National Defence / Défense nationale

Maritime Engineering Journal

January 1989

Canada

A look back at
HMS *Charybdis*
-page 29

Maritime Engineering Journal

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

Editor
Capt(N) Dent Harrison

Technical Editors
LCdr P.J. Lenk (Combat Systems)
Cdr Roger Cyr (Combat Systems)
LCdr Richard Sylvestre (Marine Systems)
Steve Dauphinee (Marine Systems)
LCdr Richard B. Houseman
(Naval Architecture)

Production Editor
LCdr(R) Brian McCullough

Graphic Design
Ivor Pontiroli DDDS 7-2

Word Processing by DMAS/WPRC 4MS
Mrs. Terry Brown, Supervisor

JANUARY 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.

OUR COVER
HMCS *Saguenay*

Editor's Notes

Due to circumstances beyond our control...

Two years ago when we put the machinery in gear to start the *Journal* on its way towards a bilingual format, we knew that the path would not be without its pitfalls. And how right we were.

Apart from our trial by fire in coming up to speed on the ins and outs of editing and producing a bilingual publication, we found that we had to contend with a seriously overtaxed translation service. Delays in translation meant delays in getting the manuscripts to typesetting — and on it went. But we were determined to have a two-language branch journal before the end of 1988.

In the end we succeeded. With publication of our April 88 issue we were able to deliver the *Journal* to you for the first time in a fully bilingual format. We realized midway in the production of that issue that translation delays would make an April distribution impossible, but a six-week delay seemed a small price to pay for finally getting our new format on the rails.

Unfortunately, the "price" for our September issue ran considerably higher and in a sense we are still licking our wounds from it. Extraordinary delays of up to three months in translation meant that we wouldn't be able to get a bilingual issue out until the beginning of December. It was a bitter pill to have to swallow, but having set the new course back in April we felt there was no turning back.

By contrast, the translation of the issue you are reading now could not have gone more smoothly. Quick turnarounds and excellent translations — we couldn't have hoped for better, and we'll never ask for less. Whether or not such service can be maintained remains to be seen, but in the meanwhile we can applaud the steps that have been taken in recent months to accommodate the needs of the *Journal*.

Among the initiatives being taken to streamline the bilingual production process, we have begun using desktop publishing to incorporate last-minute news items and more up-to-date commentaries. It becomes a bit of a tightrope act, but there is just enough time to get the late bits translated and set by hand before the major articles come back from commercial typesetting ready for paste-up.

So despite some of the frustrating setbacks we have experienced in bringing you a bilingual branch journal, we remain optimistic. The results, we feel, have by far outweighed the effort. What you see here is *not* grudging or token compliance with the Government's policy on bilingualism, rather it is a serious response to it. Today in the Canadian Forces it is the *unilingual* branch journal that stands out as the anachronism. And that is something which we can do well without.

Dent Harrison

MARITIME ENGINEERING JOURNAL OBJECTIVES

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

Commodore's Corner

TASK from a Naval Perspective

By Vice-Admiral W.B. Hotsenpiller

I am most grateful to your editor for an opportunity to provide my final contribution to the *Journal*. Given the number of years I have spent in the personnel world, it should not come as a surprise that I have chosen to comment on a major personnel issue. Lateral skill progression, or TASK (Trade Advancement for Skills and Knowledge) as it is now called, is "older" than MORPS and if implemented will have an even more profound effect on our sailors and their profession than MORPS has had.

As you are aware, the navy is currently in the throes of a lengthy, complex and challenging transition to a new CPF and submarine fleet. This process will generate many changes in the way we do business. MORPS, the most recent major personnel structure review, resulted in a realigment of our NCM occupations and capabilities to meet future fleet requirements. The MORPS decisions were made several years ago, based on our best estimate of what the new fleet would need. Since then our requirements have been refined and new technological challenges continue to be identified. As a result, further changes are in the wind.

To meet the navy's evolutionary operational, equipment and human demands, we require more flexible occupation and career progression structures. To this end, PMO TASK has been given the mandate to develop a new rank, occupation progression and reward policy framework that will meet the future needs of the CF.

TASK is predicated on the need to quantify and reward leadership (rank) and occupation skills separately. This means that as a sailor achieves a higher leadership and/or occupational qualification, he or she will be provided with tangible rewards, i.e. more pay, more authority and responsibility, and more challenging jobs. No longer will the navy be required to conform to a structure where occupational skills are rigidly linked to specific rank levels and where all tangible rewards are tied exclusively to rank progression. The TASK structure would allow the mixing and matching of leadership and occupational expertise *and provide rewards* to meet the unique needs of each MOC and its serving members. Under this system, individuals could achieve higher levels of occupational or technical expertise and be paid/rewarded for this accomplishment, regardless of whether they are promoted in rank. In turn, rank progression would more clearly focus on the requirements to provide effective leaders, supervisors and managers.

How this can be achieved and the specific impact TASK changes would have on the navy and its sailors has yet to be determined. Be assured however that this major undertaking is not an NDHQ solution to an outdated CF problem. TASK is being developed in close cooperation with Maritime Command and the naval branch advisers who are collectively looking to the future. Although PMO TASK is designing the broad policy framework, it will be the navy that decides how its MOCs will be structured and rewarded within the framework by means of a process which, among other features, will involve carefully chosen representatives of each occupation. PMO TASK will also canvass approximately 10 percent of our sailors on both coasts to determine their attitudes towards our current career progression and reward structure. This feedback will be acquired through a formal questionnaire to be given in mid-January 89.

The potential impact of TASK on naval establishments, training, occupation structures and career management must not be underestimated. Moreover, we can and will get it right. In the final analysis, TASK should provide the navy with increased flexibility to:

a. restructure our MOCs in response to new operational requirements;

b. provide career progression patterns that can be tailored to meet our future technological and human needs;

c. provide a means to attract and retain skilled recruits without having to confer rank upon them artificially; and finally,

d. adjust our reward system, which includes promotion, pay, recognition (uniforms, badges and medals), benefits and privileges to reinforce our naval values and beliefs and meet the needs of our sailors.

I am confident that the best interests of the navy and its sailors will be served by this concept and I only wish that I was going to be around to participate in its introduction.

Vice-Admiral Hotsenpiller is the Assistant Deputy Minister (Personnel)

The *Saguenay* Gearbox Mystery

By Lt(N) Kevin Woodhouse

A report on the investigation and repairs made to HMCS *Saguenay*'s port propeller shaft and gearbox.

Setting a Riddle

HMCS *Saguenay* was forced to return to Canada from Europe in November 1986 after colliding with a West German submarine. During the incident, which occurred in August, minor structural damage was sustained on the starboard side of the ship, abaft the engine-room and below the waterline, when the submarine passed underneath the ship diagonally astern, eventually striking *Saguenay*'s port propeller. Two propeller blades received minor damage, one having two or three inches of the tip removed, and the other being slightly bent over at the tip. Apart from an increase in cavitation no vibration was reported and no abnormalities were observed along the shaftline or gearing. Whilst at Wilhemshaven the minor structural damage was repaired and the propeller blades were ground fair underwater.

By the end of August *Saguenay* was back at sea completing her STANAVFORLANT deployment. All appeared well, and the staff of the Naval Engineering Unit in HMC Dockyard Halifax, NS refocused their attention on refitting a steam destroyer at the Ship Repair Unit, and doing a bit of forward planning re Christmas leave.

The first starshell appeared in early November, and the OPDEF message embodied a definite "Run that by me again?...." quality. *Saguenay* reported a sudden one-eighth of an inch oscillation of the port propeller shaft in the engine-room at the bulkhead gland. Also, oil was leaking from the gearbox at the gearbox seal, and the thrust shaft could be seen oscillating at the gearbox output. There was no report of any vibration and all gearing and shaftline temperatures were normal.

Saguenay locked her port shaft and slipped quietly into Rosyth for a closer look.

During the ensuing week a mixed progression of transatlantic telephone calls served only to deepen the mystery. There was no observable damage at either port or starboard tailshafts or A-brackets, yet the thrust shaft at the gearbox was found to be eccentric at the output flange by 0.030 inches. The only other abnormality, which had been reported earlier, was the poker gauge readings taken at the port A-bracket. These indicated a shaft run-out of some 0.050 inches, but clearance within the A-bracket was known to be in excess of 0.125 inches anyway; moreover, underwater poker gauge readings have a special notoriety of their own.

It was well documented that other ships of the class had hitherto received significantly greater damage to propellers (including having substantial portions of blades severed by underwater grounding), without affecting propeller shafts in any way. This knowledge was later to prove most misleading.

The investigations at Rosyth were quite inconclusive. The port gearbox output (thrust) shaft was observed to have suddenly bent, some two months after a minor collision incident. What had happened? How had this come to be?

A puzzled staff at the Naval Engineering Unit recommended *Saguenay* remove her port propeller, for the sake of fuel economy, and return home on one shaft.

The riddle was set.

Brainstorming

Whilst *Saguenay* was enroute to Canada the staffs of the Gearing Section at NDHQ Ottawa and the Marine Systems Engineering Division at NEUA Halifax deliberated independently and then in union to devise an investigation procedure. Time was of the essence because *Saguenay* was due to arrive in Halifax on December 5th, with docking scheduled for the 12th. There would be only one week to find out what was wrong with the ship while she was afloat, before instructions had to be passed to the commercial docking company which would be effecting repairs. A plan of action was finally agreed upon and set into motion. Permission had already been obtained from Canada Customs and Excise to commence work on the ship even before she cleared customs on arrival at Halifax.

Figure 1 shows the layout of instrumentation which was to be attached to the shaftline. The search for abnormalities along the shaftline was conducted by measuring eccentricities at key positions. The insert shows how dial micrometers were fixed to look for distortion in three dimensions whilst rotating the propeller shaft.

For the uninitiated, bearing reaction testing is a rather clever method of finding out if the propeller shaft is bent at a given position. It was planned to check the reactions at the thrust block, plummer block and stern tube. The idea is to lift the shaft by hydraulic jack in four positions of rotation, each at 90°. By measuring the force needed to lift the shaft against the amount the shaft actually lifts, it is possible to show any difference in loading in the four positions. If the shaft is bent, then in the position where the bend is acting downwards on the bottom bearing, the force required to lift the shaft will be greater. Provided the amount of lift is less than the specified bearing clearance, then reaction testing can be done with the top-half bearing in place.

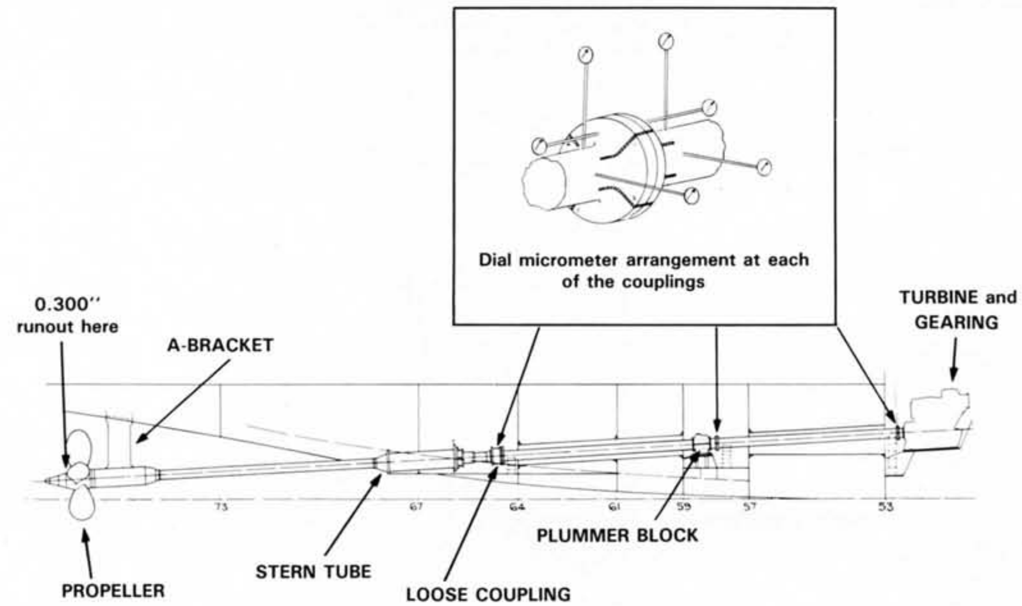


Figure 1. Shaftline General Arrangement

The graphs in *Figure 2* show the results. It will be concluded that all is reasonably well at the plummer block, but at the thrust block and stern tube there are definite bends.

The shaft radial runout (eccentricity) readings arrived next (see *Fig 2*). (The readings were taken twice, first with the shaft turning ahead and then astern.) The data was plotted in two ways — by simultaneously plotting the clock readings at 0°, 90°, 180° and 270°, and by plotting the position of the shaft in the horizontal and vertical planes through one full revolution. By plotting the locus of the centre of the shaft, a clear picture emerged as to how the propeller shaft was distorted.

It appeared as though the shaft, in the course of rotation, was moving eccentrically downwards at either end with respect to the coupling adjacent to the plummer block, which was rotating eccentrically in the upwards mode. At first it looked as though the plummer block had possibly been displaced upwards, thereby causing the shaft to bend, pulling the thrust shaft off centre. Maybe this was the answer. Or were we merely observing the natural droop of a propeller shaft some distance away from its main supports? An examination of the deckplates in the plummer block compartment showed them to be uneven. All tended to bend upwards from the periphery of the compartment towards the centre where the plummer block support webs were welded. Was this extra evidence, or pure coincidence? Structural platework is seldom flat anyway!

As soon as the Fleet Diving Unit arrived an underwater video was taken of the hull areas beneath the port plummer block. There was no sign of any structural damage whatsoever. Expectations of this idea being the solution to the problem evaporated immediately. The underwater camera also showed that there had been no contact between the submarine and the ship at all along the port side of the hull. Significantly, the port shaft and A-bracket also appeared untouched —no damaged paintwork, no marking of the tailshaft fibreglass coating. More perplexed than before, we turned our attention to the port gearbox.

The main gearwheel teeth looked very good with no sign of any damage or uneven wear. Main gearwheel bearing clearances were also checked and found to be satisfactory. Strangely, though, the thrust shaft only a few feet away from the main gearwheel was bent. The bend of the thrust shaft had caused the aft gearbox white-metal bearing seal to wipe and score the thrust shaft there.

The next day the divers bolted a stiff angle-iron extension bar to the port A-bracket to enable a clock gauge measurement of any eccentricity at the very end of the propeller shaft. Once again the video camera was used.

On a very cold December evening a small group of us huddled around a tiny TV monitor on board the diving tender. As the propeller shaft was turned we observed the most startling revelation. Contrary to all previous experiences of this kind the instrument showed an enormous bend at the tailshaft taper — measured at over 0.300 inches.

The appearance of the scant damage to the propeller blades had been completely deceiving. The impact of the submarine fin on the propeller, although inflicting only minor damage to the blades, had transmitted a massive shock through the centre of the screw. The force required to produce such a bend abaft the A-bracket was later estimated to be in the order of 800,000 — 1,000,000 lbf. The relevance of the initial dubious poker gauge readings now assumed a leading, if not embarrassing significance.

The Quick Fix

The ship was docked as scheduled and another check with a clock gauge confirmed the excessive bend in the tailshaft. Now we were reasonably confident in our knowledge as to what was wrong, namely the damage at the tailshaft and the thrust

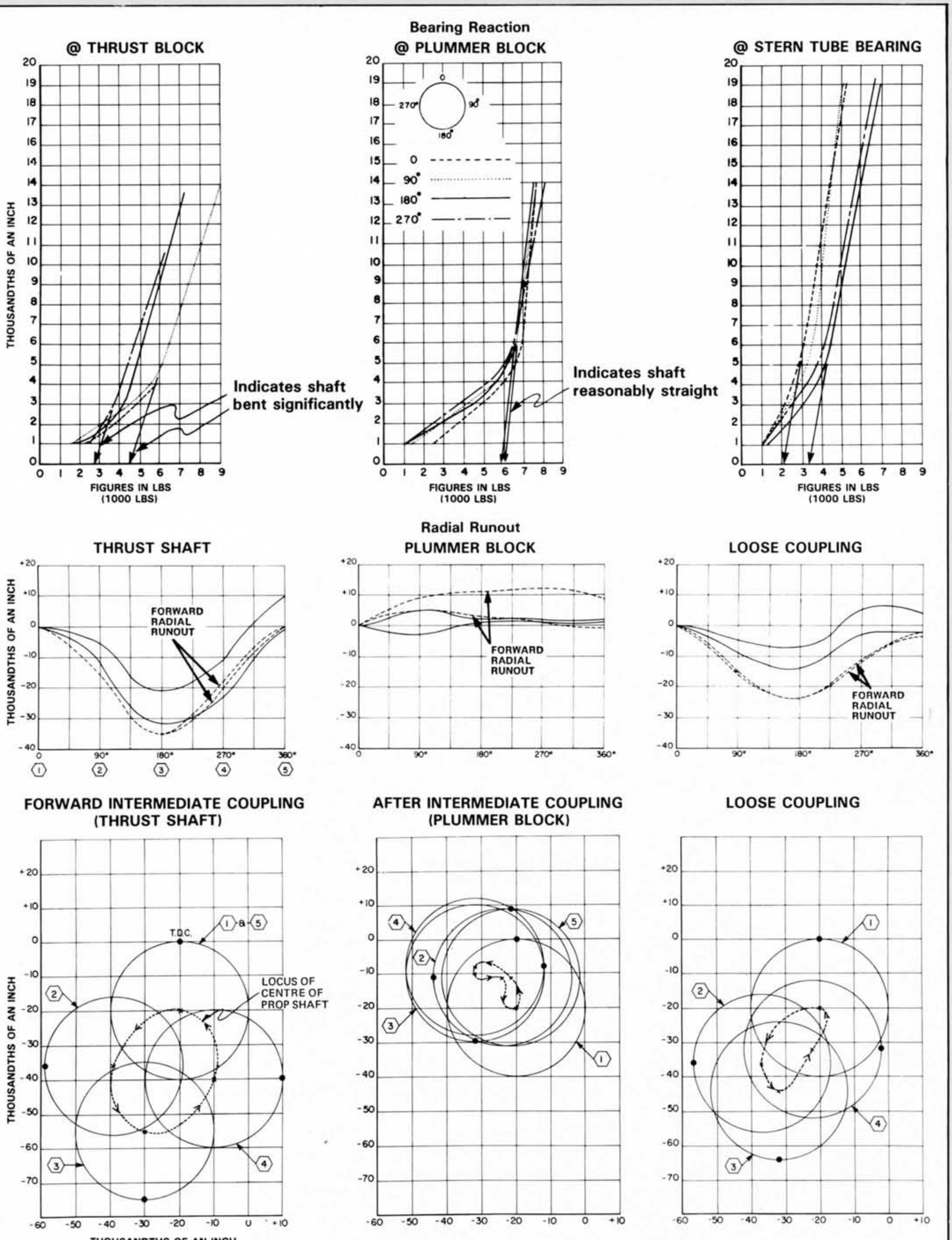


Figure 2. Shaft Distortion Readings

shaft. Replacing a tailshaft is a fairly straightforward operation. But the thrust shaft? It would take months to replace all the gearing elements and gearbox bearings. The idea of an in-situ repair immediately jumped the queue of options, and whilst the contractor was in the process of removing the tailshaft we set to work on devising a repair method for in-situ machining of the thrust shaft.

If it could be made sure that there were no fatigue cracks present in the thrust shaft, and the main gearing and bearings had not sustained any damage, then the repair was feasible.

We were lucky! X-rays of the shaft were negative and a no-load spin test of the gearbox at 196 rpm revealed no abnormal vibrations. The damage was confined to the thrust shaft, affecting both the thrust collar and the output flange (*Figure 3*). The major snag, of course, was that to machine the thrust collar and output flange a method was required to axially locate the thrust shaft. The fertile mind of our machinery inspector produced an answer which involved two methods, both of which used the main steam turbine to turn the shaft astern.

The first method was required to machine the output flange and involved using the bent thrust collar to axially locate the thrust shaft. Although the thrust collar had bent, its thrust bearing was still true. Assuming that the high point of the bent thrust collar would track on its true bearing, axial location could be accomplished. The no-load spin test had already verified there was no axial movement when turning the shaft astern. Once the output flange had been machined the second method could begin.

The second method was required to machine the thrust collar and shaft and involved connecting the propeller shaft to the thrust shaft and using the emergency trailing thrust bearing in the plummer block to axially locate the thrust shaft. A subtle but important adjunct was, of course, to transfer the thrust pads from the starboard to the port plummer block. This enabled the pads to tilt in the correct mode in order to achieve hydrodynamic lubrication. Normally the trailing thrust pads would operate with the shaft turning ahead, not astern. Also, a 1/2-inch spacer was required between the output flange and propeller shaft to maintain the thrust shaft position whilst moving the propeller shaft against the trailing bearing. (It should be noted that the propeller would be installed prior to this procedure.)

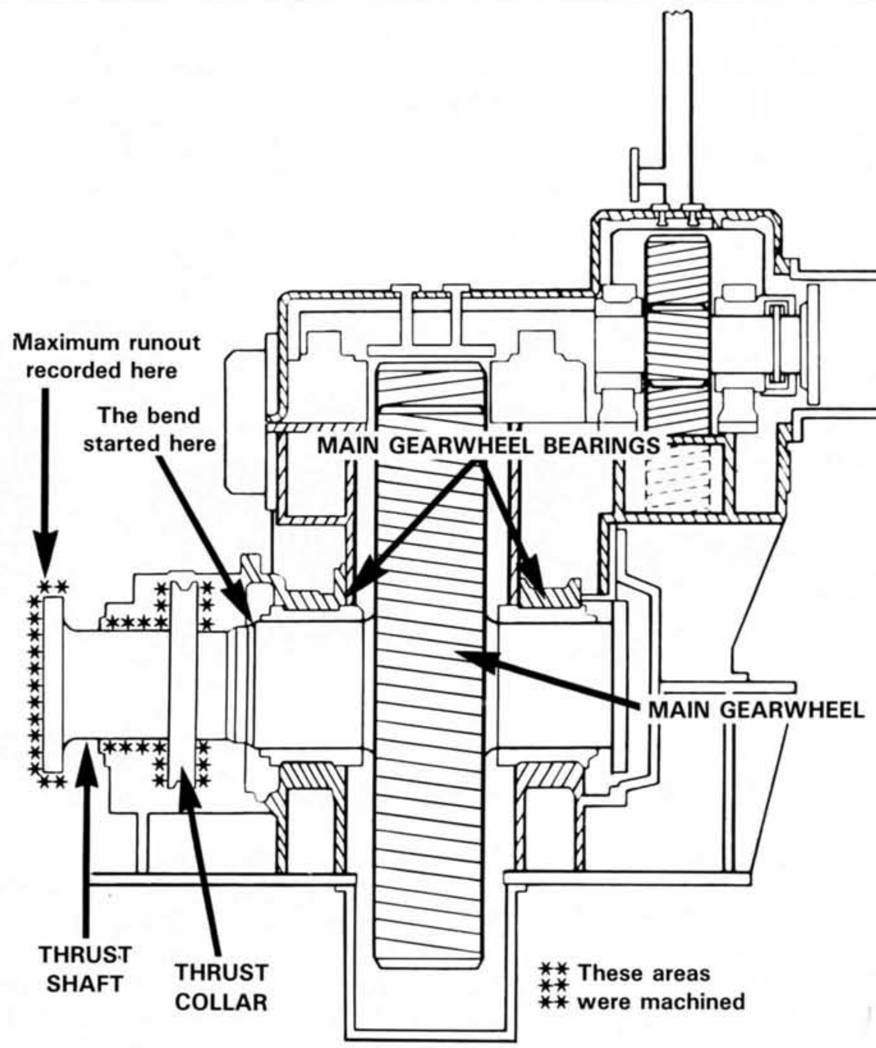


Figure 3. Simplified arrangement showing main gearwheel and thrust shaft with the pads removed.

With most of the brainstorming out of the way we could now proceed with the nitty-gritty. Checks were carried out on gearteeth meshing patterns, which proved satisfactory, and a close look at the plummer block bearings showed them to be in good shape too. Next, the loose coupling was broken, and the damaged tailshaft was removed. An optical alignment check proved that the A-bracket and stern-tube bearings were reasonably true and had suffered no serious damage. These bearings are huge and can absorb a lot of punishment.

A new tailshaft was fitted and coupled, and the inboard and outboard stern seals were replaced as a matter of routine. Once the new propeller was fitted and all the fairing plates replaced, the ship was undocked. Now afloat with her fuel evenly distributed, machining and realignment of the thrust shaft could commence. At this stage *Saguenay* was transferred to the Ship Repair Unit at HMC Dockyard Halifax for the remainder of the repairs. This work was done by SRU staff, assisted by naval personnel from Fleet Maintenance Group Atlantic.

The total indicated runout at the thrust shaft output flange was in the order of .035 inches. The first job was to machine the output flange face with the thrust shaft disconnected, then ream the thrust shaft bolt holes into correct alignment with the intermediate shaft. All this was done with the thrust pads and cover in place and was necessary before we could connect the output flange. New fitted bolts were manufactured for the coupling, and the shafts reconnected.

With the gearbox cover and thrust pads out of the way, and lube oil supply to the thrust collar blanked, a portable machine tool was bolted to the gearbox casing.

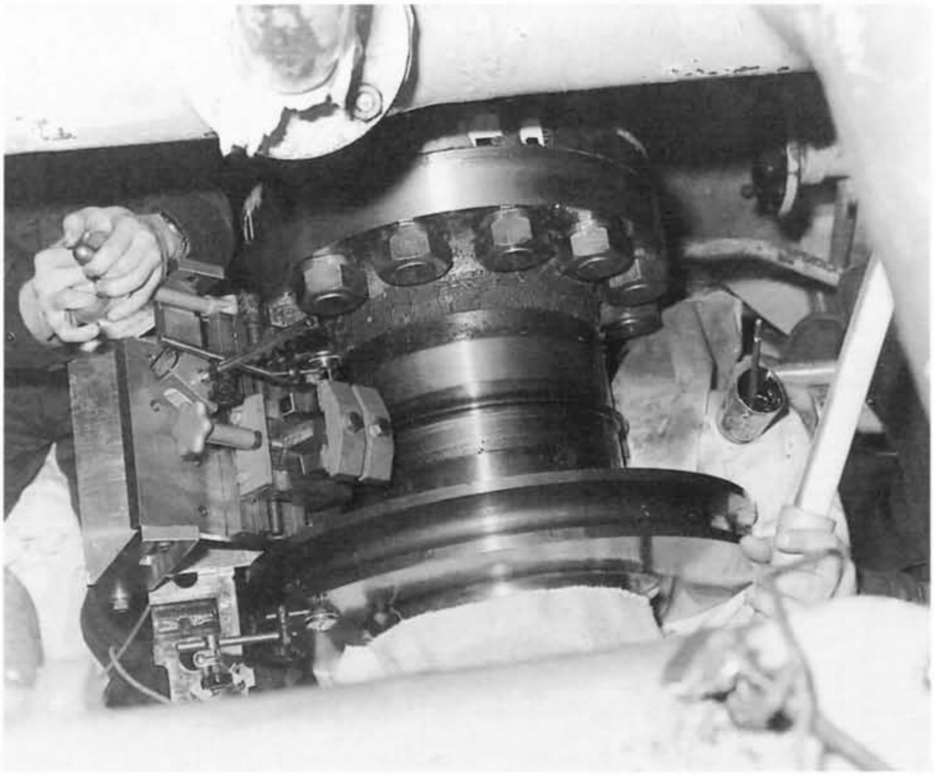


Figure 4. Machining the gearbox thrust shaft *in situ*.

Figure 4 shows this rig being used to machine the areas in way of the after oil seal and bearing. Turning astern at 50 rpm under steam, these areas and the thrust collar faces were machined true, then honed carefully to give a good finish. The simplified diagram shows the areas which were done. With machining operations complete, the thrust pads were replaced and shimmed to retain the correct thrust clearance. The reduced diameter of the thrust shaft necessitated fitting an undersize aft bearing seal. All areas were carefully cleaned out and inspected prior to flushing the lube oil system.

A successful basin trial ensued and two days later, less than ten weeks from the date she entered drydock, *Saguenay* was steaming at full power sixty miles off the coast of Nova Scotia. The rest, as they say, is history.

Non Sequitur

Despite the concerted efforts of several engineers and three scientists, one question remains. Why did the thrust shaft bend in the first place?

There was simply not enough energy at the tailshaft during the collision to transmit the required force forward to the gearbox. Moreover, the bend was not observed until two months later, even though the thrust shaft had been checked regularly during the intervening period.

Whilst several ideas have been suggested, none has gained the unanimous assent of those involved. The most popular theory was put forward by Dr. Jim Matthews of DREA. His premise is that when the submarine hit *Saguenay* abaft the engine-room the impact actually caused the entire ship to bend. The result was that the bulkhead gland abaft the gearbox pushed the thrust shaft into plastic deformation at its thinnest section inside the gearbox. The white-metal bearing seal at the aft end of the gearbox was strong enough to constrain the thrust shaft to run as though it appeared straight. As time progressed however, the extra load on the bearing was sufficient to progressively wear away the white metal, and eventually allow the thrust shaft to run with an eccentricity visible to the naked eye. This idea, although possessing the highest degree of probability, does not convince the naval architects who contend that there was insufficient force to cause the ship to bend at the time of collision.

HMCS *Saguenay* continues to run smoothly nearly two years after the repair was completed. All concerned learned a great deal from the *Saguenay* saga, but the mystery still haunts the mind.

Acknowledgment

The author wishes to express his sincere gratitude to Lt.Cdr Neil Latham, Royal Navy, lately of the gearing section at National Defence Headquarters, Ottawa, Steve Dauphinee of DMEE 2, Dr. Jim Matthews of the Dockyard Laboratory, Mr. Doug Nickerson, Machinery Inspector at the Naval Engineering Unit in Halifax, and to those staff of the Ship Repair Unit and Fleet Maintenance Group who actually carried out the repair work to HMCS *Saguenay*. They unreservedly deserve the credit for the *Saguenay* job, and it was a pleasure to work with them and to learn from them.

Lieutenant Woodhouse is the ISL Class Officer at the Naval Engineering Unit in Halifax.

CANTASS
Bringing ASW into the 21st Century

By LCdr Richard Marchand

Introduction

The Canadian navy has embarked on an ambitious procurement and modernization program. Part of this modernization process involves the development and production of the Canadian Towed Array Sonar System (CANTASS) which will supply the Canadian navy with a greatly enhanced ASW capability. This article presents a high-level description of the CANTAS system, showing how it will indeed meet the navy's current and future passive-sensor ASW requirements.

Background

Experimental towed arrays have seen service in the Canadian navy since the mid-1970s. The success of these experimental systems motivated the initiation of a full-scale development project to produce a tactical towed array sonar system for use on Canadian warships. Treasury Board approved the development project in September 1983, and in April 1984 gave preliminary approval for the production of Canadian systems.

Early in the project it was decided that Canada would buy the most up-to-date array sensor available, the USN's AN/SQR-19. Purchasing off-the-shelf equipment would minimize the technical risk and overall development time frame. A suitable display and processing system to meet Canadian requirements did not exist, so this portion had to be developed. In December 1984 a contract was let to Computing Devices of Nepean, Ontario for the production of an advanced development model (ADM). This was delivered to HMCS *Annapolis* in February 1988 and has since been undergoing extensive sea trials. The CANTASS production systems will incorporate modifications dictated by the lessons learned during these trials.

CANTASS has been designated for installation in HMCS *Annapolis*, HMCS *Nipigon* and the twelve Canadian patrol frigates.

Requirement

The stated requirement for CANTASS is to provide a passive means of detecting and tracking a hostile surface or subsurface target at a distance that exceeds the target's anti-ship-weapon release range.

The requirement was highlighted in the white paper on defence (1987) which specified the need for continued surveillance and protection of Canadian, North American and North Atlantic Treaty areas. Canada's capability for the surveillance of these ocean areas will be greatly enhanced by the use of CANTASS.

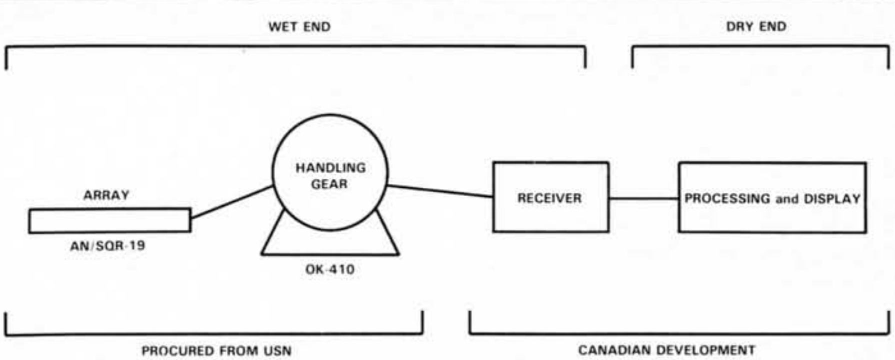


Figure 1. CANTASS Wet End and Dry End Division

System Description

The CANTAS system can be divided into two major elements: the Wet End, comprising the array, array receiver and the array handling and stowage equipment, and the Dry End which comprises the processing and display equipment. This system division is shown in *Figure 1*.

Wet End

The Wet End consists of the following four subassemblies:

a. *The Array*: The AN/SQR-19 is a neutrally buoyant, 800-foot-long array measuring 8 centimetres in diameter. The neutral buoyancy is necessary to ensure that it remains as horizontal as possible while being towed. The array consists of a number of modules which are coupled together in the configuration detailed in *Figure 2*. A general description of each module follows:

   (1) The Drogue at the aft end of the array performs a similar function to that of a sea anchor. The drogue damps out any whipping action of the array as it is being towed and provides the necessary drag to ensure the array remains horizontal during operations. The drogue consists of 75 feet of 3/4-inch polypropylene rope.

   (2) The Telemetry Drive Module (TDM) is a multiplexing module that digitizes and then time series multiplexes the acoustic data produced by the various acoustic modules and the non-acoustic data produced by the HTDM.

   (3) The Heading, Temperature and Depth Module

(HTDM) performs two functions. It measures the array's magnetic heading, sea temperature and array depth, and performs a multiplexing function for the VLF modules of the array. All this data in turn is forwarded to the TDM for onward transmission to the array receiver.

(4) The Vibration Isolation Modules (VIMS) act as shock absorbers that damp out any tendency of the array to snake through the water. They also provide vibration isolation of the array from the tow cable. This isolation reduces the tow-cable induced noise level that the array would see. The four modules described thus far make up the non-acoustic section of the array.

(5) The acoustic modules of the array consist of equally spaced hydrophones to cover the frequency bands of concern; the bands of interest being Very Low Frequency, Low Frequency and Medium Frequency. Although the AN/SQR-19 array has two high-frequency modules, in CANTASS these are used in the medium-frequency mode. The hydrophone spacing in the modules determines the highest operational frequency of the array (to maintain the directionality of the array beams), and the array's acoustic aperture basically sets the lower frequency limit. *Figure 2* shows the acoustic aperture of the AN/SQR-19 array.

b. *Winch*: The array winch assembly consists of the USN's OK-410 winch system (shown at *Figure 3*) which has capacity for holding 5600 feet of tow cable plus the array. Since the cable is negatively buoyant, array depth can be controlled by varying the amount of cable streamed and the ship's speed.

c. *Array Receiver (AR)*: The array receiver is a Canadian-developed receiver manufactured by Gould Inc. of Baltimore, Maryland. To minimize schedule and technical risk it was decided to have Gould Inc. produce the array receiver because of their expertise in producing the arrays.

The array receiver accepts the array acoustic data and the non-acoustic data (temperature, array heading and array depth) and puts it in a usable format for the CANTASS shipborne electronic system (SES). The array receiver also provides the array with a constant D.C. power supply.

d. *Data Recorder*: The data recorder is a high-density digital recorder (HDDR) unit used to collect the raw acoustic data collected by the array. The HDDR does this by recording the acoustic information provided to the front end of the array receiver. This provides the ship and shore establishments the opportunity to play back data for analysis and training.

Dry End

The Dry End, or shipborne electronic system, consists of the six subassemblies shown in *Figure 4*.

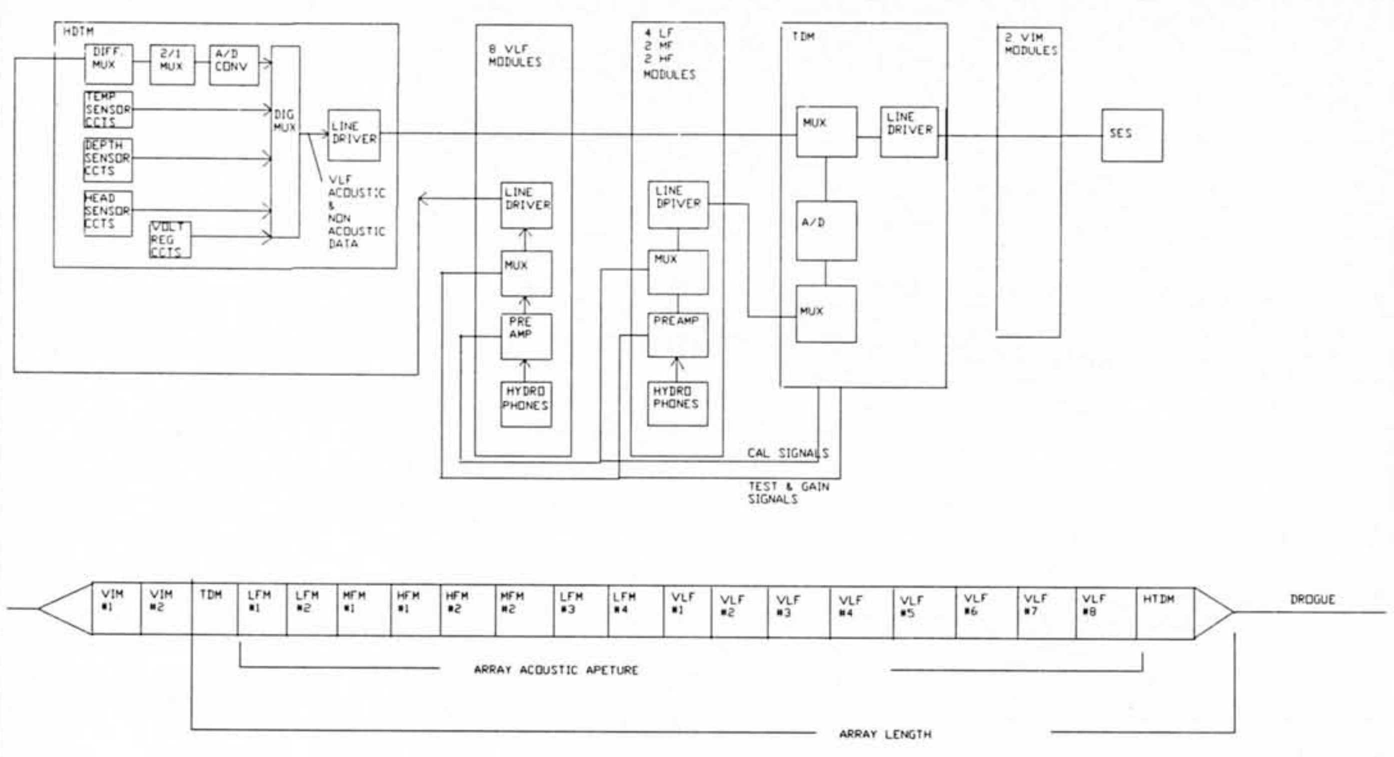


Figure 2. AN/SQR-19 Array Functional Block Diagram

a. *The Data Management and Distribution Unit (DMDU)*: The DMDU is a multiprocessor-based unit that contains 32 Mbytes of mass memory. The DMDU contains two display processors, a system controller and a tracking processor, all of which are based on Digital Equipment Corporation's Micro J-11 processor design. All four processors operate on a ring bus configuration and all are capable of accessing working memory through the system controller. The function of the DMDU is to provide the switching functions necessary to transfer data between the signal processing unit and the displays via the DMDU's working memory. *Figure 5* shows the DMDU system architecture. A brief functional description of each processor follows:

(1) The System Controller's main purpose is to control the sequencing of operations in the SES. The principal operations are:
- The orderly sequencing of start-up and running of the system.
- The gathering and distribution of data within the SES.
- The monitoring of system performance and the reporting and locating of system faults.
- The calculation of a figure of merit (FOM) for the CANTAS system. This FOM will give the operators a range performance estimation for the system.
- The estimation of a fine bearing of incoming target signals of interest. This fine bearing algorithm will give a more accurate bearing of the target. Without this process the target's direction would only be accurate to plus or minus several degrees.

(2) The Display Processors (DP) have several functions to perform. The principal functions are:
- The management of operator inputs.

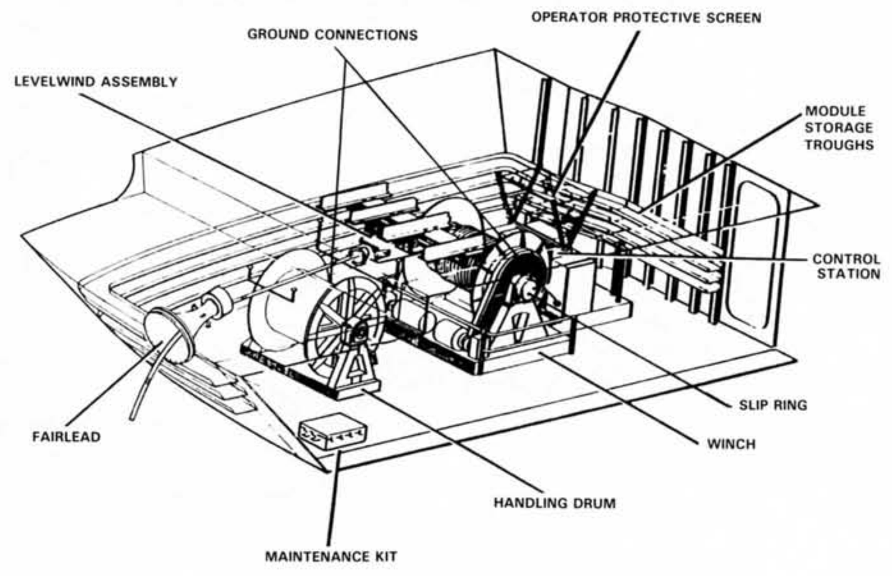


Figure 3. Typical Handling and Storage Gear Compartment Location

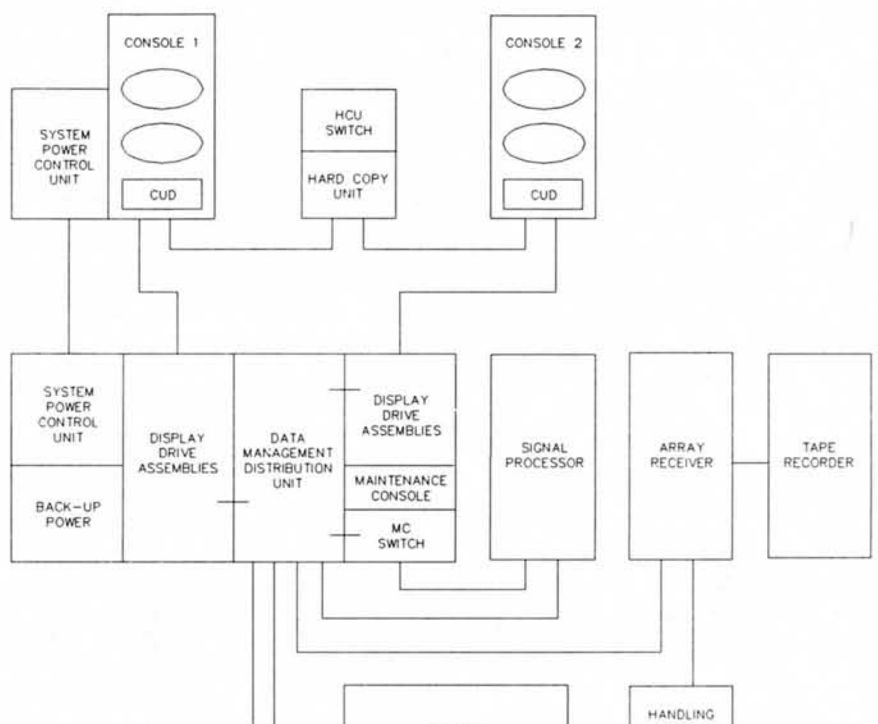


Figure 4. CANTASS Shipborne Electronic System Functional Block Diagram

- The display of environmental, alert and status information.
- The management of tabular area displays.
- The management of the acoustic area displays.
- The management of the SHINPADS display input and output.
- The performance of start-up, diagnostics and equipment health monitoring.

(3) The Tracking Processor's sole purpose is to determine if any discrete frequency components on any given bearing exceed the detection threshold, and if so to initiate automatic tracking. The automatic tracking facility can be overridden or complemented by operator entry of targets of interest.

b. *The Signal Processing Unit (SPU)*: The final production units of CANTASS will make use of the militarized AN/UYS-501 signal processor, although the CANTASS ADM makes use of a commercial version of this signal processor built by Motorola. The AN/UYS-501 is an eight-arithmetic-unit (AU) processor utilizing four megawords of memory. It has a throughput of 320 million floating-point operations per second.

The role of the signal processor is to process the time domain acoustic data into frequency domain data ready for presentation to the operator. Several stages are involved in the processing. The data is first divided into overlapping blocks and transferred into the frequency domain through the use of the Fast Fourier Transform (FFT). Next the data is beamformed, hetrodyned, decimated and brought back to the time domain using the Inverse Fast Fourier Transform (IFFT). Successive blocks of data are concatenated so that the data again represents a continuous time series signal. The data is again transformed using the FFT. The intermediate step of returning to the time domain allows for increased frequency resolution. Finally the data is integrated, scaled and placed in the working memory of the DMDU for display and track processing. The

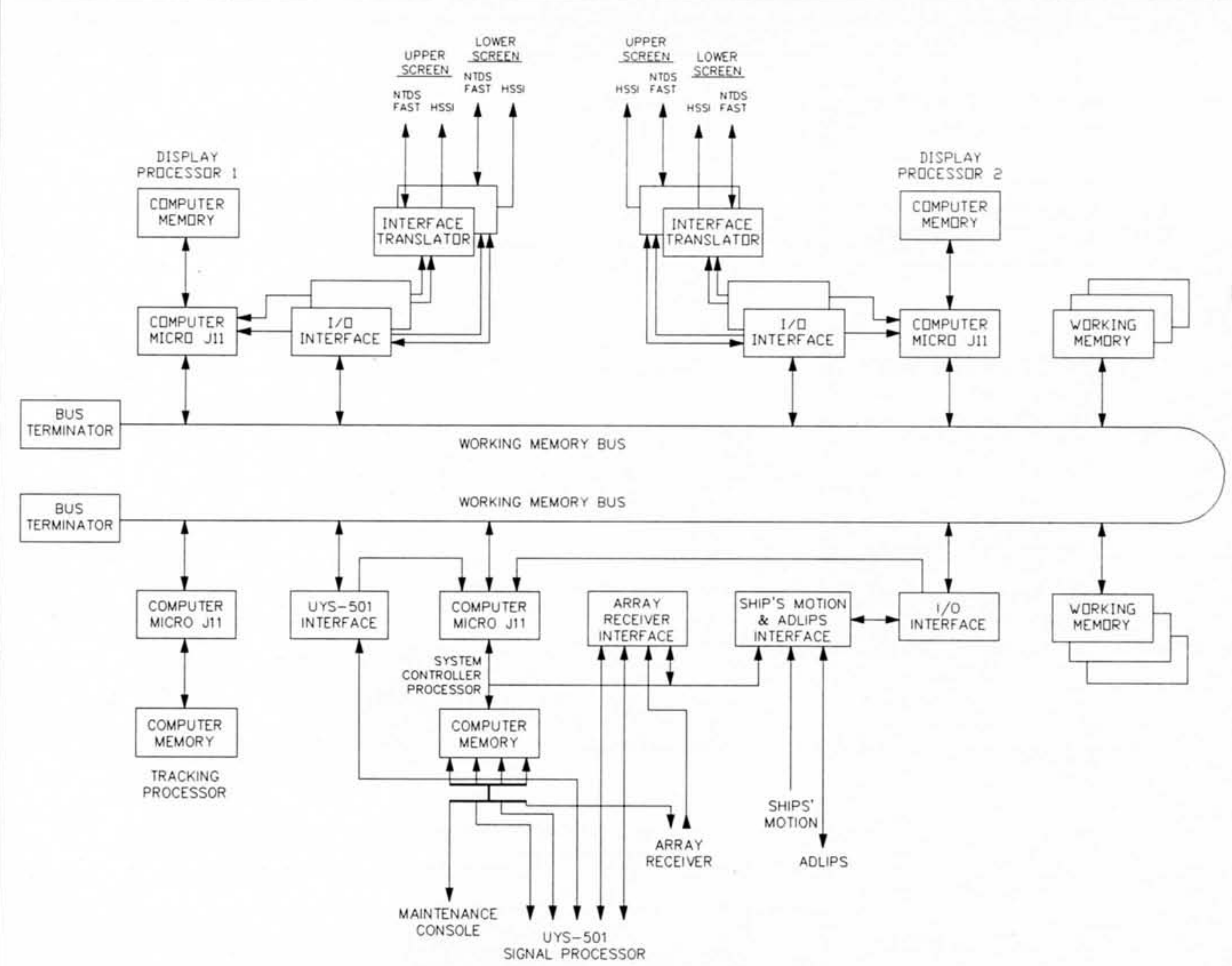


Figure 5. DMDU System Architecture

signal processing data is illustrated in *Figure 6.*

c. *The Display Driver Assembly (DDA)*: The DDA provides the interface between the DP in the DMDU and the display monitors. They provide for the display of the appropriate graphics and acoustic data on the SHINPADS displays. The alphanumeric and graphics data is received by the DDA over an NTDS fast parallel interface. The acoustic video information is received on its high-speed serial interface (HSSI). The DDA also accepts the operator input from the control unit display (CUD) and formats it for use by the DMDU's display processors.

d. *The Dual-Screen SHINPADS Standard Displays (DSDs)*: The DSDs are modified SHINPADS standard displays. To meet CANTASS display requirements, two monochrome CRTs (rather than the standard single-colour CRT) are housed in the DSDs. The monochrome monitor is used because of the requirement for high resolution for displaying LOFARgram data. The current colour monitor technology does not provide the required resolution. The operator can switch between monitors for display and tracking purposes. CANTASS makes use of two DSDs.

e. *The Maintenance Console (MC)*: The CANTASS ADM MC is an AN/UGC-504 teleprinter unit. It connects to the DMDU and allows the maintenance technician to observe equipment health monitoring reports, or to enter the diagnostic mode and perform fault isolation tests. The MC can also be used to set the system adaptation parameters in the system's EEPROMs; these parameters establish the default values that the system uses when it is first powered up. The CANTASS production systems will make use of a microcomputer as the MC.

f. *The Hardcopy Unit and Video Switch*: The SES has a video switch which allows for the connection of one of four DDA video outputs to the Honeywell VGR-5000 hardcopy unit. The VGR-5000 produces an 8 1/2" x 11" black and white hardcopy printout of the selected screen. Thus the operator will have the capability to maintain hardcopy archival information on targets of interest.

System Capabilities

CANTASS is a passive system which is capable of detecting current surface and subsurface targets out to the second convergence zone and beyond. CANTASS will therefore enhance a ship's ASW capabilities by filling the void in the detection envelope as shown in *Figure 7.* CANTASS takes the raw acoustic data and forms 43 equally spaced beams in arc-sine space. Several of these beams are illustrated in *Figure 8.* The beamformed acoustic data is presented on the two dual-screen SHINPADS standard displays, from which the operators can determine discrete narrowband frequencies and broadband signatures associated with a target, as well as determine a target's bearing. Through the use of a fine bearing algorithm, an accurate bearing can be passed to the command and control system (CCS). Target-motion analysis can then be carried out by the CCS to determine a range to the target.

The system and/or operator can create and track up to 240 tracks and markers and assign these to a maximum of 99 targets. The system will automatically track

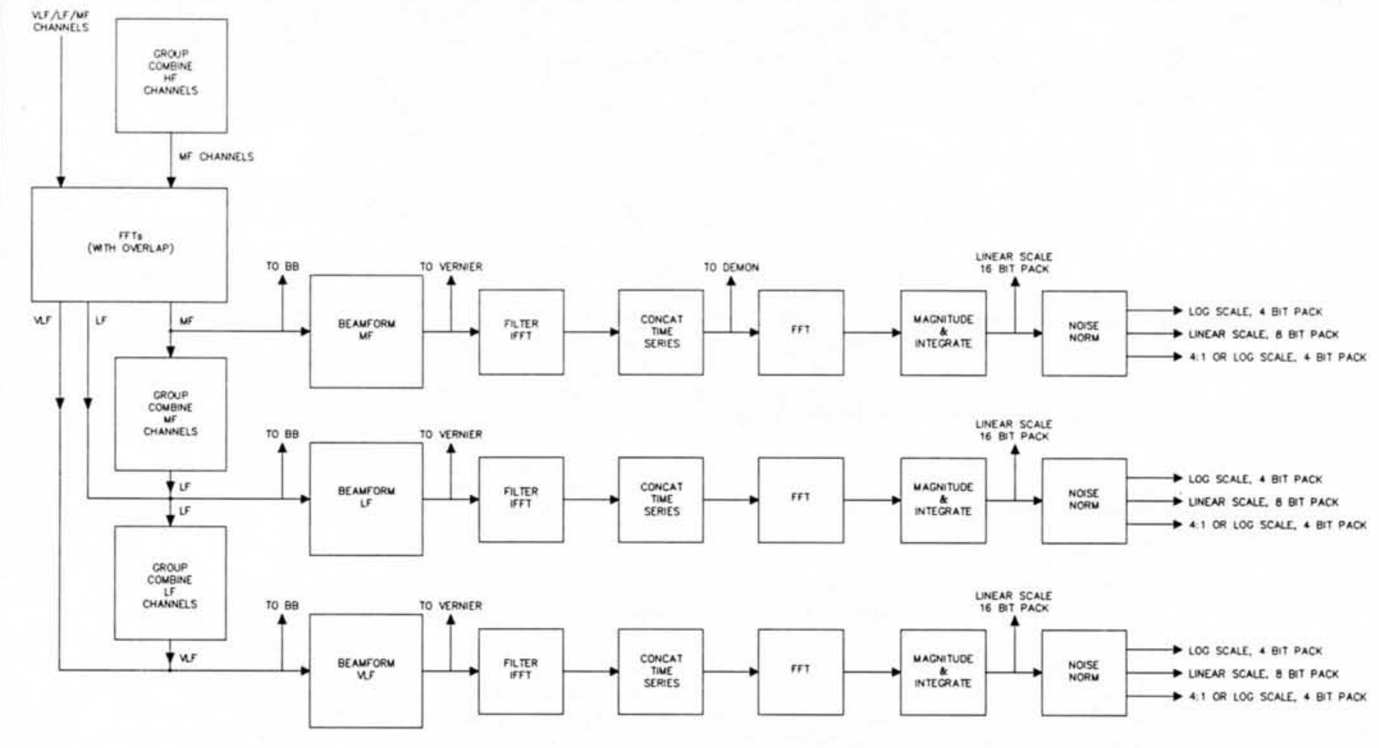


Figure 6. Signal Processing Data Flow

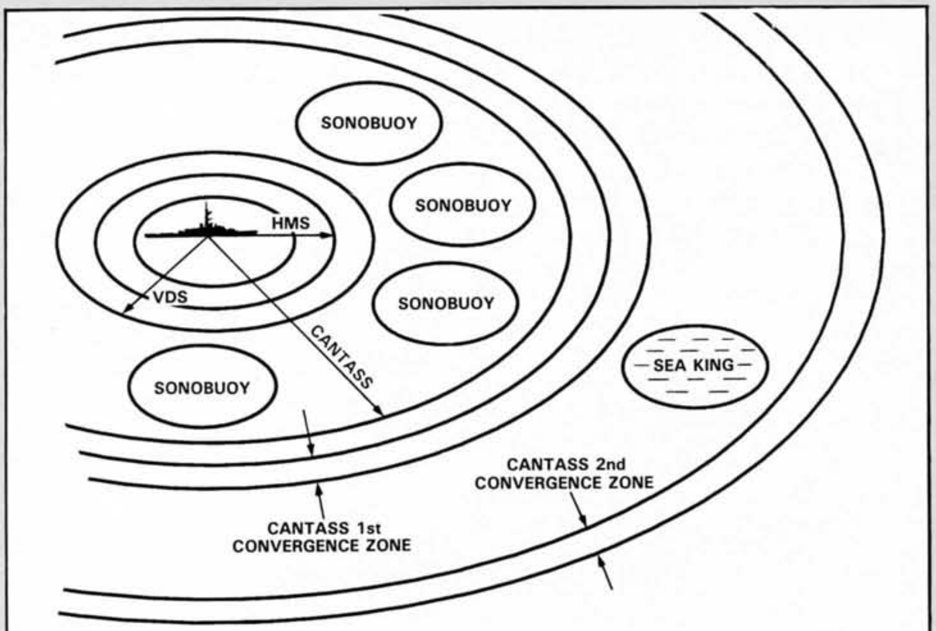


Figure 7. CANTASS Areas of Coverage

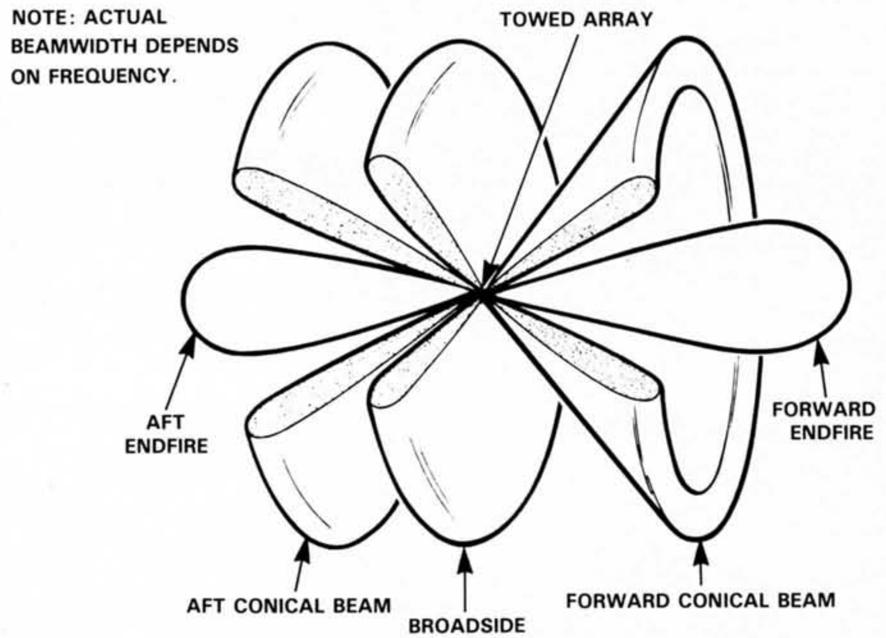


Figure 8. AN/SQR-19 Beam Shape

these targets until they become faded, lost or are deleted by the operator.

The system also possesses an equipment health monitoring function that tracks and reports the status of all system subcomponents. When faults are reported, the system maintainer can make use of a built-in diagnostic program to isolate the failure down to the lowest repairable unit (LRU) — in most cases, a circuit board.

The software design methodology for CANTASS was based on existing software design concepts within DND. The modular construction of the software tasks, combined with a global coefficient data base for use by all processors, makes the system relatively easy to update with new processing algorithms. This will allow the system to be updated to meet the ever-changing threat.

LCdr Marchand is the CANTASS project engineer at NDHQ.

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 8½" × 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.

Development of a Reverse Osmosis Desalination System for the Naval Environment

By Morris Shak and Réal Thibault

Introduction

Reverse osmosis desalination systems (RODS) are not a new concept. They have been utilized and maintained in land and marine installations for more than two decades. Over the years these systems have been improved continuously through the development of better semipermeable membranes that can withstand higher pressures, yet research and major design enhancements continue in search of an improved product.

In May 1984 the Department of Supply and Services contracted a Canadian manufacturer to build a reverse osmosis desalination system, which would incorporate a high-pressure energy recovery pump, for testing and evaluation on a Tribal-class ship. The scope of the technical requirements essentially attempted to keep the design simple and modular with materials and components compatible for the naval environment.

In June 1984 DMEE 4 tasked the Naval Engineering Test Establishment (NETE) to outline a test program that would:

a. prove the equipment integrity (shock test);

b. verify equipment structureborne and airborne noise;

c. set up SOAP on the HP energy recovery pump; and

d. confirm performance by a 200-hour endurance run.

The complete RODS was delivered to NETE for evaluation in late 1984. Had it satisfactorily met all the test program requirements, it would have left NETE in spring 1985. However, this was not the case. Deficiencies in operational parameters and structural packaging necessitated a series of modifications to be undertaken. The redesign, repackaging and retesting are still continuing and this article attempts to trace the developments to date.

RODS vs Evaporators

Past policy dictated that the navy use evaporators to provide potable water and boiler feedwater. As RODS improved and positive claims were made by other marine users, their appeal increased, especially in view of the fact that operational costs were expected to be 50 percent lower than for conventional evaporators.[1,2]

Reference 3 outlines in particular the RODS application for the Tribal class. It states, "The development of Reverse Osmosis Desalination (ROD) has changed the design authority perspective on domestic steam systems, and has also generated discussions concerning the replacement of steam with electric heating throughout the ship. A SHIPALT package is being staffed to revise the existing DDH-280 evaporators and replace them with RODs. Ships using reverse osmosis will have a significantly reduced steam demand and will be able to operate on one auxiliary boiler instead of two in all but the most extreme conditions. In this configuration, availability of domestic steam can be assured by two auxiliary boilers without a third source of steam being required."

Finally, the emphasis on the importance of reverse osmosis in warships is documented in various articles.[4,5] The overall reduction in energy and maintenance costs in addition to the space saved, safer ambient temperature, nonpolluting operation and the more convenient RODS package have been the prime reasons for the decision to phase out evaporators in favour of RODS.

Reverse Osmosis

To understand reverse osmosis, a basic appreciation of osmosis is required. Osmosis is the process of diffusion through a semipermeable membrane. It dictates that when two solutions of different concentrations are separated by a semipermeable membrane, then the purer, less concentrated fluid will pass through to the more concentrated side. This action will continue until concentrations equalize or the pressure on the more concentrated side becomes high enough to prevent any further flow. The minimum pressure that prevents further flow of the solvent is called osmotic pressure of the solution.

With the development of suitable synthetic membranes to withstand the high pressures, and enhancements to the mechanical attachments to hold the membranes in position under pressure, reversing the flow by reverse osmosis could be realized. This procedure now permits desalinating highly concentrated sea water down to the saline concentrations acceptable for potable water and boiler feedwater. Early membranes, originally made from cellulose acetate, have been superseded by polymer esters which provide for higher reject rates and are less susceptible to biological fouling. Presently, available membranes are found in two basic designs, hollow fibre and spiral wound.

Selecting a ROD System

ROD systems in general are packaged in various configurations and sizes to meet specific installation demands and a wide range of throughput capacities. The system design selected in 1984, and as contractually configured for the Tribal-class evaluation, is outlined in the flow diagram depicted in *Figure 1*.

In this arrangement, sea water is fed to a filter media tank with a boost pump. The filter media tank acts as a coarse filter removing most of the undissolved or suspended material in sea water. An electric heater prevents the water from freezing and increases the efficiency of the RODS at temperatures below 5°C. A follow-up

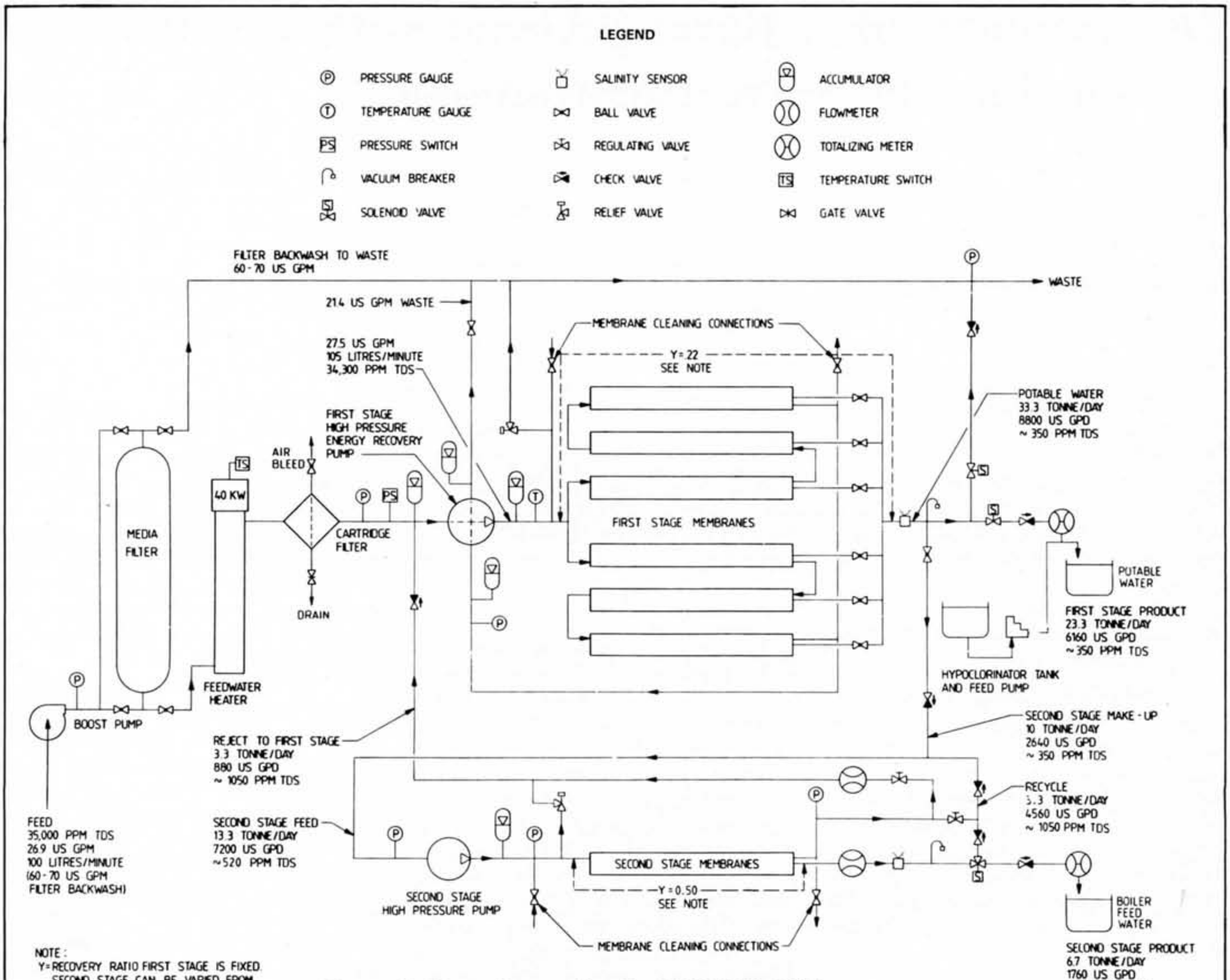


Figure 1. Flow diagram for the DDH-280 ROD system

5-micron cartridge filter further removes the finer particles that pass on through the filter media tank.

The accumulator before the high-pressure (HP) pump reduces the pulsations caused by the HP pump suction, as well as the higher frequency pulsations caused by the boost pump. An HP pump is used to deliver sea water through another accumulator to the first-stage semipermeable membranes at 800 psig. The relief valve intended to protect the HP pump and the semipermeable membranes is set to 1000 psig.

Twelve 4''-dia. x 40''-long spiral wound semipermeable membranes contained within the membrane housing are configured in two parallel flow branches. Each branch is made up of three membrane housings in series with each membrane assembly containing two semipermeable membranes. The highly concentrated brine is rejected while the potable water, with an acceptable saline concentration, now either flows entirely into a holding tank, or part of it is used as intake to a second-stage system using only two spiral wound membranes in one housing to provide boiler-quality feedwater with much reduced salinity concentration.

Performance

In the envisaged application, the performance of the ROD system was defined in the Technical Statement of Requirements as follows:

a. the rated capacity of the plant shall be 33.3 cubic metres (8,800 U.S. gals.) of fresh, potable water daily;
b. the rated capacity shall be obtained when supplied with sea water at 35,000 mg/L total dissolved solids at 25°C;
c. the plant shall be operational with sea water at −2.2°C to 31°C;
d. the post-water-treatment system shall ensure that potable water produced is suitable for human consumption and that it meets the standards specified in A-MD-213-001/FP-001, QSTAG 245 and STANAG 2136;
e. the second stage shall be capable of producing 20 percent of the first-stage capacity specified; and
f. the first-stage effluent for drinking water must contain less than 500 ppm chloride, while the second-stage effluent for boiler feedwater must contain less than 7.3 ppm chloride.

Design

To effectively design a ROD system for use on board a naval vessel, manufacturers must take into account the unique operational and environmental requirements of all applicable military specifications. The following were the major design guidelines imposed on the contractor:

- Modular design to allow the unit to be retrofitted into an existing ship and to enable subsequent modifications to be accomplished without redesigning the complete unit.
- Allow for easy access and maintenance.
- Restrict size to accommodate the geometry of the currently fitted evaporators, including maintenance space.
- Keep weight to a minimum.
- Satisfy applicable shock, noise, vibration and inclination specifications.
- Include an energy recovery pump for the high-pressure first-stage pump (for a saving of 50 percent of energy costs).
- Allow a change-over from a one-stage to a two-stage operation, and vice versa, with minimal valving.
- Produce both domestic potable water and boiler feedwater with minimal valving.

It should be noted that producing boiler feedwater requires a two-pass system to meet water qualities. One way of accomplishing this is to direct the product of the first pass to a holding tank, isolate the seawater supply, then draw the potable water from the holding tank for a second pass through the ROD unit. The alternative method, followed by DND, is to provide a second-stage RO unit within the main ROD system. Apart from being a simpler, faster and cheaper operation, this method allows the reject output of the second-stage pass to be reintroduced to the seawater inlet to reduce the saline content of the seawater supply, thereby improving the efficiency of subsequent first passes.

Finally, the contractor was instructed to provide items such as drip trays to capture and divert the condensation forming on the RODS, suitable operational monitoring and product water quality display instrumentation, and to use acceptable materials. Of primary concern were materials that would withstand the rigors of a shipboard environment both internally and externally.

Seawater handling does pose problems in the selection of materials. Copper-nickel, nickel-aluminum-bronze and high-chromium/high-molybdenum stainless steel are desirable, especially in areas of little or no flow.[7,8,9] Fasteners of 316 stainless steel should be used. Galvanic corrosion must be reduced in general and, in particular, metallic particles must be kept away from the membranes. Reinforced plastic and rubber hoses do not generally cause any difficulty in application. But, impregnated fibreglass filament-wound vessels must be used with caution by first verifying their structural integrity. Although all the hardware required to put together a commercial RODS may be available, it is extremely difficult to find materials suitable for use in the naval environment. Even then, delivery may take weeks or months.

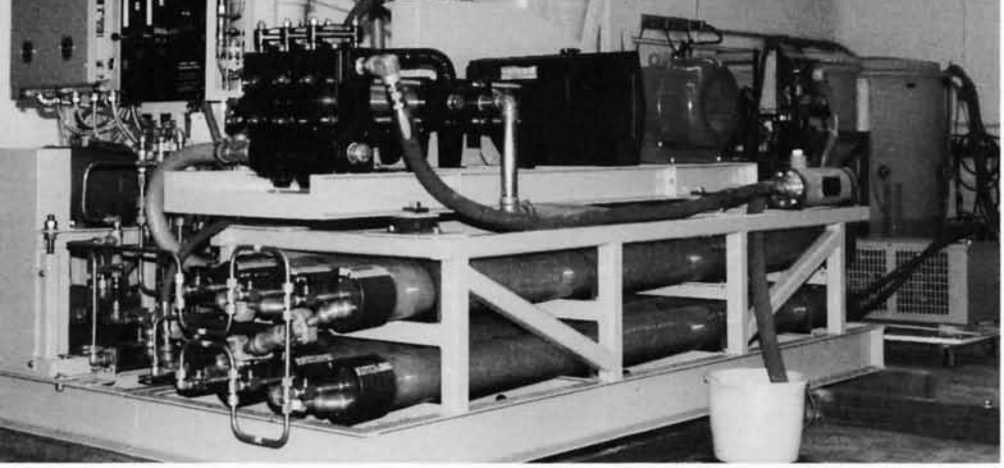


Figure 2. The first RODS prototype

The First RODS Prototype

The first RODS prototype which arrived at NETE in late 1984 was composed of four skids as illustrated in *Figure 2*. It included:

a. a Control Skid with a total weight of 2165 lb, comprising electrical cabinets, pressure gauges, salinity monitors, second-stage pump, motor and accumulator, 5-micron filter, and solenoid valves on one portion, and heater, product flowmeters and suction pump and motor on the other portion;

b. a Filter Media Tank weighing 3260 lb with its four ball valves;

c. a Membrane Skid, complete with first-stage accumulators, having a total weight of 1800 lb; and

d. a First-Stage Skid on four shock mounts, with associated pump, motor and V-belt drive, weighing 1310 lb.

The four skids, when assembled together, were isolated on eight 1000-lb vibration mounts. The complete assembly measured 66'' wide x 99'' long x 82 3/4'' high, with a total weight of 8535 lb.

Prior to arriving at NETE the RODS had passed various functional tests at the manufacturer's facilities (supervised by DMEE 4). However, the prototype failed the structureborne and airborne noise tests which were conducted at NETE in January 1985. Although the airborne test results were close to the allowable limits, they did not meet the specification in all the frequency bands. The structureborne test data demonstrated that the system was especially inadequate in the 32-Hz and 64-Hz frequency bands. As a result of these tests, the RODS supplier hired BBN Laboratories Inc. of Cambridge, MA to prepare a proposal for improving the structureborne noise performance. In May 1985 BBN Laboratories issued a technical memorandum to the supplier, who in turn requested NETE through DMEE 4 to modify the RODS accordingly.

Since the performance of the original RODS during the structureborne vibration test was extremely poor, it was important to gain a better perspective of the final expected structureborne results of a shipboard installation before implementing changes. The three factors of concern in structureborne noise determination were the equipment, its mounting arrangement and the impedance of the ship's interface structure. In August 1985 the impedance at the proposed RODS mounting location on board HMCS *Athabaskan* was measured. With favourable impedance test results, all parties concerned were optimistic that incorporating the proposed modifications would permit the new system to satisfy the structureborne criteria.

The Second RODS Prototype

The conversion process from RODS I to RODS II continued up until November 1986. Incomplete drawings, unexpected interferences in the structural steel members, on-the-spot redesigns and protracted part deliveries played major roles in the long delays. The modifications recommended by BBN Laboratories included the following:

a. *First Stage*
   (1) Add the accumulators to the first-stage skid since the skids and the motor/pump assembly had high vibration levels.
   (2) Use a softer shock mount.
   (3) Place all four mounts above the column members of the membrane skid.
   (4) Move the horizontal centre of gravity of the first-stage skid to the horizontal centre of the shock mounts in order to minimize roll response.

b. *Second-Stage Pump*
   Place the second-stage pump/motor assembly on the vibration mounts. (The original design called for three GE-100 mounts at the base and a 7M50 sway mount acting through the centre of gravity and providing restraint in the athwartship direction. This design was subsequently changed by incorporating two base mounts and two sway mounts.)

c. *Cradle*
   Remove the existing shock mounts and bolt the RODS to a supporting cradle. Mount the new RODS assembly on four 6E-2000 shock mounts located about the RODS' centre of gravity. (Since the original recommendation called for placing the mounts 80'' apart, while the RODS is only 66'' wide, the final configuration was modified. The RODS is still supported at four locations about the centre of gravity, but two 6E-1000 mounts are used at each location.)

d. *Accumulators*
   Change the high-pressure accumulators to oversized accumulators for better vibration attenuation.

By December 1986, the reconfigured RODS had passed both the airborne and structureborne tests. Following the successful tests, the RODS was disassembled into its four major skids and cradle, and the physical changes were measured and recorded. Two of the reworked skids from RODS II are illustrated in *Figure 3*.

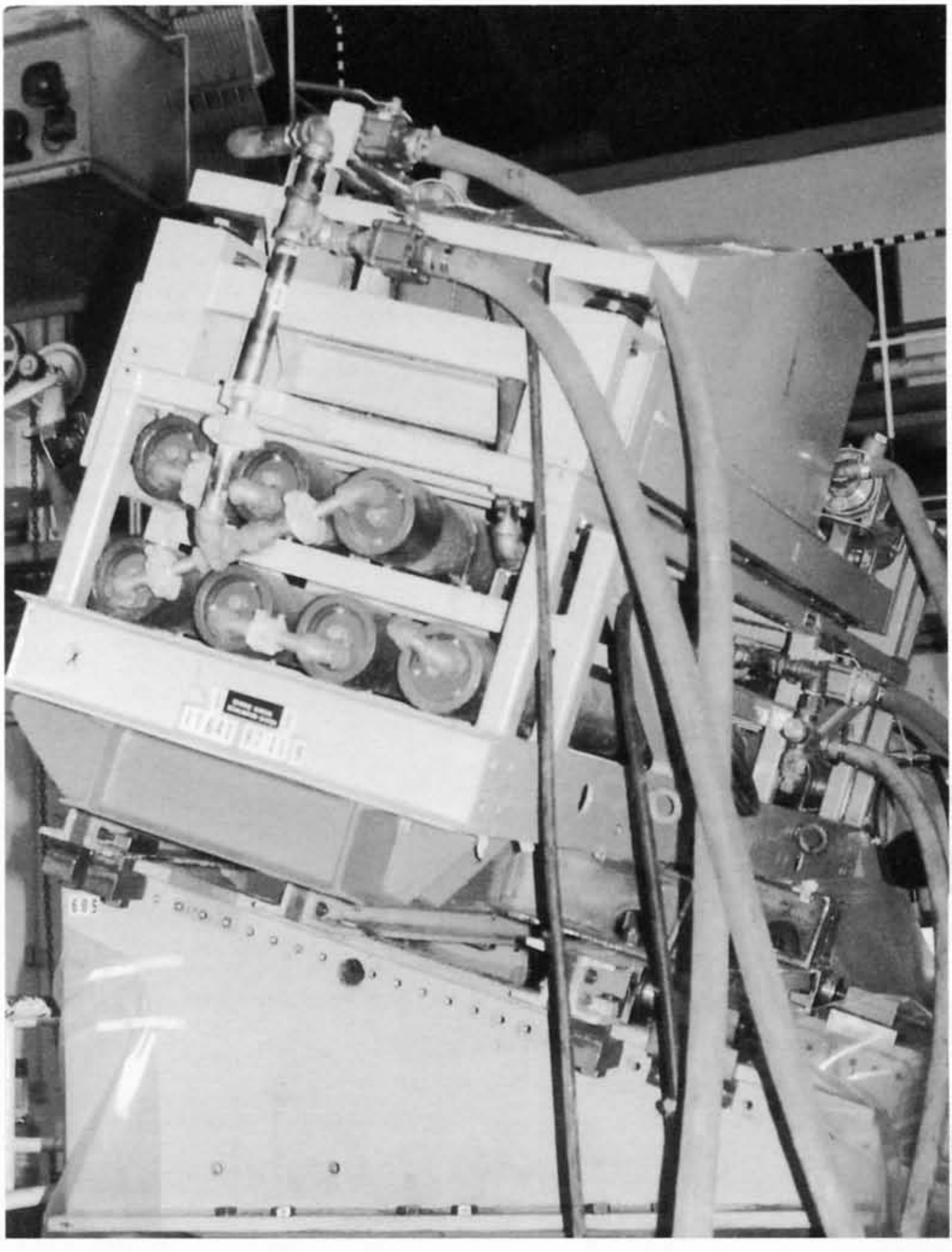


Figure 3. The first-stage and membranes skids of the second RODS prototype on the medium-weight shock test machine.

By this time many drawings were quite different from the original design drawings because of errors, general improvements, and modifications to satisfy the structureborne noise specifications. Also, the original design of the RODS did not lend itself to the potential abuse that hardware is expected to withstand in a naval environment. Installation of protection shelves and bars, and the rerouting of delicate items had to be undertaken, and some equipment had to be reoriented to better suit the RODS location with respect to ship space.

The forced-vibration test started in August 1987. By September, the lack of adequate structural rigidity to meet military forced- vibration specifications led to the failure of the control skid and the filter media tank skid. The other two skids encountered similar problems. Consequently, the design and fabrication of a third prototype incorporating extensive structural stiffening was undertaken.

The Third RODS Prototype

The major improvements incorporated on the skids in the RODS III version can be summarized as follows:

a. The **filter media tank skid** was structurally reinforced by adding angles to the two unbraced sides of the skids. These angles were designed to be easily removed for maintenance.

b. The **membrane skid**, which is the most rigid of the three, incorporated heavier brazing of pipe joints and additional structural reinforcement to prevent the membrane pressure vessel vibration pads from sliding out.

c. The **first-stage skid** frame was found to be structurally weak. The high-pressure pump, complete with energy recovery pump, resonated with an amplification factor greater than ten. The motor resonated with an amplification factor greater than five. The modifications consisted of changing the angles to heavier channels under the pump and placing gussets in the proper locations. These changes reduced the skid vibrations to a tolerable level.

d. The most complex situation developed at the **control skid** (*Figure 4*). Some of the problems encountered and attempted remedies were:
   (1) The heater thermostat did not meet military standards. It failed and was replaced with a military-standard unit.
   (2) The heater elements vibrated quite noisily at various frequencies until a restrainer was introduced.
   (3) The four spot-welded bolts holding down the electrical control cabinet were severed from the cabinet. Special arc welding was used for the four bolts while a sway support was used for the panel inside the electrical control cabinet.
   (4) The needles (pointers) of the various gauges and monitors were difficult to read due to excessive oscillations. Structural steel was added to the frame for extra stiffness.

There was a substantial improvement in the behaviour of the first three skids when subjected to vibration tests. How-

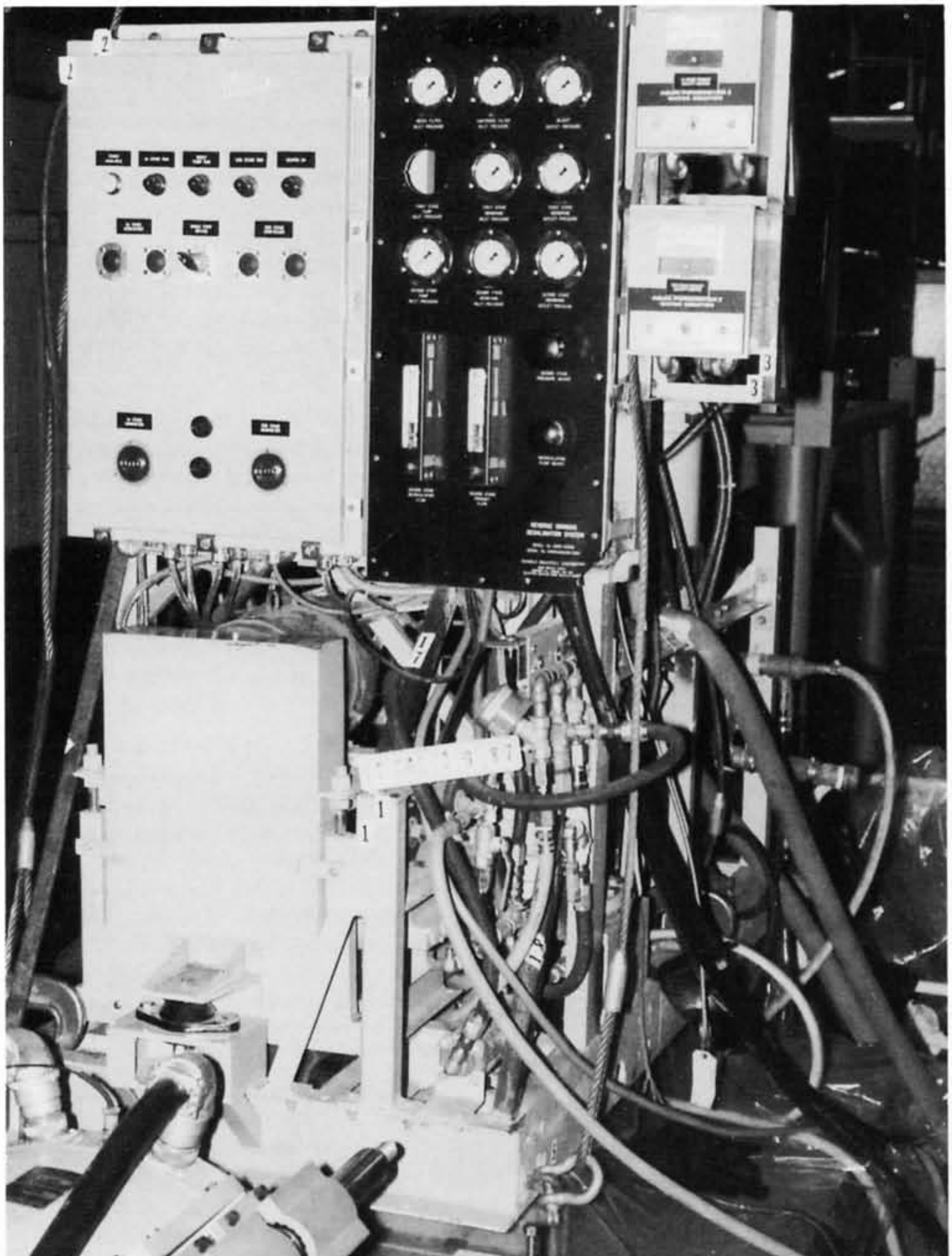


Figure 4. The control skid of the third RODS prototype on the MB-C60 shaker.

ever, although the control skid had also improved, its performance under forced vibration remained unacceptable and the heavy bracings and gusseting left much to be desired in terms of appearance and accessibility.

The Fourth RODS Prototype

It must be noted, at this point, that timing was becoming a critical factor. As the RODS designed for the DDH-280 class also met the requirements for SRP II, the second batch of Canadian patrol frigates, it was decided to have the unit tested and approved by December in order to meet the SRP II contract schedule. By October 1987, shock testing remained outstanding. The modified drawings had to be further revised to reflect the latest level of fabrication and this test alone was estimated to take approximately three months.

The basic engineering principles of the components arranged on the control skid had been ignored in the original design. The top frame was of light construction, with little gusseting or bracing. The two heavy electrical cabinets were located too high, while in one electrical cabinet the heaviest item was placed at the top.

At the risk of missing the December deadline, a decision was made to completely redesign and rebuild the control skid. Remarkably, the work was completed in only three weeks. The centre of gravity of each of the two electrical cabinets was significantly lowered. The light gauges were relocated above the electrical cabinets while the massive salinity monitors were moved below the pressure gauges. Finally, the frame was fabricated of heavier channels and reinforced along the weak axis to improve structural resistance for the second-stage pump, heater and filter housings along both athwartship directions. The results in appearance, maintenance accessibility and vibration and shock resistance were dramatic. The total new wet weight for the RODS IV increased to 9250 lb, plus 1380 lb for the cradle.

The modified RODS IV (*Figure 5*) passed the shock tests in November 1987. This was not, however, the end of the design. The four modular skids still had to be fitted on the cradle. The unit eventually passed all the required tests, and the drawings were provided to PMO SRP II in time for inclusion in the project.

The Fifth RODS Prototype

Further modifications have been made to produce a RODS V configuration, enhancing the performance of the unit with minimal changes to the unit as originally designed. An increase of approximately 40 percent in freshwater production is feasible if the energy recovery pump is not utilized. The energy recovery pump was based on an FMC model 1122D pump. Using this standard pump and a 25-h.p. electric motor in lieu of a 10-h.p. motor, the ROD system could produce 12 320 U.S. gpm versus 8 800 U.S. gpm. Since ROD units are temperature dependent, this increase would allow one unit to supply the water requirements even in northern waters. To achieve RODS V, minor changes had also to be made to the plumbing to convert to a three-parallel fluid circuit, and a throttle valve had to be installed to maintain the required operating pressure.

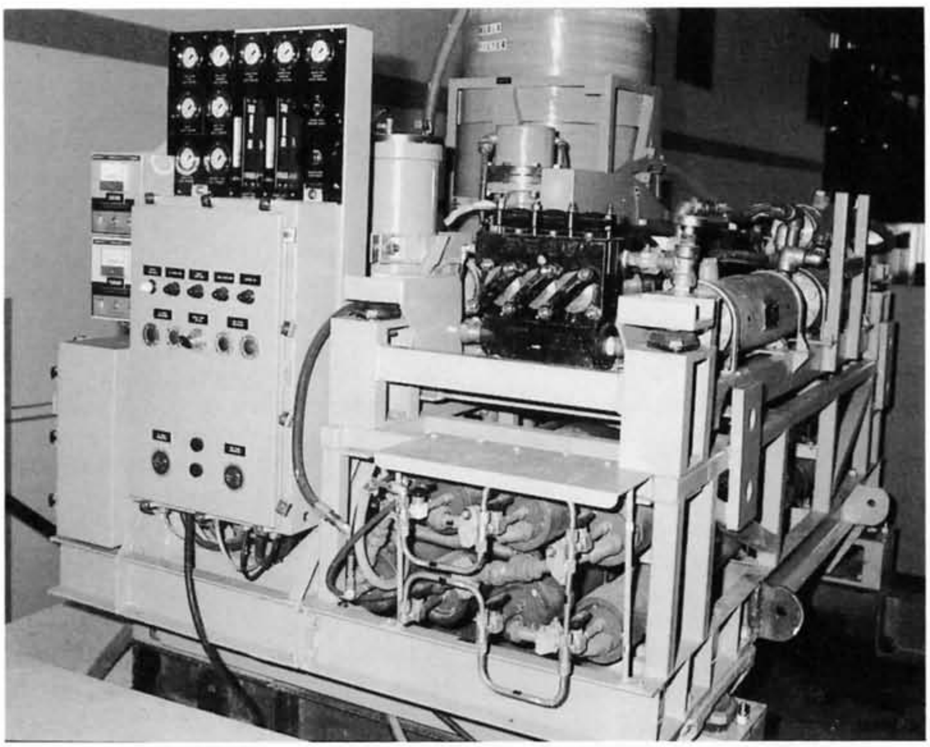


Figure 5. The fourth RODS prototype

Conclusions

It can now be seen that the long road taken to design this particular RODS was principally due to the manufacturer's unfamiliarity with military specifications. Unnecessarily high centres of gravity, unbraced light structural steel construction, the use of non-approved military components, inferior vibration mounting system and hard-mounting (second stage) when vibration mounts were required were some of the major errors committed in the original design. Lack of appreciation of the problems inherent in shipboard operation was evident in the original design.

The final package is the first modular RODS that qualifies for use in the naval environment, making it extremely convenient for installation, refit and modifications. It is also the first such system that can provide boiler feedwater in one simple, continuous operation in any proportion to potable water. Finally, it is also the first such system which employs an energy recovery pump. On certain ships, this feature will prove extremely useful.

The experience with RODS has clearly demonstrated that with increased cooperation between manufacturers and test authorities at the early design stages, suitable and efficient products can be developed for naval use. The need to test and evaluate equipment before installation on naval ships has been shown to be an integral component of the procurement and SHIPALT process.

Acknowledgments

The authors gratefully acknowledge the support of those members of the NETE organization who actively participated in the many modifications and trials associated with the RODS project. In particular they would like to acknowledge the dedicated support of Messrs J. Ouellet, J.C. Demers and J. Jansma. During two and a half weeks in late 1987 these gentle-

men drastically modified the RODS control skid without the aid of drawings. Finally, thanks are owed to Mrs C. Henderson and Mrs. D. Laberge for their patience whenever the typescript came to them with yet another change.

References

1. Sakinger, C.T.: *Energy Advantages of Reverse Osmosis in Seawater Desalination*; Desalination, 40 (1982) 271-281 — Elsevier Scientific Publishing Company, Amsterdam. Printed in the Netherlands.
2. Manuel Morris: *A Comparison of Desalting Process from an Energy Point of View*; Desalination, 40 (1982) 237-244 — (See Reference 1).
3. Scholey, J.R./Neri, J.P./Mueller, G.W.: *DDH-280 Waste-Heat Recovery System*; Maritime Engineering Journal, Winter 1985.
4. Sessions, M.P.N.: *The Efficient Use of Energy in Warship Auxiliary Systems*; Journal of Naval Engineering, Vol. 29, No. 3, June 1986, PP 508-518.
5. Blakey, R.G.: *Auxiliary Energy What Price to Pay?*; Journal of Engineering, Vol. 30, No. 1 PP. 193-201.
6. Gooding, Charles H.: *Apply the Membrane Advantages*; Chemtech, June 1985.
7. Tuthill, A.H./Schillmoller, C.M.: *Guidelines for Selection of Marine Materials*; New York, N.Y., Inco (May 1971), 2nd Edition, PP. 1-38.
8. *Aluminum Bronze Alloys Corrosion Resistance Guide*; The Aluminum Bronze Advisory Service. AB Publication No. 80. Herts, England: Copper Development Association (July 1981) PP. 1-27.
9. Hornburg, C.D./Morin, D.J.: *Design Studies and Requirements for 5.0 MSF and RO Type Desalination Plants*; Vol. I. Technical Proceedings, WSIA 10th Annual Conference and Trade Fair, Topsfield, Mass: Water Supply and Improvement Association (July, 1982).

Morris Shak is a senior project engineer at the Naval Engineering Test Establishment in Lasalle, P.Q.

Réal Thibault is a technical officer with DMEE 5. From May 1986 until February 1988 he was the NDHQ project officer for RODS.

Advanced Marine Engineering Course Projects

A Submarine Propulsion Design Tool

by Lieutenant Commander R.H. Gair, CF

Summary

The design of a total system has always been one of great complexity. This paper analyzes design theory, looks at modern techniques of applying the theory and then uses this information to solve the submarine propulsion problem. The solution uses an expert system as a decision-making tool. The final product is a computer program which provides the designer with a comparative analysis of all solutions for all design considerations.

(Royal Naval Engineering College, Manadon, July 1988)

Gas Turbine Transient Performance Health Monitoring

by Lieutenant Commander N.T. Leak, CF

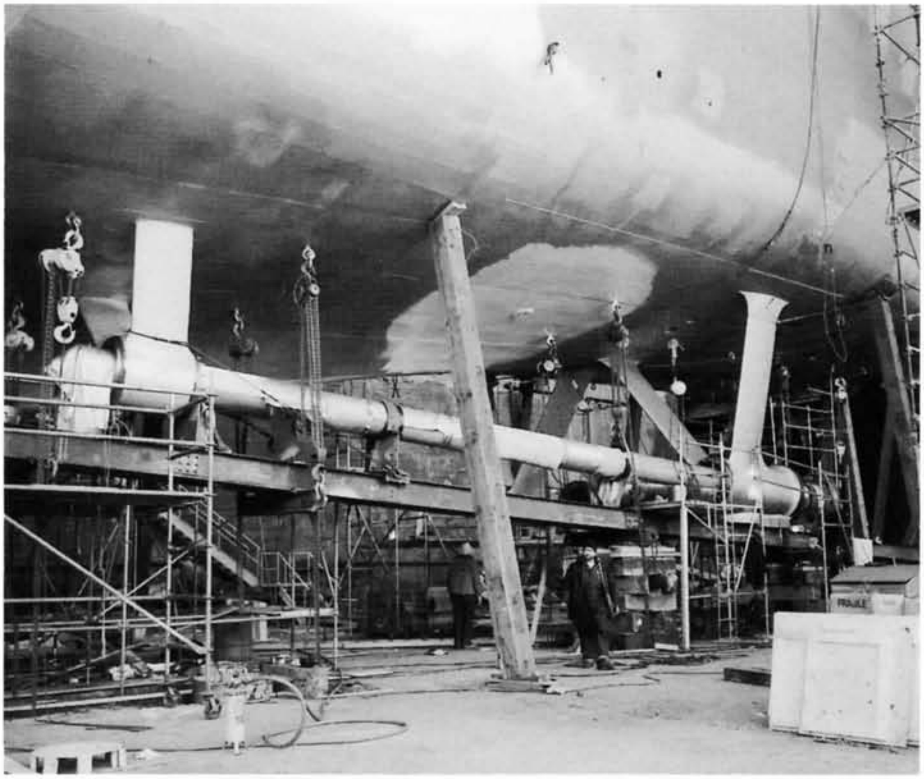
Abstract

This report investigates the feasibility of gas turbine transient performance analysis as an engine health monitoring (EHM) technique for a typical simple cycle, twin spool marine gas turbine main propulsion engine. A computer modelling program was used to simulate transient performance under fault and no-fault conditions. The report concludes that transient performance analysis exhibits sufficient potential as an EHM technique to warrant further development, particularly as a complementary performance analysis technique within an integrated EHM system.

(Royal Naval Engineering College, Manadon, June 1988)

The "Black Art" of Propulsion System Alignment

By LCdr B.B. Staples, PhD, P. Eng



Introduction

The process of propulsion system alignment in a warship has been an area of mystery and confusion to most naval officers (even, marine systems (MS) officers) due, basically, to a lack of exposure or experience. Certainly, during the working careers of most MS officers, the opportunity to "oversee" a complete installation is limited. The purpose of this paper is to help eliminate this confusion by describing what constitutes the process called alignment, some of the alignment techniques available to the shipbuilder, and what is being done in the Canadian Patrol Frigate (CPF).

Background

The process of propulsion system alignment includes the alignment of the propeller shaft system to the ship's hull, followed by the gearing to the propeller shaft system and finally the engines to the gearing. This article will speak to the more intricate of these alignment techniques, namely the propeller shaft alignment.

Although there are many articles available about specific techniques of propeller shaft alignment[1-4], perhaps one of the easiest to understand has recently been published by Vassilopoulos[4]. In his article, Vassilopoulos suggests that the terminology "shaft alignment" is a misnomer. Since the shaft is supported by bearings, the process is, in fact, one of *bearing* alignment. By moving the bearings either forward or aft, vertically or athwartships, the alignment of the propulsion shafting system can be modified.

The propeller shaft system of a warship (*Figure 1*) can generally be described as a slender, flexible shaft supported by five or more bearings which are attached to a complex, flexible foundation. The system must be capable of transmitting propeller thrust and torque, while preventing the ingress of sea water. It must also be sufficiently flexible to accommodate the "hog and sag" movement of the ship's hull.

The correct alignment of the propeller shaft is essential in preventing the following conditions:

a. bearing overload, causing damage to the bearings and shaft;

b. bearing underload, causing shaft vibration and whipping;

c. high shaft bending stresses, causing fatigue failure of the shaft;

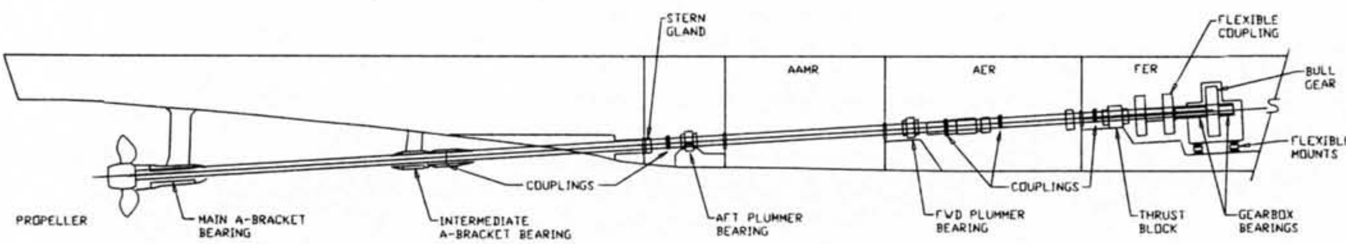


Figure 1. CPF Propulsion Shaft Alignment

d. gear-tooth misalignment resulting from propeller shaft forces and causing possible tooth failure and noise; and
e. stern tube seal leakage due to large relative movement between the hull and shaft.

In the general case (and specifically for CPF), it is necessary that the alignment plan be chosen early in the equipment design stage so as to have the maximum flexibility in modifying the design. When selecting an alignment procedure, the first assumption is that all bearings will be located along a line of sight, evenly spaced and supported by a rigid structure. A detailed computer analysis of the shaft-line is then used to calculate the bearing reactions and shaft deflections. With these results it is then possible to review the shaft system design and consider modifications to bearing location. If the bearing foundation design has been frozen, then it will only be possible to modify the bearing position either vertically or athwartships. This is accomplished by specifying, relative to the line of sight, the centre off-set and inclination of the bearing in both the vertical and athwartship planes. It will be demonstrated later how this philosophy was applied to the CPF.

Having revised the bearing locations, further computer analysis is undertaken to determine the impact of hull movement on the shafting system. This calculation will only provide a rough estimate for bearing reactions. With the complexity of hull structures and the limitation of present computer programs, it is not possible to calculate the precise hull deflection. Thus, practical experience must be used more extensively if modification of the bearing positions is being considered at this stage in the design process.

Once the design has been established, the alignment process continues with the selection, implementation and monitoring phases illustrated in *Figure 2* (Vassilopoulos[4]). The selection phase lasts through the course of the contract and detailed design stages of the ship. It is carried out by the ship's designer, shipyard specialist and occasionally by equipment manufacturers. The implementation phase is carried out by the shipyard during construction and the monitoring phase commences during pre-delivery trials and, in some cases, could continue throughout the life of the ship with suitable instrumentation.

Methods of Alignment

There are several methods available for measuring or checking the state of alignment of a shaft system at any phase of installation and these are discussed in detail elsewhere[1-4]. For the purpose of this paper, only a list of these techniques is necessary; to wit:

a. piano wire — the simplest and most common method which is still used extensively by shipyards, basically a line-of-sight method based upon a fixed reference;
b. optical techniques — similar to the above method, but using telescopes or laser instruments, hence eliminating errors associated with wire sag;
c. gap and sag — (generally used in combination with a. or b.) consists of measuring closing tolerances (at couplings) just before components are assembled;
d. bearing reactions — the "normal" approach in alignment implementation using hydraulic jacks or load cells (this is used after a., b. and c. and is the primary proof that alignment has been achieved); and
e. strain gauges — a "new" technique in which gauges are affixed to the shaft itself to allow for in-service alignment checks (may be used with an RF transmitter to give dynamic strains with shaft in motion).

In the case of the CPF, the prime contractor Saint John Shipbuilding Limited (SJSL) has used a combination of the first four methods. This is considered "common" shipbuilding practice as these techniques were employed during construction of the DDH-280 destroyers. It is the responsibility of the Prime Contractor (SJSL) to devise an alignment procedure to demonstrate that he has met the contractual requirements of the technical specification.

CPF Contract Requirements

The requirement for alignment of the propulsion machinery is as stated in the prime contract[5].

"The design alignment of the propulsion machinery shall be achieved with the ship afloat in a load condition approximating that under which the Contractor's Sea Trials shall be undertaken. The design alignment shall be achieved with the ship subjected to low ambient temperature gradients and with the propulsion machinery in the warm running condition."

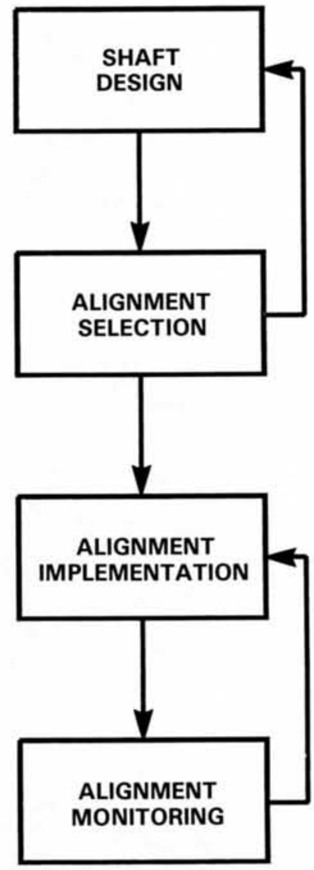
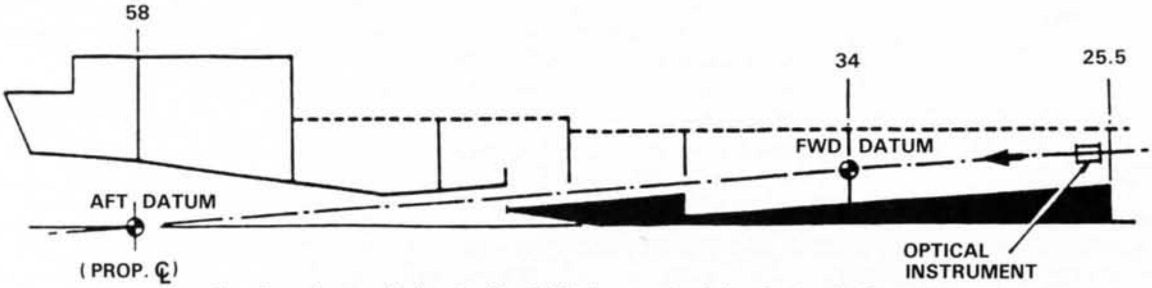


Figure 2.
Shaft Alignment Phases

Futhermore, the contract specifies the position of the shaft axes relative to the bearings, gap and sag allowed and the bearing load and influence numbers. In order to achieve all of the criteria, the contract describes a "minimum" procedure to be followed. As previously stated, this procedure should be subject to change during the design process (as has been the case). Specifically, SJSL and their sub-contractor, YARD Ltd of Glasgow, developed a "Unique Procedure" for the alignment and installation[6] based upon the original contract document. This is a "living" document which will be constantly reviewed and revised by the contractor and DND until the design alignment is achieved. The final stage of the process will be the trial of the installed system[7] just prior to the commencement of sea trials.



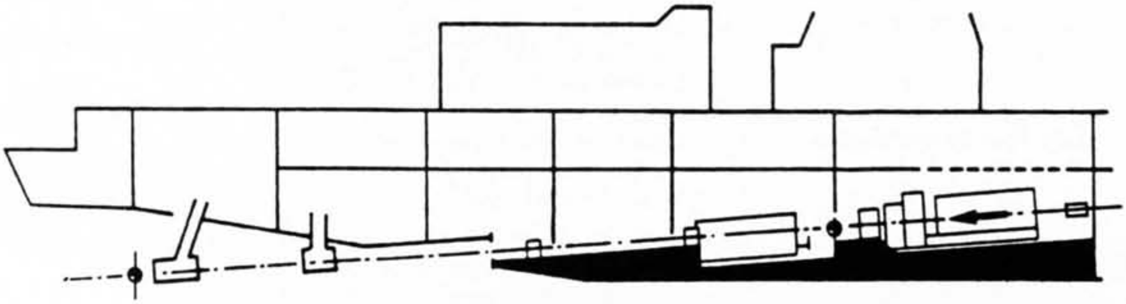
1. Erect bottom hull units. Establish datums. Optimize design shaft centre lines to ship seatings.

2. Ship gearbox, gas turbine raft, diesel engine and main thrust blocks.

3. Weld hull up to No. 1 deck. Temporarily install A-brackets. Drop stern.

4. Transfer aft datums to hull. Check propeller tip clearance. Align and weld A-brackets.

5. Align gearbox to design shaft centre lines.



6. Erect upper hull units. Bore A-brackets. Finalize design shaft centre lines relative to gearbox output shafts.

7. Align and bolt gas turbine raft to gearbox. Align gas turbines, diesel engine and main thrust blocks. Fit resilient mounts under rafts.

8. Align plummer bearings. Install shafting. Check pre-afloat shaft alignment and bearing loads.

9. Check afloat alignment. Realign inboard shaft bearings as necessary. Fit main shaft flexible couplings. Check afloat bearing loads.

Figure 3. CPF Alignment Procedure

CPF Alignment Procedure

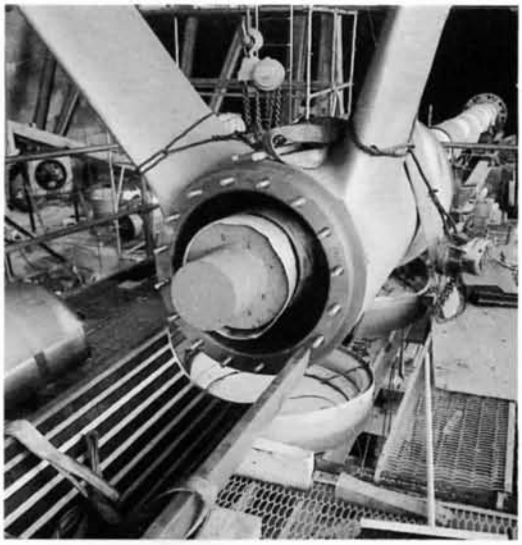
The exact details required for each step of the procedure, and most of the reasoning behind those requirements, are discussed at length in the Unique Procedure[6] and will not be repeated here. However, *Figure 3* is extracted from the reference to illustrate the steps being followed.

Discussion

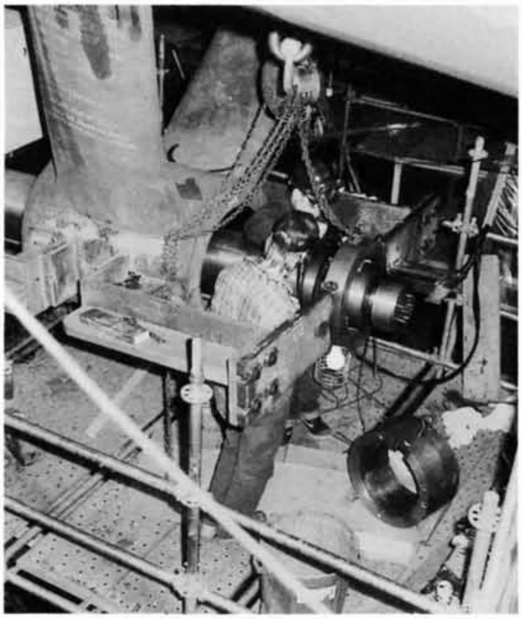
The methods used by shipbuilders to apply the alignment procedure are all basically scientific measurement techniques applied to a physical environment. They appear to be an exact method of determining if a bearing or piece of machinery is aligned. What then is the mystery? Why is alignment a problem?

The problem arises from the fact that a ship afloat is not in a static environment. It is subject to hogging and sagging along its length and, to a certain extent, racking. The designer must allow for this when he establishes his theoretical axes for alignment. This procedure is also relatively easy to model. However, the difficulty lies in determining exactly how to account for the artificial constraints placed upon a ship when it is in the graving dock and not supported by buoyant forces.

It is also noted that because of the effects of creep and temperature distortion upon the design, alignment is not normally achieved by a straight line-of-sight process. This is illustrated in *Figure 1* which shows that the design shaft centre



Intermediate A-bracket showing installation of bearing stave.



Setting up the boring machine for the starboard main A-bracket.

Final check on the port main A-bracket bearing.

line for the CPF can be established optically, however, the deflected shaft axis in the operational afloat condition requires that the barrels of the intermediate and main A-brackets be slope bored. Also note the requirement for the aft plummer bearing to be raised 4.0 mm above the design shaft centre line.

When building a ship, the approach is from the other extreme. It is almost impossible to predict what a ship will do when it is floated-up. Although breakage readings and stern-drops are done, the best a ship designer can hope for is that the ship will assume a fair curve upon float-up. Ships of the same class have been known to move in completely opposite ways. The result is that the design alignment is such that it is a median about which there is a great deal of movement.

The "black art" is to design a shaftline with enough flexibility to take into account all of the possible configurations. This is usually a result of a great deal of experience and some good luck. That is why the procedures tend to be conservative and somewhat redundant in that in the case of a design error there will be enough information available to rectify the problem at minimum cost. In the case of the CPF procedure, it is felt that the inherent flexibility of the shaftline and the very basic approach should allow for correct alignment despite the fact that this system is one of the first dual-shaft, cross-connected installations in North America (albeit the DDH-280 raft is very similar).

Conclusion

The paper has tried to explain that the mystery surrounding alignment procedures is not so much one of technique of achieving an "alignment" (the process is a controlled measuring process using any of several methods) as much as it is a problem of determining how a ship will behave while afloat. This can vary from ship to ship and hence the design alignment must have enough flexibility to allow for the dynamic environment that a ship must endure. In fact, for an MS officer, the procedures are precise and exact, however, the final result of a well-aligned machinery system is dependent upon the ability of the designer to predict what his ship will do in a seaway.

Acknowledgments

The author would like to acknowledge that the majority of the CPF-01, HMCS *Halifax* pictures and figures are used with the permission of Saint John Shipbuilding Limited. Also, the assistance of LCdr P.J. Horsted, RN for suggestions and discussions about the "black art" was much appreciated.

References

1. C. Archer and D.K. Martyn, *Static and Dynamic Alignment*, Trans I Mar E (C) Vol. 91, Conf No. 4, Paper C31, pp. 24-31, May 1979;
2. A.W. Forrest Jr. and R.F. Labasky, *Shaft Alignment Using Strain Gauges*, Marine Technology, Vol. 18 No. 3, July 1981, pp. 276-284;
3. Y. Latron et al, *The Why and How of Shaft Alignment*, Trans I Mar E (C) Vol. 91, Conf No. 4, Paper C29, pp. 3-11, May 1979;
4. Vassilopoulos, *Static and Underway Alignment of Main Propulsion Shaft Systems*, NEJ, May 1988, pp. 101-116;
5. CPF Contract Schedule A, Part 3, Section 3, Annex 2, V3B4P2S5 Propulsion Machinery Installation and Alignment;
6. CPF Propulsion Machinery Installation and Alignment Procedure Rev. 2, CDRL 368X, DID QA-015 04 May 1988;
7. Inspection of Installed Shafting, Gearbox and Engine Alignment, Rev. S1, Trial Serial No. 619, Trial No. M/24/150/201/00/000, 29 Oct 1987, CDRL 371X, DID QA-019.

Prior to his posting last October, LCdr Staples served three and a half years as the CPF Marine Systems and Quality Assurance Officer in Saint John, NB. He is currently with the directorate of nuclear safety policy at NDHQ.

Evolution of the Man/Machine Boundary in Combat Systems

By Cdr Roger Cyr

Introduction

The Canadian navy has experienced quantum leaps in combat system technology over the past few decades. Much of this evolution has affected particular sensors and weapons which form a warship's combat suite, but significant technological advances have also been realized in the way in which sensors and weapons are integrated. And, this, it is believed, is the area that holds the greatest potential for technological advancement. The advent of artificial intelligence and mass data-storage devices is clearing the way for the development of so-called "smart" machines. Capable of high-speed, high-level decision-making, these smart machines will likely effect the gradual replacement of what is arguably the weakest element in the command and control of a combat system — the operator.

Background

In the 1960s the command and control (C^2) function on board Canadian warships was performed solely in a manual fashion. Sensors and weapons were manually operated and monitored, tactical data was transmitted via voice commands and tracks were plotted manually. Ten years later, the new DDH-280 Tribal-class destroyer brought forth a great improvement in shipboard command and control through some integration of the various elements of the combat suite. Although there were marked ameliorations in the Tribal's sensors and weapons with the introduction of surface-to-air missiles, the evolution in C^2 technology was undoubtedly the decade's most significant improvement in combat systems.

The 1980s saw the start of construction of the new Canadian patrol frigates. Again, these ships reflected major enhancements over the class of the previous decade as a number of tactical functions became automated to provide automatic detection and tracking and limited capability in threat evaluation and weapon assignment. But where the state of the art in system design, processor memory and processor speed placed certain limits on the extent of automation and integration in the ship, further automation of the CPF C^2 process was undoubtedly stifled somewhat by institutional constraints and an unwillingness by humans to accept too high a level of automated decision-making.

Manual command and control of the 1950s

Operator Shortcomings

In many systems operator intervention is introduced in order to make up for deficiencies in system design. That is, the particular function could well have been performed automatically, but the design did not cater to it and an operator function was created to compensate. Many functions still heavily dependent on human intervention, such as the identification of threats, can best be performed by a machine in today's complicated combat environment. Indeed, the human may well have become the weak link in the process and his intervention may have to be suppressed.

There is plenty of evidence to prove that the human element is a risk factor in today's complex C^2 environment. A USN investigation into the downing of an Iranian commercial airliner in the Persian Gulf last July by the U.S. cruiser *Vincennes* revealed that the ship's Aegis air-defence system worked properly, but that crew members misread the data which was presented to them. Under the stress of combat they expected to see an Iranian F-14 fighter attacking their ship, so in spite of the information being presented to them by the ship they assumed the aircraft was an attacking F-14. Their psychological biases precluded them from making an

Semi-automated command and control of the 1980s

accurate assessment of the situation. According to U.S. psychologist Michael Canter, an expert on perceptual bias, such human mistakes are almost unavoidable in battle. Where it is called human error, it is in fact human nature or human shortcoming.

In other cases the risk factor stems from a human shortcoming much more straightforward than anything so lofty as perceptual bias. It is the human's inability to react quickly enough to a modern threat at sea: USS *Stark* damaged by an Iraqi-launched Exocet missile in the Gulf last May, HMS *Sheffield* destroyed by an Argentinian Exocet missile in the Falklands in 1982.... The list goes on. A report of the *Stark* incident stated outright that because missile attacks evolve so quickly, leaving little time in which to defeat even a single threat, computer-to-computer automation should be used to cut reaction time in a number of critical paths where operator decisions are currently required.

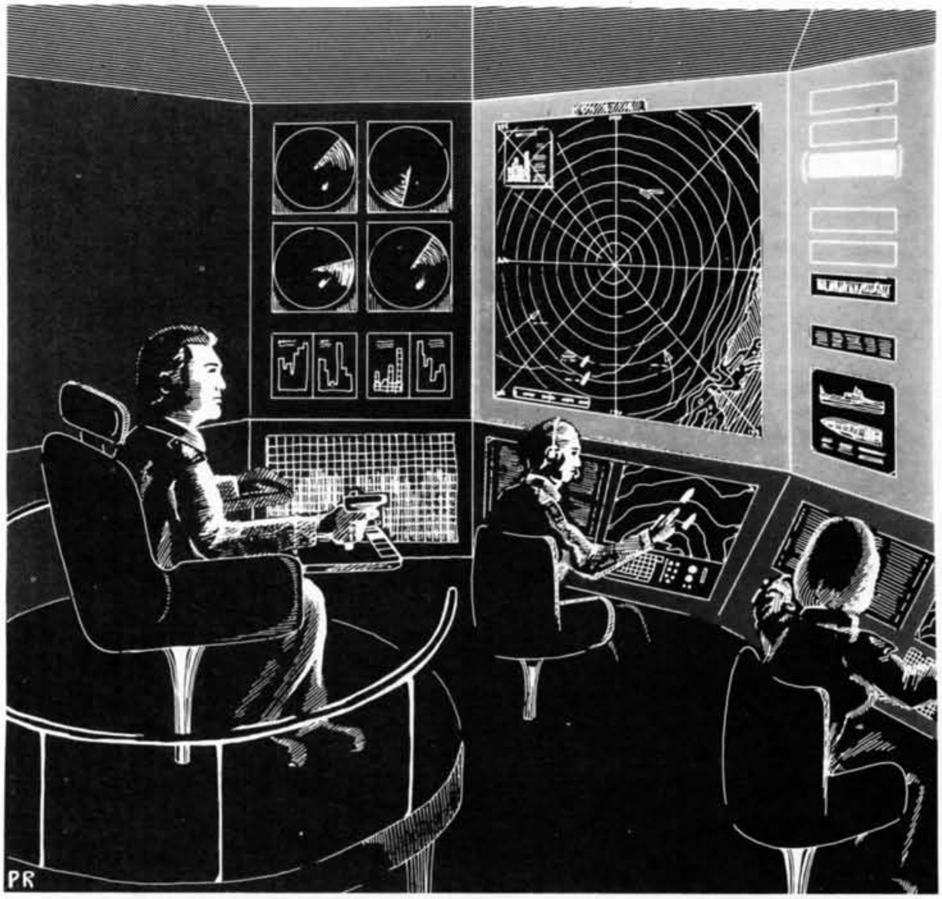
Even in non-battle situations the consequences of man attempting to cope with complex systems can be fatal. At an air show in Paris last June an A-320 Airbus crashed during a demonstration flight. A sophisticated aircraft, the A-320 was designed to be able to prevent most pilot mistakes, but not quite all. The aircraft system prevents the pilot from taking the aircraft outside a safe flight envelope — overstressing the aircraft by turning too tightly, or stalling by flying too slowly — but if he wants to, the pilot can still fly the aircraft into the ground.

In Canada, recently, a CF-18 high-performance fighter was caught in a spin. The on-board computer advised the pilot of the corrective manœuvres to take, but, disoriented by the spin, the pilot elected to ignore the advice and fly the aircraft as he read the situation. The aircraft crashed.

In each of these incidents had the aircraft been totally computer controlled the proper evasive action would have been initiated automatically and both aircraft would likely have survived. It was the human element that placed the system at risk. The human himself, subject to the weaknesses of psychological and perceptual prejudice, exhaustion, stress, indecision and a limited, volatile memory, that was the weak link.

The Future

From a technical point of view, the automation process has been limited only by the memory space and data-transfer speeds of available processors. But technical innovations of immense proportion



Fully automated command and control for the year 2000, with the commanding officer actually driving the ship with a joy stick.

are now taking place in computer hardware and data-storage devices. For example, where the pre-TRUMP DDH-280 combat system memory space totalled some 250 kilobytes, that for the new frigates will total over 15 *megabytes*, or about 60 times as much. Logic and memory component density have been quadrupling every three years (a trend expected to continue) and processor memory availability will be virtually limitless with the advent of the four-megabit chip.

The development of efficient relational processors will eventually ensure instant access to virtually infinite data bases, and the optical disk will offer tremendous potential as a storage medium for tactical data and images. As far as data transfer is concerned, great advancements are being made with laser, electro-optical systems and Gallium Arsenide transmission and reception circuits that are expected to produce switching and driving speeds of at least 600 megabits/second, or 60 times faster than the present SHINPADS.

Expert systems are also now emerging in military applications. These systems duplicate the kind of results achieved by human intelligence. They are able to solve problems, make predictions, provide rationale and make decisions. The expert system of the future will be able to perform reasoning processes which will result in command and control systems no longer requiring human intelligence or intervention for decision-making.

The processing power to achieve these supersystems will be available in the very near future. What is still lacking is the software productivity to accomplish this with 100-percent reliability. However, it is expected that vast improvements in the way we produce combat system software will be forthcoming with innovative knowledge-based systems and better object-oriented programming languages such as Ada.

The Smart Ship

In the navy the aim for the future will be to produce the smart ship. The smart frigate would see a reduction of crew size from the present complement of about 200 members to a maximum of 50 members. Reductions in the operations branch would be achieved by the utilization of smart machines to replace the human as the integrating and decision-making element in combat systems. These machines will be superknowledge-based systems which, through a logical process, will control all warfare functions during an engagement, ensuring optimum response to a threat by an elaborate deductive process. They will be able to model the environment based on procedures, doctrine, tactics and rules of engagement, and search vast memory banks of parameters, looking for the optimum match to validate and verify the sensor and weapon data with a precision and speed that would be humanly unattainable.

Conclusion

The technological advances of the decades ahead are expected to bring unlimited innovations in the way in which war at sea will be conducted, particularly with respect to the man/machine boundary. It remains to be seen, however, if these innovations will be constrained by man's natural resistance to change and by his reluctance to accept machine-based decision-making processes.

References

1. Preston, A., *The Smart Ship*, Defence, Nov 87.
2. Hill, B., *Technology Failure or Human Error*, Ottawa Citizen, 30 Jun 88.
3. *A Case of Human Error*, Newsweek, 15 Aug 88.
4. *Navy Reports Raise New Questions About Stark*, News Supplement to IEE Spectrum, Jan 88.

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

Looking Back: 1880-1882

HMS *Charybdis* — The Black Sheep in Canada's Naval History

Could it be that this ship and a winter gale in Saint John more than a century ago delayed the Naval Service Act of Canada by almost thirty years? The idea isn't as farfetched as it sounds.

By LCdr Brian McCullough

You've probably seen a photograph of *Charybdis* orphaned somewhere in the introductory pages of a naval history book. But did you ever wonder why this old three-masted steam corvette, the first warship ever owned by the Dominion government, didn't rate a place in the main text alongside the likes of *Rainbow* and *Niobe*?

Brief though it was, HMS *Charybdis*' appearance on the Canadian naval scene in 1881-82 was to be long remembered as an unpleasant episode in the country's move toward naval self-reliance. Virtually overnight, what was supposed to have been the flagship of Canada's naval effort became instead a wooden-hulled pariah despised by the politicians. For almost thirty years afterward, in fact, the cry of "Remember *Charybdis*!" would be enough to scuttle any naval proposal of the day.

So what happened? Well, the story as it's told in the *Naval Service of Canada* and in Joseph Schull's *The Far Distant Ships* goes something like this:

When the question of Canada defending her own coastal waters was first officially raised by the Admiralty in the late 1870s, the commander of the Canadian Militia came up with the idea of drawing from the country's 90,000 fishermen and other seafarers to create a naval reserve. He also suggested it would be of mutual benefit if the British government were to provide the Dominion with a warship which could be used for coastal defence and naval training.

The Canadian government supported this recommendation and on October 8, 1880 the governor general sent a dispatch to the colonial secretary stating that his government "would not be adverse to instituting a ship for training purposes if the Imperial Government would provide the ship." The Admiralty responded by offering HMS *Charybdis*, a decrepit steam corvette just then limping homeward after seven years on the China Station. She was offered at first as a loan, then shortly afterwards as a gift. The Canadian government accepted and sent Captain Scott, a retired RN officer, to England to fetch her.

Things got off to a slow start when the ship's chief engineer reported that the boilers would not stand a winter Atlantic crossing. The boilers were replaced at the expense of the Canadian government, and early in 1881 Scott "coaxed and coddled" *Charybdis* safely across the Atlantic to Saint John, New Brunswick.

It's not clear exactly when, but soon after arriving in Saint John *Charybdis* broke loose from her moorings in a gale and damaged much of the shipping in the harbour. She had hardly been secured, and the clamour of aggrieved shipowners had not died down, when two Saint John citizens, attempting to go on board the ship, fell through the rotting wood of her gangplank and were drowned. That was sufficient naval experience for the government. The Admiralty was asked to take their gift back and in August 1882 the ship (Schull calls it a wreck at this point) was towed to Halifax and turned over to apparently unwelcoming authorities of the Royal Navy.

"*Charybdis*," Schull wrote, "became a gruesome memory, a political flying Dutchman which heaved over the horizon when any naval proposal was advanced during the next thirty years." That was her legacy. And it wasn't until 1909, in the face of a rapidly developing maritime threat from Germany, that the cries of "*Charybdis*!" began to be drowned out by the more strident, urgent calls for a naval service. On May 4, 1910, the Naval Service Bill of 1909 was enacted and the Canadian Navy came into being. A year later, by command of the King, the service was designated the Royal Canadian Navy.

News Briefs

Captain Garneau to promote manned space program

Four and a half years after becoming the first Canadian astronaut to fly a mission in space, Captain(N) Marc Garneau has retired from the navy to become deputy project manager of the Canadian astronaut program.

A naval combat systems engineer, Captain Garneau flew on the Oct 5, 1984 mission of the space shuttle *Challenger*. Even though he stayed on with the National Research Council's astronaut program in the years following his spaceflight, he said his decision to leave the navy last January after 23 years' service was not easy. "It's a decision I've been mulling over during the past year," he said.

"I want to promote Canada's manned space program," the 40-year-old Quebec City native said. At the moment he is involved with solar radiation and shuttle luminescence experiments which will be carried into space on a future mission. "I'm helping to get these experiments ready from an engineering and procedures point of view," he said. He has already developed the special graphics software which will be used with the Space Vision System during shuttle space-docking and Canadarm operations.

"I would love to get back into space," he said, " but I'm very happy to be in the support role. I would like to see other Canadians fly - - I don't want Canadians to think it was just a one-mission affair and now it's over."

Working on Canada's manned space program is "extremely exciting," Garneau said. "It's on the edge. I get the chance occasionally to roll up my sleeves....to do the kind of things I enjoyed in the navy - - a combination of desk work and field work."

(DND photos by Cpl Paul Howe)

Commodore Broughton (DGMEM) with Captain Garneau at the farewell.

Commander Dave Jacobson introduced the world's first "Marc Garneau" doll.

MARE selected to make CSME student-lecture tour

LCdr Rick Francki, DMEE 2 manager of the DDH-280 cruise engine replacement project, has been selected to represent DND in support of the Canadian Society for Mechanical Engineering's sixth annual lecture tour of Canadian engineering universities starting January 25.

The tour is sponsored annually by the CSME to bring university students up to date on topics which have a "significant impact on Canada in the field of Mechanical Engineering."

The DGMEM involvement this year comes at the Society's request for DND participation. LCdr Francki's presentation, "The Re-engining of the DDH-280s and Associated Engineering Problems," is being delivered as a case study of a current project involving hard mechanical engineering.

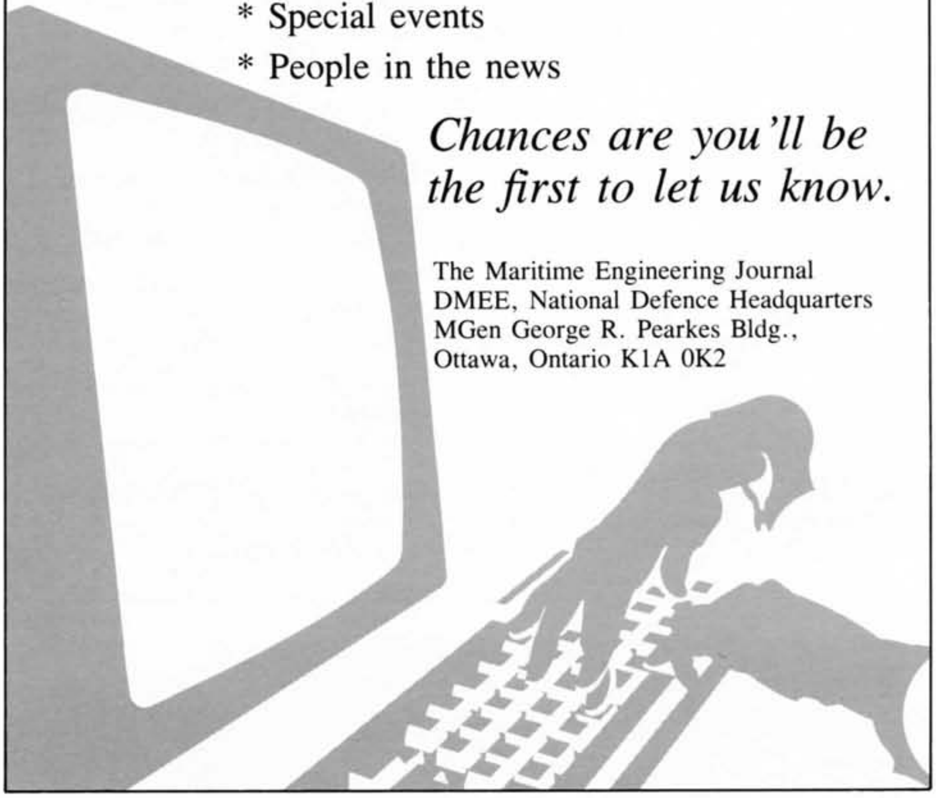
There are 26 stops on the seven-week coast-to-coast tour, including one in Kingston in February for a combined presentation to students of the Royal Military College and Queen's University. Five French-language universities will also be visited before the tour winds up March 16 at McGill University in Montreal.

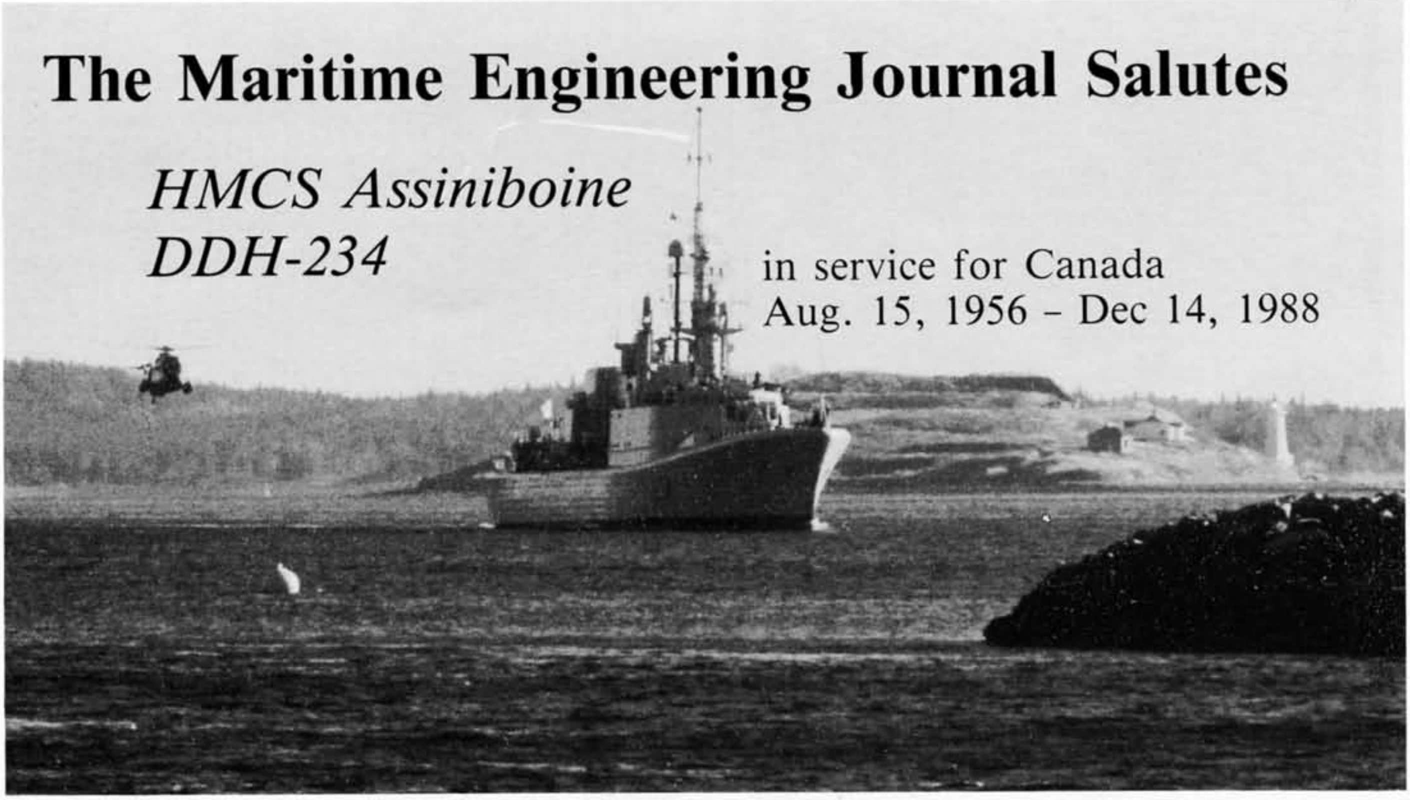
Go ahead, string us a line.

* Project updates
* Special events
* People in the news

Chances are you'll be the first to let us know.

The Maritime Engineering Journal
DMEE, National Defence Headquarters
MGen George R. Pearkes Bldg.,
Ottawa, Ontario K1A 0K2





Index to 1988 Articles