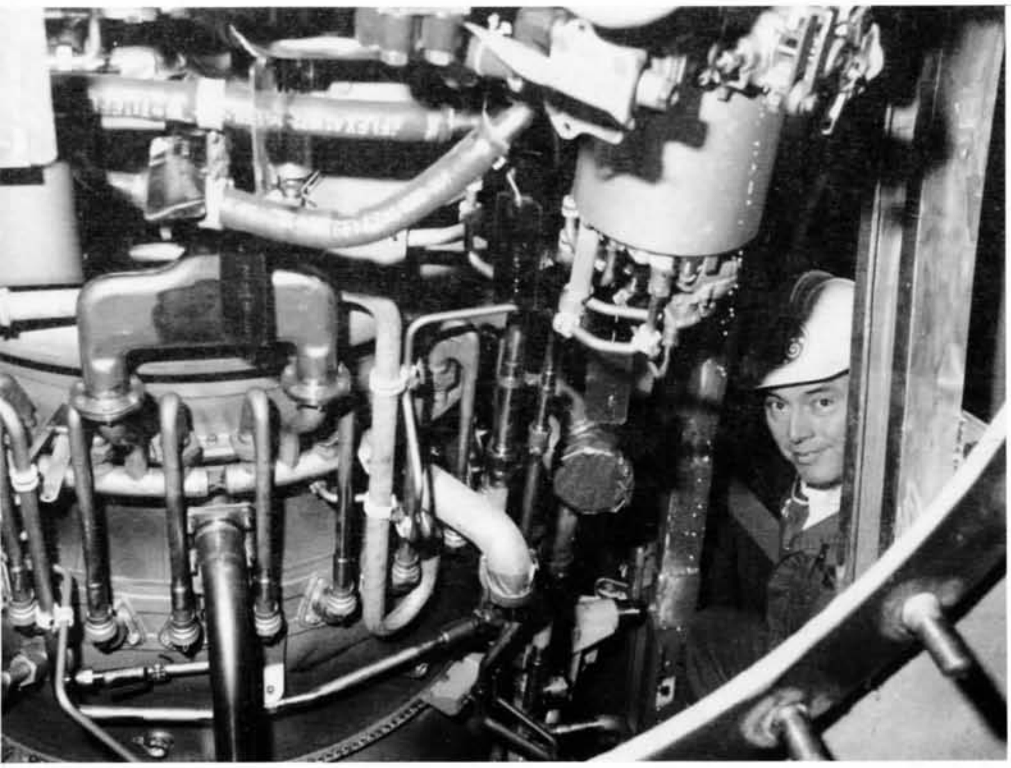


Fig. 4 GE Fleet Service Representative Bill Greenlaw smiles as the engine clears the critical portion of the intakes.

To steer the gas generator through the ducting, three guide rails (two to port and one to starboard) were temporarily installed along the path of the intakes. The two guide rails on the port side extended above the inlet housing to steady the machinery as it was lifted clear of the ship.

During normal operations, this procedure should make it possible to remove and replace an engine in 48 hours.

Total Systems Responsibility
Will it work?

By Capt(N) Roger E. Chiasson

Introduction

A very large proportion of my naval career has been spent in new construction or ship repair. I was a member of the overseeing staff in Davie Shipbuilding, Lauzon, PQ, during the construction of DDHs 282 and 283, detachment commander in 201 CFTSD (Vickers, Montreal) during the height of multi-ship DELEX refits of steam destroyers, and, more recently, Project Manager Ship Refits (DMEM 5) in NDHQ.

A posting as Deputy Project Manager (Construction) in the Canadian Patrol Frigate project seemed a logical extension of my previous experience. Yet when I arrived on the project in the summer of 1987 I was acutely aware that the new frigates were being procured under considerably different ground rules from the ones with which I was familiar. There was a much more pervasive quality assurance program than I had heretofore seen applied in Canadian shipyards, but I was aware of a new concept of "total systems responsibility" being applied to new ship acquisition.

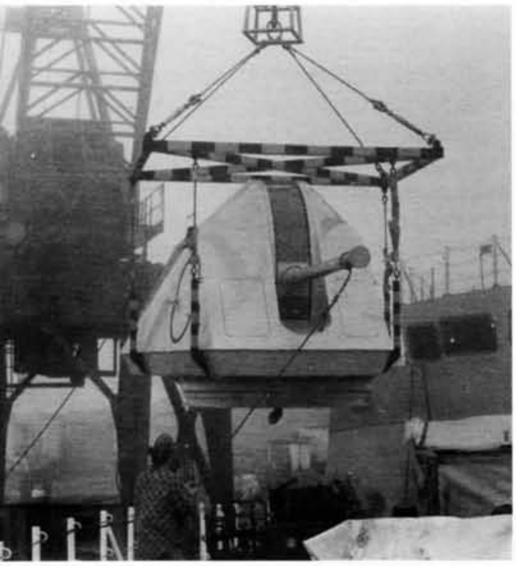
I was pleased that a high standard of quality assurance had finally crept into a Canadian industry which, until then, had not been particularly noted for its respect for QA. But I was somewhat skeptical about the industry's ability to accept total systems responsibility (TSR) for delivery of a ship which would meet performance requirements without considerable guidance and direction from DND. I was not sure industry was up to the task, and I was equally concerned that the navy could not adjust to what appeared to be the abrogation of our technical responsibility.

History

Ship procurement has evolved over the last 40 years. In the 1950s and 1960s ships were built to naval design with government-supplied equipment in shipyards across the country. Although contracts evolved over the years from cost-plus towards the "incentivized" target or ceiling type, escalation provisions and the lack of a frozen design prior to the detailed design and construction phases played havoc with cost and schedule control. Construction was overseen by a large staff of naval personnel who guided the contractors in the interpretation of the specification, defined the work standards and took an active role in the planning, scheduling, trials, and virtually every other aspect of the job. The navy was the only organization that could be expected to perform the functional design, systems integration, procurement and inspection roles. The leadyard did the detailed design, but to naval overseeing approval. It was an era in which military standards outstripped commercial practice in complexity and sophistication.

In addition to this technical "culture gap" between the navy and Canadian shipyards, there was a severe lack of industry expertise in quality assurance, project management and integrated logistics support. The navy was not much farther ahead. Any weaknesses in the technical specification were rectified by the on-site overseeing staff. Shipyards also had little incentive to deliver within budget or on schedule, especially since changes to the contract and specification were directed by the Crown and implemented on a cost-plus basis. It was no wonder, then, that shipbuilding contracts became notorious for their lack of adherence to budget and schedule.

The DDH-280 project made some valiant attempts to address the inherent weaknesses of the ship procurement process. The supply of major systems (notably main propulsion, auxiliaries, and major combat systems) was parcelled out to major contractors who were expected to deliver integrated "packages." However, the combat system and ship-level integration remained within DND, as did the responsibility for project management, logistics support and configuration management. For the first time in Canadian shipbuilding history a stringent quality assurance standard (DND 1015) was specified, but for reasons beyond the scope of this paper it was applied with only limited success. Suffice it to say that the old naval overseeing approach contributed substantially to the quality that



was achieved. But how good was that quality? Why did DND resolve never to acquire new ships by the same process in the future?

Although some would contend the DDH-280s were well built, they were delivered unfinished and contained a number of flaws, primarily because they were built to specifications and not to performance requirements. Also, to avoid repetition of what the Government considered poor procurement practice in the DDH-280 project, Treasury Board issued policies intent on stemming a continuing trend of schedule delays, cost overruns and equipment performance far below expectation. The trend was to be reversed by introducing the principles of project management and by transferring to industry many of the responsibilities and functions previously performed by government. If the navy wanted new ships, it would have to acquire them under a new set of ground rules.

In addition to the concern for cost and schedule overruns and performance shortfalls, there was a perception that DND simply did not have the personnel to totally manage ship procurement without it adversely affecting other activities. (During the implementation of the DDH-280 project, for example, DGMEM did little other work, including fleet support.) Contracting out TSR was a very controversial position and was seen as an indictment of the navy's ability to manage capital acquisition. It was seen as a threat to the naval engineering community and, perhaps more importantly, to the navy itself — Was there sufficient capacity and capability in industry to design, manage, build and support projects of such magnitude? And even if our professional egos survived, would we get a credible ship out of the process?

The jury is still out on whether or not our trust in Canadian industry has been well-founded. The concept of total systems responsibility vested in the prime contractor is still being put to the test, so the final judgment must wait until after the ship has been trialed and delivered. Nevertheless, with construction now well advanced, this is an appropriate juncture to ponder the merits of what, so far, is proving to be a successful venture.

Discussion

Under total systems responsibility the contractor is clearly responsible for fulfilling the project requirements within given cost, time and technical performance constraints. So what, then, is the Crown's role in the process? Do we merely sit back and watch?

Obviously not. The project office employs more than 240 DND and 65 DSS personnel (not including project augmentees in DGMEM, etc.) to oversee the contractor's work and manage the Crown's interest. This seemingly large organization manages all the technical/contractual changes necessary to keeping an evolving, detailed design specification contractually in line. It ensures that the conduct and progress of work are contract-compliant with respect to quality and schedule, and performs the important function of keeping the "customer" informed on the nature of the product through *design exposure*.

The main consequence of the need for design exposure and monitoring the work is the large number of *technical data deliverables* built into the contract. These are documents which the contractor is required to submit to the CPF project management office for review, concurrence, approval, or some other form of vetting. In addition there are any number of workshops, technical specialist meetings, design reviews, progress reviews and other meetings that require PMO representation (as well as DGMEM or other expert presence). The purpose of these deliverables and meetings is, in essence, to manage the risk — the risk inherent in the "hands-off" approach.

Such an extensive commitment to written and verbal communication, the vast majority of which is contractual (and therefore non-discretionary), not only requires considerable resources, but also creates a potential conflict between the contractor and the customer. The success of the relationship depends to a large degree on the inherent reasonableness of people on both sides.

For many of the DND technical people involved, the contractual "hands off" approach has been difficult to accept. In addition to our reliance on data deliverables and meetings to gain insight into the CPF design, the strategy of "negative guidance" has been an added source of frustration. DND can point out where the contractor is failing to meet the specification, but not how to correct the deficiency. Adopted during the contract definition phase, this strategy was not intended to carry over into the implementation phase. Nevertheless, it still influences people's behavior. Every opportunity is taken to provide positive guidance when requested, but there is a conscious effort to refrain from directing the contractor lest his total systems responsibility be usurped.

Total systems responsibility in the hands of the contractor should result in a compliant ship. Still, detractors of the concept argue that the need to keep the contractor's total systems responsibility sacrosanct has become more important than the finished product, or that the product is being acquired through an unnecessarily difficult and costly process. They maintain that in the end the navy will assume the responsibility (or take the blame) for shortfalls in performance. Despite what the contract says, their concern is that TSR will not work and the navy will have to pick up the pieces.

Total systems responsibility requires a disciplined approach, and the contractor has to be reminded at every turn that he *is* responsible. A system of incentives and warranty clauses incorporated in the contract serves to reinforce the requirement. Without a doubt, the success of the approach depends to a certain degree on faith and trust. On the one hand the navy has never had to rely so heavily on outside resources, and such a bold venture naturally carries with it an element of risk. On the other hand, there is no evidence that the venture will fail, or even that the procurement process is severely flawed.

No other major ship procurement project in this country has ever had a single point of focus for *total* ship design and acquisition. That focal point happens to be a contractor. We should ask ourselves whether, had we chosen the total ship systems responsibility for ourselves, we could have provided that singleness of purpose. Clearly I think the answer is No, which is precisely why we chose to contract out that responsibility.

There is no doubt whatsoever that DND involvement in some areas of the CPF work has saved the contractor from making some bad decisions. Contractor TSR notwithstanding, the prime contractor has listened to the navy's advice in many areas (in spite of the frustrations imposed by the lack of customer direction and the need for innumerable data deliverables to expose the design). Still, even though DND representatives may have provided advice, or argued or defended a position, only the contractor had the mandate and the total resources to make the trade-off decisions. Warship design is a compromise (*Figure 1*) and very few technical or contractual decisions can be made in isolation. It is my contention that by vesting total responsibility in the contractor, and *paying* him to manage it, we will inherit a ship that has a reasonable balance of endurance, survivability, reliability and performance *within ceiling cost and schedule constraints.* The degree to which each of the factors is optimized or compromised will, of course, always be open to argument.

In spite of the complexities of ship design, we must assume that one body of reasonably competent and dedicated people can do as good a job as any other. As much as we may profess to have the expertise, sea experience and end-user interest on our side, we simply cannot be expected to keep abreast of the *total* ship design and acquisition process. We lack the resources and therefore the necessary ability to focus on the total ship. By contracting out TSR *and* providing the expert advice whenever needed, I believe the end result will be considerably better than if we had attempted to manage the entire process in-house.

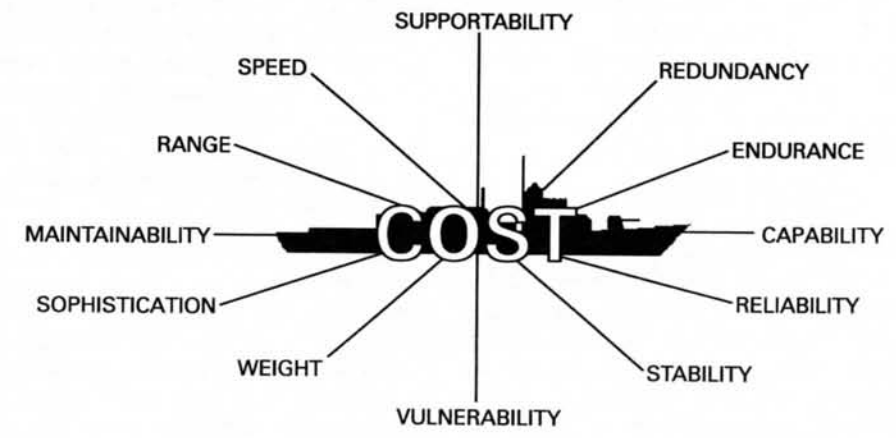


Figure 1. THE WARSHIP AS A COMPROMISE

Conclusion

In the context of our navy's history with respect to ship procurement, the decision to contract TSR was nothing short of momentous. Apart from ceding what traditionally has been a naval responsibility, the navy made what amounts to a leap of faith in acknowledging industry's ability to respond to the challenge. To paraphrase Winston Churchill, who passed similar judgment on democracy, Contractor TSR was probably the worst approach to ship procurement possible — except for all other approaches. The navy had little choice in the matter.

As the first ship of the CPF project approaches completion, the navy is closer to being able to judge the success of its faith in Canadian industry. But until HMCS *Halifax* has been delivered, and operated by sailors, any final judgment would be premature. Nonetheless, a prognosis at this time is not inappropriate.

Although the first of class has not yet been delivered, and a number of "design divergences" have been uncovered (areas in which the ship deviates from the specification), there have been no glaring deficiencies to invalidate our faith in the TSR concept. The technical/contractual disputes seem no more difficult to resolve for CPF than for any other project and, in fact, our reliance on TSR and *performance* criteria has generated sensible solutions. From first-hand observation of ship progress I can state, albeit somewhat subjectively, that the navy is getting a good ship.

In a nutshell, our bold experiment with TSR so far has worked. The process, as imperfect and frustrating as it is, is not endangering our likelihood of acquiring a fully compliant ship with CPF. The skeptics can maintain their guarded optimism for now, but they may be pleasantly surprised at the results.

Captain Chiasson is the CPF deputy project manager (Construction) in Saint John.

A Proposed Naval Combat Trades' Structure for the 1990s

By Cdr Roger Cyr

Introduction

When the Maritime Other Ranks Production Study (MORPS) was implemented in 1985, it established the combat trades' structure as it exists today. The major change brought about by MORPS was the abandonment of the user/maintainer concept, where operators were also trained as technicians and were responsible for both the operation and maintenance of their systems. MORPS separated the user and maintainer functions into distinct occupational groups. But while the separated trades' structure is indeed well suited for the present fleet's technologically limited combat systems, it is perhaps less suited to the needs of our future fleet. The fleet of the 1990s will be made up of ships having complex and sophisticated combat systems, and these will require maintenance skill levels that are not in line with MORPS.

Present Structure

The MORPS split trades were introduced because it was perceived that the technical skill levels of combat system personnel were not sufficient to cater to present-day technology. It was assumed that the level of knowledge required to both operate and maintain our present systems was beyond the capability of individual members. In fact, this assumption is valid as it applies to our present fleet of steam destroyers which are equipped with technologically unsophisticated systems such as the ADLIPS command and control system and the AN/SPS-503 air-search radar. These systems are maintenance-intensive and make little use of automated maintenance and diagnostics tools.

At a time when we have to deal with maintenance-intensive and unsophisticated systems, we are also running out of our most highly qualified maintainers. Record numbers of them are leaving the navy, primarily because their professional qualifications as combat systems technicians are going unrecognized.

Maintenance Skill Levels

Skill levels required to maintain electronic systems can be broken down into three basic categories according to technical knowledge and training:

Low Level: *consists of replacing defective card assemblies or modules after a fault has been diagnosed by an automated process using built-in test equipment (BITE) and automated test equipment (ATE). This level of maintenance requires limited knowledge of electronic theory and can be performed by the operator of the system with little additional training. Maintenance-friendly systems which prompt and direct the operator to the faulty card or module are now available, and they do not require the user to have any technical skills.*

Medium Level: *requires the maintainer to have a fair degree of technical knowledge of the system since interpretation or evaluation of diagnostic data might be necessary. This is the journeyman technician level, the level to which our combat system technicians are presently trained.*

High Level: *requires the maintainer to possess a high degree of technical knowledge of the total system and the interactions between its various subsystems or components. It requires training to the engineering technologist level.*

PLANNED (Technicians)		PROPOSED (Technologists)	
TACTICAL	7	SENSORS	3
COMMUNICATIONS	4	WEAPONS	3
ACOUSTIC	3	COMMAND CONTROL AND COMMUNICATIONS	3
WEAPONS	9		
TOTAL:	23	TOTAL:	9

Figure 1. CPF
Combat System Maintainers

Proposed Structure

The proposed structure to meet the needs of the Canadian patrol frigate and the modernized Tribal-class destroyers would make use of two levels of technical skill: low-level, for running ATE, BITE, diagnostics, and replacement to black box or card level as dictated by the system; and high-level to cater to the system faults which cannot be detected by automated means. With the technology incorporated in the systems of our new ships, the medium-level maintenance skills are no longer required.

The *low-level* maintenance functions would be performed by the operator, who would now become a user/semiskilled maintainer. Ships are such that at times there are high demands for operator skills and at other times high demands for maintenance skills. These demands do not necessarily or usually occur at the same time. For example, in harbour there is little demand being placed on the operator, but there is a heavy burden on the maintenance activity to complete the required planned maintenance tasks. Hence, the operator would be able to complement the maintenance activity at the lower skill level when available to do so since this maintenance level requires limited technical skills.

The *high-level* maintenance functions would be performed by a Combat System Engineering Technologist (CSET). Because of the diversity and complexity of modern systems, there would be three CSET specialties: CSET (Sensors), with specialty training in signal processing; CSET (Weapons), with specialty training in electromechanical technology; and CSET (Command Control and Communications), with specialty training in data networks and architecture.

Ship complements of CSETs would vary according to the equipment inventory of a particular ship or class. For example, it is estimated that CPF would require nine Combat System Engineering Technologists as opposed to the presently planned complement of 23 technicians (*Figure 1*).

There should be two sources for obtaining trained CSETs. The preferred should be through subsidized technical training at civilian technical colleges, with CSETs joining the fleet as master seamen upon graduation as technologists. There should also be a direct entry program at the master seaman rank for civilians who have already graduated as technologists. Direct-entry CSETs would undergo short applications courses specific to their projected employment specialty.

Unlike the present situation where technicians receive substantial operator training, CSETs would be employed solely as technicians throughout their careers. The combat operators, on the other hand, while being employed primarily as operators, would be required to perform low-level maintenance.

The combat operator trades would necessarily be changed to: Radio, Fire-Control, Electronic Warfare, Radar and Sonar. The combat operator complement of ships would remain unchanged, but all operator trades' training would be modified to incorporate low-level, or semiskilled maintenance training.

The Royal Navy is presently looking at restructuring its combat trades as a result of combat experience in the Falklands. The structure being considered will have all combat operators trained as semiskilled maintainers. System-level maintenance will be performed by technologists who will be enrolled through a lateral entry program as combat system artificers.

Conclusion

The CPF and TRUMP ships will bring with them a myriad of new, sophisticated systems, with a totally new technological dimension. The combat trades need to be restructured so that they more realistically reflect the level of complexity of our systems, and at the same time optimize our limited personnel resources.

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

Looking Back

The Bell of *Kapuskasing*

The story of a Northern Ontario town and a Canadian navy ship that became namesakes almost 50 years ago.

By LCdr Brian McCullough

Kapuskasing, Ontario lives up to its motto of *Oppidum Ex Silvis* — "Town out of the Forest." In this densely forested region 800 km north of Toronto, the last thing you'd think to find is a memento of the Royal Canadian Navy.

Yet that's exactly what you do find. And in a train, no less.

The train never goes anywhere. Since 1971 it has housed the town's public museum. But among the artifacts inside one of the coaches is a somewhat unlikely exhibit — the engraved, bronze bell of a Second World War Canadian navy minesweeper.

The bell seems strangely out place here, tucked away in this forest resource community. But curiosity or not, the bell of HMCS *Kapuskasing* is exactly where it belongs.

Ship and town began their association in 1943. Early that year the federal government offered communities a chance to "adopt" ships of the Canadian navy. Kapuskasing jumped at the opportunity and submitted an application to Defence headquarters. Not long afterward, the town was granted permission to adopt an Algerine minesweeper then building at Port Arthur (now Thunder Bay).

The town's ship-adoption committee, chaired by Town Councillor Angus Anderson, launched a fundraising campaign. In all, some $2,300 was collected for the extras that would make shipboard life easier for the crew. It was a generous contribution, considering the town's population in 1943 numbered only about 3,700.

That July several members of the committee went to Port Arthur for the christening and launching of their town's namesake. Thirteen months later, on August 17, 1944, HMCS *Kapuskasing* was commissioned into the Royal Canadian Navy under pennant J326.

The bell of *Kapuskasing*. (*Laura Wallace photo*)

The ship arrived in Halifax in early September and immediately underwent modification for wintertime duty in the North Atlantic. On Oct. 1 she sailed for Bermuda to begin work-ups, but while there had the misfortune of colliding with the frigate HMCS *Hallowell*. She was repaired in Bermuda, then in November returned to Canada to become Senior Officer's ship to EG W-1 of Western Escort Force.

Arriving late in the war as she did, *Kapuskasing*'s contribution to the Allied effort was necessarily modest. Yet along with the rest of her W-1 Group of Alger-

HMCS *Kapuskasing* in 1944. Although the Algerines were designed as fleet minesweepers, Canadian units were not fitted with sweeping gear. (*DND photo M-1259*)

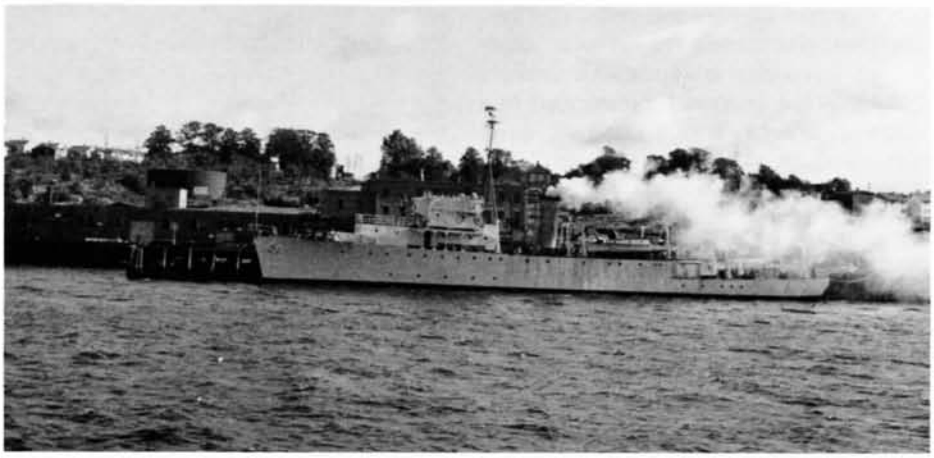
ines and corvettes, her service was indispensable.

For eight months she escorted primarily coastal convoys between Halifax, New York and St. John's. But she also escorted ships of the oceangoing convoys safely to and from the mid-ocean rendezvous off Newfoundland. Throughout, the citizens of Kapuskasing, Ont. kept in touch with the ship's activities and provided various comforts.

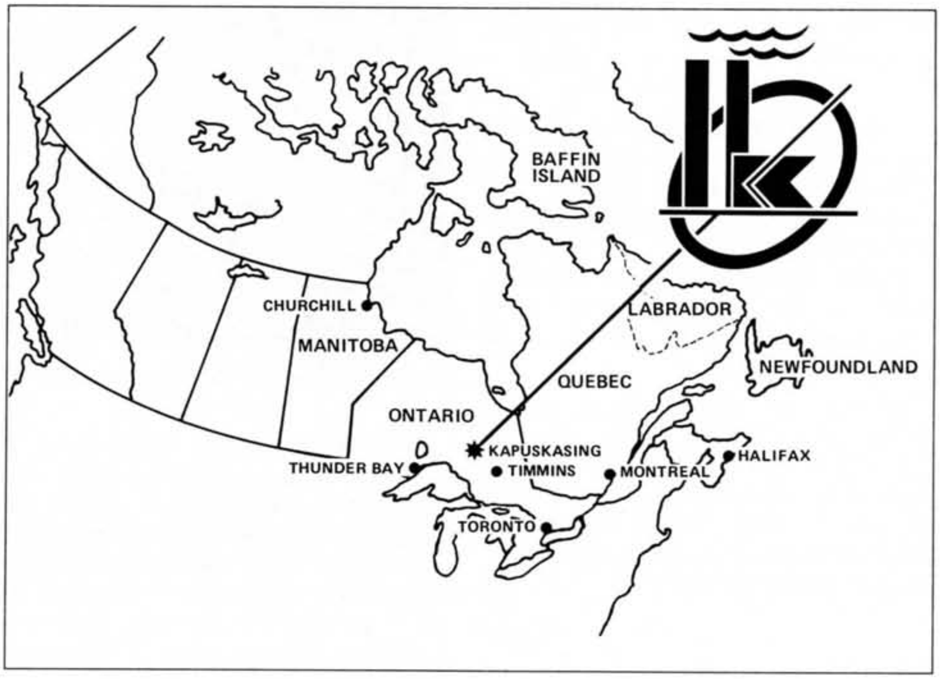
Kapuskasing was at sea on VE-Day and continued in service until all danger of enemy action was past. When the Western Escort Force was disbanded in June 1945, the ship went into maintenance reserve at Sydney for five months before proceeding to Halifax for refit. On March 27, 1946, her active naval service over, the navy paid off HMCS *Kapuskasing* into ready reserve.

A year and a half later the ship's bell was presented to the town of Kapuskasing. A naval veterans' guard of honour under the command of Lieut.(E) Dick paraded for the ceremony in the town's community club. A leading seaman first rang eight bells to signify the end of the bell's navy career, then Mayor Alex Stevenson rang in the start of its civilian career.

Accepting the bell on behalf of the townspeople, the mayor expressed his pride that a ship in the Canadian navy had carried the name of his town. "The bell will serve as a reminder," he added, "of the many Canadian lads who served in the navy, and particularly those who did not make a home harbour at the end of their service."



Kapuskasing in Halifax in October 1949 after conversion to an oceanographic survey vessel. (*W.R. Crosby/DND/National Archives of Canada/PA-171393*)



The Ron Morel Memorial Museum in Kapuskasing where the ship's bell is kept. For train buffs, CN locomotive 5107 was the largest steamer in Northern Ontario and made its last run between Cochrane and Kap in 1961. (*Laura Wallace photo*)

In 1949 *Kapuskasing* was handed over to the Department of Mines and Resources. She was converted for oceanographic survey service, and worked the Atlantic coast and Gulf of St. Lawrence for more than 20 years. In 1972 she was declared surplus and returned to the navy. Six years later, on October 3, 1978, *Kapuskasing* was taken to sea and expended as a naval target.

Acknowledgment

The assistance of Veronica Duczek, curator of the *Ron Morel Memorial Museum* in Kapuskasing, is gratefully acknowledged. She kindly allowed me access to the bell exhibit and historical records three weeks before the museum's annual opening, and later provided me with details of the bell's history not available during my visit in May.

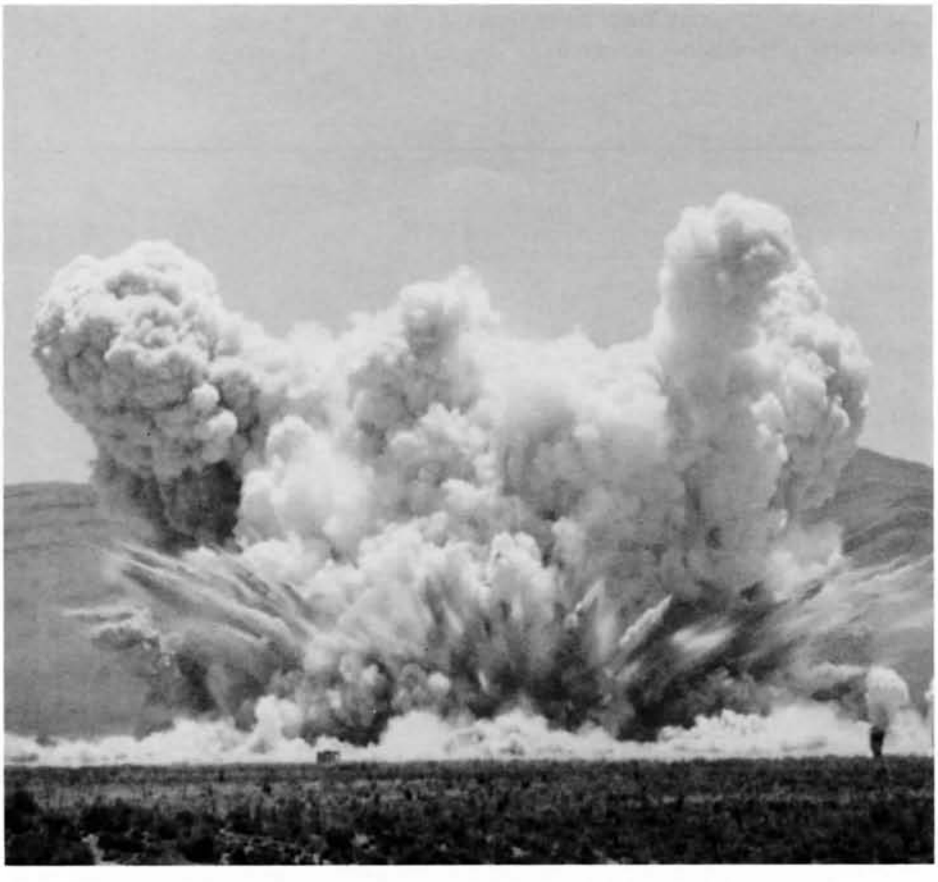
News Briefs

Nuclear blast simulated

DGMEM engineers were on hand at White Sands Missile Range in New Mexico last June 1 to witness chemical-blast effects of a simulated nuclear detonation on various naval structures and equipment.

The test, called Miser's Gold, was the fifth in a series of nuclear-blast simulations conducted by the U.S. Defense Nuclear Agency since 1976, the fourth with active DGMEM participation. More than 2,440 tons of ammonium nitrate and fuel oil — equivalent to a four-kiloton nuclear device — were detonated for the test.

DGMEM sponsored a total of 18 experiments for Miser's Gold, most of them designed to test the effects of air blast and ground shock on topside equipment and new technology in structures. A naval digital recording system to be used for the upcoming CPF trials was also successfully evaluated.



NaMMs DEVAL interim evaluation

An initial assessment of the Naval Maintenance Management System destroyer evaluation now under way in HMCS *Huron* concludes that this DEVAL is a success. The interim evaluation, conducted last March, was based on interviews, surveys and recorded usage information.

The NaMMs configuration consists of a network of ten microcomputer-based workstations and a Digital Equipment/Rugged Micro-VAX II central processing unit and file-server. The maintenance administration software is a dBase III application, developed by Fleetway Consulting Services Inc. The application, *Equipment Management System*, addressed three areas of maintenance management: Equipment Record Register; Maintenance Action Forms; and Equipment Health Monitoring.

Despite early start-up problems, the ship's company warmly endorsed the project and adapted its work pattern to the automated information system. One aspect of the system, the electronic equipment record register (Kalamazoo), received enthusiastic approval as a work- and time-saving feature from more than 90 percent of personnel surveyed.

NRMP at project definition with MCDVs

Two project definition prime contractors are in the midst of a year-long competition for the design and delivery of 12 fully supported maritime coastal defence vessels (MCDVs). Eventually, either Canadian Shipbuilding & Engineering Ltd. or Fenco Engineers Inc. (a wholly owned division of Lavalin) will be given the go-ahead to proceed with project implementation. The two have until next July to submit their proposals to Government.

The MCDVs, which are being acquired under the Naval Reserve Mine Countermeasures Project (NRMP), will provide the navy with patrol and surveillance capabilities in addition to a mine countermeasures capability. The vessels will be operated primarily by Canada's naval reserve. Delivery of the first vessel is scheduled for April 1993.

Apart from the 12 MCDVs, the NRMP will separately procure minesweeping equipment for the mine countermeasures auxiliaries *Moresby* and *Anticosti* commissioned last May, exercise mines and diving support equipment.

Bravo Zulu

Congratulations go out to LCdr Kevin Woodhouse and Cdr Darryl Hansen.

LCdr Woodhouse's article "The *Saguenay* Gearbox Mystery" (MEJ Jan 89) was reprinted in the April issue of Marine Engineering Digest; Cdr Hansen's article "CPF Quality Assurance — Who cares?" (MEJ April 89) is scheduled for reprinting in the fall issue of Quality Assurance Review.