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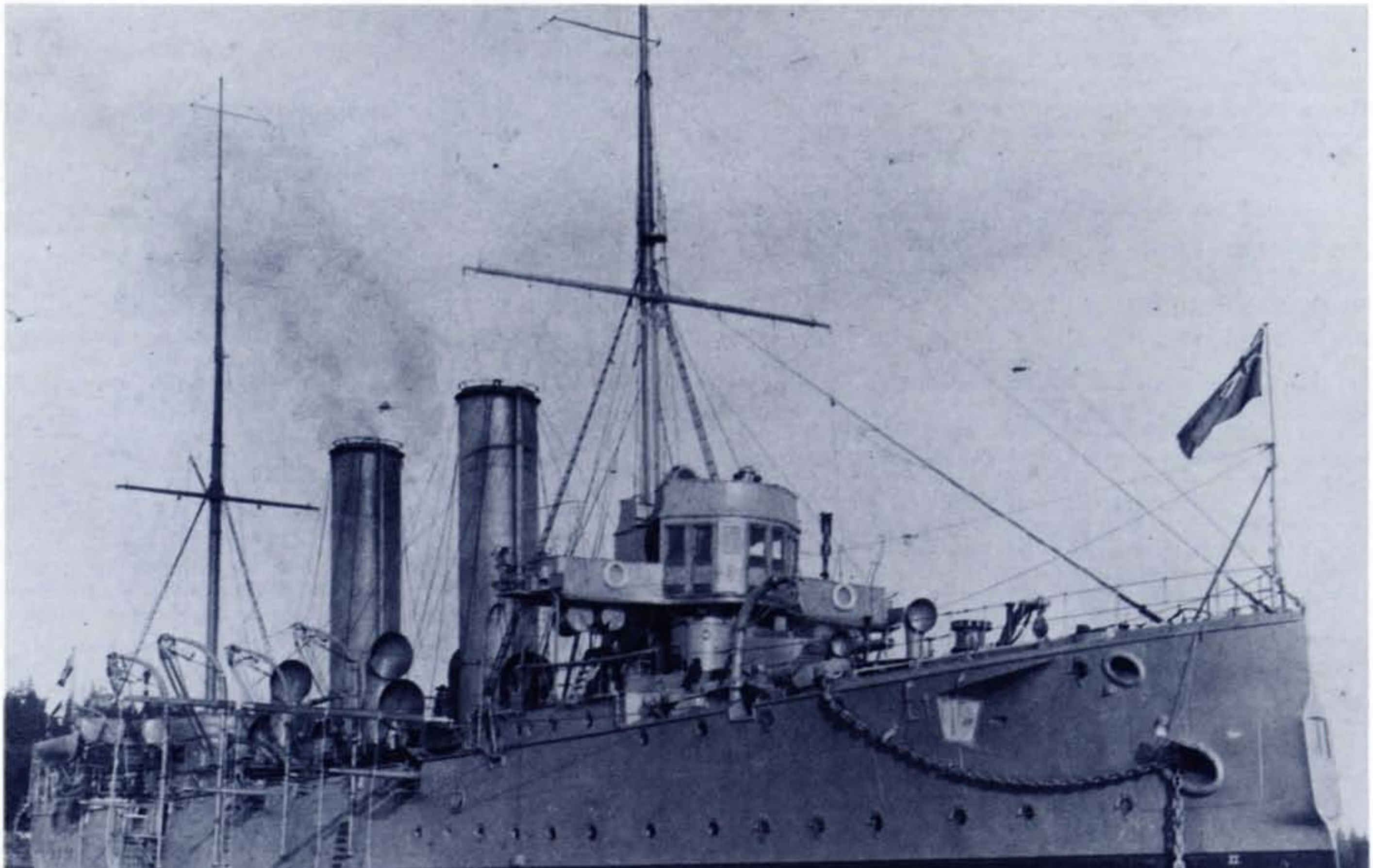
MARITIME ENGINEERING Journal du GÉNIE MARITIME



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DIRECTOR-GENERAL
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Commodore J.A. Gruber

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Le Journal du Génie maritime (ISSN 0713-0058) est une publication autorisée et non-officielle des ingénieurs des Forces canadiennes. Elle est publiée trois fois l'an par le Directeur général du Génie maritime et de la maintenance. Les opinions exprimées sont celles des auteurs et ne reflètent pas nécessairement les politiques officielles. Le courrier doit être adressé au **Rédacteur en chef du Journal du Génie maritime, DMGE 5, Quartier général de la Défense nationale, Ottawa, Ont., K1A 0K2.** Le Rédacteur en chef se réserve le droit de rejeter ou d'éditer tout matériel soumis. Les articles de ce journal peuvent être reproduits tout en tenant compte des mérites de l'auteur.

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 programmes, situations and events.
- To provide announcements of programmes concerning maritime engineering personnel.
- To provide personnel news not covered by official publications.

WRITER'S GUIDE

We are interested in receiving *unclassified* submissions on subjects that meet any of the stated objectives. Manuscripts and letters may be submitted in french or english, and those selected by the Editorial Committee for publication will be run without translation in the language which they were submitted.

Article submissions must be typed, double-spaced, on $8^1/_2 \times 11$ white bond paper and should as a rule not exceed 6,000 words (about 25 pages double-spaced). Photographs or illustrations accompanying the manuscript must have complete captions, and a short biographical note on the author should be included in the manuscript.

Letters of any length are welcome, but only signed correspondence will be considered for publication. The first page of all submissions must include the author's name, address and telephone number.

At the moment we are only able to run a limited number of black and white photographs in each issue, so photo quality is important. Diagrams, sketches and line drawings reproduce extremely well and should be submitted whenever possible. Every effort will be made to return photos and artwork in good condition, but the **Journal** can assume no responsibility for this. Authors are advised to keep a copy of their manuscripts.

OUR COVER

HMCS *Rainbow* was the first warship to be commissioned in the Canadian navy. She arrived in Esquimalt on 7 November, 1910.

MARITIME ENGINEERING
Journal
du GÉNIE MARITIME

September 1985 Vol 4 No 2

DEPARTMENTS

FEATURES

Editor's Notes

In the three years that the *Maritime Engineering Journal* has been in existence, its format has remained virtually unchanged. But now, starting with this issue, the *Journal* has a new look while the editorial philosophy remains as it has always been.

When the *Journal* first appeared in 1982, its primary objective was to promote professionalism among our maritime engineers and technicians. The idea all along has been to provide an open forum where topics of interest to the maritime engineering community can be presented and discussed. Since 1982, the response from readers and contributors alike has more than established the need for a professional branch journal, and it was with this in mind that a way was sought to publish the *Journal* more frequently. Now, in its new format, the *Journal* will be coming to you three times a year instead of two.

Redesigning a magazine is not something that is done without a great deal of thought and careful consideration. It is easy to throw the baby out with the bath-water, as the saying goes, and care must be taken to carry over as many of the good features as possible from the old to the new. Even in its new format the *Journal* retains many of its familiar elements. For example, you'll find the Letters section and Commodore's Corner in their usual spots, and a slightly modified branch crest has been reduced in size and placed on the back cover.

Among the changes you'll see in this and following issues are a redesigned cover that will let us highlight our feature articles, a restyled masthead, and a new print style typeset in a column format for easier reading and more attractive page layouts. You'll also notice that the biographical notes on the authors are generally shorter, now, and are placed at the end of articles.

Producing three issues of the *Journal* every year (in January, April and September) means that it is now possible to publish some 15 major articles annually. There is a virtual profusion of noteworthy engineering activity taking place in the fleet and its support units, and it is hoped that in the months ahead many of you will take the time to contribute articles so that we can continue to feature these activities in the *Journal*.

Perhaps it is fitting that the *Maritime Engineering Journal* gets its new look during the navy's 75th anniversary year. After all, the anniversary theme *is* "Pride and Commitment", and it *is* our year to celebrate.

Letters to the Editor

I would like to offer my congratulations to members of your staff for the excellent article entitled "The DDH-280 Waste-Heat Recovery System". This article is an honest assessment of the present status of the WHRS and provides a way ahead which should have a high degree of success.

Please pass on my congratulations to authors Scholey, Neri and Mueller.

R.L. Preston
Capt(N)
PM TRUMP

Ottawa Newsletter

by Constructor Lt. Cdr. David Morris

The exchange post has the title "Surface Ship System Naval Architect". The organisation it belongs to doesn't have a simple parallel with Bath but rather bundles together several of the functions that D.C.W. and D.C.W.E. separate out. It reflects, too, the in-house structure and workload left when the contracting-out process has run its course.

By way of a brief outline, my post combines a mix of C.N.A. and running ship-section activities. It embraces the C.N.A. elements of professional authority on standards and methods to be applied to stability, strength and hydrodynamics; support to the various projects in assessing contractors' design proposals; proposing and progressing the appropriate R and D.

There is a considerable activity on all fronts. Several major projects are running concurrently, each demanding a slice of the professional pie. Standards are subject to close scrutiny, both internally and externally, and the Directorate is keen to expand its knowledge base through additional research. Add to this the problem of two elderly fleets — one on each coast, separated from each other by nearly seven hours of air travel, and from Headquarters by two hours (east) and five hours (west) — and the mix provides a lot of work, considerable travel and no lack of challenges.

Oh, and by the way, as the resident Brit Nav Arch you are automatically imbued with an Encyclopaedic knowledge of all matters Naval Architectural within M.O.D.(N) and most R.N. topics outside that sphere! If you need to feel wanted, Ottawa is the place. It's a warm feeling if you don't weaken.

However, all is not grim-faced toil. There was the episode when, albeit briefly, yours truly became the Papal Naval Architect.

Both the Pope and the Queen visited Ottawa last summer. The Queen, sensibly, stuck to road transport. The Pope, however, was scheduled to make part of his progress along the Rideau Canal in a water version of the genus "Pope-mobile" (christened within the Directorate as the "Bateauneuf du Pape").

Preparations, apparently, went well until altercations between the visit organisers and the "designer" of the vessel led to the latter's departure. Concern set in that the houseboat hull (two cylindrical pontoons) might not support the armour glass, 2 x 75 HP outboard motors(!), Papal entourage, bodyguards, R.C.M.P. crew, et al. And if it did float, would it be level? They needed a Naval Architect (I knew we were of some use).

What chain led the organisers to this Directorate never did become clear but, whatever the route, yours truly found himself addressing the stability of a houseboat with the representatives of the Safety Division of the Ministry of Transport. Fortunately, my section possessed a houseboat owner/expert who could temper any theoretical excesses with common sense. He even knew how to launch one, much to the relief of the organisers who hadn't got that far in the plan.

With a little anxiety, the boat was officially blessed and launched. It floated — upright and moderately level — whether through the blessing or the calculations never did seem clear, nor to matter. We Anglicans were shown to have our uses and the Pope made triumphant and colourful progress — to the delight of thousands. Perhaps he will put in a kind word.

Lt. Cdr. Morris' "Ottawa Newsletter" appeared in the January 85 issue of The Journal of The Royal Corps of Naval Constructors. It is reprinted here in part by permission of the author who is currently on exchange to the Canadian Forces from the Royal Navy.

Commodore's Corner

by Commodore E.E. Lawder

I am honoured to have been asked to write the Commodore's Corner for this issue of the MARE Journal, particularly in this the 75th anniversary year of our navy. During this year we will be taking the Canadian Forces Tattoo from coast to coast with 46 performances in 12 major centres in Canada. We will be conducting naval assemblies on the east coast and on the west coast. On the east coast we will have 18 Canadian ships and 17 foreign ships representing 12 different countries. On the west coast the Naval Assembly is in Esquimalt and Vancouver where we will have 10 Canadian ships and up to 16 foreign ships representing four different countries. We will see the reintroduction of distinctive environmental uniforms and the keel-laying for the first CPF on 6 July in Saint John, N.B.

This is a most significant year as can be seen from these activities. The 75th Anniversary is truly the "Year of the Navy" and what more appropriate theme could we have than "Pride and Commitment"? The aim of Pride and Commitment is through the venue of the 75th Anniversary of the Naval Service of Canada to achieve the involvement and participation of members of Maritime Command and sailors everywhere in this historic event, thereby instilling a sense of pride and commitment in the Canadian Forces and in our navy.

Does the theme apply to we of the MARE community, you ask? Many of us are certainly members of Maritime Command and all of us are sailors in the Naval Operations Branch. We can certainly show our pride through our quality of work and our commitment to the overwhelming job that has to be done. I would like to stress here that this is a personal challenge to each and every one of us.

The MARE community has a daunting challenge. Commodore Ball in the Summer '84 edition of the Journal wrote that "the maintenance and improvement of the operational availability and capability of our ships and their equipment have always been our goals". Commodore Gruber wrote in the Winter '85 edition that ". . . the long period of drought in programs and inevitable storms and conflicts we have encountered have toughened us in a way that we can now go forward with a real resolve and purpose". There is no question about what our goals are — Commodore Ball has stated them very succinctly. There is also no doubt that there is a "horizon full of new programs" and the drought is over as is evident by CPF, TRUMP, SRP II, CASAP and the multitude of other capital projects. The navy is indeed getting the lion's share of the capital budget over the next 10 years or so, and will need every ounce of "resolve and purpose" to respond. Thereby hangs our challenge.

We have more commitments and more programs than we have ever had before. We are also experiencing a time when we are chronically short of MAREs to cope with the programs, and it would be tempting to say that the work can't be done because of the personnel shortages. The fact is that we *must* do it because it is now the Navy's turn. We will get one opportunity, and if we "drop the ball" we will lose our chance to obtain the resources we need to rebuild the fleet. If this happens we will have to go to the back of the queue, and who knows when we will get another chance like this again.

The MARE Get-Well Project is starting to increase the numbers of MAREs. At the same time the new projects are very demanding of engineering talent, and the serious shortages in the fleet and in shore establishments are likely to continue for the next three to five years. Not only do we have to devote considerable effort to the new projects, we will have to devote considerable effort to continuing the tempo of the MARE Get-Well Project as well as responding to the needs of the existing fleet.

I wrote earlier that the MARE community has a daunting challenge. We have more projects now and proportionately fewer people to do the work. Our professional challenge, then, is to do as much as is possible and then a little bit more. To maintain the function of the community we must all extend ourselves and be even more conscientious of our efforts. To preserve our credibility in the naval community we will have to exercise our best competence and our best engineering judgement. We must strive to get the best job done within intolerable constraints.

Coming back to my earlier quotation from Commodore Gruber's "Winter '85 Corner", I am confident that ". . . the storms and conflicts . . . have toughened us in a way that we can now go forward with a real resolve and purpose". What better purpose can we all have in this 75th anniversary year than to rejuvenate the fleet, and what better resolve than to do the best job possible, and then a bit more? What better theme can we personally have than *Pride* through the quality of our work and *Commitment* to the overwhelming job that has to be done?

(Commodore Lawder is the Chief of Staff for Materiel in Maritime Command Headquarters)

Origins of the Species "MARE"

by Captain J.H.W. Knox, P.Eng., CD, RCN (Ret'd)

Now that the Maritime Engineering or MARE sub-branch of the Canadian Forces personnel structure is well established and described, it may be of interest to look back over the 75-year history of the Canadian navy to see how this structure has come about and what its origins were. Prior to the Second World War the RCN, and before that the Canadian Naval Forces or CNF as the Canadian navy was originally titled, had adopted an organization which, in its personnel arrangements, was essentially identical to that of the Royal Navy although less extensive in its scope and development. The explanation for this was quite simple: the Naval Service Act of 1910 in creating the Naval Service of Canada provided that the King's Regulations and Admiralty Instructions, the QR&O for the Royal Navy of the day, was to be the governing set of orders for the newly formed navy. Since KR&AI provided, amongst other matters, a comprehensive personnel structure, this structure, *ipso facto*, became the organization of the CNF.[1]

In 1910 the Royal Navy's only fully established technical body was its Engineering Branch. The other executive branches — Gunnery, Torpedo, Signals and Navigation — were officered by non-technical or seaman officers. This remained the situation for the next three decades in the Royal Navy and also in the Canadian navy. Thus the earliest precursor of the MARE Branch was almost exactly modelled on a well established prototype. It was also staffed at the more senior levels by officers on loan or transfer from that prototype. Further, the small number of Canadian engineering recruits was trained in a Royal Navy system largely in and by the Royal Navy.

Thus the Engineering Branch of the Canadian navy in the first 30 years of its existence, like the remainder of the navy, was made up of officers either drawn directly from the Royal Navy or trained by the Royal Navy in its image. For that reason it is relevant to recount here something of the status of the Royal Navy's engineering branch during and shortly prior to that first 30 years of Canadian naval existence.[2]

Prior to 1903 the engineering branch of the Royal Navy was a civil or non-military branch whose officers were responsible for machinery but not empowered to award punishment, not permitted to sit on courts martial or to exercise executive control over their own departments. They were distinguished from their military contemporaries by title and by uniform — they did not wear the "executive curl" but did wear a purple "distinguishing cloth" insert beneath each gold rank-stripe on their sleeves. In 1903 the title "Engineer" suffixed by the naval rank was introduced to describe the civil branch officers who were in charge of warship machinery. For example, the former Chief Inspector of Machinery became an engineer-rear-admiral, and the Staff Engineer, Chief Engineer and Engineer all became engineer-lieutenants.[3]

In January 1903, following the publication in December 1902 of the "Selborne-Fisher" memorandum, Sir John Fisher (the new First Sea Lord and co-author of the memorandum) set about introducing his scheme of organization which was regarded at the time as revolutionary. It was "designed to give back to the executive officer his old control of the motive power of the ship. It recognized the necessity for engineering training for all officers, and the main objective was the amalgamation of the (executive and engineering) branches. The engineer, as such, was to cease to exist, and his duties were to be absorbed, as had been those of the Master some thirty years before, by the executive officer."[4] Executive officers would be trained in the full range of disciplines but with "a much greater amount of practical science and engineering" than formerly. As lieutenants they would be permitted to specialize as engineer(E), gunnery(G), navigation(N), torpedo(T) or marine(M) officers. The large majority would remain as specialists only in the junior ranks and then revert to general duties and command. These officers would be the sole cadet-entry to the Engineering Branch and would wear no distinguishing cloth. The old-school or pre-Fisher "Engineer-" officers were to be the last to wear purple and it would disappear with them upon retirement.

In 1910 the last of the Engineer Student entries graduated from the Royal Naval Engineering College (RNEC) Keyham and it was closed. In 1915 the former "Engineer-" officers were brought into the military branch and given the executive curl. Following the First World War the pendulum began to swing back. In 1921 it was decided that (E) officers would commence their separate training as midshipmen, and the following year the RNEC reopened to accept them. The course they underwent came to be known as the "Long(E)" course. In 1925 the entry of sub-lieutenants and lieutenants to specialist courses ceased and in November of that year an Order in Council reversed the Selborne-Fisher arrangement by establishing 12 "categories" of officer (all military), limited command to executive officers, extended the purple distinguishing cloth to (E) officers and required them and the "Engineer-" officers to wear a "more distinctive shade of purple". At the same time engineer officers under training adopted the style Midshipman(E) and Sub-Lieutenant(E).

On 4 May, 1910 with the coming into force of the Naval Service Act, the Naval Service of Canada numbered four uniformed persons, all transferred from the Royal Navy and none either Canadian born or an engineer.[5] Both these early deficiencies were corrected on 10 August of that year by appointing to the newly commissioned HMCS *Rainbow* Acting Engineer-Sub-Lieutenant A.D.M. Curry, CNF. Curry and his non-engineer

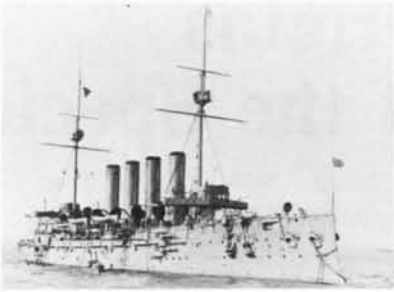
A.D.M. Curry

contemporary, Acting Sub-Lieutenant E.G. Hallewell who was simultaneously appointed stand-by to HMS (soon to be HMCS) *Niobe*, were evidently the first recruits from shore to the CNF.

A further five acting engineer-sub-lieutenants were among the first officer recruits to the CNF. Hallewell was joined in *Niobe* on her commissioning by A/Eng Sub-Lt. H.J. Napier-Hemy. When *Niobe* reached Halifax from Portsmouth these pioneers were joined by A/Eng Sub-Lts (CNF) G.P. Clarke, A. Hollingsworth, F. Jefferson and S.N. de Quetteville. Of this first group of Canadian naval engineers: Hollingsworth's naval career ended before the First World War began; de Quetteville was killed in action on 31 May, 1916 while serving in HMS *Indefatigable* at the Battle of Jutland; Napier-Hemy appears to have been released "medically unfit" in the early 1920s after a colourful career including service at Jutland in HMS *Colossus*; Clarke died in 1930 while still serving in the rank of engineer-commander, RCN, having been appointed Engineer-Overseer for the building of *Skeena* and *Saguenay*; Curry and Jefferson both retired having served from October 1939 and July 1940, respectively, through the Second World War in the rank of engineer-captain.

While *Niobe* and *Rainbow* and the few hundred men who formed their skeleton ships' companies may not have provided the spectacular beginning which some would have wished for the Naval Service of Canada, the crews did provide much of the seed upon which that Service was to survive through the first three precarious decades of its existence.

In 1910, apart from the newly recruited officers of the CNF, *Niobe* and *Rainbow* brought with them to Canada a number of what can only be described as remarkably influential pioneers who elected to stay on with the Naval Service of Canada after the completion of their first period of loan service. Included among these are Engineer-Lieutenant John F. Bell,[6] Artificer-Engineer R.H. Wood and Engine-Room Artificers 2nd Class "Dickie" Pearson and G.L. Stephens. Pearson, who had RN submarine experience, played a key role in the commissioning of Canada's World War I submarines, CC1 and CC2. Later, having retired from the RCN, he became a civil servant and right-hand man of the senior naval engineer in Ottawa. Bell returned to the RN but in 1940 came out of retirement, took up a position as Assistant Director of Naval Engineering Development in NSHQ and retired again from that position as an engineer-captain toward the end of the Second World War. From the time of *Rainbow*'s arrival on the West Coast, Wood was seconded



HMCS Niobe *was the second warship to be commissioned in the Canadian navy. She arrived in Halifax on 21 October, 1910.*

as Chief Engineer, Esquimalt Dockyard. He retired in July 1920 and, as a civilian, became Manager of Halifax Dockyard retiring from that position in the mid-1930s. Stephens, having been promoted from engine-room artificer (ERA) to acting artificer-engineer in October 1912, rose steadily through successive ranks to become the first technical officer to reach flag rank. This he achieved while serving in NSHQ as Chief of Naval Engineering and Construction — once again as an ERA, but this time as engineer-rear-admiral. He retired from this position, and as a member of the Naval Board, in February 1946.

Another pioneer deserving mention is T.C. Phillips. First appointed as engineer-lieutenant, RN, to *Niobe* in February 1917, he was promoted and appointed Consulting Naval Engineer at NSHQ in August 1918. Promoted again and transferred as engineer-commander, RCN, in February 1923, he remained in the position of Consulting Naval Engineer (from 1932 Director of Naval Engineering) in NSHQ until 1933. He spent his final three years of active service as Chief Engineer in Esquimalt Dockyard, being promoted engineer-captain, RCN, (the first to reach this rank) on retirement in November 1936.

From its modest beginning with the acquisition of two cruisers in 1910 the Canadian navy continued, often barely, to exist on an equally modest scale until the latter part of the 1930s. Despite the early recruitment of six officers into the Engineering Branch, numbers in that branch, like the navy as a whole, continued to be very sparse. The Canadian navy had to rely considerably on Royal Navy transfers to maintain even these.

Officer recruits to the Engineering Branch were not numerous in the early years. By 1917 the only permanent addition to the initial entry had been one Ninian Bannatyne who joined as an acting engineer-sub-lieutenant in August 1914. This officer retired after the First World War but returned as a temporary lieutenant-commander(E) in September 1939.

While a number of chief artificer-engineers and artificer-engineers served during the first World War, only three remained beyond. M.D. O'Leary returned to full-time service in the Second World War as a temporary lieutenant(E), RCNR. T.H. Evans became an acting artificer- engineer in January 1916, retiring after the end of the Second World War as a Captain(E), OBE. Amongst the early engineers, mention should be made of Acting Carpenter C.H. Brown first shown in the Navy List as appointed to *Rainbow* in April 1913. His service continued into the Second World War, and he was promoted shipwright-commander in July 1940.

A.C.M. Davey, a graduate of the Royal Naval College of Canada (RNCC), was the first RCN cadet-entry to specialize in engineering and to enter the RNEC. This was in 1922. Davey's service continued until his retirement in the rank of commodore(E) in 1956 having spent the last seven years as Engineer-in-Chief. The RCN Engineering Branch has continued to the present day to utilize the RN facilities at Keyham (which were later transferred to the Manadon site) for officer professional training. Following the

T.C. Phillips

closure of the RNCC in 1922 and until the opening of the Royal Canadian Naval College in 1941, RCN engineer, executive and paymaster cadets received their basic naval training with their RN counterparts at the RN College, Dartmouth, and in the RN cadet-training cruisers. Until the 1950s seagoing engineering training was also provided by the RN for RCN cadet-entry officers. The RCN College at Royal Roads from 1944, and later the Canadian Military Colleges, took the place of the RN College, Dartmouth, and the RN cadet-training cruiser, first in providing basic naval training and then, from 1953, in providing basic engineering training.

As the demands of the expanding Canadian fleet increased, and following the pattern already established by the RN, the RCN Engineering Branch embarked in 1942 on formal sub-specialization with the introduction of gun-mounting and ordnance training. In 1944 aeronautical engineering was introduced as a second sub-specialization. (Although the Royal Canadian Naval Air Service was established and operating in the last year of the First World War and had recruited and trained Canadian aircrew, maintenance and ground services were provided exclusively by U.S. personnel. Canadian naval aeronautical engineering had therefore to wait a further quarter century to become a reality.) A few years later the submarine sub-specialization appeared.

The relationship of the Engineering Branch to the remainder of the navy in being at the end of the war remained unaltered until the introduction in 1960 of the "General List". It might, however, be noted in passing that with the introduction of a "tri-service" pay scheme in 1947, the engineer ceased to receive the pay advantage over his executive contemporaries which he had enjoyed for many years in the ranks of lieutenant through commander. "Charge money" for engine-room (and later engineering) artificers and technicians was to continue until 1975.

The Electrical Branch

Prior to the Second World War, electrical responsibility devolved largely and as a secondary duty on officers of the Torpedo Branch. The Signals Branch was responsible for radio and signal lamps. As the war progressed and weapons developed, a host of new electrical complications flooded into ships in a continuous and disjointed stream. These included:submarine detection devices (asdic, later sonar); radio direction-finding (RDF, later radar); remote-power-controlled gun-mountings; increasingly sophisticated internal communications and signal transmission systems; duplicate and alternate power supplies; degaussing systems; A.C. motor-generator sets and many others. The result was a multiplicity of competing interests and agencies each responsible for one or more of the electrical arrangements but none responsible for the whole.

The problem was particularly acute for the RCN which, until WW II, had depended totally on the RN for the design and supply of, and instructions for, electrical material. In the Admiralty shore organization electrical matters were dealt with by a professional civilian body. The rapidly expanding RCN recruited a substantial number of officers with varying types of electrical background, but they were brought in for specific tasks or activities by the responsible agencies and interests as each recognized the need for professional assistance. Most of these officers were placed in the newly created Special Branch, a personnel catch-all with no functional organization.

The need for organization out of the electrical chaos was first recognized by the Chief of Naval Engineering and Construction, then Engineer-Captain G.L. Stephens. Having convinced the Chief of Personnel and, in turn, the Naval Board in June 1942 of the need for an Electrical Branch, the search was on for a man who could sort things out as head of a new Directorate of Electrical Engineering (DEE). The Director of Engineering Personel, then Commander(E) W.W. Porteous, had just the man for the job — Professor E.G. Cullwick of the University of Alberta who had already made his mark on campus in training naval and air force personnel in electrical engineering. In requesting Cullwick's services from the university, the Minister of the Naval Service wrote in part:

> *Since the outbreak of war, the Canadian Navy has expanded beyond any of our expectations and in consequence our technical development has to a large extent not been properly co-ordinated because of the immediate urgency of our problems. In no department has this lack of co-ordination been more apparent than the electrical department, which, with the ever increasing use of electricity in fighting equipment, has of necessity developed in watertight compartments without that cohesion which is essential to efficiency.*
>
> *The Department has now decided to create a branch which will co-ordinate and control Naval electrical activities and it is of the utmost importance that it be headed by an officer of electrical knowledge and experience. It is, of course, essential that this officer have administrative ability.*[7]

Cullwick took up his appointment as DEE on 1 January, 1943. He quickly reached his own conclusions on the need for cohesion within the naval electrical world, but encountered substantial opposition particularly from the Torpedo and Signals branches. Typical was the response to his proposal for seagoing electrical officers: "there would be very little work for them in a destroyer". While progress on a comprehensive branch was slow, Cullwick made gains in the recruitment of electrical engineers and in their deployment to the naval schools in Halifax, to the building and repair yards, and to his own directorate. In August 1943 the Admiralty released a report by Rear-Admiral Phillips which recommended the establishment in the RN of separate Electrical and Ordnance branches. Copies of the report added much grist to Cullwick's mill and opinion began to swing behind him. By early 1945, the Post-War Planning Committee had been tasked with consideration of the question of an Electrical Branch. In July, Reserve electrical officers were authorized to transfer to the Permanent Force in anticipation of the formation of a new branch.[8] On 13 September, 1945 a general message was released outlining the principles of work of a Permanent Force Electrical Branch.[9] That fall an all-inclusive east-coast electrical school was approved, DEE was given responsibility for the coordination of all NSHQ electrical work including radio, and positions as Manager of Electrical Engineering were established in the dockyards. At year's end the branch was fully established with a Naval General Order on "Electrical Branch Officers — RCN".[10]

G.L. Stephens

It should be recorded here, as an aside, that early in the Second World War the RN was much quicker in capitalizing on the untapped resource of Canadian graduate electrical engineers than was the RCN. The RN had a pressing need for radar officers and turned to the RCN for assistance. The RCN, acting as a recruiting agent, scoured Canadian campuses. By the end of 1940 some 40 RCNVR recruits had crossed to Britain, and thereafter the traffic increased steadily. The total number involved is indicated by the fact that at its 10th anniversary in 1955 the "Canadian RN Radar Officers Association" counted 265 members. Throughout the war a very substantial proportion of RN radar officers were Canadian, and many RCNVR officers devoted the whole of their wartime service to the RN in this capacity.[7]

The Ordnance Branch

The formation of the Ordnance Branch in the RCN followed some months later a similar pattern to the Electrical Branch and, in doing so, departed from the RN prototype. Despite the Phillips recommendations the RN instituted an Electrical Branch but not an Ordnance branch in its post-war reorganization. In that service the Torpedo and Gunnery branches continued as user groups supported by the new Electrical Branch and the Gunnery engineers.

As in the case of the Electrical Branch, the imperative for the RCN in forming an identifiable Ordnance Branch with a complete range of design and maintenance expertise across the weapons field was the need to retain a capability which resided almost entirely in wartime recruits to the RCNVR. These technical experts needed a clear and distinctive career avenue if they were to be attracted to the Permanent Force. The formation of the branch was based on the premise that use and maintenance of weapons systems would be separated.

An NSHQ Staff organization known as the Directorate of Naval Ordnance was established early in the Second World War. Reporting initially to the Deputy Chief of Naval Staff, the directorate was subsequently moved into the Naval Equipment and Supply Branch, DNO being also Deputy Chief of Naval Equipment and Supply (DCNES). Toward the end of the war, DNO was separated from CNES and established as the Naval Ordnance Branch responsible directly to CNS. (The description "Branch" in this context was only in the NSHQ staff organization sense as it was also for the Personnel, Naval Equipment and Supply, and Naval Engineering and Construction branches. It was not a personnel grouping.) With the formation of the Chief of Naval Technical Services (CNTS) organization in 1947, the Naval Ordnance Branch became the Directorate General of Naval Ordnance responsible to CNTS. Concurrently, the Naval Ordnance Branch was formed as a distinct and service-wide personnel grouping including both officers and men.

On formation, the new branch drew its officer recruits from many sources. These included: executive officers experienced in ordnance work, gunnery and torpedo officers; engineering officers, a number of whom had specialized in gun-mounting work; the Special Branch; commissioned and warrant ordnance officers, gunners, gunners(T), engineers and electricians. The rating structure initially included ordnance artificers who had been trained and employed from entry as tradesmen in ordnance work as well as armourers who had converted from the user branches — Gunnery, Torpedo, Radar Control and Engineering.

The technical split between the Electrical and Ordnance branches was never a clear-cut or easy one. In any modern weapons system the interdependence of the two disciplines, and hence of the two personnel groupings, is, quite evidently, complete. In 1953 a committee was established to determine what organizational changes might bring improvement. One suggestion was to amalgamate Ordnance and Engineering. Another, ultimately closer to the eventuality, was the amalgamation of Ordnance and Electrical. The 1953 committee was overtaken by (or generated) the Tisdall Committee which reported in 1959 with recommendations for far-reaching changes in all personnel structures.[11]

The Constructor Branch

Carpenters were included in the engineering departments of HMCS *Rainbow* and HMCS *Niobe*. They and their sub-departments, led later by commissioned or warrant shipwright officers, continued to be included as members of the Engineering Branch of the Canadian navy throughout that branch's existence. With the advent of naval architects, whose inclusion was made essential by the massive building programme of the Second World War, a new professional dimension was added to the Engineering Branch.

While the Constructor Branch does not appear to have enjoyed quite the same separate and distinct existence as the other technical branches, this was a matter of both scale and balance as much as anything else. The proportion of officers to men was high in this grouping while the absolute numbers were relatively small. In addition, the distinction between the essentially non-seagoing professional naval architects and the seagoing technician shipwrights with their Engineering Branch connection always remained sharp. The first naval architect or constructor officers entered during the Second World War via the Reserves. The first Director of Naval Construction in NSHQ, Constructor-Captain A.N. Harrison who was appointed in December 1941, was loaned from the Admiralty's Royal Corps of Naval Constructors (RCNC) as were his successors until the appointment of Constructor-Commodore F. Freeborne, RCN in July 1956.

The First RCN cadet-entry constructor officer was selected in 1946 for training as a constructor with the RCNC, initially at RNEC Keyham and completing the course at RNC Greenwich. Later the U.S. Navy post-graduate programme at the Massachusetts Institute of Technology was used as an alternate source of professional naval architecture training.

The Recent Past

As mentioned above, the Tisdall Committee or, properly, the "Ad Hoc Committee on RCN Personnel Structure" was convened in November 1957 to consider amongst other matters "the effect upon the RCN of amalgamating all existing technical services branches into one Technical Branch and whether the Supply Branch should be included or become a separate branch". The committee report in 1959 recommended bringing together maintenance and operating responsibility in one man, proposed an officer structure which would have three lists — general, special and limited duty, and recommended removal of distinguishing cloth and distinguishing suffixes to accentuate the breakdown of the former branch atmosphere. The report noted that, above all things, the present and future naval officer must be a seaman whose basic knowledge would be that of a practical engineer. The common educational requirement for General List officers would be a university (or service college) four-year degree course biased toward liberal engineering. In simplistic terms all officers would henceforth be engineers.

In 1960 the General List was introduced. Coloured stripes disappeared (as they had from the Royal Navy four years earlier) and a set of seven-digit numerical designators was introduced in the Navy List to describe individual officers' qualifications.

The new approach had some rather interesting consequences. A number of technical officers who had previously taken the opportunity while at sea to obtain bridge watchkeeping and even command qualifications, were redesignated to recognize these qualifications. Some, in fact, went on to appointments as Executive Officers and, later, Commanding Officers of frigates and destroyers. One, Admiral J. Allan, went on to become Director General Maritime Engineering and Maintenance and subsequently Maritime Commander.

A further consequence was the decision to cease using the RNEC Manadon for specialist marine engineering training and to establish a Canada-based marine engineering applications course. In the event, this course was inadequately staffed and not provided with suitable facilities. After three years a reversion was made to Manadon.

Subdivision of the General List into General and Restricted Duty sections as proposed by Tisdall was never effected. The Restricted Duty section would have sheltered officers with post-graduate qualifications who would exchange the opportunity for broad employment, including command at sea, for narrower employment in the chosen field of specialization accompanied by enhanced promotion prospects to the rank of captain.

In 1963, and in the face of an acute shortage of recruits with the requisite education, a Personnel Structure Review Team was established under Admiral Landymore. This report was tabled in 1964.

The Landymore report took a pragmatic approach and considered that the spirit of Tisdall could be met despite accepting graduates in other than engineering or general science programmes, and that a lower level of mathematics and physics would meet most naval requirements. Those who were to sub-specialize in engineering would, like all General List officers, obtain a bridge watchkeeping certificate in their first 16 months at sea. Thereafter they would follow a unique programme of both training and employment. Once again in simplistic terms, all engineers would become seamen (bridge-qualified) officers — an interesting twist of the original General List philosophy. This reintroduction of sub-specialized engineers rendered the Restricted Duty list redundant.

With amalgamation of the three separate services into the unified Canadian Forces (CF) a new cut was required at the personnel structure. Unlike their fellow engineers in the land and air elements and their naval Supply Branch contemporaries who had no option, the naval engineers elected to join company with the naval Operations and Weapons sub-specialists in what became the Naval Operations Branch of the new CF personnel structure which was put in place in 1970. Two officer classifications were recognized in the branch: Maritime Surface and Sub-Surface (MARS), and Maritime Engineer (MARE).

In the fullness of time the MARE classification became subdivided into Combat Systems (CS) and Marine Systems (MS) groupings. The naval architects were originally included with the MARE (MS) group but have more recently acquired a separate existence as a third MARE group in their own right.

Conclusion

This article has restricted itself to the development of the engineering officer structure in the Canadian navy. The parallel development of the engineering other ranks structure has been every bit as interesting and certainly merits telling. The initial post-war developments were described in three useful articles published in the *Journal of Naval Engineering*.[12,13,14] Fuller and more up-to-date description is more than due.

In the 75 years since its inception the Canadian navy has developed from a carbon copy of its parent, the Royal Navy, to a navy with a completely Canadian character. The engineering officer structure has developed in a similar manner. The development of both the navy and the officer structure has been progressive and has matched the developing character and capabilities of the nation. The navy and its officer structure still reflect much of their British origin in both form and tradition, but these have been adapted and applied to a product which is now unquestionably Canadian.

That the process of development will continue is certain. The development will be influenced by the evolving character of the nation, by resources and by technological change. There are, however, some constraints among the influences. These include the versatility and resourcefulness of the people who are the navy, and the uncompromising demands of the sea, the element in which the navy must operate. Those responsible for the continuing development of the Canadian navy have exciting challenges to meet. They may, however, get both encouragement and inspiration if they cast an occasional glance over their shoulders as they carry the Canadian navy forward.

Captain(N) J.H.W. Knox joined the RCN as a midshipman (E) in 1948. In addition to his service in HM Ships Victorious *and* Liverpool, *and HMC Ships* Quebec, Huron and Bonaventure, *he served in appointments ashore as Commanding Officer of the Ship Repair Unit (Pacific), Director of Marine and Electrical Engineering in NDHQ, project manager of the FHE-400 hydrofoil programme, and Naval Adviser with the CDLS in London, England. He was educated at Upper Canada College, RCNC Royal Roads, RNEC Plymouth, RNC Greenwich, Queen's University and the Royal College of Defence Studies in London. Captain Knox retired from the navy in 1983.*

Footnotes

1 Background material in this paper for the period to 1945 has been borrowed extensively from G.N. Tucker, *The Naval Service of Canada*, (Ottawa: King's Printer, 1952).

2 Certain material included in this article has been extracted from chapters by the same author which appeared in J.A. Boutilier, Ed., *The RCN In Retrospect, 1910-1968*, (Vancouver: UBC Press, 1982).

3 For a more detailed account of the development of the position of engineers within the Royal Navy see: Commander G. Penn, RN, *Up Funnel, Down Screw*, *The Story Of The Midshipman*, (both London: Hollis and Carter, 1955 and 1957 respectively) and *HMS Thunderer, The Story Of The Royal Naval Engineering College Keyham And Manadon*, (Emsworth: Kenneth Mason, 1984); also Captain S.W.C. Pack, RN, *Brittania At Dartmouth*, (London: Alvin Redman, 1966).

4 Quoted by Penn in *Up Funnel, Down Screw*, p. 139.

5 The information which follows has been extracted in large part from *Canadian Naval Force and Royal Canadian Navy 1910 - 1914*, (Ottawa: Queen's Printer, 1955) and from a selection of issues of *The Canadian Navy List*, (Ottawa: Government Printing Bureau/King's Printer/Queen's Printer, November 1914 - October 1963).

6 Naval officers named in the text were, at the time in question, members of the RCN unless otherwise indicated. Where abbreviated rank titles are used they are those current at the time in question.

7 A.L. Macdonald, Minister of National Defence for the Naval Service to Dr. Newton, Pres. U of A, 6 October, 1942.

8 Naval General Order 5049, 28 July, 1945.

9 NSHQ message 131746Z September, 1945.

10 General Order 5398, 29 December, 1945.

11 Commodore E.P. Tisdall, Commodore(E) B.R. Spencer, Commodore A.H.G. Storrs, A/Commodore(L) H.G. Burchell, A/Commodore J. Plommer, Commander(S) F.D. Elcock, *Report Of The Ad Hoc Committee On RCN Personnel Structure*, (NHQ Ottawa: 9 November, 1959).

12 Lieutenant(E) F.C. Moore, "RCN Engineering Branch Reorganization", *J.N.E.*, 10, No. 1 (January 1957) p. 72.

13 Lieutenant-Commander J.P. Edwards, RN, "RCN Engineering Branch Training", *J.N.E.*, II, No.2 (June 1958) p. 239.

14 Lieutenant-Commander P.G. Robson, RN, "RCN Engineering Training", *J.N.E.*, 13, No. 3, (June 1962) p. 351.

Ship Passive Protection (Part I)

by Lt(N) Derek W. Davis, P. Eng.

Editor's Note: Part II of this article deals with the measures that can enhance a ship's ability to survive damage and weapons effect, and will appear in the January 1986 issue.

Abstract

Warship design has undergone a major revolution since the coming of the nuclear age and accompanying advances in electronics technology. Extremely powerful weapons and sensor systems being fitted into seemingly fragile steel hulls are forcing ships to rely on such "active" defence measures as ECM and rapid-fire anti-missile guns to ensure survivability. In many ways, both defensive and offensive operations have become perceived as a battle between competing black boxes, with the ship relegated to the role of weapons platform. The platform design itself, however, can play an equally important role in ship protection by incorporating features that will reduce the likelihood of the ship being detected.

Introduction

Avoiding detection by the enemy is of vital importance to the warship operator. In earlier times this was solely dependent upon the visual acuity of the protagonists, with countermeasures restricted to the use of deception or camouflage. However, within this century, the power of the electron has led to an explosion in the variety of detection methods based on the various components of the frequency spectrum.

Owing to its nature, a warship emits and reflects radiation in each of the spectrum's acoustic, electromagnetic and magnetic bands. Each emission or reflection represents not only a chance of being detected by one of the multitude of passive sensors currently employed by ships, aircraft and satellites, but also a possible degradation of one's own sensors since a strong self-produced signal can interfere with the detection of a signal emitted by the enemy.

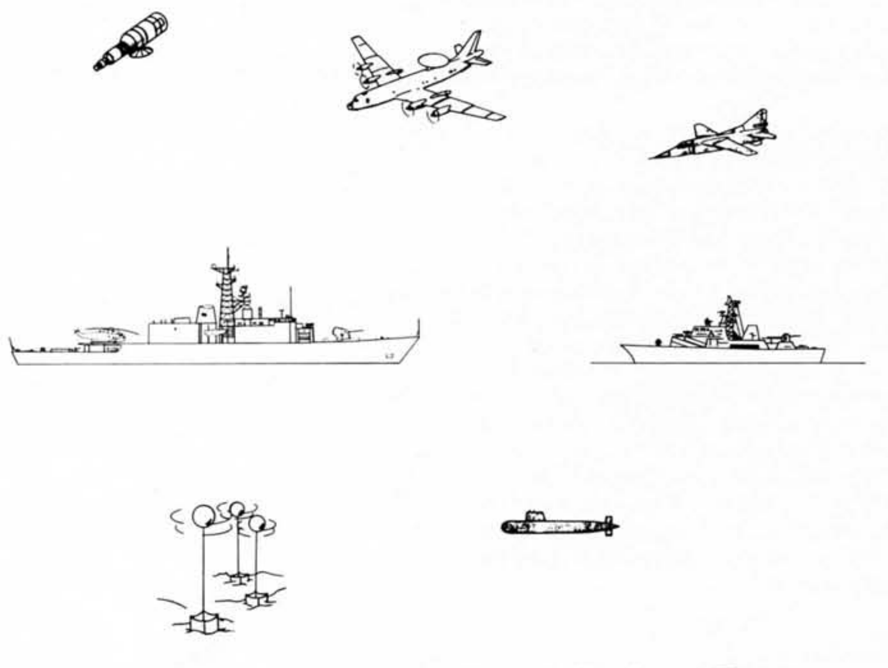


Figure 1. The Sensor Threat

Therefore, to decrease the effectiveness of enemy sensors while enhancing one's own, the ship designer and operator must ensure that the platform least disturbs the environment in which it operates — the frequency spectrum. This article will identify some of the causes of these disturbances and the measures which the ship designer can take to either avoid or minimize their occurrence.

Acoustics

ASW is heavily dependent upon acoustics, and it is well understood that the noises emitted by a surface ship not only provide a target for enemy submarines, but also make the task of its own sonars more difficult. The reduction of this self-noise is becoming increasingly important, now, with the introduction of passive towed arrays (TA) which must listen for submarine-generated noises rather than reflected signals from the ship's own active sonar transmissions.

In terms of generating noise, there are two main causes: the operation of the ship's machinery and systems, and the passage of the vessel through the water. Machinery noise tends to predominate at lower ship-speeds but, as velocity increases, hydrodynamic noise gradually becomes dominant. Together, these noise sources create a distinctive ship's acoustic signature. The ship designer's work, therefore, is to reduce this signature through careful attention to detail in both of these problem areas.

Machinery and Systems

To reduce machinery generated noise one must not only be concerned with the vibration induced into a ship's structure by operating machinery, but also with airborne noise and the noise generated by moving air and fluids within the ship's systems. Each of these areas must be carefully studied and balanced off, since expending a great deal of effort on one aspect of noise reduction is useless unless every machine or system is quieted to the same standard.

The issue of reducing machinery generated noise must first start at the conceptual level — that is, in the choice of propulsion system for the ship. Usually, systems employing rotating machinery, such as steam and gas turbines, are preferred over reciprocating engines (typically diesels). The uniform loading of the former is inherently quieter than the impulsive loading of the latter. There is an exception, however, when the diesel serves as part of a combined diesel-electric propulsion plant and is placed far enough above the waterline to sufficiently minimize the amount of noise transmitted to the sea. A good example of this is the RN Type-23 Frigate where a diesel-electric propulsion system was chosen over the more usual gas-turbine arrangements because of its quiet operation at TA streaming speeds. The mounting of the diesel-electric generators above the waterline, and the use of electric motors, allowed for a very quiet propulsion system. Moreover, by mounting the electric motors directly on the shafts the designers did away with the need to use a gearbox at towing speeds, which eliminated another source of noise problems.

Once the type of machinery has been chosen, attention must then focus on the individual machinery design features. Noise can be decreased by implementing tighter gear-meshing tolerances and by preventing cavitation producing velocities in pumps. Another method of reducing noise involves isolating the machinery components from the ship's structure. This can take the form of installing simple shock and vibration mounts or, at the other extreme, complete machinery isolation rafts such as those fitted in the DDH-280.

While isolating the machinery from the ship's structure one must not forget to minimize airborne noise. This can take the form of individual acoustic machinery enclosures, such as fitted about the DDH-280 main gas turbines, or acoustically cladding the machinery space itself.

Acoustic cladding and isolation is also important for fluid systems since high velocities of air and liquids in piping and ducting systems contribute towards both structure-borne and airborne noise. Hence the importance of maintaining moderate, non-cavitation producingflow velocities and ensuring the flexible mounting of such systems.

Although to this point the concentration has been on incorporating "quieting" features into a vessel's design, it should be remembered that the best design features can be negated through poor maintenance or repair. Such things as noise shorts due to overtight flexible mounts or rigid machine/system connections, out-of-balance rotors, poor bearings, oil whirl and worn pump impellers can all contribute to noise creation and the degradation of the ship's acoustic signature.

Finally, as a means of isolating all the various machinery and system-generated noises from the sea, one can fit a system such as MASKER which provides a mass of smail air bubbles between the hull and the sea to create a sound-absorbent layer about the ship.

Hydrodynamics

As a conventional surface vessel moves through the water, a complex disturbance is caused by the interaction of the ship's hull, the means of propulsion and the sea surface. This disturbance or wake consists of:

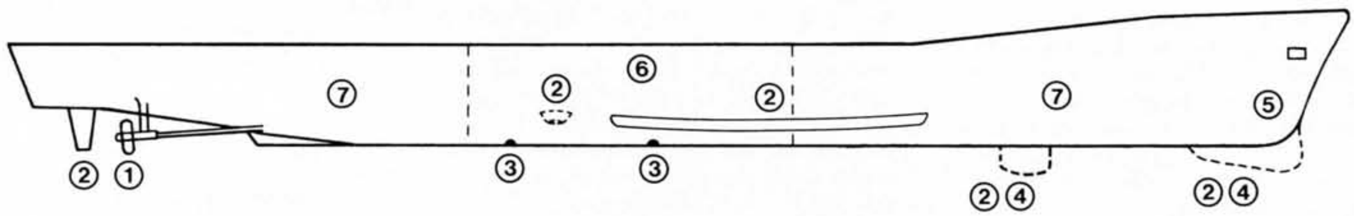
a. a thin boundary layer immediately next to the hull;

b. regions of positive pressure at the bow and stern of the vessel (creating bow and stern waves), and a region of negative pressure amidships;

c. a range of water velocities between the ship's hull and the surrounding water due to the motion of the vessel; and

d. disturbances such as boundary layer turbulence, propeller and appendage cavitation, eddies and vortices, and such effects as wave slap and bow splash.

All of these aspects of the wake lead to the generation of noise, but additionally represent a loss of energy to the sea and an inefficiency on the part of the



1. Propeller design should delay or, if possible, avoid cavitation.

2. Hull appendages should follow natural flow-lines to prevent cavitation.

3. Seawater inlets and outlets should be minimized to prevent eddy formation.

4. Sonars should be positioned well away from noise-producing machinery and systems.

5. Bow shape should prevent cavitation and bow slap.

6. Noise-reducing features should be introduced to machinery spaces and systems.

7. Hull design and surface-preservation features should minimize deformities and maintain good flow-lines.

Figure 2. Areas of Concern to Acoustic Noise Reduction

hull and propulsion system design. Therefore, not only does wake reduction decrease noise generation, but it also often leads to greater energy efficiency.

To reduce wake generation, in general, an efficient, well streamlined hull design with a minimum number of appendages is the best approach. However, as with machinery noise reduction, the detailed design aspects are of great importance. For example the shape of the bow is particularly important in preventing bow splash and the creation of vortices, each of which produces noise that can affect the performance of bow-mounted and hull-mounted sonars.

It is very important that any necessary appendages be streamlined and carefully aligned with the hull flow-lines so that cavitation can be avoided or, at least, that its onset can be delayed. For this reason the benefits of fin stabilizers to seakeeping must be weighed against their noise-making potential. When operating at large angles of attack they not only produce large amounts of cavitation around their own surfaces, but may cause problems with flow into, and hence noise production by, the propellers.

Another aspect of reducing hull-generated noise is the need to minimize the number of hull inlets and outlets. Each one not only produces eddies and vortices, but also serves as a sound conduit from the ship's interior and systems into the sea.

The hull structure itself must be designed to incorporate features which minimize noise. The structure should be stiff enough to prevent excitation by either the ship's own machinery or hydrodynamic forces, and the underwater hull-plating must be sufficiently thick to prevent local dishing as such surface irregularities lead to eddy formation.

The condition of the hull surface can affect noise production, and measures taken here to reduce resistance and improve hull life also directly benefit noise reduction. The removal of weld beads, and the prevention of fouling and corrosion are of particular importance these days since they all help to reduce fuel bills, but by maintaining the ship's smooth skin they also prevent the creation of small areas of turbulence which, in turn, create noise.

After hull design, the propellers form the other principal source of hydrodynamic noise. Once again the emphasis is on preventing or at least delaying the onset of cavitation. To do this one can employ air-emission devices such as PRAIRIE or AGOUTI, but the best method is to ensure the propeller is properly designed. For most applications, large slow-turning, lightly loaded conventional propellers offer the best chance of delaying cavitation and reducing noise, although there are other quiet alternatives such as pump jets. This in turn affects the ship design since, given the constraint of limited propeller diameter and the need to deliver a certain power, two propellers will be less loaded than a similar size single propeller, and therefore less noisy — hence, part of the reason for the many twin-screw ASW frigates.

In terms of cavitation reduction, fixed-pitch propellers (FPP) are better than controllable-pitch propellers (CPP). Owing to its method of operation the CPP often works at other than its designed pitch setting. This produces early cavitation and, hence, noise. Although most frigates and destroyers are currently equipped with CPPs, the RN's Type-23 Frigate is equipped with FPPs and this may be an indication of a possible change in thinking for future ASW frigates.

Electromagnetic Bands

Since the Second World War this part of the frequency spectrum has in many ways become the primary sensor battleground. The importance is due not only to the power of modern electronics, but also to the variety of detection methods made possible by this and other new technologies. Owing to the speed and breadth of this technological revolution, many future sensor threats can now only be guessed at and speculated upon. And although one can now discuss countermeasures to threats in the visual, radar, radio and infra-red parts of the spectrum, one should remember that within the near future there will probably be several more sensor categories which will require the development and implementation of additional countermeasures.

Visual

In most modern warships, apart from an overall grey paint scheme, little emphasis seems to have been placed upon measures to reduce the risk of visual detection. This is understandable when one considers the vast array of electronic sensors which currently compete with the human eye. But as events in the Falklands demonstrated, there is still a need for attention to this problem. The paint scheme should merge the vessel with the sea background and, in so doing, should avoid sharp shade differentials, straight lines or right-angle corners which provide ready visual reference points for targeting.

Avoiding visual detection can be even more important for the smaller warships, especially those designed to operate close inshore or in archipelagoes where electronic sensors have problems. Good examples of attention to this concern are the dabble-painted camouflage schemes adopted by many Swedish patrol boats. Unfortunately, though, small high-speed craft can often be detected by the spray thrown up by their bows or by the wash generated at their sterns. Reducing the conspicuous white stern-wash (clearly visible from the air) would require a change in hull lines, but simple suppressors can be effective in diminishing the spray at the bow.

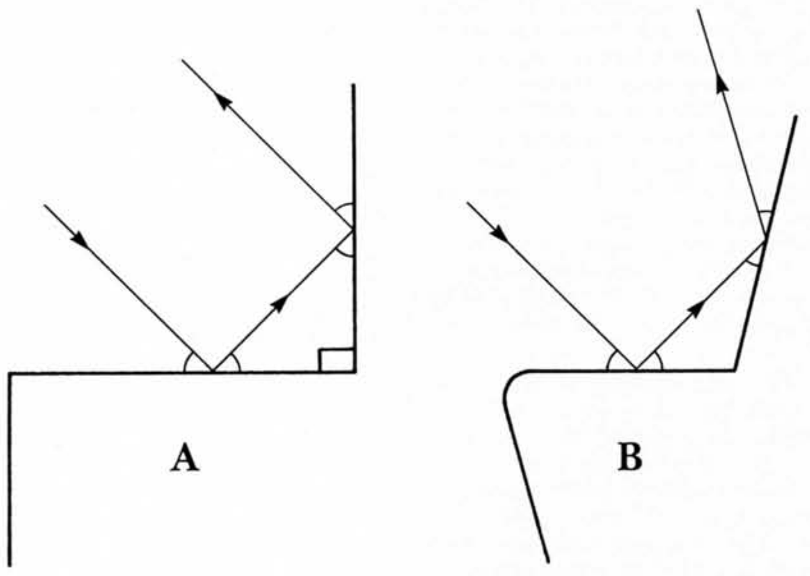
There are also certain problems which pertain to all warships — the prevention of the emission of smoke, and ship arrangement features to prevent or reduce light emissions. Examples of this are general arrangement features in the upper-deck and bridge designs, and the arrangement and control of lights for helicopter and RAS operations.

Radar

In view of the heavy reliance placed upon radar detection and the electronic countermeasures employed to increase the difficulty of such detection, it is not surprising that the reduction of radar cross-section (RCS) has become of increasing concern to the ship designer. By reducing the radar return by a few decibels, detection by an enemy sensor can be put off by several miles. Additionally, with regards to the anti-ship missile threat, a reduction in the RCS makes the missile-seeker's job of targeting more difficult, and increases the effectiveness of the ship's countermeasures in decoying the seeker from the target.

Reducing radar cross-section involves the avoidance of areas of high radar reflectivity. This can be done by avoiding ship features which "focus" and directly return the incoming signal, or by preventing absorption of the signal, resonance and subsequent reradiation.

The principal method of preventing such focusing involves the avoidance of orthogonal intersections by sloping the ship's horizontal and vertical surfaces. Such intersections include upper-deck deck-bulkhead connections and overhangs. As the number of such intersections usually increases with the amount of superstructure, this is one argument in favour of trying to fit most ship compartments within the hull. When compared to conventional wall-sided vessels, the implementation of this feature can produce a low overall superstructure and ship height, and a hull with flared sides throughout its length. This not only reduces RCS, but also decreases wind



Right-angle intersections reflect radar signals directly back to the emitter as in A above. Obtuse-angle intersections (B) significantly diminish the signal return to the source by deflecting the signal away from the emitter.

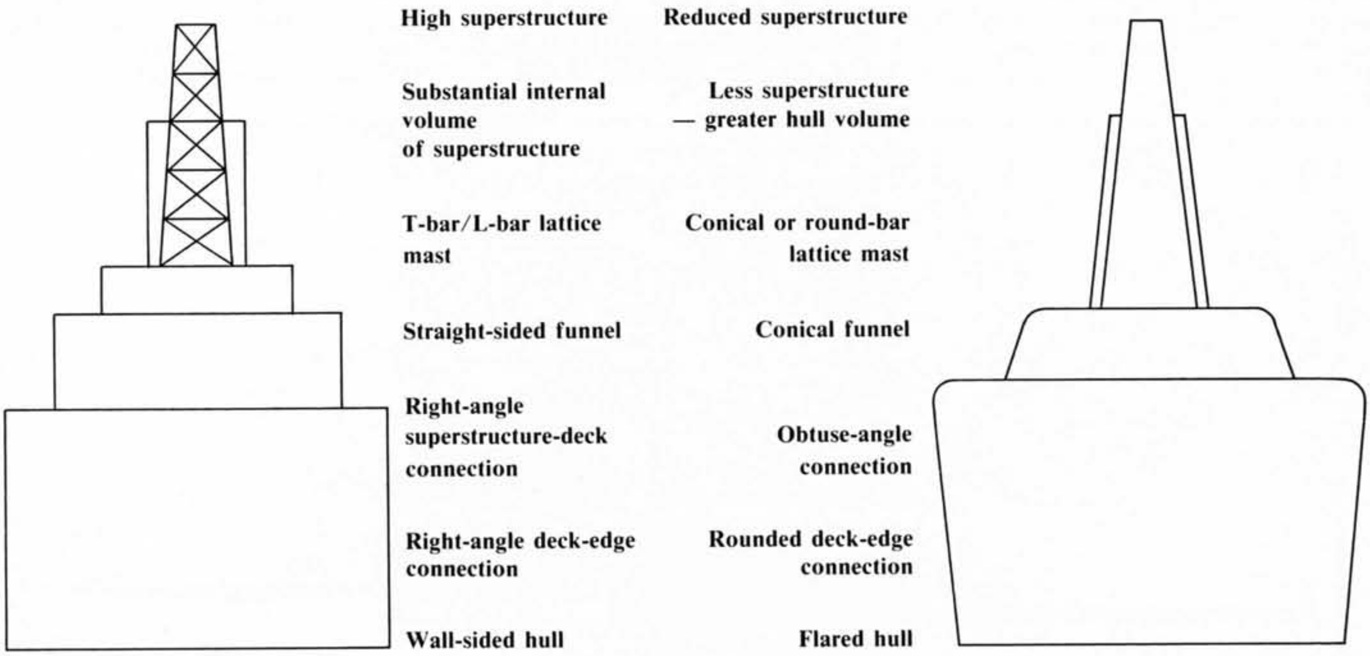
Figure 3. Radar Cross-Section

resistance and increases protection from air blast.

In addition to the intersection of major ship's structures, other seemingly minor features can result in orthogonality and increases to RCS. Lattice structures with L-bar and T-bar components, and wall-sided masts prove poor in reducing RCS while conically shaped masts and funnels are usually better. Also, where upper-deck lockers and deck fittings increase the RCS, a solution is to build the lockers into the superstructure.

Other features which decrease RCS are curved surfaces which tend to scatter the incoming signals, and radar-absorbing materials which absorb them and, thus, decrease the strength of the return signal. Unfortunately radar-absorbing material has drawbacks in that it is generally soft and can be easily damaged. (Neither of these characteristics makes for a smart-looking warship. A possible solution, however, would be to develop the material such that it could be readily applied and repaired in wartime, thereby avoiding degradation of the ship's appearance in peacetime.)

Resonance of a ship's structure or fittings in sympathy with an incoming signal, and the subsequent reradiation



Cross-section of conventional ship

Cross-section of ship with RCS reduction measures applied

Figure 4. Configuration of Conventional and RCS-Reduced Ships

to the sensor, is another cause of great concern to the ship designer. Features such as rigging, antennas, chains, ladders and sharp structural intersections whose lengths are multiples of the incident energy wavelength can all act as resonant antennas. The extent and strength of the reradiated signal, of course, are dependent upon the configuration and electrical resistance of the "antenna" and the intensity of the incident energy.

To reduce the possibility of resonance taking place, the use of metal components in the features likely to resonate should be avoided, and curved surfaces should be used at structural intersections. For example, wire guard-rails and metal ladders should be replaced by those of fibreglass or non-metallic composites, and an upper-deck round-down should be introduced.

Infra-red

The danger posed to a ship by infra-red sensors lies in the large number of "heat generators" present in any ship, and the inherent nature of metal structures which absorb and then reradiate heat and solar energy. In particular, temperature gradients are more easily detected than absolute levels of heat output. In other words, hot spots prove more troublesome than the overall amount of radiated energy. Because of this, atmospheric conditions can have a marked effect on detectability as a ship will tend to stand our from her environment much more on a cold day than on a hot one.

In terms of designing ship features to reduce infra-red signature, one should first attempt to eradicate any particular hot spots, and then seek to reduce the ship's overall signature. The hot spots include such things as the ship's galley, laundry, main and auxiliary machinery spaces, electronics spaces, and machinery exhaust outlets with their associated hot-exhaust plumes. The reduction of the overall signature encompasses means of decreasing the general heat output through the ship's structure and preventing the reradiation of solar energy.

To reduce hot spots on the ship's outer shell, the best solution is to locate offending compartments away from the ship's side, and where this is not possible, suitable insulation and/or space-cooling arrangements can be used. Exhaust gases represent a particular hazard since they produce a large plume above the ship which increases the range at which the ship can be detected. As well, any structure that they come in contact with will be heated to become another hot spot. The solution to this problem involves lowering the exhaust-gas temperature through choice of propulsion plant and energy conservation steps, or by mixing large amounts of ambient air with the exhaust prior to its exiting the ship. If necessary, a cooling system can be used to lower the temperature of the funnel or exhaust-ducting structure.

The type of propulsion system is of fundamental importance since its characteristics influence the extent of other countermeasures necessary to reduce the IR emissions. In order of desirability from an IR viewpoint, diesels are best, then steam, with gas turbines presenting the worst problem. This ranking stems not only from the temperatures, but also from the volumes of exhaust gases produced.

Energy conservation measures such as boiler economizers, waste-heat boilers and the American RACER (exhaust-heat recovery) concept all reduce the exhaust-gas temperature and therefore benefit IR signature reduction. However, to be effective, they must be so integrated into the ship's systems that they operate continuously and are thus not "off" at the critical moment.

Cooling the exhaust gases by mixing them with the ambient air requires either large fans to draw in and mix the gases, venturi arrangements which use the flow of the exhaust gases to draw in outside air, or a combination of both. All of these methods usually lead to increased volume needs in the funnel area, often in the form of extra- large exhaust trunks. A good example of these arrangements was the funnel of HMS *Sheffield*.

To reduce the overall signature, thermal insulation should be used throughout the ship. Apart from reducing the IR signature, insulation would contribute towards energy conservation and improving the comfort of the crew. Additionally, to reduce the absorption of solar

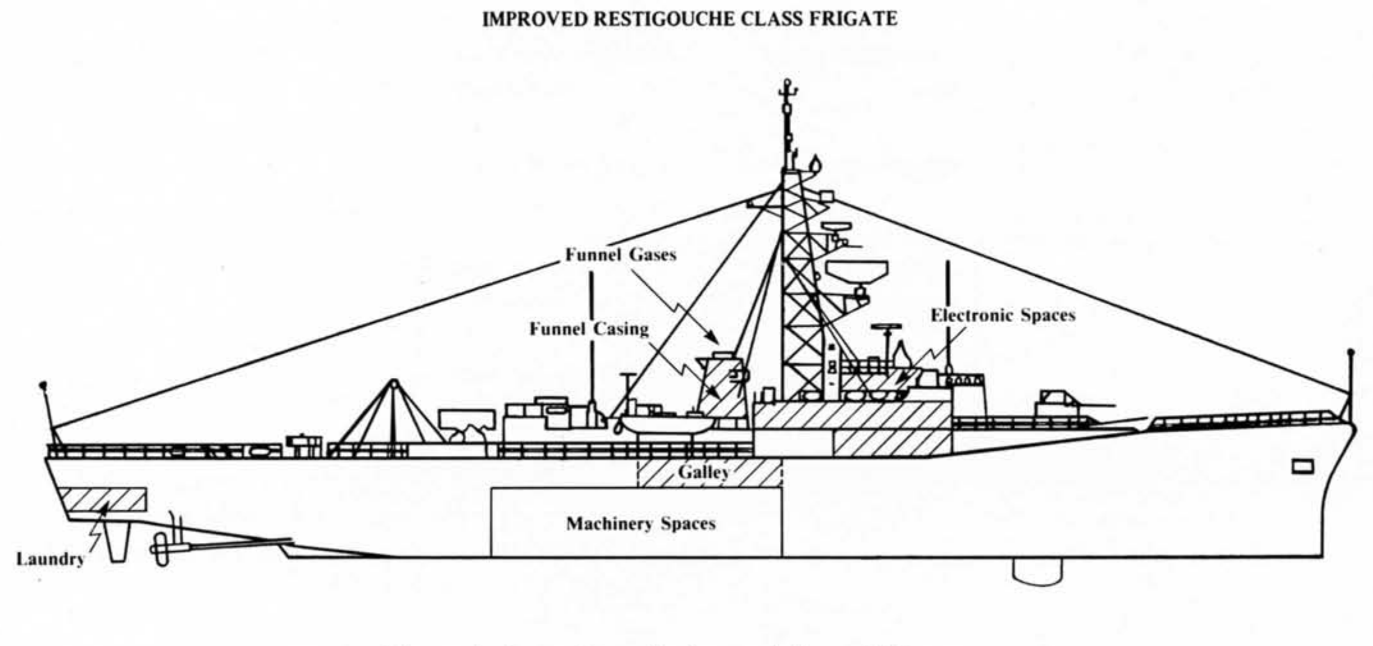
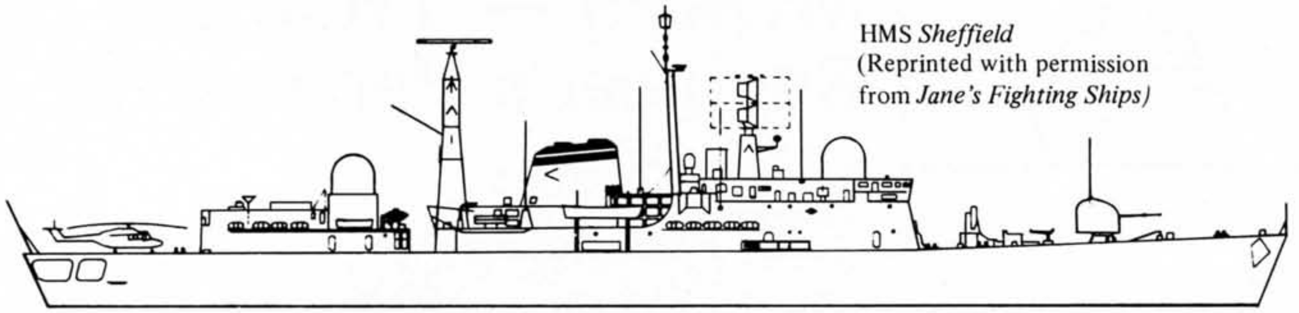


Figure 5. Areas Contributing to Infra-red Signature



HMS *Sheffield*
(Reprinted with permission from *Jane's Fighting Ships*)

radiation, suitable light-colour paint schemes can be used although this can conflict with camouflage requirements. Finally, although more an operational than a design option, the pre-wet system can provide a means of cooling the ship's structure to reduce the IR signature when in a threat situation.

Electromagnetic Emissions

The prevention of unintentional electromagnetic emissions is for the most part the domain of the ship operator and the individual equipment designer. The ship designer's main role is to ensure that the ship's structure maintains a Faraday cage about the various electronic system components. This pertains not only to the overall hull and superstructure configuration, but also to the internal features to reduce interference between various electronic components. For example, high-power transmitters should be isolated in a different compartment from internal communications equipment.

The establishment of a Faraday Cage about the whole ship is relatively simple for most vessels due to their metal structure, but in the case of fibreglass construction special measures such as wire cages about electronic equipment spaces must be used owing to the material's inherent electronic transparency. As with all protective measures details can be very important. Even in a metal structure the connecting arrangements for cables and waveguides entering the ship must be designed to prevent unintentional "holes" in the cage.

An additional benefit to giving attention to this problem area is that many of the features are beneficial for electromagnetic pulse (EMP) protection. This will be discussed in Part II of this article.

Magnetism

The danger posed to a vessel by her magnetic signature became of extreme importance during the Second World War with the introduction of the magnetic mine, a device triggered by a vessel's distortion of the earth's magnetic field. This threat led to the methods of degaussing and deperming, countermeasures which, incidently, were developed by Canadians and which are still in use today. The degaussing system neutralizes the ship's magnetic signature by generating a magnetic field pattern through fitted electrical coils which cancels the disturbance of the natural field. Deperming is an infrequent expedient, and involves looping electrical coils about the ship's hull through which a current is passed to correct an inordinately large ship's own field. (Alternatively, ships emerging from, for example, a lengthy bows-north refit can counteract the considerable induced magnetism by pointedly docking "bows south" at every opportunity for a period of several months following the refit.)

Although both these methods can remove a great deal of a steel ship's permanent and induced magnetism, they can never be totally effective due to compromises in design, the complexity of the ship's field and the varying nature of the earth's magnetic field. In cases where an absolutely minimum signature must be achieved, such as in minesweepers and minehunters, other measures must also be adopted. These typically include constructing the hull and machinery from non-ferrous materials, which accounts for the many wooden and fibreglass vessels now being built with bronze fittings and aluminum engines.

Conclusion

There are various means of reducing ship detectability and, thus, increasing survivability. Each of these measures offers its own form of protection in terms of concealing a ship from enemy sensors and, at the same time, contributes to the overall effectiveness of one's own equipment. But while each has its own attributes, in many cases the different measures complement one another to the extent that the provision of one and not the other is often useless.

The complementary and interdependent nature of protective measures becomes particularly important when, as is inevitable in ship design, there is a need to accommodate such factors as cost, availability and operational convenience. These factors will certainly come into play, and certain compromises will have to be made to achieve the necessary balance of passive and active defensive features in a warship's design.

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MORPS — From an Engineer's Perspective

by LCdr B.T. Irvine

Abstract

Over the past few years considerable information has been published regarding the basic issues of the Maritime Other Ranks Production Study. For the most part this information has been directed towards those who were the subject of the study — the naval tradesmen. Little, however, has been published that discusses the issues from an engineer's standpoint. This, then, is an engineer's perspective of the changes brought about by MORPS and how they affect us as engineers.

Introduction

The Maritime Other Ranks Production Study was organized in 1977 under the chairmanship of Capt(N) Kirby. Its aim was to recommend action to improve the professional welfare of our naval tradesmen as a means towards improving an unsatisfactory state of recruiting and retention. In June 1978 the MORPS Steering Committee submitted its findings and recommendations in a sweeping two-volume report. Volume I addressed the topics of naval organizations and institutions, while the naval trades and rank structures were covered in volume II.

Maritime Command was able to act upon most of the recommendations in Volume I, however the Volume II recommendations required coordination and action by various NDHQ agencies. Such action included occupational analyses of the trades, preparation of trade specifications and revisions to the trade structures. Throughout the whole process, all action was reviewed by MARCOM, ADM(Per) and the engineering community. Thus, the final trade restructurings were subjected to detailed analysis and negotiation by both personnel and engineering experts. In several cases the final trade structures bore little resemblance to those proposed in the MORPS report, but since the engineering community had significant input to the final structures they should be exactly what we want and need.

MORPS Concepts

The MORPS report proposed several changes to the basic trade structures to ensure that we have the best qualified personnel at each rank level. The rank of Petty Officer First Class was chosen to be the highest level for the senior section operator-maintainers — the highest level hands-on expertise onboard. Thus over the next few years we will gradually see a reduction in the number of senior NCOs onboard the ships. In particular, once we have sufficient Cert-4 qualified CPO2 MAR ENG ARTs, the coxswain will become the only CPO1 onboard and the total number of CPO2s onboard will also significantly decrease. With a reduction in the number of senior NCOs in each trade comes a corresponding increase in the number of junior personnel. This is being done to ensure that each trade has rank-to-rank ratios that will offer good promotion flow and selectivity. This will eliminate the nearly automatic promotions which occur in some trades because of the inverted pyramid rank structures (i.e. fewer tradesmen at one specific rank than at the next higher rank), and should ensure that only the best individuals are promoted. In keeping with the Defence Management Committee "Ops/Non-Ops" duty ratio policy, the sea/shore ratios for the MORPS trades were designed to ensure that personnel will generally receive incresing shore time over their career.

The most fundamental change however was the decision to move from user-maintainer trades to separate operator and maintainer trades. The MORPS report concluded that the recent technological advances had rendered the user-maintainer concept no longer viable. The modern equipment going into our present ships, and the state-of-the-art equipment which will be found in the CPF, requires competent, dedicated operators who know their jobs thoroughly. And this same equipment, with its integrated circuits and microprocessors, requires highly trained technicians to diagnose and repair it at sea. Furthermore, the training costs under the user-maintainer system were becoming prohibitively high, as every individual was trained as both an operator and technician even though onboard the ship he was employed as only one or the other. Consequently it was realized that separate trades would be much more cost-effective from a training standpoint, and would also ensure that individuals with aptitudes as either operators or technicians would work solely within their areas of competence.

Implementation

Due to the complexity of the process, the implementation of the new MORPS trade structure was phased in over several years. The process for each trade included trade restructuring where required, introduction of new training (including conversion and interim training), establishing the present positions in the new trades and establishing the additional positions required by MORPS for the new trades.

The new trades were introduced over three years, with the NW TECH, BOSN and NAV SIG trades being introduced on 1 Jan 83, the MAR ENG MECH, MAR ENG TECH, MAR ENG ART, H TECH, MAR EL, E TECH, CL DIV and CL DIV TECH trades on 1 Jan 84 and the NAC OP, NRAD OP, NCI OP, NES OP, NE TECH A, NE TECH C, NE TECH T and NE TECH S trades on 1 Jan 85. MARCOM raised Establishment Change Proposals to ensure that the required positions in the new trades were established. And with the approval of the MORPS PCP on 13 Dec 84, the 787 additional positions required for the essential sea and shore jobs identified for each trade could be established in a phased, orderly fashion.

The New Trades

How do the new trades and their associated trade structures affect us as engineers? Looking first at the Combat Systems Engineering side of the house, the major change onboard the ship is the creation of the new CSE Department which includes the Electronic Maintenance Division and the Weapons Section. The CSE now has at his disposal all of the combat systems maintainers — a department commensurate with his maintenance responsibilities onboard. On a typical 280 this will equate to 16 NE TECHs and 25 NW TECHs. When one includes the CPO2 CSE Department Coordinator and the Assistant CSE this means that the CSE will have 43 personnel working under him.

During the transition period (up to 1990), the full MORPS establishment will not be in place and many individuals will be required to perform both the maintainer and operator functions. This will be particularly noticeable when individuals are sent ashore for conversion training courses, as reliefs will not normally be provided. Thus, for example, a PO2 NCI OP may be required to perform maintenance tasks on his equipment because the PO2 NE TECH T is ashore on course. For this reason, all Naval Combat Operators who were terminal tradesmen on 31 Dec 84 will continue to receive Specialist One pay until the end of the implementation phase (31 Dec 89).

The creation of the eight new MORPS trades from the old trades also brought about the requirement to remuster personnel into the appropriate operator or technician trade. With many factors taken into account, this process has been completed and all personnel are now either Naval Combat Operators or Naval Electronics Technicians. While the selection process was designed to provide for an overall balance of maintainers and operators, this could not be done on a unit by unit level. Thus some ships may seem to have an abundance of Naval Combat Operators while others seem to have an excess of Naval Electronics Technicians. These irregularities will be ironed out by the normal posting process over the next few years.

It is important to remember that no one "loses"any qualification, experience or expertise by being remustered to one of the new trades. If Petty Officer Bloggins was your best maintainer as a COMM TECH SEA, he might well continue to be your best maintainer even though he has remustered to NRAD OP. During the implementation period you have the licence to employ these tradesmen where you need them. By 1990 most of the tradesmen should have completed at least one of the new operator or technician trade courses, and should then be reasonably expert in their fields. As well, the new MORPS establishments should be fully in place by then, and each ship should have the proper mix of operators and technicians.

On the Marine Engineering side of the house, the major change effected by MORPS was the creation of three new Marine Engineering trades from the two previous ones. This change has allowed for promotion to be tied to certification, and will enable the rank of a ship's Chief ERA to be lowered to CPO2. In the long term this will provide the stable rank structure that the trade so badly needs, and will ensure that the tradesmen can enjoy the pay and shore time that they deserve. However, this is not an overnight cure for the woes of the Marine Engineering trades. Despite a substantial increase in thenumber of personnel achieving Cert-3 and Cert-4 in 1984 (53 and 12, respectively), the severe unscheduled attrition left a net gain of only 12 Cert-3 and 4 Cert-4 tradesmen.

The greatest problem that we face as engineers is convincing our senior NCOs that their lot will improve if they themselves do something about it. Above all, they must remain in the service. The loss of 38 Chiefs and Petty Officers last year kept our pool of Cert-3 and Cert-4 qualified tradesmen at a near-critical level, and guaranteed that the sea/shore ratio would remain poor. The trade is in dire need of Cert-3 and Cert-4 qualified tradesmen, and personnel must be encouraged towards attaining their next certificate whether it be Cert-3 or Cert-4. Without a pool of personnel holding these certificates the career manager will have no choice but to send the same people back to sea again and again with little time ashore between sea postings. Each individual who attains Cert-3 or Cert-4 helps himself and his fellow tradesmen in attaining more time ashore. Our challenge as engineers is to motivate our PO2s to attain Cert-3 and our POls to attain Cert-4. The MORPS trade structure has set up the basic framework with which to rebuild the Marine Engineering trades, but it is now up to the tradesmen to make it work.

The Electrical and Hull trades were not changed significantly, except in the area of training where changes in course lengths and content have made the training much more effective. The elimination of the H TECH TQ4 course means that a ship will no longer be faced with the loss of one and sometimes two junior H TECHs for the four-month period of the old TQ4 course. Of course the elimination of this course required a corresponding increase in both the TQ3 and TQ5 courses. But as a ship gets its personnel *after* TQ3 training, and receives a replacement for anyone posted to the TQ5 course, with the exception of absences for leadership training or illness a ship should never have to sail without a full complement of Hull Technicians. For the electricians, a much greater emphasis has been placed on both theoretical and practical electronics training in the expanded TQ5 and TQ6A courses. This will ensure that E TECHs are well prepared for the expected electronic technology in the TRUMP and CPF ships, and will give them an excellent background for the TRUMP/CPF Control and Instrument TSQ which is presently being developed.

Conclusions

The advent of MORPS has caused much upheaval in the naval community over the past few years, but it has had the welfare of the sailors as its prime aim. The new training profiles, for instance, are designed to give the tradesman much improved trade training, which will allow him to perform his job more effectively, and should provide him with greater job satisfaction. The new trade profiles and establishments are designed to provide each tradesman with the best possible sea/shore ratio and good promotion opportunity. However, there is always a lag between establishing new positions and having them filled by personnel with the proper rank and trade qualification. This will be particularly noticeable in the Marine Engineering trades where the new ships' establishments call for CPO2 Chief ERAs, for example. It is a known fact that it will take several years to qualify sufficient personnel to fill the new establishment, and in the meantime over- and underranking will occur.

As with any change, it will take time before the new trades and trade structures become accepted by all personnel. In the meanwhile it is our task as engineers to ensure that everyone, particularly the senior NCOs, realize that these changes were made for their benefit, and that in the end these changes will benefit their careers. MORPS was not implemented to cut costs — the steady state *increase* in personnel costs will be $46 million by 1990 — or to save the navy any training time (even though it has cut the training increase that would have been required under the old user-maintainer system). MORPS was implemented to improve the unsatisfactory state of recruiting and retention in the hard sea trades, and was designed to do this by improving the conditions of service for all hard-sea tradesmen. The introduction of the new trades, training and structures is now complete. Time and effort, now, are required to ensure that we have the necessary qualified personnel toman the navy into the next century.

LCdr Irvine has been the NDHQ MORPS Team Leader since July 1983. During the past two years he has worked with MARCOM and various NDHQ agencies in the implementation of the MORPS Phase II and III trades, and on the preparation of the MORPS PCP.

A History of The Helicopter Hauldown and Rapid-Securing Device

by George Huson

Abstract

The helicopter hauldown and rapid-securing device system was developed to enable rotary wing aircraft to operate from DDH-class ships during day or night, rough-weather, anti-submarine operations in the North Atlantic. Since its inception in the 1950s, the Canadian-developed HHRSD has been the subject of great interest by other maritime nations and has become a world-wide success. This article chronicles the 29-year history of the system, and briefly discusses the future of the HHRSD.

Introduction

It was recognized in the early 1950s, after four years of carrier-based trials, that the helicopter had a major role to play in anti-submarine warfare. The first Canadian ASW helicopter squadron (formed in 1955) was designed to operate from aircraft carriers, but around the same time the RCN began studying the feasibility of operating helicopters from warships other than carriers. From this study it was determined that providing conventional DDEs with a helicopter capability would be a feasible method of extending the ships' ASW search and attack weapon systems.

Development Project Launched

In 1956 a platform was constructed on the aft end of the escort vessel HMCS *Buckingham* and trials were conducted at sea using an HO4S-3 helicopter to demonstrate the results of the feasibility study to date. As a result of these trials the landing platform was modified and installed on HMCS *Ottawa* where a second series of trials was carried out using an H-34 (S-58) helicopter. From these trials it was concluded that it would be feasible to operate a large helicopter from the deck of a small ship, but a mechanical means of securing the helicopter to the deck on touchdown, a handling system for moving the aircraft, and a hangar for the protection and maintenance of the aircraft would be required. In 1958 a project was raised, and a statement of objective defined, for the development of a device capable of securing and traversing a helicopter on an unsteady deck.

Development

Between 1958 and 1961 many basic schemes were studied, but all were rejected because they could not accept the helicopter landing up to four feet away from the ideal position for marrying it to a securing device and handling system. During this period the finances for the project were uncertain and industrial interest was difficult to arouse. As well, there were many skeptics in industry and most of the early development work had to be done by RCN and civilian project officers.

In July 1960, trials were conducted at VX10 Squadron (Shearwater, N.S.) to determine whether the HO4S-3 helicopter could be pulled safely to the ground from a hover position. For the trial, a nylon rope was attached to the cargo-hook sling at the release point, led through a block, and attached to a ring-bolt in the tarmac. Then seven men hauled on the rope to pull the helicopter down. The trial was a success, and it was concluded that a helicopter could be pulled down from a hover position without upsetting the stability of the aircraft.

Meanwhile, the United States Navy was doing its own trials using a constant-tension (Eddy Current Clutch) winch to bring a drone helicopter down to the deck. Results from these trials indicated that the constant-tension hauldown technique had great potential for guiding a helicopter to a more accurate landing, and a decision was made in Canada to adopt and develop the technique for use in a Canadian system. Use of the constant-tension technique greatly simplified the task that would follow in developing a securing device that could trap a helicopter in a target area of 36 inches.

The Royal Navy had developed a "harpoon" securing device which was a grid of half-inch steel cable meshed together to form a net with three-inch-square openings. The harpoon, which was attached to the under-side of the aircraft, penetrated the mesh on landing and secured the helicopter on the deck. While the harpoon system, as it stood, failed to meet most of the feature requirements specified in the 1958 statement of objective for a securing and traversing device, it eventually served as an important model-base for the Canadian system.

Industrial Design Competition

New schemes were investigated and industry was invited to participate in a design proposal competition for a helicopter quick-attachment device to handle the CHSS-2 (modified SH-3A) helicopter. There was a regrettable lack of progress towards meeting the very demanding requirements for this equipment. Proposals received from industry were rejected because of incompatibility with deck structure, inability to meet operational requirements, and size and weight complications in the aircraft.

Fairey Canada Ltd. submitted a number of proposals which were also rejected, but their last actually offered the most promising solution to the attachment problem yet. Then after a year of study and consultation with the RCN, Fairey submitted a modified proposal (complete with scale model) for the development and construction of a prototype hauldown and rapid-securing device. This proposal, which described the now well-known "beartrap" system, was accepted by the RCN, and in September 1962 Fairey was awarded the development contract.

HSS-2 Compatibility Trials

In April 1962 a contract had been placed with Canadian Pratt and Whitney Co. Ltd. to conduct an engineering investigation and trials of the techniques and equipment necessary for the operation of a Sikorsky HSS-2 helicopter from destroyer escorts. The Canadian Government drafted a loan agreement with the United States for an HSS-2 helicopter to be used by Pratt and Whitney in their trials at the Sikorsky plant in Stratford, Connecticut.

The trial was conducted by attaching a light cable to the keel of the aircraft, feeding the cable through a snatch-

As the helicopter hovers over the flight-deck, the constant-tension cable is manually connected to the aircraft's messenger cable to be winched up.

block secured to a landing spot on the ground, and attaching it to a reel fitted on a tractor. The aircraft took off with the cable attached, took up the slack, and hovered at about fifty feet above the snatch-block. It was at this point, in a planned maneuver, that the tractor moved forward to draw the helicopter to the ground. The maneuver was repeated several times, and forces on the helicopter were recorded to determine where an attachment point could be built onto the aircraft which would accept the loads required to restrain the helicopter, from what minimum height the helicopter could be hauled down to a deck which is rolling 31 degrees, the desirable cable tension to be used, and if flight instability would result from using a constant-tension hauldown attached to a point just forward of the sonar well on the keel of the aircraft.

It was found from later trials that a constant-tension cable actually exerted a definite stabilizing influence on the helicopter. It minimized the reaction due to turbulence, keeping the helicopter steady near the point of landing. Instead of hampering the pilot's control of the aircraft, the winch-line improved it by making the response to stick movement less demanding. The conclusion was that the aircraft winchdown technique was practical and safe, and should be considered as the technique to be used with the HHRSD system.

On the strength of Fairey's proposal for the HHRSD system, work was started to design and assemble a prototype helicopter handling system and main-probe assembly for the CHSS-2 aircraft. The design was broken down into the rapid-securing device, track installation and cable reeving system, winch unit, powerpack and constant-tension control system. Fairey, as the prime contractor, subcontracted the winch, powerpack and control system to Dowty Equipment of Canada, Limited who, in turn, subcontracted the control system to Cowley Consultants Ltd.

Evaluation and Proof-Testing Programme

HMCS *Assiniboine* (in refit on the west coast) had been selected as the first of the DDEs for conversion to DDH, and was scheduled to receive the beartrap system for trials in 1963. That year, Phase 1 of an evaluation and proof-testing programme for the HHRSD system commenced at various service installations and contractors' plants. This was to ensure that the design construction and load-carrying capacities of the components conformed to the design specification. Functioning and straightening trials

The pilot, still in control, flies the Sea King down to the deck with the assistance of the constant-tension hauldown cable. Once on the deck, the helicopter main probe is trapped in the jaws of the RSD by the Landing Signal Officer.

using the beartrap, a dummy helicopter and dummy track system were carried out by FCL to capture the details of loads exerted on the beartrap and cable system while moving a dummy aircraft. After a tight schedule, with many problems, the beartrap shop-testing was completed, and although the system still had some deficiencies it was shipped to the west coast for installation in HMCS *Assiniboine* in order to meet the ship's conversion schedule. The prototype hauldown and traverse winches were tested at Dowty in June and found to be satisfactory, however the control system was totally inadequate except for running the traverse winches and moving the trap. But with the tight conversion schedule it was decided to install the winch unit, power-pack and traverse system. Functioning and straightening trials using the beartrap and a dummy helicopter loaded to 15,500 lbs. were continued under varying conditions of ship motion onboard *Assiniboine* while the ship was at sea enroute to Halifax.

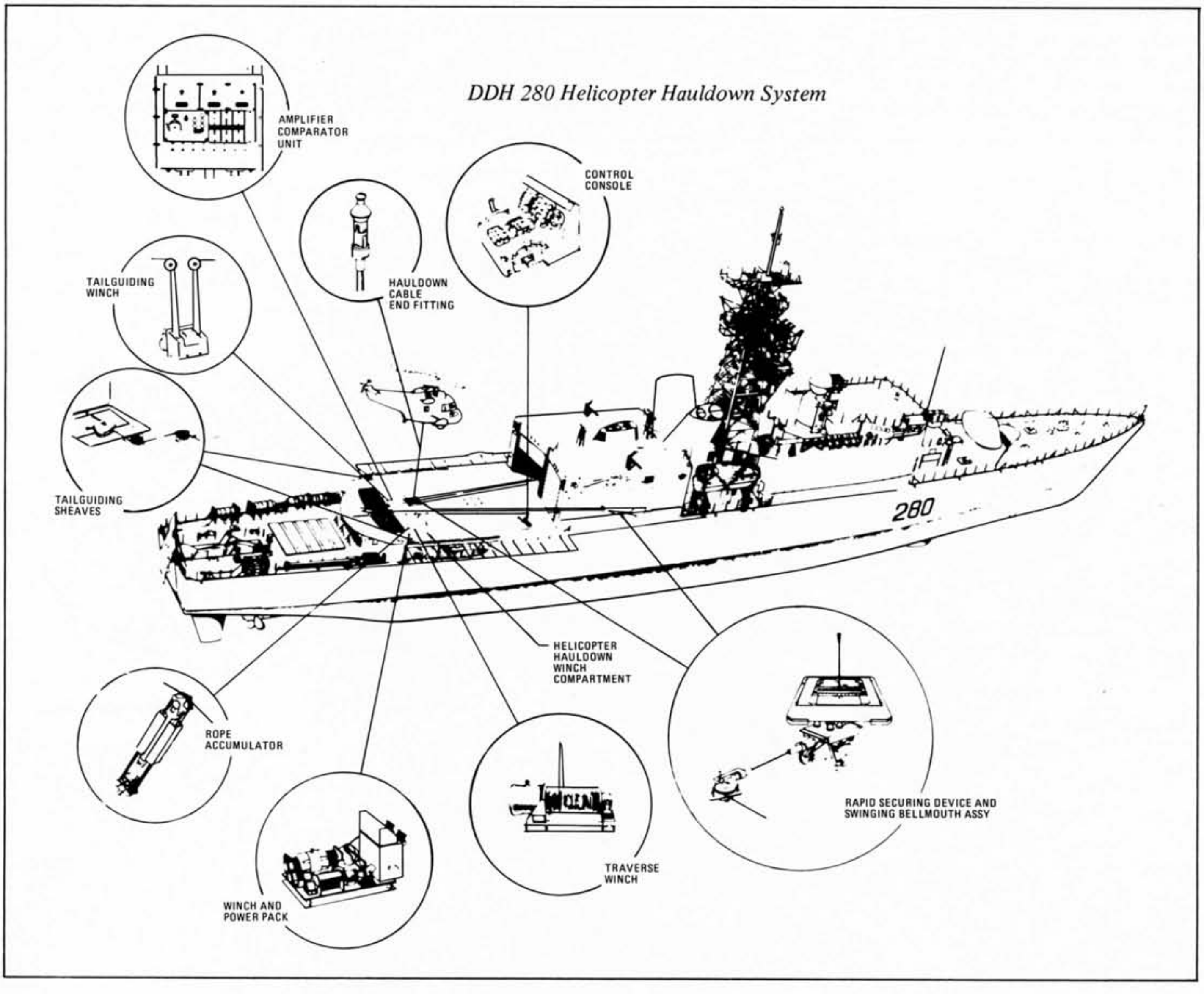
Flying Trials 1963

Flying trials were conducted in HMCS *Assiniboine* over a two-year period to evaluate the entire shipborne helicopter system, and also to establish the degree to which the system met design specifications, the safe flight-operating envelope, and the deficiencies of the system which would offset service suitability. Instrumentation was fitted to the aircraft and hauldown system to record and display information vital for ship-flight safety during trials. It would also provide quantitative data to determine the limits to which the system had been proven, and would record data necessary for further design studies towards increasing automation of the winchdown operation.

Trials were conducted under varying ship-motion conditions where landings were achieved with and without the beartrap. Techniques were developed for picking up the hauldown cable, quick releases of the cable, and traversing and straightening routines. The effects of the tensioned hauldown cable upon the aircraft's stability and handling characteristics were investigated throughout the available envelope. As trials of the system and aviation facilities continued, major modifications were required. The control system, for instance, still did not meet the specified performance and stability. But with the DDH conversion schedule pressing, and the inadequacies of the control system known, an in-house control system was developed, assembled, tested and fitted so that trials could be continued.

Production Contract Placed

Upon completion of the Feasibility of Concept trials, a procurement specification was developed and a contract placed with Fairey Canada for the production of eight HHRSD systems. But due to the ongoing development required to perfect the performance of the control



system, the number of control systems was limited to four.

Assiniboine Refit Trials Continue

In December 1965 *Assiniboine* was scheduled for a cyclic overhaul programme, and as a result HMCS *Annapolis* was selected as the follow-on ship to continue trials. Since the production contract had just commenced with development trials and testing still in progress, many design changes were implemented as they evolved. The production schedule was very tight and the company was advised that the trial ship (*Annapolis*) was due to be ready for sea duty with a tested and operational system onboard by January 1966 "latest".

First Production System Fitted

Installation of the first production beartrap and winch system along with the prototype tail-guiding winch and the in-house control system was on schedule. Trials were continued to evaluate the ability of the system to operate during daylight conditions of ship motion which closely approached the design specification for the HHRSD. The production control system was again trialled and failed to perform consistently or meet performance requirements with the winch system. FCL requested Nova Scotia Technical College's electrical engineering division to conduct a theory study and to modify the "Cowley Control System" accordingly for the performance specified. On completion of the study the equipment was redesigned, and bench tests were conducted at Dowty Ltd. where successful performance tests were completed. In September 1966 the modified control system was installed in *Annapolis* and trials were conducted to evaluate it. Flight tests were conducted to cover all the parameters required for the specified performance of the control system. On completion of the trial it was recommended that the present modified control system could be considered suitable and cleared for service use.

HHRSD System at Sea

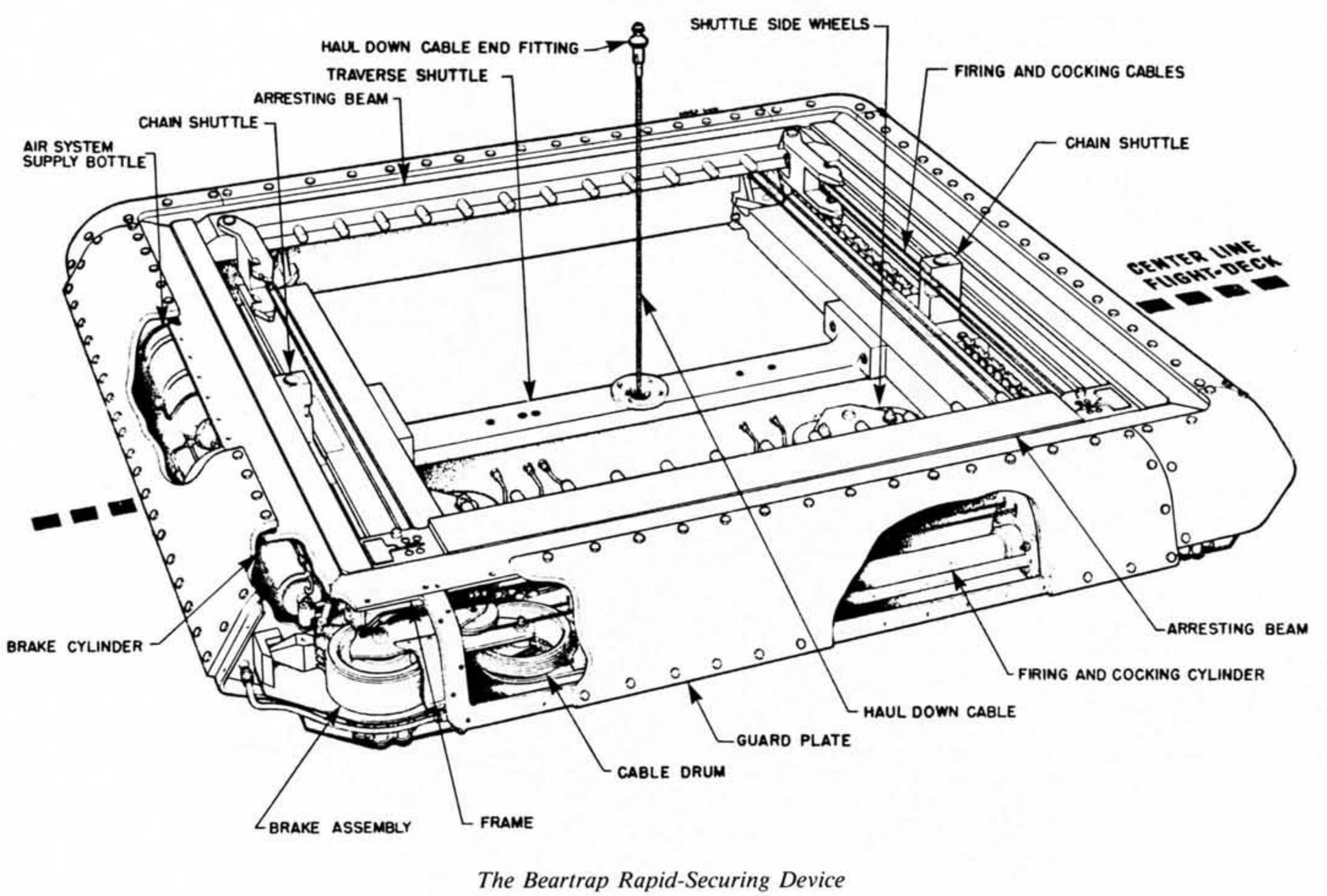
During the period from 1960 to 1969 a number of milestones were reached. The HHRSD equipment underwent environmental and shock-testing, the flight-deck and hangar compatibility trials were completed, the HHRSD system was refined and proven at sea, rough-weather trials in *Annapolis* were completed, and the first operational air detachment with a Sea King helicopter was embarked in *Saguenay*. By November 1969 all nine DDHs were operational in their new role.

New Shipbuilding Programme

With the commencement of the DDH-280-class shipbuilding programme, new ships were designed specifically as helicopter-carrying destroyers. A requirement was specified for an aircraft recovery and hangaring system capable of handling two Sea King helicopters.

Pre-Production Proposal

In 1967 Fairey Canada Ltd. was requested to submit a pre-production engineering proposal for a DDH-280 twin-HHRSD system. A main objective was to utilize the fully proven 205/265-class HHRSDs and eliminate new development. After some review it became quite evident that two fully duplicated systems would be uneconomical in terms of weight and cost, and that new development could not be avoided. FCL had previously embarked on a development programme for the redesign of a rapid-securing device for the German navy and the United States Coast Guard. The redesigned RSD retained the basic principles of operation of the original beartraps,



The Beartrap Rapid-Securing Device

but the pneumatic system was replaced with a hydraulic system. In January 1968 Treasury Board approval was obtained and authorization was given to proceed.

Pre-Production Engineering

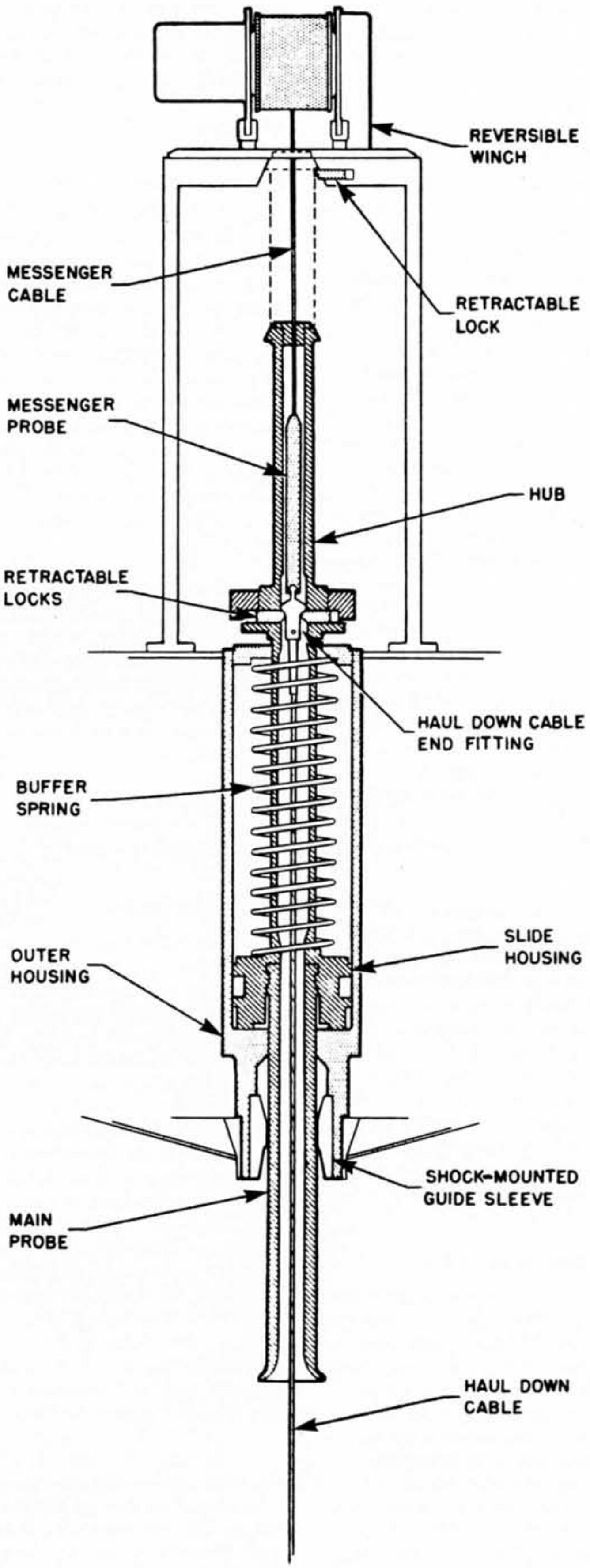
The pre-production engineering contract was placed with FCL for the supply of a complete technical and price acquisition package for the manufacture and installation of twin-capability helicopter hauldown systems. Many weeks of meetings and correspondence between Department of Defence Production, National Defence Headquarters, Fairey Canada Ltd. and the Naval Central Drawing Office took place to accomplish design work in the area of the track-trough and equipment interface. On the completion of this phase, a document was published ("CN1924", dated 4 June, 1968) which formed the basis for the procurement contract. Maximum effort was made to ensure that the track-trough arrangements and those design details affecting the shipbuilder would be known as quickly as possible. A preliminary sketch of the track-trough was passed to the Naval Central Drawing Office in March 1968.

DDH-280 HHRSD Production Contract

In November 1968 a production contract was placed with Fairey for the manufacture of four complete helicopter hauldown traversing and tail-guiding winch systems, including class spares, provisioning documentation, and shock and environmental testing. Production was monitored by project officers in the Directorate of Marine and Electrical Engineering (DMEE), and meetings were held at regular intervals to assess design-change proposals and scheduling problems. Because of the critical shipbuilding schedule and the requirement to achieve integration of the total system with the ship, a bonus formed part of the contract for ship-sets number one and two if they were delivered no later than December 1969. The production was divided in two parts, with the winch, powerpack and rope accumulator subcontracted to Dowty Equipment of Canada, while the remainder of the system was manufactured and assembled at FCL. Following shop trials of the total system at Dowty's plant, the first and second systems were delivered to the shipyard on schedule.

HHRSD and Ship Construction

After the delivery of the HHRSD equipment in the fall of 1969, activity started at the shipyard to fit major assemblies into the hauldown compartment, still in crates, while the modular ship's construction progressed. This was followed by the construction of the flight-deck and track installation. For



Helicopter Main-Probe Assembly

many weeks the battle was on to fabricate the decks without some degree of waviness, and to fit a straight track and maintain the design track-trough tolerance so the beartrap and rollers could pass without obstruction.

Fairey Canada Plans Shutdown

Following the delivery of the fourth HHRSD ship-set and class spares early in 1970, Fairey Canada Limited advised the Department of Supply and Services that a decision had been made to terminate the helicopter hauldown marketing and licensing agreement with Canadian Patents and Development Limited (CPDL) and close its Canadian plant. Because of the critical DDH-280 programme and the department's proprietary interest in maintaining DND support and export marketing of this equipment, CPDL was requested to select another Canadian company to obtain a licensing agreement for Canadian and export marketing of hauldown systems. Seven Canadian industries were requested to indicate their interest and submit a statement of capabilities related to aircraft handling and marine equipment. After many weeks of review CPDL decided that the capabilities of DAF Indal Limited of Mississauga, Ontario most nearly met the selection criteria. DAF was chosen as the successor to Fairey Canada Ltd., and on 22 July, 1970 a marketing and licensing agreement was negotiated for a non-exclusive right to sell to Canada and all countries of the world.

In July, DAF's president and senior engineering staff visited HMCS *Fraser*, while the ship was alongside in Toronto, to view an HHRSD system. Then, in September 1970, FCL's caretaker management was directed to sort, collate, catalogue, pack and ship all design engineering and other relevant data to DAF. Late in 1970 a spares contract for the support of HHRSD systems was directed to DAF to assist the new contractor in getting quickly involved and familiarized with aircraft handling systems.

Setting Equipment to Work

Work commenced late in 1971 (at Sorel, P.Q.) on HMCS *Iroquois*, the lead ship of the DDH-280 class, and continued through until July 1972 in an attempt to set the HHRSD system to work in preparation for equipment acceptance trials. Equipment was installed by the shipbuilder with guidance from DAF (who had hastily recruited an ex-Fairey Canada employee), but there were many ship interface problems. Although the equipment was jury-rigged to run, the system's wiring and logic controls were unacceptable. Time ran out and, due to ship trials and scheduling, set-to-work and acceptance trials were re-scheduled for a later date. In the months that followed, as the field service representative gained experience and with the assistance of DMEE staff, the system was refined, documentation corrected and successful trials completed.

Flight-Acceptance Trials

In October 1972 the Air Engineering Test Establishment at Cold Lake, Alberta developed a flight-acceptance trial for DDH-280 HHRSD system compatibility with the Sea King helicopter. In early 1973 trials commenced to functionally prove compliance of the installed HHRSD system, and to evaluate the operation of the installed horizon-bar reference system and LSO indicators. As well, the trials assessed the general suitability of the DDH-280 to conduct helicopter operations, under all environmental conditions, up to the design limits of the HHRSD system.

Throughout 1973 and into early 1974 equipment and flying trials were continued, and many defects and deficiencies were uncovered and rectified in the total system before clearance for service use was finally given. Not long afterwards, *Iroquois* and *Athabaskan* joined MARCOT in sea-duty operations with Sea King aircraft embarked. In the months to follow *Huron* and *Algonquin* achieved successful trials and were cleared for service use.

USN Rast System

The USN had been working with a Recovery Assist, Secure and Traverse system (using the the Eddy Current Clutch and Manipulator), but found that it did not accomplish the goals set for it. In 1976 a United States Navy team arranged to visit HMCS *Athabaskan* and HMCS *Assiniboine* to evaluate the Canadian beartrap system. The visit was an attempt to familiarize the respective U.S. ship and aircraft people with the HHRSD system, and if possible assist in the U.S. decision in a hauldown system procurement. Numerous technical discussions were held and two generations of hauldown systems examined. This was the first occasion that the U.S. technical personnel had to examine the system in depth, and for the USN flight personnel to actually fly on the wire and land a helicopter during daylight and night-time hours.

In early 1977 the USN initiated a research and development contract with Canadian Commercial Corporation for the design and development of a modified HHRSD system for use with their MK3 Light Airborne Multi-Purpose System (LAMPS) aircraft. The USN wanted, eventually, to fit 100 or more of their ships with a RAST system for the SH-60 Sea Hawk helicopter.

As a result of the USN's interest in obtaining a hauldown system similar to the Canadian navy's, a number of events happened in quick order: the Director-General Maritime Engineering and Maintenance (DGMEM) accepted Canadian Commercial Corporation's request for DMEE involvement and support for the USN; CCC, DND, and the USN met in Washington to determine ways and means and the controls for CCC to manage the USN development contract; DND and the USN drafted a memorandum of understanding, and a programme agreement was reached between the U.S. Department of the Navy and Industry Trade and Commerce to cover the financial and industrial implications.

RAST Joint Project

With the announced intention of using the beartrap system for the LAMPS MK3 programme, and the drafting of a memorandum of understanding for project assistance, authorization was given to establish a joint USN/DND helicopter hauldown project office. Officially named the *RAST System Joint Project Office* (JPO), the office was opened on 1 May, 1977 to monitor the schedule, cost and technical performance of the contract project with Canadian industry. This highly visible project was monitored by the JPO staff throughout the development, shop-testing, acceptance trials, production readiness review of contractor and subcontractors and configuration control phases of the total system.

CPF — January 1977

At the commencement of the CPF programme there was a requirement to develop a representative system to achieve an aircraft handling and support system. With the successful performance of the DDH-280 rapid-securing device, and the new development achieved in the U.S. RAST project, a Technical Statement of Requirement was drafted, and a contract placed, with DAF Indal to assemble a procurement data package for a complete CPF RAST system which captured the RAST and DDH-280 baseline. A decision had been previously made to remain with the 280-style RSD and track system because of the requirement to handle the Sea King helicopter. The below-deck equipment, control system and control console benefitted from the spinoffs of the U.S. RAST development programme. Also included in the CPF RAST system are recommendations from the Defence Civil Institute of Environmental Medicine, and from veteran pilots and operators for the configuration design of the Landing Signal Officer's control console, and the addition of variable-speed trav-

The ability to operate large ASW helicopters from small-deck ships in heavy sea-states is still considered a major naval achievement 30 years after its inception.

ersing and automatic brake-release features which had been previously proven by operational evaluation and fitted in the DDH-280 systems.

Present Achievements

Over the past 17 years two generations of helicopter hauldown systems have been installed in three classes of Canadian navy ships. The 12 DDHs have successfully operated helicopters in ASW, fishery patrol and air/sea rescue roles, accomplishing more than 3,000 deck-landings in the often severe sea-states encountered in the North Atlantic. The success of this unique system is owed to the ships' maintainers, operators and repair personnel who over the years have contributed to the refinement and continuing modification of the total system.

Canadian industry and the Department of National Defence have proven to be leaders in the development and manufacture of helicopter handling systems which are now marketed throughout the world. International interest, to date, has enabled Canadian industry to successfully market HHRSD systems in different configurations to the United States Navy, Japanese Defence Force, Indian navy, Argentine navy and Canadian navy. This has resulted in an estimated 4,000 jobs for DAF Indal, five major Canadian contractors and more than 100 small firms across the country.

Future Systems

With experience gained by Canadian industry and the Department of National Defence design authority, it is hard to visualize a change in the helicopter handling technique presently being used. It has been found that the size and configuration of the securing device is dependent upon the helicopter's ground-clearance, undercarriage characteristics and footprint in relation to its main-probe position and centre of gravity. With the proposed increase in the all-up weight of the Sea King replacement aircraft, and a possible change to a nose-wheel undercarriage, major changes may be required to the existing RSD design. From ship-motion modelling programmes that have been previously studied, the greatest loads on the equipment and deck structure are found to be present when traversing, straightening or parking. With an increase of aircraft weight to 30,000 lbs, a design review of the existing securing device and deck structure will be required. With the ever-changing requirement for automation, a development scheme has been recently proposed to develop a guidance system that will enable the helicopter to locate and land in a predetermined spot unassisted by the constant-tension hauldown cable. This will not, however, eliminate the requirement for securing the aircraft on touch-down, or for providing a traversing and tail-straightening device. Time will tell.

George Huson served as a technical officer in headquarters performing the life-cycle management duties related to the HHRSD and CPF RAST systems. He also provided guidance to the USN/DND RAST development project, and served as a member of the Helo-Ship Interface Committee for aircraft handling systems. Mr. Huson retired in 1984.

The Total Maintenance Profile

A Proposal to Include a Periodic Ship Refit/Modernization Requirement in the Maintenance Profile for Future Ships

by Cdr R. Chiasson

Author's Note

The maintenance profile for future ships proposed in this article is not original. It was first suggested by LCdr P.R. Neal at the MARE Conference in Victoria in 1980. The main thrust of his paper was that the (then) 48-month cycle should be extended, since we were over-maintaining the fleet. Since then, the maintenance profile for the majority of the surface fleet (except ISLs) has been extended to 60 months. What prompted this paper, however, was an underlying concern that we are running the risk of overcorrecting, by virtue of the fact that refits are not intended for the future fleet. Also, the maintenance profile for the future fleet ignores the need for some inevitable major configuration updates over the life of the ships.

The aim of this paper is to address the anticipated shortcomings of the future-fleet maintenance philosophy, to highlight current refit and configuration management problems, and to propose a maintenance profile for future ships and amendments to the refit management process which will address these shortcomings.

Introduction

The CPF and follow-on ships will be commissioned under a radically different maintenance policy from the one currently in vogue. The advent of the Reliability Centred Maintenance (RCM) concept and the Repair-by-Replacement (RxR) approach will ostensibly obviate the need for regularly scheduled, lengthy refits typical of earlier generations of ships. The maintenance profiles of the future will consist of regularly scheduled short work periods, as at present, but will be uninterrupted by extended refits. This pattern will only be broken for short docking periods at approximately 48-month intervals to progress docking-dependent work. The success of the RCM/RxR approach and reliance on the short work period is dependent on a number of prerequisites, such as the availability of pipeline R&O spares, greater emphasis on "plug-in"/modular designs, and a comprehensive health monitoring programme.

While not disputing the validity of the future-ship maintenance philosophy, there is cause for concern that the new approach runs the risk of ignoring two major areas of maintenance, which may well require retention of some vestige of the traditional maintenance philosophy, and, therefore, reliance on lengthy refit periods and the attendant refit management infrastructure and methodology. The two areas are:

a. "systems" in the ship which do not lend themselves to RCM/RxR, such as hull structure, habitability, piping and ventilation, shafting, shaft bearings and propellers, cabling, and painting/preservation of bilges, tanks, and voids. These "systems" require periodic baseline maintenance; and

b. major configuration changes.

Periodic Baseline Maintenance

Reliability Centred Maintenance is essentially a disciplined approach to *condition-based* maintenance, as opposed to the present/former Planned Maintenance System which is a disciplined, but *time-based*, approach to maintenance. For the majority of fitted equipment, Repair-by-Replacement, supported by an effective health monitoring programme and adequate spares, is a sensible and feasible maintenance technique. However, hull structure, hotel services, and other similar "systems" do not lend themselves to this approach for a variety of reasons:

a. the "health" of these "systems" cannot be assessed without extensive surveys (e.g. hull structure in bilge areas);

b. the repairs are normally of such scope that they cannot be completed in a short work period and/or afloat (e.g. shell- plating repair);

c. Repair-by-Replacement is not practical. (Ventilation trunking, for example, can only be effectively cleaned as an entire system over an extended period, preferably when the ship is unmanned.); and

d. maintenance cannot/should not be done piecemeal; a succession of piecemeal repairs renders an entire "system" substandard (e.g. deck coverings, internal paint work).

There are no doubt other examples of areas in the ship which periodically need to be brought to a "baseline" standard in order to arrest deterioration, and which should be grouped into one major maintenance activity for convenience, cost-effectiveness, and minimal/predictable impact on operational availability.

Major Configuration Changes

Past experience has demonstrated the utility and necessity of configuration changes throughout the life of a ship. Although some of these changes in the past have been implemented during short work periods, the vast majority of them have been implemented during scheduled refits. In fact, traditionally, such configuration changes have significantly extended normal refits.

Major configuration changes can be grouped into three majorcategories:

a. The *post-construction design update* resulting from:

   (1) changes introduced but not implemented during construction due to a design "freeze" or lack of funds; and/or

   (2) changes introduced after delivery due to shortfalls in performance, technological advancement, safety requirements, etc.

   Note: This type of configuration change is exemplified by the major group of SHIPALTS introduced in the DDH-280 class within 10 years of delivery.

b. The *mid-life modernization requirement*, due to:

   (1) the changing threat;

   (2) the shrinking "half-life" of technology which renders the weapons and sensors obsolete;

(3) the unsupportability of existing equipment; and/or

4) reduced growth margins in electrical power generation, stability, etc., as a result of 15-20 years of cumulative configuration changes.

Note: This type of configuration change is exemplified by TRUMP, which is intended to address these types of shortfalls in the DDH-280 class.

c. *The life-extension requirement*, due to:

(1) retention of a ship beyond its intended life-span, necessitating "safe-for-sea" modifications or repairs;

(2) unsupportability of existing equipment; and/or

(3) the need to maintain or improve operational effectiveness in order to retain training value/ interoperability with other ships/navies, etc.

Note: This type of configuration change is exemplified by the DELEX programme.

Total Maintenance Profile

It is fair to assume that future classes will require some or all of the types of configuration changes described above. However, current planning does not appear to have addressed the need. It is suggested that since these major configuration changes are virtually inevitable, they should be adequately catered for, along with the need for periodic baseline maintenance, in the maintenance profiles of future ships.

In order to establish a reasonable periodicity for baseline maintenance, while allowing adequate time for planning/engineering/integrating of major configuration changes and minimizing operational downtime, it is suggested that three periods in a ship's 30-year life-span should be earmarked for major refits/updates. The first of these (the Post-Construction Update) should occur 7-8 years after commissioning, the second (Mid-life Modernization) 15 years after commissioning, and the third (Life Extension) at the 22- to 23-year mark. The latter of these refits/updates could be tailored (or even cancelled) depending on such factors as anticipated delivery of replacement vessels, preservation of the vessels when paid off, and the relative supportability/operational effectiveness of the ships. The proposed "total" maintenance profile is illustrated in Figure 1.

Refit/Modernization Management

A recent review of the Ship Refit 10-Year Plan foresaw the demise of extended baseline refits on the assumption that the advent of newer ships and a revolutionary maintenance philosophy would render such refits obsolete. Acceptance of the Total Maintenance Profile, as outlined in this paper, will necessitate a major change to the current prognosis, and the maintenance of the current refit management infrastructure. There are, however, shortcomings in the current approach to the refit/configuration management interface that need to be addressed.

The process to date has suffered considerably from the lack of "total ship integration" of configuration changes. With the exception of TRUMP and DELEX (both of which fit the Total Maintenance Profile concept) configuration changes have taken the form of SHIPALTS and/or "stand-alones" which have been introduced as individual

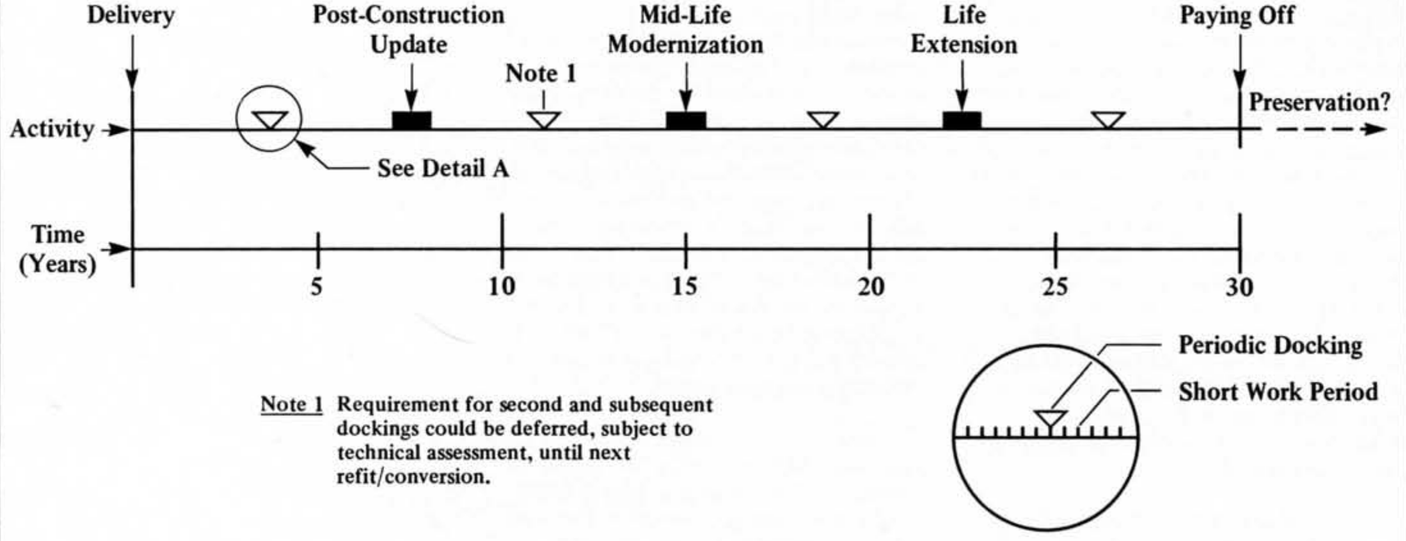


Fig. 1. Proposed Total Maintenance Profile

proposals/initiatives to meet specific shortfalls, with only a modicum of integration as part of the refit planning process. There is a need for configuration change to gain pre-eminence over the refit motive in the planning and execution of future "refits". The practice in the past has been to attempt to integrate individual SHIPALTS into the refit package, with heavy reliance on local engineering to resolve discrepancies, often with dramatic effect on cost and schedule.

What is envisaged under the proposed Total Maintenance Profileapproach is a major departure from the current Standard Ship-Repair Work Catalogue (SSRWC) concept, except for those vestiges of the previous baseline refit requirement retained for those "systems" previously mentioned which would not lend themselves to RxR or Repair by Exchange. The specification for future "refits" would consist primarily of SHIPALTS integrated into a package which was based on a "baseline" configuration established either on delivery from new construction, or at the previous refit, and amended by minor SHIPALTS implemented during the interim.

The proposed approach would have very little impact on the current refit management process. The major changes would occur in the make-up of the specification, and in the planning process. The activities immediately preceding (up to 18 months prior to) a major modernization/update, which are primarily associated with the procurement process, would remain. There would be greater emphasis, however, on the documentation, detail design, and integration of the configuration changes as soon as the last major update (or construction) was completed. This configuration management function could be performed in-house, as it currently is, with the assistance of design agents, or, alternatively, the design-agent function could be expanded and contracted out.

This expanded design-agent function, which could be termed a "configuration management" function, would consist of a marine design, *integration*, and drawing service capable of:

a. translating a statement of requirements or performance specification into technical guidance and, ultimately, into a detailed design; and

b. integrating various discrete configuration changes into a "conversion" package.

This facility is envisaged as being somewhat more capable than the current MDDO facility, which is capable of performing a ship-design *agent* function, but not the systems/ship-integration function intended by the need for a major conversion package. The facility would, of necessity, be required to integrate the "refit" package with the evolving "conversion" package.

Conclusion

This paper has attempted, briefly, to establish a requirement for a total maintenance profile for the future fleet, which includes major update phases and which is based primarily on the need for major configuration changes to ships over their lifetime, and the need to retain a vestige of the existing time-based baseline maintenance concept. In spite of forecasted trends to the contrary, such major updates would appear to be inevitable based on Canadian naval experience over the last thirty years. The proposed approach is to adopt a "proactive" mode, in recognition of the need, rather than a 'reactive" posture. Such an approach would ease the financial and managerial impact of major configuration changes to ships and provide earlier visibility in the Defence Services Program. By incorporating relatively minor changes to the currently contracted design-agent functions, an industrial centre of excellence could be created (or utilized, if one already existed) in ship-level design and configuration management.

Commander R. Chiasson graduated from the Royal Military College at Kingston, Ontario in 1965 with a degree in Civil Engineering. He has served as Engineer Officer in Fraser *and* Skeena, *and the bulk of his shore experience has been in refits and new construction. He was employed on the overseeing staff during the construction of* Athabaskan *and* Algonquin, *and was the Detachment Commander of 201 CFTSD in charge of ship-refit quality assurance for portions of Multi-ship III and IV. Since the summer of 1982 Cdr Chiasson has been the Section Head for in-service ships and the Project Manager for ship refits in NDHQ.*

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