National Defence Défense nationale

Maritime Engineering Journal

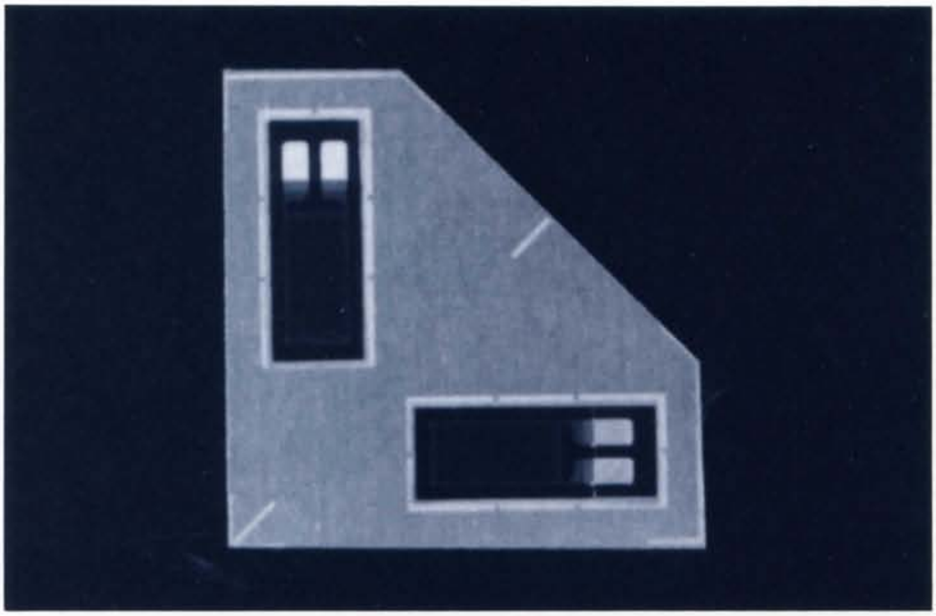
January 1993

A MARE takes a Somalian Sojourn

Also:

- *"On leadership" in this month's Forum*
- *Looking Back at the "DMEE Desk"*

Canada



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Do you know what this is?

Don't strain yourself. The answer can be found in the News Briefs starting on...

...page 19

Maritime Engineering Journal

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JANUARY 1993

DEPARTMENTS

FEATURES

GREENSPACE:

LOOKING BACK:

OUR COVER

For five days last October a Maritime Engineer travelled with a CF reconnaissance team in Somalia and neighbouring countries to scout out a suitable base of operations for Canadian humanitarian assistance in Somalia. *(CF photo by Cpl Brad Fishleigh)*

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

Editor's Notes

Reorganization calls for co-operation and communication

By Capt(N) D.W. Riis, OMM, CD
Director of Marine and Electrical Engineering

Two reorganizations in DGMEM and one in the Command in a two-year period might send the more cynical among us rushing off to quote Petronius's timeless observation:

> We trained hard, but it seemed that every time we were beginning to form into teams, we would be reorganized. I was to learn late in life that we tend to meet any new situation by reorganization, and what a wonderful method it can be for creating the illusion of progress, while producing confusion, inefficiency, and demoralization.
> **— Petronius the Arbiter, AD 66**

But how will the new organization affect MAREs? Will it help or hinder us in our quest to continually improve engineering and maintenance support to the fleet? Obviously it is too early to make the final call on this — there are still some rough edges to be smoothed off as we become familiar with the new relationships — but so far all the indicators are positive.

Reestablishing our naval headquarters at arm's length from fleet operations has created a new relationship with NDHQ that will take time to evolve, but it does have the potential for simplifying the way in which we support the fleet. Establishing a MARLANT on the East Coast in line with how MARPAC already operates on the West Coast clarifies the picture of who is responsible for running the fleet in Halifax. This is good news to those in support roles, especially as SRUA, NEUA, Fleet School Halifax and CFB Halifax will now be accountable to the line manager responsible for operating and maintaining the fleet.

You might not have noticed it, but the "KISS" principle was also applied to last June's reorganization of DGMEM. The overall aim was to restructure DGMEM in the best way possible to continue serving the navy during an era of downsizing (or is that "right-sizing?"). One objective was to consolidate, to the extent practical, LCMM activities in two directorates. The Directorate of Marine and Electrical Engineering (DMEE) now looks after the life-cycle management of platform systems which are operated, maintained and supported by MARE MS officers and by Marine Engineering, Electrical and Hull technicians. The Directorate of Maritime Combat Systems (DMCS) looks after all combat systems maintained by MARE CS officers and Naval Weapons and Electronic technicians.

A second objective was to retain the class desk concept in the Directorate of Ship Engineering (DSE). (For example, a single class desk would receive the CPF technical data package and configuration management responsibility from PM CPF.) Also, the ship-level technical authority for habitability, vulnerability and survivability, as well as for hull, propeller design, stability and specialty engineering is now consolidated within DSE.

A third objective was to consolidate policy (including software maintenance policy), resource and project management support, and R&D co-ordination into one directorate — the Directorate of Maritime Engineering Support (DMES). This simple expedient leaves the other directorates free to turn their full attention to supporting the fleet and projects.

Managing the influx of "new and improved" ships into the fleet during a major downsizing has demanded changes both in how we organize ourselves and in how we do business. Because we are part of a complex team, the key to the success of these reorganizations will be our awareness of the roles of all players. This, combined with a determination to foster co-operation, communication and initiative, will ensure that we continue to provide the Maritime Commander with capable, reliable warships at affordable cost during these challenging times.

* * * * *

Finally, the *Journal* extends best wishes to several senior officers who have retired recently from the navy: **Commodore Eion Lawder** (CF Naval Attaché, Washington), **Captain(N) Jim Dean** (CPF Deputy Project Manager — Ship), **Captain(N) Ron Richards** (CF Naval Attaché, Tokyo), **Commander Al Kennedy** (DGMEM Naval Support Cost Reduction Study) and **Commander Roger Cyr** (DMCS 6).

Throughout careers that have spanned well over 30 years, these officers have distinguished themselves by their unswerving loyalty and dedication to duty. Each has made significant contributions to the naval service of Canada, exemplifying along the way what is the very best of Maritime Engineering. Best wishes for an enjoyable retirement.

In bidding farewell to Cdr Cyr, who leaves the navy to take up a senior NATO position in Luxembourg, this special note is warranted: Roger has been a stalwart supporter of the *Journal* for many years, and is well known for his highly opinionated articles which have sparked so much debate in the pages of our branch journal. He knew only too well that certain of his ideas would not win him any friends, but he still had the courage of his convictions to put them on paper for review by his peers. For this we owe him a tip of the hat along with our thanks.

Commodore's Corner

By Commodore Robert L. Preston

The past year has seen some major changes within the MARE branch with the change of incumbents in the three commodore billets normally assigned to MARE officers. It was particularly gratifying to see the promotion of Rear-Admiral Saker along with his appointment as Assistant Deputy Minister Engineering and Maintenance.

Important as they are, these changes reflect only in a small way the greater changes that are affecting the Canadian Forces today. In my nearly 35 years of service I have never before witnessed such rapidity of change as is presently taking place in the structure and relations of nations all around the world. Fortunately, thanks to the acquisition projects of the eighties and early nineties, the Canadian navy will have the equipment it needs to respond capably to the demands of this shifting world order.

In the last decade we have seen the completion of the majority of the engineering and development effort associated with the Canadian Patrol Frigate and Tribal-class modernization projects. I have witnessed first-hand the dedication of naval personnel (in particular, the members of the technical branch) to the extensive effort that guided the design and initial construction phases of these two projects. I now see the same effort taking place in the Maritime Coastal Defence Vessel project and in support of the New Shipborne Aircraft.

While the delivery and acceptance of our new patrol frigates and modernized Tribal-class destroyers are major visible milestones for us, the extensive and complex technical process which must take place to achieve those milestones is not as visible. Members of the technical branch should be proud of the major role they have fulfilled, although there remains a great deal of trial and acceptance work to complete the final stages of the acquisition process.

It is gratifying to visit Halifax these days and see the activity associated with the new ships in harbour. That the initial development of many of the most sophisticated systems was managed by Maritime Engineering officers and technicians is especially noteworthy. The efforts they dedicated in the 1980s to such systems as command and control, interior communications, machinery control and infra-red signature suppression, to mention only a few, have resulted in technical achievements of which the Canadian navy can be proud.

The above words might suggest that engineers have done their job and can now settle into the life-cycle management phase. I believe that is not the case. The focus afforded by the achievement of tangible goals associated with the acquisition phase is now gone. For that we must substitute new goals aimed at reliability, availability and reduction of the maintenance effort. I know that we will not be daunted by this challenge.

The acquisition projects of the eighties and early nineties will place the Canadian navy in the position of having new and sophisticated equipment with the capacity to respond to the unknowns of the changing world order that we see unfolding around us. I look forward to an exciting future as we in the technical branch in conjunction with the operational community display our ability to operate and maximize the effectiveness of our new equipment.

On behalf of the Maritime Engineering community, the *Journal* welcomes Commodore Robert L. Preston as the new Director General for Maritime Engineering and Maintenance.

Prior to his appointment as DGMEM last July, Cmdre Preston served one year as Chief of Staff (Materiel) in Maritime Command Headquarters, and before that two years as commanding officer of Ship Repair Unit Pacific. He also served five years as program manager for the Tribal-class Update and Modernization Project and four years as Marine Engineering Staff Officer to the naval attaché in Washington, DC.

During his naval career Cmdre Preston has served as an engineer officer in both steam and gas-turbine destroyers, completed a two-year tour of duty in a U.S. naval shipyard and commanded Fleet Maintenance Group Atlantic.

Cmdre Preston holds a baccalaureate degree in mechanical engineering from the Royal Military College in Kingston, and is a registered professional engineer in the province of Ontario. He is married and has two children.

A Somalian Sojourn

By LCdr James Earl Jollymore

In September 1992 I was contacted at my engineering staff officer's position in Maritime Command Headquarters and offered an extraordinary opportunity. I was asked to join a team being assembled to reconnoitre a suitable beach-head for a Canadian Airborne Regiment relief operation in Somalia. It was a prime example of the increasingly varied and challenging roles being offered to Maritime Engineers in the "new world order," and I soon found myself (a Marine Systems Engineer) in the company of a navigation specialist MARS officer, a Sea Logistics officer, the NDHQ/J3 section head for Peacekeeping, the commanding officer of the Canadian Airborne Regiment and 13 other specialists. What followed proved to be the most venturesome undertaking of my career.

The team was formed in anticipation of a United Nations request for Canadian military assistance with the distribution of humanitarian aid in Somalia. The brunt of the Canadian relief effort would fall to members of the Canadian Airborne Regiment based at CFB Pettawawa. The supply ship HMCS *Preserver* (AOR-510) would be on station to provide domestic water, fresh provisions, medical support and recreation facilities to the regiment for the first 60 days while the UN support system was being set up. *Preserver* might also be permitted to contribute direct humanitarian aid wherever feasible and appropriate.

One potential location for the beach-head was the town of Bosasso on the northern coast of Somalia. Before the war this town had been a quiet fishing village and minor seaport, but a jetty of unknown capability had been recently built which might significantly increase the port's value. It was the naval contingent's role to assess the adequacy of this port for operations by *Preserver*, determine what local support facilities were available for the ship and what humanitarian assistance the ship might be able to undertake. We were also there to provide expert advice to the other members of the reconnaissance team on the ship's capabilities and limitations.

From the beginning, the reconnaissance team was placed on 24-hour alert to leave Canada. We completed our inoculations, began a malaria prophylaxis, drew combat fatigues and desert tan uniforms...and waited. The decision to proceed rested on UN authorization for Canadian participation and on the successful deployment of a Pakistani battalion into Mogadishu, the Somalian capital. Finally, on October 7, permission was granted for the party to leave Canada on the evening of the 12th.

We arrived in Nairobi, Kenya just before midnight on October 13. Before heading on to Bosasso we spent a day in Nairobi setting up a reconnaissance plan and being briefed by the Canadian High Commission staff, the International Red Cross and the local United Nations headquarters. We learned that Bosasso was controlled by the Somali Salvation Democratic Front, and was not a major famine area. Best-guess estimates put the population of the town between 300,000 and 500,000 people, including refugees.

The UN and Red Cross confirmed that Canadian units might be expected to secure relief operations, monitor/control distribution routes and centres, and provide one supply ship for 60 days in support of the Canadian ground forces. To fulfil its tasks, the Airborne regiment would have a total of 750 personnel, 150 vehicles and about 200 sea containers of equipment on site. Of this, some 200 personnel with 15 vehicles would be deployed as an advance party. In addition to transporting the regiment's fuel, ammunition, food and medical team, HMCS *Preserver* would carry a water purification unit, a reverse-osmosis seawater desalinator and the means to deliver large quantities of water ashore. *Preserver* also boasted a fully equipped machine shop as well as electrical, hydraulic and electronic workshops.

On October 15 the reconnaissance team made the four-and-a-half hour flight from Nairobi north to Bosasso in a Canadian Forces C-130 Hercules aircraft, one of three already deployed in the area to assist with food distribution. Although the

airstrip at Bosasso was in good condition, there was absolutely no support infrastructure in evidence. Not one of the airport buildings was standing. On the ground we were met by several armed Somalis who spent the remainder of the day giving us guided tours of the port facilities and town. Just before sunset forced the closure of the runway, we bundled into our aircraft and flew on to Djibouti, an hour-and-a-half to the west.

That evening we contacted the local French naval garrison and arranged for a quick overview of Djibouti's port facilities the next day. Interestingly, the members of our team who had visited Djibouti during Operation Friction commented that the city and its facilities had degenerated even in the short period since the 1990-1991 Gulf War. The political situation was described as unstable, the port itself was filthy and

Fig. 1. The freezer plant at Bosasso. The local naval commander is on the left and, at centre, the plant superintendent holds a box containing a failed component which he later asked me to replace. Note the "oil?" marking on the freon line.

Fig. 2. It would take extensive work to bring the freezer plant's No. 2 diesel on line.

poorly maintained, fuel supplies were substandard, maintenance facilities were limited, recreation facilities were practically non-existent and the streets were crime-ridden and crowded with homeless people. As Djibouti was clearly unacceptable as a base for Canadian operations, the naval and Movements contingents of the reconnaissance party decided to investigate the southern port of Mombasa later on our return to Kenya.

While the Logistics and Movements personnel were inspecting Djibouti on the 16th, the bulk of the party flew back to Bosasso for a more detailed reconnaissance. The disembarkation was a bit more exciting on this occasion as the aircraft had to return immediately to pick up the members left behind in Djibouti. With the Herc's props still turning, we alit in a swirl of heat and dust and stood clear as the aircraft began its taxi down the runway. As we watched it lift off I doubt I was the only one wondering about his prospects should the plane fail to return as scheduled. None of us was armed and we had only one day's supply of food and water with us.

As the Airborne regiment's personnel began their inspection of the site for the proposed base camp, the naval contingent made a more thorough survey of the harbour facilities. The jetty itself had been constructed in 1987/88 and was of solid concrete construction. By measuring the jetty and charting the harbour and approaches using a portable echo sounder and the local naval patrol boat (a cross between a motor workboat and the *African Queen*, as one wag put it) we were able to confirm that although the jetty was unsuitable for use by an AOR, an adequate anchorage was available only about two kilometres from the harbour entrance. We also noted that the port was continuously busy with the movement of trucks and, despite the lack of any fitted cranes on the jetty, with the loading and unloading of hay, goats, water and other sundries to and from numerous small coastal vessels.

The only other technologically advanced facilities in the town were a freezer plant for the potentially large fishing industry in the area, and a power station. The freezer plant had been built by Danish interests only three or four years earlier. Although construction was complete, the system had never been set-to-work. Externally, the refrigeration equipment and controls were in fairly good condition (attributable, no doubt to the extremely dry conditions), but the townspeople had neither the spare parts nor the freon to make the system work. Although the maintenance superintendent had an apparently complete set of English-language operating and maintenance manuals for the refrigeration and diesel generating units, the fact that someone had marked *Oil?* on the freon piping (*Fig. 1*) led us to believe that the expertise of the local maintenance personnel was likely inadequate to the task of reconstruction.

The power plant for the facility was also unusable, suffering from the same lack of parts and maintenance skills. At least one of the diesel engines (*Fig. 2*) would require extensive work to be brought on line. The power plant produced 380 volts at 50 Hz, but could be supplemented by the town's 220-volt 50-Hz power supply. The town's electrical generation facility (which was not available for viewing) was reported to be operational, although electricity was supplied to the town for only two or three hours a day due to an extreme fuel shortage. The local authorities assured us that it could be a 24/7 operation given sufficient diesel fuel.

My major concern when contemplating this trip back in September was not for the job I would be doing (I had confidence that my training had prepared me well enough), but rather for what I might see in the way of human suffering among the starving in Somalia. Fortunately, the refugees in Bosasso were generally well fed and cared for by the indigenous population. This was probably attributable to the fact that the refugees and the locals were of the same tribe or tribal group and, unlike the non-Somalis starving in the south, were considered "family." Their relatively good health and nutrition notwithstanding, on the single occasion when it was necessary for us to enter one of the refugee camps, we discovered that the camp's hygiene was very poor and its poverty extreme. No television picture can even begin to convey the smell of thousands of people living on top of their own garbage. The experience was an eye-opener which increased my appreciation for Canadian health and housing standards.

By the time the aircraft returned from Djibouti, all members of the team had successfully completed their allotted tasks and were quite ready to move on. After saying our goodbyes to the Bosassans, we boarded the aircraft for our return flight to Nairobi.

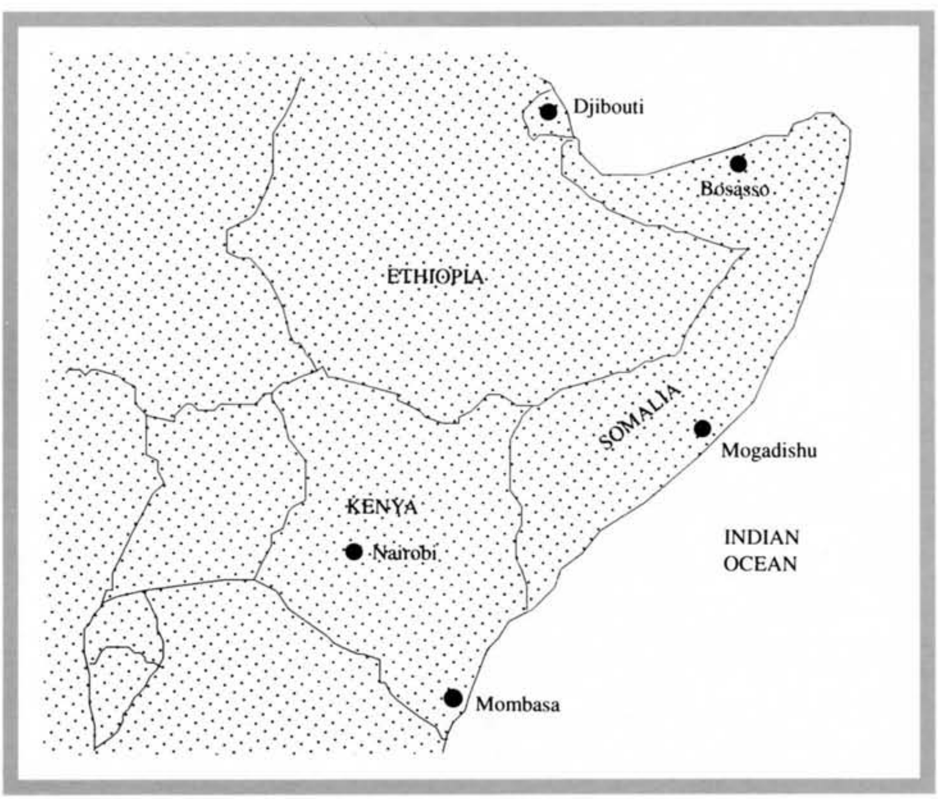
On October 17th the reconnaissance team leader (NDHQ/J3 Peacekeeping) was ordered to fly to the capital, Mogadishu, in southern Somalia. As this was an altogether more unstable and dangerous place than Bosasso, he did not wish to take any naval or Movements personnel, among others, with him. We accompanied him in the Hercules as far as Mombasa, Kenya where we would remain the few hours until we were picked up by the return flight from Mogadishu. The excursion to Mombasa added a few hundred kilometres to the aircraft's journey, but allowed the naval and Movements personnel practical use of what might otherwise have been a wasted day.

As expected, Mombasa proved to be a very well-equipped and well-situated world-class port. Mombasa has one of the deepest natural harbours in the world, with plenty of room for an AOR to anchor or berth alongside. (The United States Navy and Royal Navy were able to find accommodation for entire carrier battle groups in the port.) Mombasa also had numerous fine hotels and resorts (outside the city centre), good quality fresh food sources, adequate repair facilities (except for a dock large enough to accommodate an AOR), agents for most major equipment manufacturers and very good rail, road and air connections. As well, the Canadian High Commission 400 km away in Nairobi was ready, willing and able to provide any required diplomatic or liaison functions.

In summary, the reconnaissance team found that Bosasso would make an acceptable staging area for the Canadian Airborne Regiment. Landing craft or other small vessels could easily be used to ferry materiel the two kilometres or so from *Preserver*'s anchorage to the port. In terms of humanitarian aid, if spare machinery parts were provided by the UN or some other agency, *Preserver*'s crew and workshops could be well employed helping the Bosassans to refurbish the freezer plant and set it to work. Also, given the local fuel shortage, a portion of *Preserver*'s large fuel supply could be used judiciously as barter, in lieu of cash, for local services for both the Airborne regiment and the ship. On another note it was determined that the port of Mombasa in the south could and should be used as a recreation, resupply and, if necessary, repair facility for *Preserver*.

It was not until early in the morning of the 18th, while on the flight from Nairobi back to Canada, that I had time to rest and reflect on the mission. What an exciting, interesting, educational, challenging and successful few days these had been. Although I never expected to be doing this sort of thing during my career, I would gladly do it again and recommend it to anyone seeking challenge and adventure as a Maritime Engineer.

LCdr Jollymore is the Senior Staff Officer for Engineering Development in Maritime Command Headquarters.



Computer-aided HF Antenna Analysis of a Warship*

By Lt(N) J.B. McLachlan, P.Eng.

***Adapted from the author's 1991 M.Eng. thesis.**

Introduction

An important consideration in the design of any communication system is the type and location of the antennas to be used. Of particular interest are the antenna radiation patterns and input impedance which will result from a particular installation. These two parameters are dependant on the geometry of the antenna, the frequency of operation and the surrounding environment. Determination of these quantities mathematically requires the solution of Maxwell's equations for the fields surrounding the antenna; not a trivial exercise even for simple antenna structures. If the structure is of a complex design, as with a warship, then the solution of Maxwell's equations requires that certain simplifying assumptions be made. Unfortunately, these assumptions render the accuracy of the results somewhat dubious. The usual alternative is to carry out scale-model measurements of the proposed design, but this is a costly and time-consuming process.

There is another alternative, however, a purely mathematical solution, which has been made possible by recent advances in computer technology. Here an approximate solution to Maxwell's equations is obtained by modelling the ship "electromagnetically" and then solving for the fields using an iterative computer code. The modelling technique is referred to as wire-grid modelling, so called because it approximates the electrical characteristics of the structure as a series of interconnected wires. The iterative computer code employed here is Numerical Electromagnetic Code (NEC), a highly respected computer algorithm which generates accurate results for antenna modelling problems.

Background

Electromagnetic modelling of structures dates back to the early 1950s. Then, as now, the drawback of this technique is its computational intensity (which swamped early computers). For a model with N wires, N3 computations are required to define just one wire on the model! Only recently have computers of sufficient power become readily enough available to make this a worthwhile endeavour.

Considerable research in this area has been undertaken internationally, with Concordia University of Montreal being among the leading institutions. Much of Concordia's work has been devoted to simulating aircraft models, although some initial work with warships was performed. Results from their CP-140 aircraft modelling demonstrated that computer modelling can produce reliable radiation pattern and impedance values when interpreted correctly.

This paper describes experimental work performed by the author at the Royal Military College in pursuit of a Master's degree in Electrical Engineering. The work presented here, a modelling of the HF antennas on board a Canadian patrol frigate (CPF), represents the most extensive investigation ever undertaken into the utility of using this technique to model structures in the naval environment.

Model Synthesis

The task of performing antenna analysis using this technique can be divided into three areas:

- model design;
- solution of the electromagnetic problem; and
- analysis of the results.

Designing the CPF model was a relatively straightforward process in which the location of the wires comprising the model was laid out by hand on scale drawings of the ship. A number of guidelines stemming from the numerical methods software had to be adhered to, which effectively placed restrictions on the length, diameter, location and interconnection of wires. For example, a wire's length could be no longer than 1/5th of a wavelength at the frequency of interest. (For a structure of a given size, therefore, the number of wires required to model it properly would increase with the frequency. Above 30 Mhz the number of wires makes solution with the numerical methods software an extremely slow process.) Experimentation has also shown that best results with wire-grid modelling are obtained when the surface area of the wires on the model is equated to the surface area of the structure being modelled.

A computer program referred to as DIDEC (digitize, display, edit and convert) was used to convert the two-dimensional design drawings into a complete three-dimensional computer model. (The two-dimensional design drawings were converted to a DIDEC model file using a digitizing tablet.) The model can then be modified by using DIDEC commands accessed through the computer keyboard. Once the design is complete, the DIDEC model file is converted into NEC input file format. The wire-grid model for the CPF is shown in *Fig. 1*.

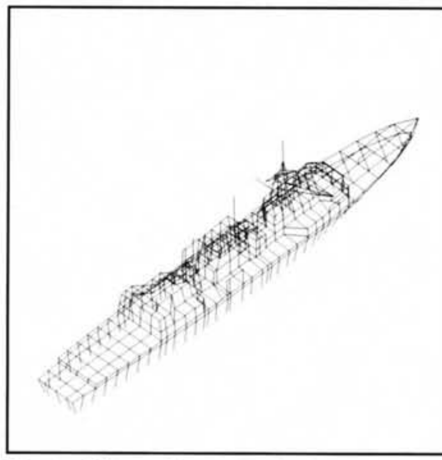


Fig. 1. Wire-grid model of a Canadian patrol frigate.

Research with aircraft models has shown that the NEC code will compute accurate values for antenna input impedance and radiated fields resulting from a radiating element on a wire-grid model. The algorithm uses a "method of moments" technique to determine the current at the centre of each wire. The radiated fields are subsequently computed by integrating (at every point in space) the fields resulting from these currents. The results are output in tabular form, but for ease of analysis are presented graphically using any number of graphics software packages. For the CPF model, Sigmaplot software was used.

The CPF computer model was validated against 1/50th scale-model measurements of seven antennas on the CPF conducted at the U.S. Navy's Naval Ocean Systems Center in San Diego. A brass model was constructed to evaluate whip antennas, twin whip antennas and fan antennas. Modelling of the ship structure aside, modelling the antenna installations presented its own challenges. Special care had to be taken to ensure the electrical characteristics of the antennas, their feed structures and the portions of the ship adjacent to the antennas were accurately preserved in the model. The antennas were modelled as thin wires the same length as the original antennas.

An example of a whip antenna installation that produced promising results is shown in *Fig. 2*. In the model, the antenna is excited by impressing a voltage across the feed segment. Note that unlike the actual antenna installation, the antenna here is connected directly to the ship model. The diagonal wires serve to ensure the current has a clear path from antenna to model.

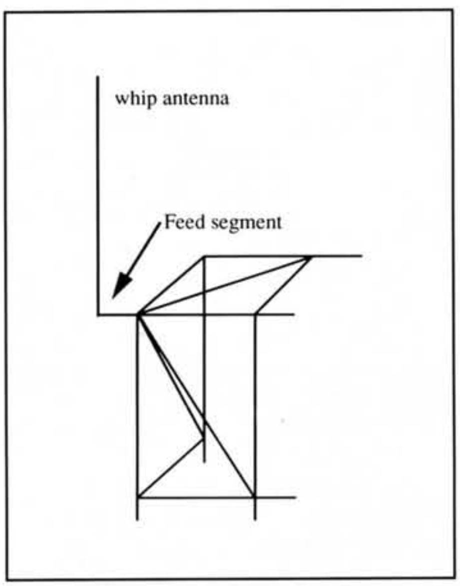


Fig. 2. Feed area configuration of a whip antenna.

While the results of these computer simulations are not an exact duplication of the scale-model results, there is sufficient agreement to warrant their use for design purposes. *Figure 3* shows a comparison of computed and measured impedance results for one of the whip antennas. Apart from a discrepancy with the computed results at 11 Mhz, there is general agreement between the two sets of data over the frequency spectrum in question. What is very encouraging is that the computer model accurately predicts the resonant frequencies of 5.5 and 10.5 Mhz.

Figure 4 shows a comparison between the measured and computed radiation patterns at 4, 8 and 12 Mhz. Although the lobes are not identical in shape and size in all cases, there is agreement on the location of the nulls. Generally, as the figure shows, the best agreement occurs at the lower frequencies. This is a result of the lack of current resolution on the model at the higher frequencies and shorter wavelengths and could be rectified by increasing the density of wires on the model. There is disagreement in the predicted

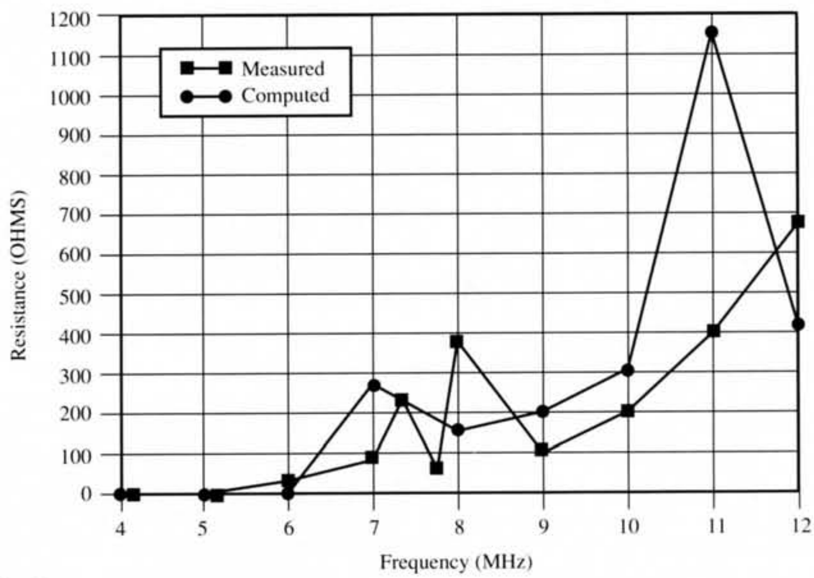


Fig. 3a.

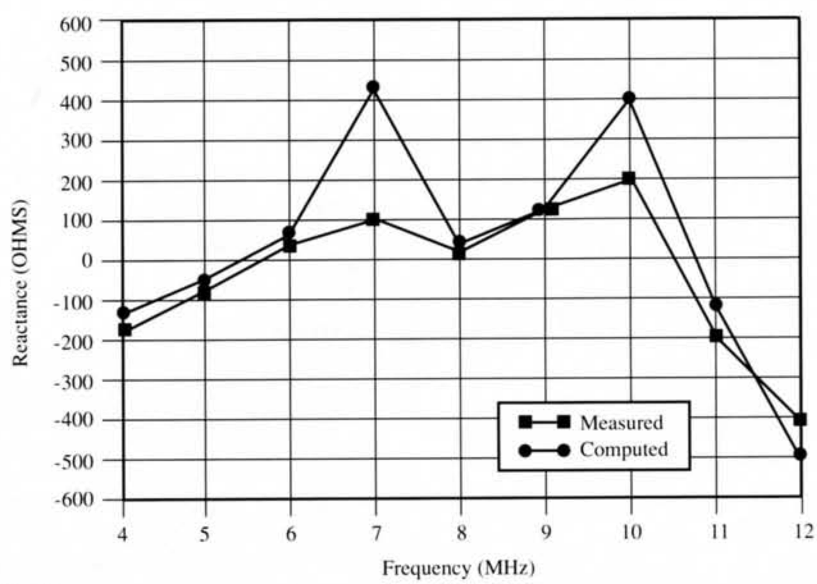


Fig. 3b.

Antenna input resistance (a) and reactance (b) versus frequency for a whip antenna.

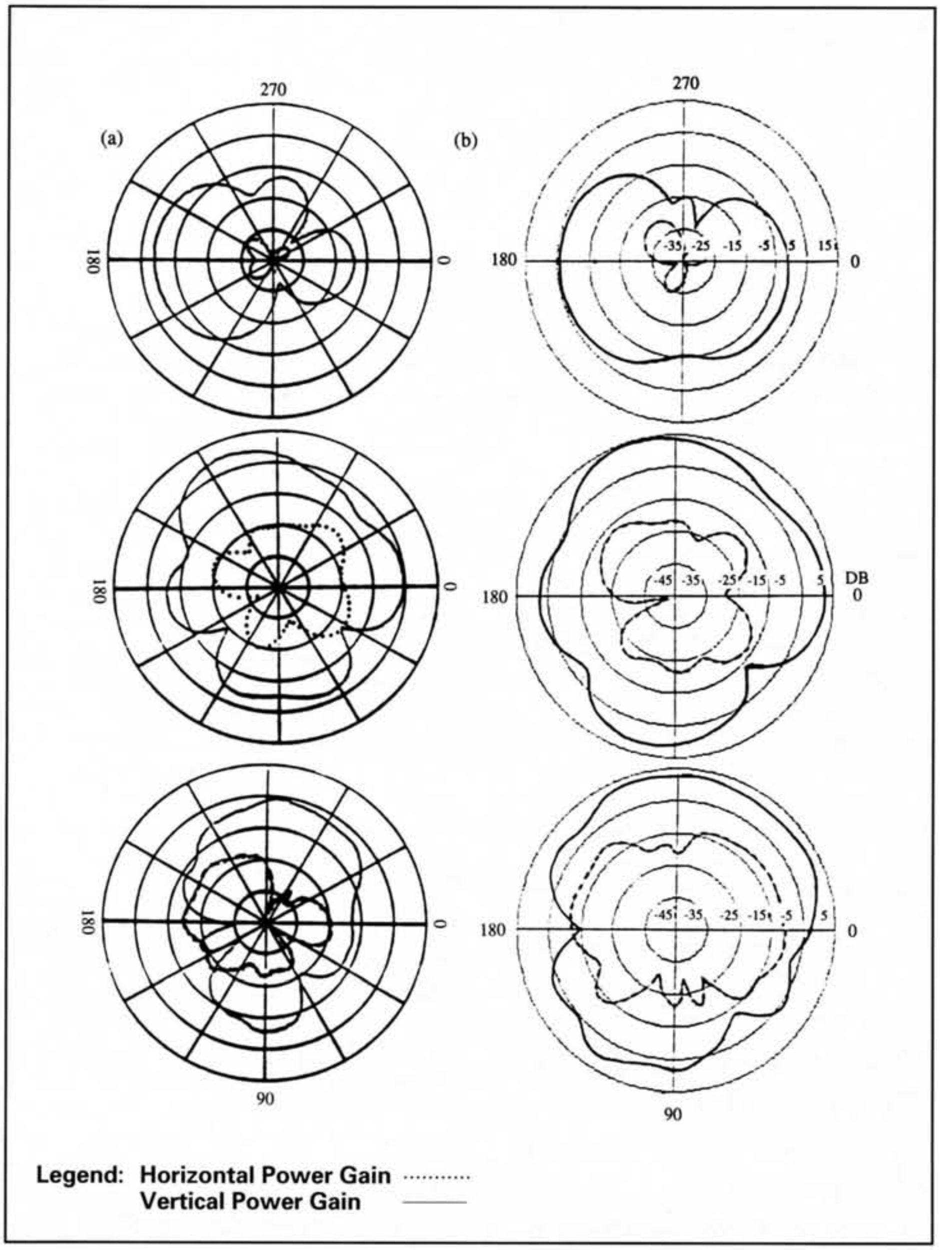


Fig. 4. Azimuth plane pattern for measured (a) vs. computed (b) results at 4, 8 and 12 Mhz.

gains of the antenna which is due to the manner in which gain is computed in the NEC software.

Is this a useful tool for the navy?

It is worth mentioning which resources would be required to undertake wire-grid modelling. The DIDEC software was written jointly by Defence Research Establishment Ottawa (DREO) and Concordia University and is the property of DND. It is available in a PC version which will run on an 80286 processor or greater, and a VAX version. The NEC software is the standard for antenna modelling and has been purchased by DND for use by DREO. NEC is written in Fortran and can be run on either a workstation (preferably of RISC architecture), or a VAX computer.

When comparing the results of computer modelling and scale-modelling, it is important to keep in mind the relative costs of the two techniques. Scale-modelling is a very costly and time-consuming business. Apart from building the model, a complex set of measurements must be taken at a fully instrumented range. In contrast, computer modelling requires the efforts of a technician and the application of the above-mentioned computer hardware and software.

This is not to say that scale-modelling should become a thing of the past, at least not yet. It is desirable to verify the accuracy of a computer model against actual experimental results. Once the model has been validated, however, additional measurements can be taken to complement those of the scale-model and for future antenna engineering work. An additional benefit of this technique is a product of the method of moments solution. Recall that in computing the fields the NEC code first determines the current on each wire. Knowledge of the surface current distribution provides valuable information about the manner in which an antenna interacts with its surroundings. The surface current distribution of a metallic structure cannot be directly measured.

Conclusion

This research has demonstrated that with care and attention to detail, computer-aided modelling can provide an accurate prediction of antenna input impedance and far-field radiation patterns for shipborne HF antenna installations. With further research, wire-grid modelling could alleviate the need to perform scale-model field measurements, thus taking antenna engineering out of the brass age and into the computer age.

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Lt(N) J. McLachlan is a DMCS 3 project engineer with the AN/SQS-510 sonar.

On Leadership

By Cdr Manfred Kling, CD, BESc, MS, OE

"And a young warrior said: Speak to us of Leadership. And he answered saying: These my innermost thoughts on Leadership I give you, so that you and your subordinates might be better prepared to lead."

I recently came across an excellent book humorously titled "Leadership Secrets of Attila the Hun"[1]. That book, plus a discussion over a glass of nonalcoholic beer with a group of young MARE officers at the Naval Officer Training Centre in Esquimalt, prompted this essay. It reflects what I wish I *had* said to that group of young MAREs.

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It is essential to the MARE classification that we have among us leaders at every level who possess the skills, abilities and attitudes that will enable them to successfully carry out the responsibilities of their offices in the furtherance of the interests of the classification and the navy. Those from whom we expect this must be guided early in their careers to develop certain essential leadership qualities and must be given opportunities to mature them.

The most important quality of a leader is loyalty — to those he serves and to those who serve him. He must at the same time have the wisdom to understand that disagreement is not necessarily disloyalty, and that one who in the best interest of the service disagrees, should be listened to. A leader should not feel threatened by capable contemporaries or subordinates. Rather, he should be wise in selecting them to achieve those things which can be attained only through strong and motivated subordinates.

A leader must also have the courage to accept the risks of leadership and to act with confidence in times of uncertainty. He must have the fortitude to carry out difficult assignments and be committed to persevering in the face of opposition. He must be decisive, knowing when to be firm and when to compromise; but over-eagerness must be tempered with preparation, experience and opportunity.

A leader must develop empathy — an appreciation for, and an understanding of, the values of others; a sensitivity for other cultures, beliefs and traditions. He must be able to anticipate thoughts, actions and consequences; a skill learned by observation and through instincts sharpened by experience.

The quality of unyielding drive to accomplish goals is a desirable and essential quality of leadership, as is the intrinsic desire to win. It is not important to win all the time, only to win the important issues (bounded always by moral and ethical principles). Through training and experience a leader can develop a personal feeling of assurance with which to meet the inherent challenges of leadership. Pertinacity is often the key to success. However, while exhibiting self-confidence, a leader must be cautious not to take on an aura of false pride or arrogance. He must be willing to learn, to listen, to grow in his awareness and ability to perform the duties of his office, and to accept the simple fact that he will need to work every day to become a better leader than he was yesterday. This can seldom be accomplished without tremendous effort or sacrifice of other interests.

"The Most important quality of a leader is loyalty — to those he serves and to those who serve him."

A leader must be credible and dependable. His words and actions must be believable. He must be trusted to have the intelligence and integrity to provide correct information and to be dependable enough to carry out his roles and responsibilities. He should understand that those serving above and below him are counting on his ability to lead, and he must be proud of having been entrusted with such a responsibility. He must have the essential quality of stewardship, a caretaker quality, and must serve in a manner that encourages confidence, trust and loyalty. Subordinates must not be abused, rather they must be guided, developed and rewarded for their performance. Discipline must be reserved as a consequence of last resort and applied sparingly. Without subordinates there can be no leaders. Leaders are therefore caretakers of the interests and well-being of those people, and the purposes, they serve.

Each succeedingly higher level of leadership places increasing demands on the emotions of the leader. He must be willing to make unrecognized and thankless personal sacrifice for those he serves and those he leads. He must have the stamina to recover rapidly, to bounce back from discouragement; to carry out the responsibilities of office without becoming distorted in his views and without losing clear perspective; and he must have the emotional strength to persist in the face of seemingly difficult circumstances.

A leader must be determined to apply common sense in solving complex problems and must understand that success will often depend largely upon sustained willingness to work hard. Sweat generally rules over inspiration! He must never accept an office of leadership for which he is not willing to pay the price necessary to fulfil its obligations.

And finally, a leader must exercise great care to avoid placing otherwise capable people into positions of leadership that they have no desire to fulfil.

These, in my view, are the characteristics of a leader. It must be recognized that this is not a comprehensive list and that leaders will be of no composite character. They will be as different from one another as one person can be different from another. They will not be laden with all human virtues, nor will they possess a flawless character. However, committed leaders, those with a willingness to serve, will be distinguishable by their wisdom, sincerity, benevolence, authority and courage. They will have a human quality and a strong commitment to their cause and to those they serve.

Post Scriptum

Copies of the essay "On Leadership" were offered anonymously (by the author) to a group of young MARE trainees for comment. As you will see, their views provide interesting food for thought. I am pleased they did not pull their punches since the article was intended to spark discussion. If we are to mature as leaders we must each, at some point in our career, reflect upon and strive toward those qualities *we* believe to be important.

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"Being believable is not good enough, one needs to be thoroughly truthful."

Author's reply: I fully agree that one must be truthful. Intrinsic to believability is truthfulness; indeed, the dictionary defines "believable" inter alia as "putting trust in the truthfulness of a statement."

"I disagree with 'selecting subordinates wisely.' A leader does not always have this luxury. He should be able to take any subordinate and work with the strengths and weaknesses to obtain the desired results."

Reply: I couldn't agree more. Perhaps a better turn of phrase would have been, "...he should be wise in selecting *among* his subordinates to achieve those things which he can only attain through strong and motivated subordinates." This embodies the concept that each person has special talents which must be recognized and encouraged if he is to achieve and demonstrate his full potential.

"It is not important to win. It is important to learn from the experience and be able to analyze why you lost. A leader should put forth the arguments to the best of his ability. If a (contrary) decision is made by his superior, he must be willing to accept his leader's decision and get on with the job."

Reply: Learning from experience and being able to analyze why you lost subsumes the principle that you want to win next time. I agree that winning is far less important than "giving it your best shot." However, there are issues for which you must be prepared to fight, and be determined to win, even in the face of opposition. What those issues are will depend on the circumstance. Never forget that senior officers base their decisions on staff work. They are not always right, and they rely on you to have the courage to tell them when they are wrong. Having said this, you may infrequently come across those who believe that wisdom and knowledge are directly proportional to rank, in which case be silent and learn from the experience.

"The author brings up some good points but he has a very idealistic view of a leader. The author should state more about how one goes about obtaining all these qualities. There needs to be a balance between the effort to become a good leader and other aspects of your life."

"The author talks of "sacrifice of other interests." How far is he willing to go? What interests is he talking about? Is his family included in his list?"

Reply: Both of these comments touch on the issue of personal values, which makes them among the most difficult to deal with and comment upon. Values (for better or worse) change with time, culture and circumstance. Not too many years ago the "company response" would have been: "Queen and country before all else." Today this dogma is voiced less frequently. Where does one draw the line between sacrifice for country versus family or friend? Is the good of the many more important than the good of the few? I have my own views and I encourage you to develop yours. These issues require a great deal of individual soul searching and the courage to act in accordance with your beliefs.

"The most important characteristic of any leader is decisiveness. Of all the qualities mentioned in the article, none can have such an adverse affect on a leader than if the followers think he is wishy-washy."

Reply: Indecisiveness can indeed have a deleterious effect on one's ability to lead. It brings into question not only the leader's ability to provide firm, clear direction, but also puts in doubt a number of other qualities such as courage, dependability and emotional stability. Whether one quality is more important than another is debatable. You may be correct that indecisiveness, or indeed any of the other qualities, should rank higher than loyalty on the list. My personal feeling however is that I could work with, and trust, an indecisive person, but I could neither work with, nor trust, one whom I know to be disloyal.

Reference

[1] Wess Roberts, *Leadership Secrets of Attila the Hun* (New York: Warner Books, 1990).

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An Artificial Intelligence Approach to the Threat Evaluation and Weapon Assignment Problem

By Robert Carling

Introduction

Anti-ship missiles launched from air, surface or subsurface platforms can be considered a serious threat to warships and to merchant ships under naval escort. Thus, an important function of a warship's command and control system is the threat evaluation and weapon assignment (TEWA) process. This function takes output from the ship's automatic threat detection and tracking process to rank the firm tracks according to specific criteria, then assigns hardkill and/or softkill weapons to either destroy the threats or decoy them away from their intended target.

A knowledge-based approach has been taken for modelling the TEWA process because of its flexibility when dealing with complex problems and the ease with which a knowledge base can be modified to solve the TEWA problem for different sensor and weapon suites. This paper describes the design of such a knowledge base, the methods used to test it in a simulation environment and the results obtained.

The knowledge-based approach allows the modelling of uncertainty in target sensor measurement, target identification and classification, and in processes (like TEWA) which depend on sensor measurement and target identification. A variety of uncertainty models — Mycin, Bayesian Probability and the Dempster-Schafer Theory of Evidence — have already been applied in these areas[1, 2, 3]. In these models, uncertainty coming from various sources may be combined to produce a value for a variable which depends on all these sources. In a conventional TEWA process, such as is simulated in the Ship Combat System Simulation (SCSS) (*see MEJ, July 1990, p.13*), there is no provision for modelling uncertainty. Threat values which are calculated from corrupted sensor values are taken to be representative of the tactical situation and all decisions are made from them.

An advantage of knowledge-based systems is that they are often associated with windowing systems and hence are relatively easy to use. The data input to scenarios is accomplished by selecting the appropriate menu with the mouse and typing in the correct data as required. In addition, the domain knowledge for TEWA can be divided into a number of knowledge bases for the principal air-defence functions making up TEWA. In the conventional TEWA, the whole idea of resource planning involving functions that measure destruction of threats and interference between hardkill and softkill weapons is missing.

Background

TEWA can be thought of as a two-stage process. In the first stage a tactical situation evaluation is made by consolidating data from the ship's sensors, and in the second stage a resource allocation is made based on engageability criteria, weapon effectiveness and interference criteria. Work in these two areas has been carried out in the United States and the United Kingdom.

The use of knowledge-based systems in multisensor data fusion for a single ship and for many ships has been reported[4, 5]. The work presented in this article concerns a single, stationary TRUMP-like ship under attack from air-launched anti-ship missiles. The TEWA process must rank threats and assign weapons within a matter of seconds since an entire air attack involving multiple threats can be completed in minutes. Aside, therefore, of the functionality of this process, it must execute in real time.

In the area of resource allocation, certain systems are either ready or under development[6]. For example, Ferranti is building a demonstrator known as RRASSL (Reaction Resource Allocation — Single-Ship Level) which automates the TEWA process. RRASSL will be able to recommend the optimum combination of defence measures — missiles, guns, jammers and decoys — to maximize their effectiveness and prevent mutual interference. In the same reference, allusion is made to a knowledge-based data fusion system (including tactical situation evaluation and resource allocation) which will undergo sea trials on the Type 23 frigate HMS *Marlborough*.

Objectives

A preliminary investigation was begun to determine whether a knowledge-based system alone or with additional support programs (such as an object-oriented environment or specialized numerical routines) could be used in the single-ship TEWA process. The purpose of this work was to implement a ship's TEWA function using artificial intelligence and assess the decisions made by it in simulated AAW scenarios.

The first objective was to see whether a knowledge-based TEWA could evaluate the tactical situation around a ship accurately enough for weapon assignment. Normally, tactical situation evaluation involves identifying friendly units, identifying hostile units and estimating their intentions, and ranking the threats posed by weapons targeted at the ship. However, to keep the financial burden of the simulation reasonable, only the case of a ship being attacked by air-launched radar-guided missiles was considered here. Since the simulation was built in Smalltalk 80, the knowledge base could be extended later to accommodate additional hostile surface and air platforms. After each step in building the tactical situation evaluation model, verification was necessary to ensure the artificial intelligence gave credible anti-air warfare (AAW) results in simulation testing.

Second, since TEWA is a process receiving input from sensors and transferring decisions to weapons, and some weapon systems have much in common, it was thought that a knowledge-based TEWA could control equally well a two-phase semi-active system such as the Sea

Sparrow, or a three-phase mid-course guidance, semi-active system such as the SM-2. Similarly, if the radar-guided system were changed for a two-phase guidance system in which the second phase employs infra-red homing (such as the Rolling Airframe Missile system), one has only to change the weapon system characteristics in one of the knowledge bases to have the TEWA control the new weapon system.

The third objective of the study was to use the knowledge-based TEWA to study anti-air warfare and in particular learn more about TEWA. A question still to be resolved for each ship's air combat system is whether ship rotation before or after weapon assignment significantly increases its survivability. The fourth objective was to study the way in which a knowledge-based system can handle uncertainty in sensor data.

The Design of the Knowledge-Based TEWA

An initial knowledge review was made of the TEWA process to facilitate the choice of knowledge-base shell and the simulation environment in which it would be tested. Smalltalk was chosen as the simulation environment since it is known to be a rapid prototyping tool with a windowing operator-machine interface. An interactive electronic warfare simulator has been built from it[7] and validated with real data. Together with C++, it seems to be one of the natural choices for the building of a knowledge-based AAW environment. In addition, data transfer between the expert system shell (Humble) and any of the Smalltalk objects (sensors, weapons) is easy to implement.

The knowledge-review process indicated initially that forward chaining, backward chaining, temporal reasoning, spatial reasoning, compact handling of multiple confidence factors and a blackboard structure were necessary for the TEWA. After examining the search space of the TEWA problem, however, it became evident that there were few objectives in the rule base, but many branches. Under these circumstances backward chaining is far more rapid than forward chaining; hence, the requirement for forward chaining was removed. Humble has internal functions to implement backward chaining and the handling of multiple confidence factors. The other required structures — temporal reasoning, spatial reasoning and the blackboard structure — were implemented in the Smalltalk language.

To conserve project funds while focusing on TEWA-related issues, the knowledge-based TEWA was implemented with the following assumptions and limitations in addition to the single-ship constraint:

- The ship is stationary;
- The only reactions that can be implemented by the ship are the use of hardkill and softkill weapons. Reactions to improve force knowledge through sensor queuing or to improve force efficiency through suitable force ship formations were not considered.

The design of the TEWA evolved over a one-year period. Initially, it was based on a five-function plan which finally took the form of *Fig. 1*. Here a central TEWA Smalltalk object interrogates four knowledge bases: Target Evaluation, Force Resources Evaluation, Result Evaluation and Candidate Reaction Evaluation. Each of them has been built from Humble and can be easily accessed by the central blackboard architecture.

Threat Evaluation

The target (threat) evaluation knowledge base is divided into two levels. The first deals with an initial estimation of target track attributes, the second constitutes a limited set of propositions concerning the threat levels for these tracks. These threat levels are based on the previously estimated attributes and may be refined using temporal reasoning (i.e. the current threat level is calculated from the attributes at the current time step and the threat values or attributes from previous time steps). The first level of the knowledge base subdivides into four important classes: identity, kinematics, engagement status and threat radar state. All track identities are categorized into one of five classes: friend, weak enemy, moderate enemy, strong enemy and unknown.

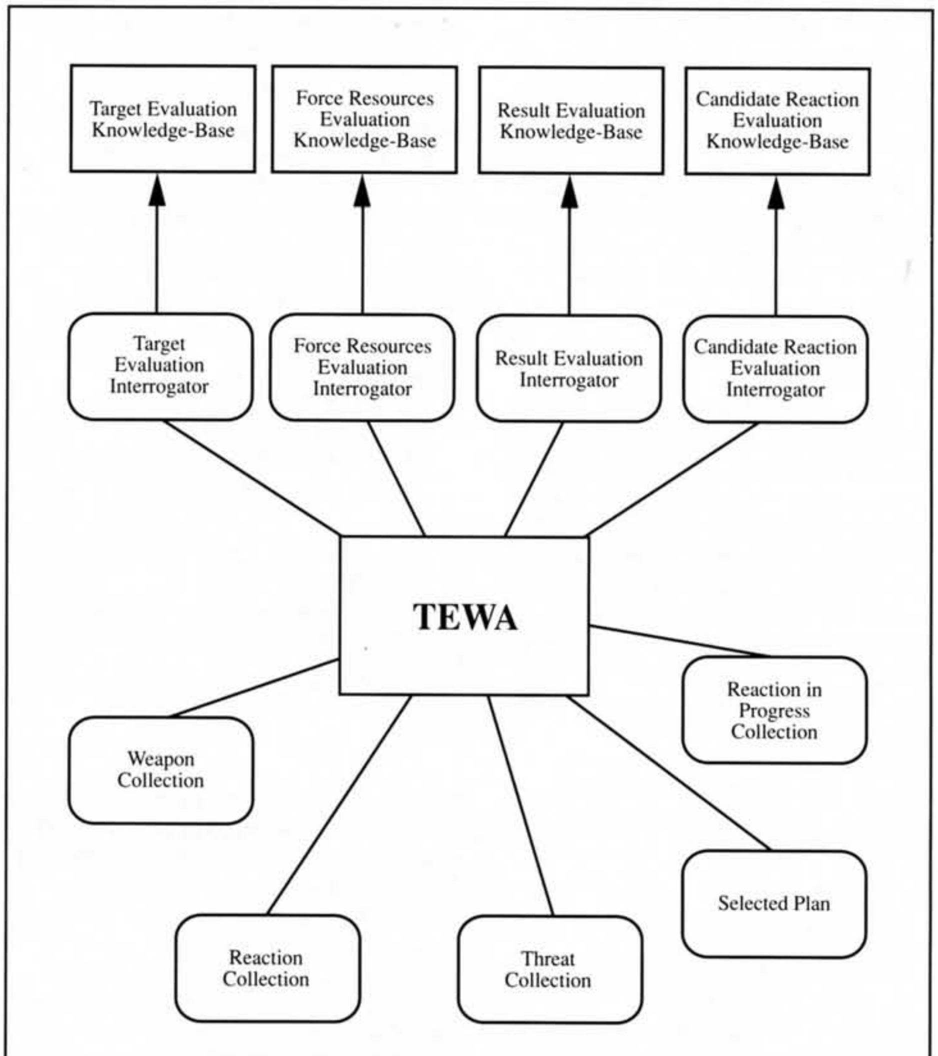

Fig. 1. Structure of the Knowledge-based TEWA

The rules of the kinematic class quantify the degree to which the kinematic behaviour of a track is threatening. The rules quantify a closing track as one with strong, moderate or weak kinematics, depending on CPA (closest point of approach) and TTGI (time for the target to reach CPA if it continues with the same velocity). For example:

> If the target is closing, and the CPA is equal to or less than 100 metres, and TTGI is greater than 20 seconds, but equal to or less than 40 sec., then kinematics are quantified as strong, with certainty 1.0.

Whether or not a track is currently under prosecution bears on the threat level posed by the track. A track that is under attack is less of a threat than would be the same track if it were not under attack. A fourth class of rules concerns the state of the threat radar seeker-head which can be in either active or passive mode (the former obviously being more dangerous than the latter).

Once the status of a track has been determined in these four classes, the rule base combines the information to obtain a preliminary threat ranking with its associated uncertainty. For example:

> If identity = weak enemy, kinematics = moderate, engagement status = not engaged and radar state = passive, then the level of threat is 3, with certainty 1.0.

In this rule, identity, kinematic, engagement status and radar state values are combined to obtain a value of the level of threat, which can range from one (least dangerous) to five (most dangerous). In the example just given, a threat level of three is obtained when the radar state is passive — a similar rule assigns the value of four when the threat seeker-head radar state is in search or track mode. This constitutes a measured threat level $MTL(t_0)$ because it is the threat level calculated from the most recent information about sensor tracks at time t_0, say. Filtered threat levels with associated uncertainties are now calculated from the past two measured values at t_0-1 and t_0-2 according to the following formula:

$$FTL(t_0) = [(4 \times MTL(t_0)) + (2 \times MTL(t_0-1)) + MTL(t_0-2)]/7$$

To take into account any slight target manoeuvres, there is a rule for measuring the deviation of target direction about the straight line joining it to the ship at the current time and at a previous time step. If the sensors indicate the target is manoeuvring slightly toward the ship, the target threat level will be increased and the certainty that it will be at its new level will also be updated.

Weapon Assignment

The remaining knowledge bases contribute to weapon assignment. The purpose of the Force Resources Evaluation knowledge base is to provide the Candidate Reaction Evaluation function with information describing the readiness of various weapon systems. The resource evaluation knowledge base contains rules concerning the stock level and availability of weapons on the ship. When interrogated, it reports the status of each weapon as operational, degraded or non-operational.

The Result Evaluation knowledge base evaluates the current reaction used, to observe the outcome of the reaction and to record the time that the observation is made. For each weapon, the knowledge base determines whether the ship is aware that a threat has been destroyed or decoyed after a certain time interval.

The Candidate Reaction Evaluation knowledge base has two functions. It must first determine the engageability of each surviving track with respect to each weapon, and then predict the effectiveness of each threat-reaction pair that survives the engageability calculations. For this simulation, calculations were done for the following weapon systems:

SHIELD
RAMSES
76-mm gun — LIROD
76-mm gun — STIR A
76-mm gun — STIR B
CIWS
SM-2 (Salvo) — STIR A
SM-2 (Salvo) — STIR B
SM-2 (Single missile) — STIR A
SM-2 (Single missile) — STIR B

The engageability of the SHIELD and jamming systems is found by setting together a rule set concerning the important softkill parameters for these two systems. For the jamming system these are the softkill weapon deployment time, the time for it to start having an effect, the time before burnthrough and, finally, the turn-on time. For the chaff system, the first two jamming variables have chaff system counterparts, while the last two must be replaced, respectively, by the time at which the threat seeker-head will home on the ship instead of the chaff cloud, and the time at which the chaff canister explodes. If the conditions concerning these variables and the threat in question are satisfied, then the target is declared engageable by the softkill weapon. Otherwise, it is not engageable. In the case of the hardkill weapons the track must be within the engageability envelope of the weapon and the fire-control radar (FCR) must be able to track the target inside this envelope. The effectiveness of each weapon is determined by estimates of the kill probability or decoy probability.

In the central TEWA object there is a ranking-of-candidate-reactions function that generates a plan of action for dealing with threats. A plan is a complete assignment of weapons to threats, including multiple assignments of weapons to each threat. The plans are scored according to an optimization function which ranks them to maximize the survivability of the ship from air threats, to minimize the expenditure of force resources on the single warship and to minimize the interference between resources. Survivability, as defined in the following paragraph, is the largest number of anti-ship missiles that can be destroyed by the weapons of the TRUMP-like ship. This definition is equally valid whether there is a merchant ship in the vicinity or not. The weapon assignment is completely defined by the knowledge in the knowledge bases and the plan scoring which, at the moment, do not depend on the presence of a merchant ship. If the warship were often to accompany a merchant ship during air raids in area-defence scenarios, it might be necessary to modify the knowledge base to give better protection to the merchant ship.

Weapon assignment plans are scored in the following way. An effectiveness value is calculated for all the engageable weapons that can be assigned to each track in the track data base. This value is multiplied by the uncertainty in knowing the threat level of the track and by the threat level itself. These products are summed over all threat levels and the sum constitutes the survivability factor used to rank plans for weapon assignment. The survivability factors are modified so that a plan that assigns weapons to $n+1$ tracks receives a higher value than a plan that assigns them to n tracks. In any assignment of hardkill and softkill weapons, there must be a measure of the interference caused by their simultaneous use. A mathematical function calculates the instantaneous interference between chaff and fire-control radars. A global optimization function scores the plan with a large weighting for maximizing survivability and a small weighting for minimizing interference. The plan with the highest score is implemented immediately.

Testing procedures for the Knowledge-Based TEWA

The knowledge-based TEWA was tested in a Smalltalk framework environment called a TEWA simulator. A target-track generator was also built in Smalltalk to simulate the output of a ship's ATMS (Automatic Track Management System) to its TEWA. The target-track generator produces system tracks for a TRUMP-like ship equipped with long- and medium-range radars, an electronic support measure system and an infra-red search and track system (*Fig. 2*). These tracks are submitted to the TEWA simulator for threat evaluation and weapon assignment as described in the two preceding sections. The selected reaction then updates the state of an object in the TEWA simulator.

Following a simulation run, a report generator records all the decisions made by the TEWA. In the scenario shown in *Fig. 3*, seven missiles are attacking a TRUMP-like ship and an escorted merchant ship. When the tracks corresponding to these threats were submitted to the knowledge-based TEWA, the weapon assignments shown in *Fig. 4* were produced. It is interesting to note that three assignments were made sequentially against the sixth target, starting with the SM-2 missile system and followed by the 76-mm gun and CIWS. In this case the SM-2 missed and the 76-mm gun was responsible for shooting down the target. The CIWS back-up was not required. The knowledge-based TEWA was tested in other AAW scenarios and credible results were obtained.

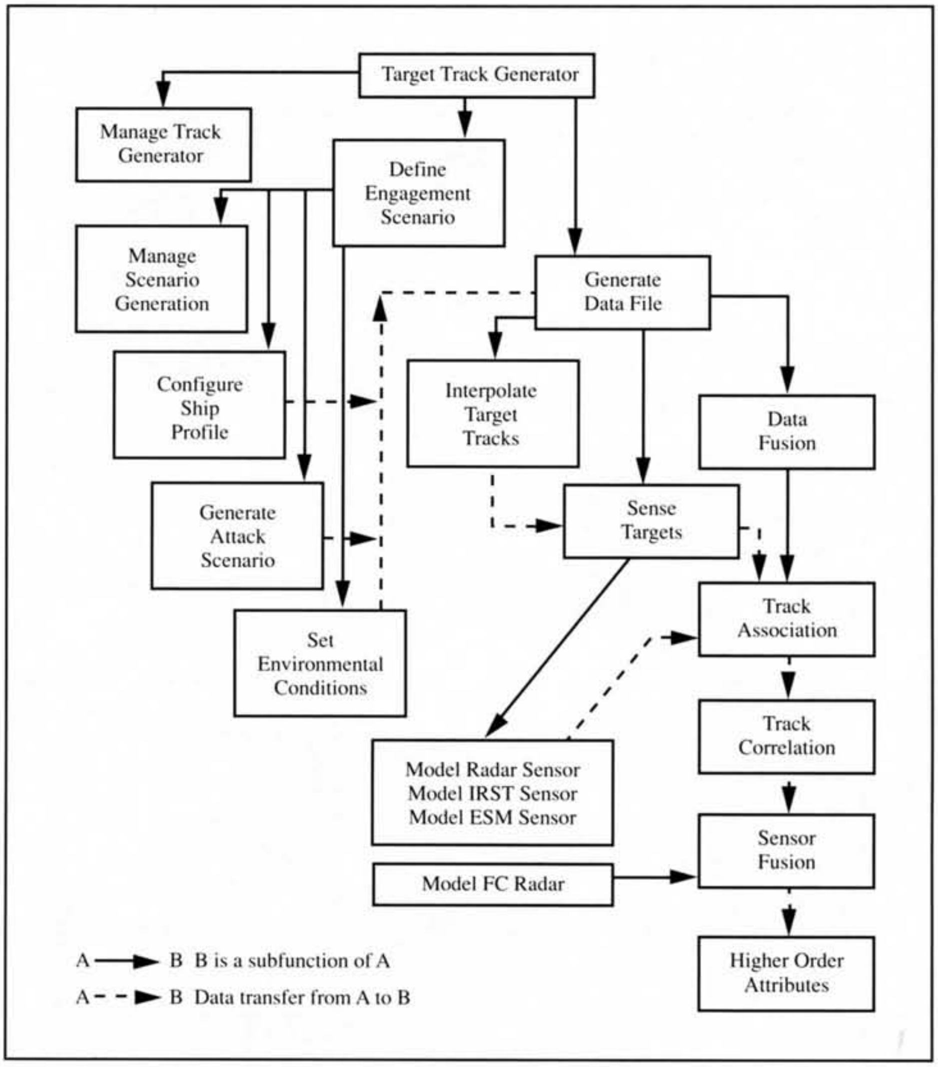

Fig. 2. The Target-track Generator

Conclusions

A successful knowledge-based TEWA has been built for a single TRUMP-like ship under attack by anti-ship missiles. It was successful in the sense that the knowledge-based TEWA destroyed approximately the same number of threats as in anti-air warfare scenarios run using the Ship Combat System Simulation (SCSS) and a conventional TEWA. The author's experience is that the knowledge-based TEWA always has an alternative weapon assignment for the combat system when a previously assigned weapon misses a target. In the SCSS simulation of the TRUMP destroyer, however, there is sometimes no alternative weapon assignment in the multiple-threat scenarios that the author has studied.

The performance in the testing scenarios showed that the knowledge-based TEWA can do a satisfactory tactical situation evaluation in preparation for weapon assignment. This consists of air tracks with appropriate threat ranking values. The values depend on identity, kinematic, radar state and engagement status parameters and currently, to a minor degree, on target manoeuvrability.

A successful knowledge-based TEWA has been built with sufficient functionality to do threat evaluation and weapon assignment for surveillance radars, an electronic support measure system, an infra-red search and track system and radar-guided weapons. Since many weapon systems have common attributes, the difference being the numerical values associated with these attributes, one can conclude that the knowledge-based TEWA can do threat evaluation and weapon assignment for a wide variety of hardkill/softkill weapons.

In the case of some hardkill/softkill weapons, integration is required not only of the TEWA with the weapon system, but also of the TEWA with the functions of the platform. For example, to obtain a more realistic chaff reaction against anti-ship missiles, it is often necessary to rotate the ship before or after chaff deployment. This is true for most ships deploying chaff. It is also frequently necessary to rotate the ship to clear blind arcs when anti-ship missiles appear in the blind zone of a missile's fire-control radar. This difficulty did not manifest itself in the TRUMP-like testing scenarios, but it is envisaged that for a very high-density attack in a missile's FCR blind zone, rotation of the ship to assign another fire-control radar could possibly increase the survivability. In spite of this, many hardkill/softkill weapon systems have characteristics in common that can be handled by a knowledge-based TEWA.

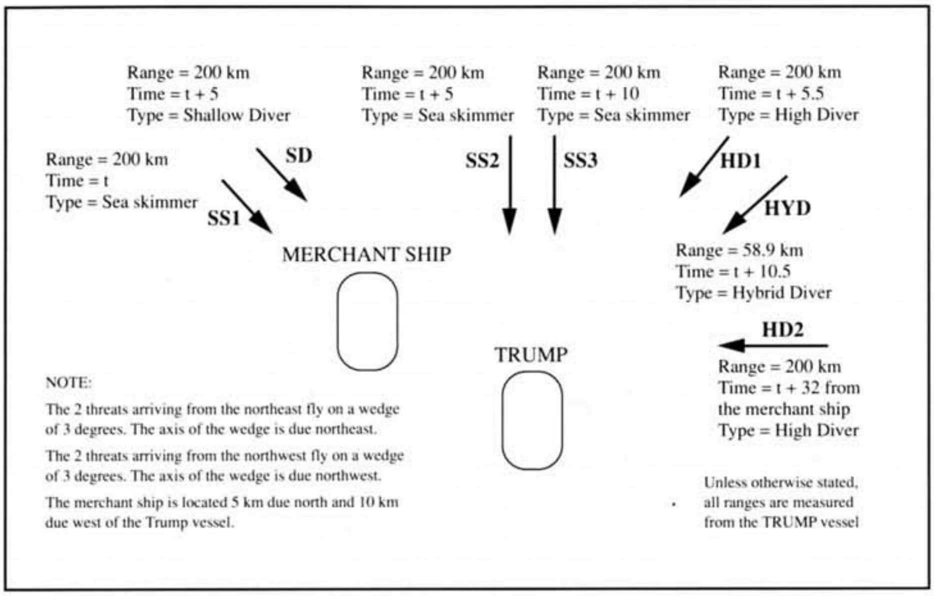

Fig. 3. A Testing Scenario for the Knowledge-based TEWA

	Weapon/Radar						
Weapon/Radar	HYD	SS1	SS2	SD	SS3	HD1	HD2
SM-2/STIR A	Killed	Killed		Killed			
SM-2/STIR B			Killed			*	
GUN/STIR A						Killed	
GUN/STIR B							
GUN/LIROD					Killed		
CIWS						*	

SM-2 = Standard Missile 2 CIWS = Close-in Weapon System
LIROD = Gun radar STIR A,B = Radars

* Indicates that a weapon (row name) has been assigned to the threat (column name)

Fig. 4. Snapshot from a Knowledge-based Testing Scenario

The tactical situation around the ship is perceived through its sensors which measure target characteristics. Radar sensors, for example, will measure the slant range and bearing of a target and will return values which are subject to errors. In the target evaluation knowledge base, a beginning has been made with Mycin type uncertainty to obtain a consistent set of threat levels from kinematic, radar state and threat identity parameters. Although the results obtained were satisfactory, there is no guarantee that this is the best method for dealing with sensor data uncertainty.

It is evident from this first study in knowledge-based systems that further research can be done to look at other ways of modelling uncertainty in sensor measurement, to test various uncertainty models for target identification and classification, to study the feasibility of introducing other kinds of knowledge into the knowledge base and to assess the impact of these ideas on TEWA.

The knowledge-based TEWA built from Humble is not a real-time system. To make it execute in real time, each of the knowledge bases is currently being analyzed to estimate the data throughput from TEWA to the combat system. Other real-time issues such as task scheduling, concurrency, computer architectures and computer protocols are being studied to see whether a real-time knowledge-based TEWA could be integrated into the air combat system of a warship.

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Update: MEPP — The Maritime Environmental Protection Project

By LCdr Bob Jones

Canada's far-ranging naval operations and the very nature of a warship's flag-carrying role pose some unique environmental challenges. The Canada Shipping Act regulates the discharge of solid and liquid wastes from ships operating in Canadian territorial waters, and beyond this our vessels must adhere to the ratified MARPOL regulations and the regulations laid down by the port authorities of host countries.

MARPOL has established special maritime areas where the disposal of solid waste is entirely prohibited. Ships operating in the Mediterranean, Baltic, Black and Red seas and the Persian Gulf (the Caribbean and North Sea are expected to be added soon), have no alternative but to store their waste on board until it can be disposed of lawfully and safely. For large commercial vessels carrying small crews, compliance poses something less of a hardship than it does for smaller naval vessels.

During the late 1980s several standalone projects were created to deal with the most urgent naval shipboard environmental concern — blackwater disposal. These involved the installation of blackwater collection systems in the majority of Canadian warships, but much more needed to be done to address the total shipboard generated wastestream. For this reason the Maritime Environmental Protection Project, or MEPP, was created. MEPP is currently undergoing departmental approval and a Treasury Board decision giving the project a green light is expected soon.

The aim of the MEPP is to augment existing pollution control systems in HMC ships and auxiliary vessels with known technology (*see table*) to enable compliance with national and international environmental protection regulations. The project will commit $52 million (constant year dollars) over eight years to procure and install a selection of equipment and systems, including compactors, pulpers, plastic waste processors, oily water separator systems, oil content monitors and liquid waste treatment systems.

Maritime Enviromental Protection Project (MEPP)
Planned Equipment Installation[1]

Class of Vessel	City 330	AOR 509	TRL 280	ANS 265	ASL2 0	AGOR	YNG	QTY
No. of Ships	12	2	4	2	1	2	3	
MIL-SPEC Compactor		X						2
MIL-SPEC Pulper	X	X						14
Commercial Pulper			X	X				6
Plastic Waste Processor	X	X						14
MIL-SPEC Oily Water Seperator	X	X	X	X	X	X		23
Oil Content Monitor		X	X	X	X	X(*)		10
BW/GW Liquid Waste Treatment		X	X			X(*)		7
Greywater Collection		X	X			X		8
Blackwater VCHT				X			X	5

*** Since one of the two AGORs was previously fitted with this equipment, only one vessel remains to be fitted under the MEPP.**

[1] Selected auxiliary vessels and yard craft will be fitted with commercial chemical toilets.

The breakout of planned equipment installations shown in the table was determined by taking several factors into account such as the remaining life of a vessel, equipment fitted under previous programs, a vessel's space and weight constraints, and the scheduled refit program. Because Canadian naval vessels generally have large crews for their size, equipping them to store *all* waste on board when operating in areas where disposal is prohibited has become a major challenge of the MEPP.

Storing shipboard waste for proper disposal later won't be easy. However, with the Maritime Environmental Protection Project, the resolve is there to provide effective environmental control systems to meet the challenges of the 1990s and beyond.

LCdr Jones is the DMEE 5 project officer for the MEPP.

Looking Back

The DMEE Desk

Some desks are born to greatness, others have greatness thrust upon them.
— Anon.

On the third floor of the Louis St. Laurent Building in Hull, Quebec, in the office of the Director of Marine and Electrical Engineering, a 50-year-old mahogany desk bears mute witness to a colourful past. Over the years this finely fashioned furnishing has served a succession of senior naval engineers and, for a brief period, even a minister of national defence.

The desk was made in Newfoundland in 1942 for Royal Navy Engineer-Captain Simms, DSO, and was based on a design seen in a Spanish ship. At some point the desk was greatly admired by Engineer Rear-Admiral GL Stephens (Chief of Naval Technical Services) who expressed a desire to have it. An agreement was reached and when Newfoundland naval operations wound down at the end of the war the desk was shipped to him in Ottawa.

Following RAdm Stephens' retirement from the navy in 1946 the desk remained a treasured furnishing in the office of the chief naval engineer for many years. In 1974 the desk was handed off to DGMEM who, for some reason, offered it to DMEE (Captain Jim Knox, at the time) who gladly accepted it. The desk has more or less remained the property of the Chief Marine Engineer ever since — with one notable exception.

In the late 1970s the desk was commandeered from DMEE by none other than the minister of national defence himself. He had spied the desk one day in passing and expressed the same desire to own the piece as did RAdm Stephens nearly 40 years before. Unlike the good admiral, however, there were limits to the minister's patience and he appropriated the desk forthwith.

Unfortunately for him his joy of ownership was not to be long-lived. To his peril, he had failed to reckon with the resolve of the injured party to reclaim the prize.

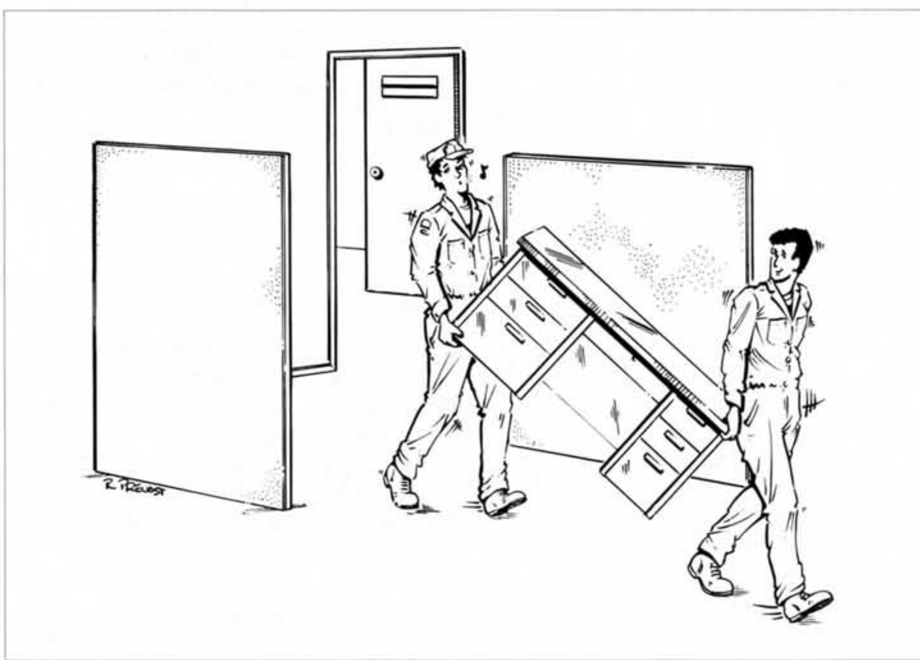
Retribution was swift, even by engineering standards. Not long after the original injustice, on the evening of Mr. ______'s departure as defence minister, four shadowy figures presented themselves to the minister's office staff. Disguised in coveralls, they produced "orders" to remove the desk to the minister's new office. Efficient as ever, the executive staff unwittingly assisted the DMEE removals crew in their task.

And so the desk found its way back to DMEE's office, where it has remained ever since...except for one other brief interlude when Captain(N) Dent Harrison was appointed DMEE in early 1988. He naturally inherited the desk but, unfortunately, desk and director did not see eye to eye (something to do with the height of the desk). It quickly became apparent that one of them would have to go. It was Clash of the Titans II — and the desk got the boot.

The story of the mahogany desk's long association with the Maritime Engineers could have ended right there if it weren't for the resourcefulness of the DMEE section heads. Galvanized into action by the grunts and screams coming from the inner office, they quickly drew straws and fielded a punt returner who recovered the desk on the first bounce. The desk was hauled off to protective custody for the next two and a half years until the present DMEE took up his appointment and reclaimed the desk.

Today, barely a chair's throw away from Parliament Hill, the DMEE desk stands as a timeless beacon of unflagging industry in the halls of Canadian naval engineering. Unsullied by its misadventures and indignities, it proudly symbolizes the spirit, grit and professionalism of the engineering masters it serves. True, it's only a desk — two pedestals, six drawers and a top — but there is no question that this matchless masterpiece of mottled mahogany makes a monumental mockery of its more mundane mates!

Not to put too fine a point on it, this is a desk with a difference — a desk with a heart of oak, gentle reader, which in the true spirit of the navy stands Ready Aye Ready to champion the noble endeavours of the marine engineers who...er, who sit at it. Long may it serve!



News Briefs

Thermal imaging for EHM

At first glance the hand-held camera unit focusing on the fused disconnect switch looks pretty much like an ordinary home video camera. The first clue that it isn't, is the mottled "*negative*" image coming across on the monitor.

What we are looking at is a thermal image — a thermogram. The camera's detector is sensing not the visible light, but the infra-red energy radiating from the switch. The various shades of grey that appear in the thermogram represent the temperatures across the surface being imaged, the darkest areas indicating the coolest sections, the lighter areas the hot spots.

The potential of infra-red technology as an equipment health monitoring (EHM) tool is well known. Thermal imaging — or TI, as it is called — makes it possible to detect everything from loose electrical connections and deteriorated power cables, to problems with tank flow patterns and deficiencies in the refractory linings of ships' boilers — without having to tear everything apart. "It's not just non-destructive," says DMEE project manager **Art Antopolski**, "it's non-*intrusive*!"

And that's just one of the attractions of TI. Its predictive ability means failing components can be identified and repaired (or replaced) *before* the inevitable failure occurs. "We will minimize the number of failures for which we are unprepared," Antopolski said.

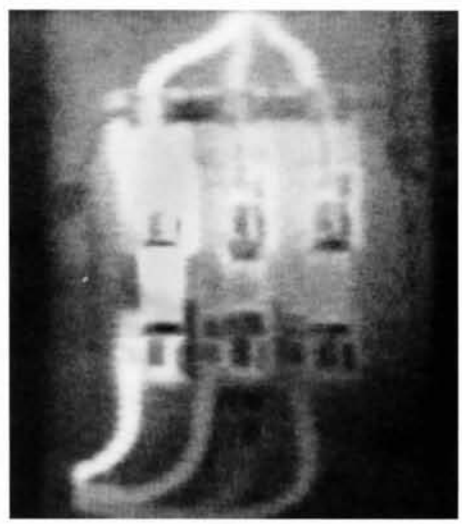
The USN currently includes thermal imaging as part of its fleet maintenance program, and our own navy used it to great advantage in 1990 when HMC ships *Protecteur*, *Athabaskan* and *Terra Nova* were subjected to thermal imaging surveys prior to their departure for the Persian Gulf. An evaluation program is now under way in the Canadian navy to identify specific, fleet-wide applications for thermal imagery in EHM.

The Maritime Engineering and Maintenance division of NDHQ, in conjunction with the Naval Engineering Test Establishment (NETE), is examining the results of test surveys using TI equipment conducted in *Provider* and *Nipigon* in 1991-92. While nothing is conclusive at this point, the immediate plan is to continue testing equipment, techniques and EHM applications.

PHOTO: GEORGE CSUKLY, NETE

The Inframetrics thermal imaging system: note the portability of the system with its hand-held camera and vest-mounted control unit. The Sony 8-mm Video Walkman on top of the control unit allows thermal images to be displayed and recorded.

PHOTO AND IR IMAGE: NETE



The components of this fused disconnect switch appear normal in visible light. However, in the IR thermal image, the whiteness of the cable, fuse and switch on the left reveal an abnormally hot area indicative of a problem in the electrical circuit.

Because of the complexity of the equipment and techniques, it is unlikely that thermal imaging cameras will be issued to ships. As NETE project engineer **David G. Nickson** put it, "It's easy to go and shoot pictures, but it's like any TV program — you need a good director."

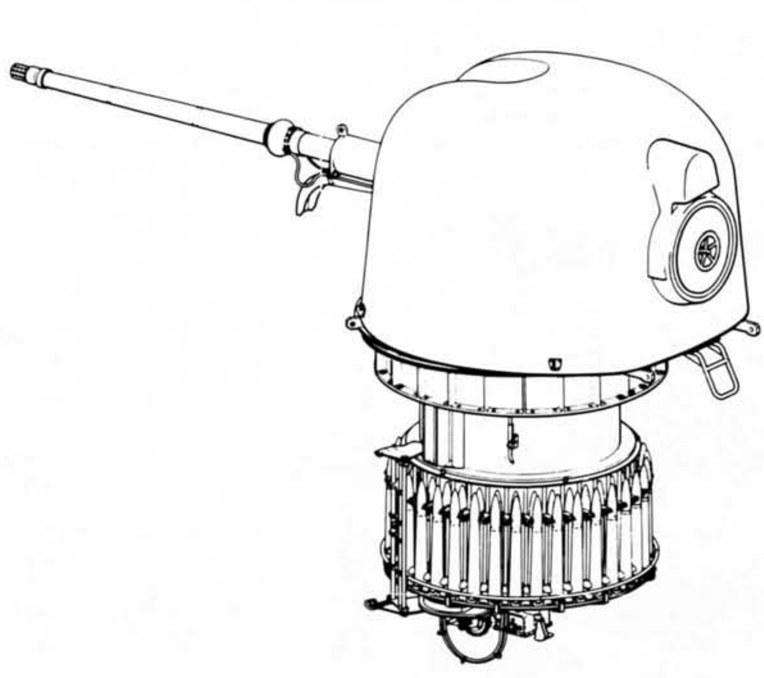
First firing for TRUMP Super Rapid Gun Mounting

In March 1992 Litton Systems Inc. conducted a firing trial of the Oto Melara 76/62 Super Rapid Gun Mounting (SRGM) on board HMCS *Algonquin*. The trial marked the initial Canadian firing of the new medium-calibre gun mount selected to replace the Oto Melara 127/54 (5"/54) in TRUMP ships. The SRGM has a maximum rate of fire of 120 rounds per minute and provides an air-defence capability not available with the 5"/54.

The objective of the trial was to demonstrate gun functioning and the ability of the deck mounting to withstand protracted firing loads. For the trial, two ammunition hoists were operated to transfer ammunition from the ship's magazines to the mount, where 50 rounds were fired at various rates and salvo sizes under the direction of the HSA LIROD (light-weight radar optronic director) fire-control system. During the firings, measurements of muzzle velocity, recoil distance, and training and elevation servo deviations were recorded.

Blast and deflection trials are currently in the planning stages to test the ability of the ship's structure and adjacent equipment to withstand blast loads from the SRGM.

▼



TRUMP Super Rapid Gun Mounting

CPF weapon blast and deflection trials

CPF first-of-class category III weapon blast & deflection trials were conducted on board HMCS *Halifax* during the first half of 1992. Conducted by PMO CPF and DSE 6, the trials were to assess the effects on personnel and ship structures of selected weapon firings. Test firings and trials of the off-board ECM launcher, Phalanx close-in weapon system, Harpoon missile system and gun weapon system were completed. The Mk 48 Seasparrow guided-missile vertical launch system was scheduled to undergo trials in late 1992.

Structural responses to weapon blast were monitored through measurement of acceleration and strain, while transient excitation effects were characterized via temperature, thermal flux and pressure readings. All dynamic signals were captured on programmable digital recorders developed by DSE 6-4. These same recorders, which allow accurate and reliable acquisition of highly transient field events, have been employed successfully during nuclear blast simulations at the White Sands Missile Range. Noise measurement and video recording equipment, including high-speed cameras, completed the trial instrumentation. Photographic and instrumentation support were provided by the Naval Engineering Test Establishment.

Strain gauging HMC ships

DSE 5 is developing a reliability based methodology for designing ship structures in Canadian warships. The approach involves comparing estimated extreme hull girder bending moment to the hull girder ultimate strength. To date, a ship's hull girder bending moment has been determined by static balancing the ship on a trochoidal wave. In an attempt to improve the accuracy of the assumed bending moment, a project to record real-time strain data for a given ship type and operating profile was initiated in late 1988.

The goal of the project is to automatically capture the maximum and minimum strains induced in representative ship sections over a period of at least four years. Measurements are made with precision foil-type strain gauges (*see photo*) that are

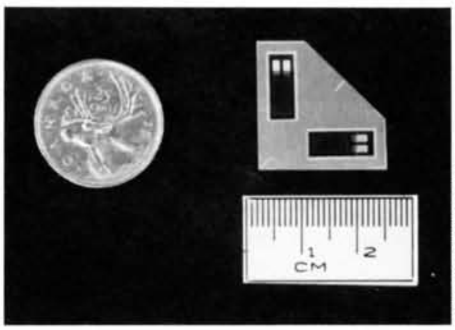


PHOTO: G. CSUKLY, NETE

Small, electrical strain gauges like this one are spot-welded to selected girder web locations to sense structural strain in a ship's hull.

spot-welded directly to selected structural elements of the hull. A stand-alone multi-channel data acquisition system, complete with data reduction software, is used to monitor and capture the output of the strain gauges. Strain data will be correlated with ocean wave conditions and ship's speed and heading.

The first semi-automatic data collection system was installed in HMCS *Nipigon* in the autumn of 1990. A more advanced, almost fully automated system, incorporating a bridge interface to enter wave height and direction parameters directly into the strain recording system, began operation in HMCS *Annapolis* in early 1992. During the next decade as many as 10 warships, including ships of the FFH-330 and DDH-280 classes, will be included in the survey. HMCS *Terra Nova* is scheduled for the next installation of a strain gauge system sometime in 1993.

Order of Military Merit

— Congratulations go out to Capt(N) D.V. Jacobson, shown here receiving his OMM from Governor General Ray Hnatyshyn. ▶

1992 MARE Council

The navy's senior engineer officers met in Ottawa last December for the annual two-day meeting of the Maritime Engineering Council. Under the chairmanship of MARE Branch Adviser **Commodore Robert L. Preston** (DGMEM), the 20-member advisory council discussed major issues affecting the Maritime Engineering classification and NCM technical occupations. ▼

Front (L to R) **— Capt(N) DJ Marshall, Cmdre RL Preston (DGMEM), RAdm MT Saker (ADM EM), Cmdre DG Faulkner, Cmdre D Reilley and Capt(N) TF Brown.**

Centre **— MARS Capt(N) DS MacKay (special invitee), Capt(N) DW Riis, Capt(N) HW Schaumburg, Capt(N) JR Sylvester, Capt(N) RE Chiasson and Capt(N) ID Mack.**

Rear **— Capt(N) PJ Child, Capt(N) DV Jacobson, Capt(N) JR De Blois, Capt(N) B Blattmann, Capt(N) R Westwood and Mr. RA Spittall (DMES).**

(Not present) **— Cmdre FW Gibson, Capt(N) RA Sutherland and Capt(N) SB Embree.**

Revised CSE course introduced

A two-day seminar was held at CFB Greenwood in October to introduce members of the East Coast CSE community to the revised 30-week MARE 44C Combat Systems Engineering Course (CSEC). The new CSEC replaced the CSE Applications Course last month. **LCdr Mike Sullivan**, CSE Training Officer at the Naval Officer Training Centre in Esquimalt, was on hand to bring attendees up to date on pertinent changes introduced by the revised MARE 44A training being conducted on the West Coast. Future ship needs were also presented for discussion by three CPF-qualified CSEOs who were in attendance.

Participants spent a day and a half examining and discussing the various elements of the new CSEC in detail. On completion of the seminar, participants agreed that the new training standard, training plan and individual performance objectives for 44C training were a major step forward in meeting the current and future needs of the MARE Combat Systems community.

Front Row: **LCdr Connor, Cdr Parks (DMES 5), Capt(N) Brown (DCOS EM), Cdr Wilson (CSE Div Cdr) and LCdr Harrison.**

Middle Row: **Lt(N) Hughes, Lt(N) Turpin, Lt(N) Conrad, Lt(N) MacLennan, Lt(N) Verret and Lt(N) Van Nostrand.**

Back Row: **LCdr MacAlpine, Lt(N) Page, LCdr Finn, LCdr Williamson (Chairman), LCdr Sullivan and Lt(N) Topp.**

1992 Central Region EHM Seminar

With economy and efficiency the watchwords for the proceedings, the first-ever equipment health monitoring seminar for life-cycle material managers got under way in Hull, Quebec last September 22. Hosted by DMES 6 (**Cdr Dave Hurl**), the three-day seminar offered an EHM equipment display, as well as a number of short presentations and informal workshops on a variety of EHM techniques.

The seminar/workshop format was markedly different from the formal "meeting-type" EHM conference of previous years. Recognizing the need for involving LCMMs in the EHM loop, two of the workshops were specifically organized to obtain LCMMs' thoughts on EHM responsibilities and a possible EHM feedback system. It was generally agreed that the workshop format was effective and organizers said they plan to run workshop sessions again in 1993.

For the second year in a row, a display featuring the navy's most significant in-service EHM equipment was set up by the Naval Engineering Test Establishment. The display tied in nicely with later presentations and workshops on vibration analysis (VA OPI: **Mike Belcher**, DSE 6) and oil and coolant condition analysis (OCCAP OPI: **Sue Dickout**, DSE 6, with NETE's **Donald Sams**). Also on display were the in-development techniques of shipboard machinery performance testing (SHMaPT) and thermal imaging.

The presentation program was well received by seminar attendees. In addition to the lectures on VA and OCCAP, the program included a presentation on the success achieved by LCMMs in a recent DMEE initiative promoting EHM through reliability centred maintenance (OPI: **Lt(N) Andrew Bellas**, DMEE 7). Guest speaker **Andrew Tait** from the Canadian Coast Guard's fleet technical services section in Ottawa gave participants an interesting, different slant on EHM and fleet maintenance. NETE's EHM Section Head **Fumio Motomura** and his colleagues wrapped up the day's lecture program with a presentation on EHM techniques under development.

New CSE position opened up in NCM career manager shop

A new CSE position has been established in NDHQ's personnel shop for a PCOR/CS Tech subsection head (PCOR 3-4) responsible for NE Techs and NW Techs. Daily career management will still be handled by the section's chief petty officers, but CS Tech career decisions previously made by PCOR/Sea Operations, a MARS officer, will now be handled by a qualified CSE.

Lt(N) Tony Crewe, the position's first incumbent, said the establishment of a CSE career manager's position for CS Techs was one of the recommendations to come from the Naval Electronics Technician Working Group. "With the new NET structural reorganization, they thought it would be best to have a CSE who knew the structure," he said. Crewe, a HOD-qualified CSE, has fleet school experience with core training of QL5 and 6A NE Techs and NW Techs, and has served both as a CSE instructor and an NW Tech training officer.

The current NCM career managers are **CPO1 Vic Herasimenko** (NW Techs), **CPO1 Bill Guiney** (NE Tech MS and above), and **CPO2 Ron Taylor** (NE Tech LS and below).

Index to 1992 Articles

Maritime Engineering Journal Objectives

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

Writer's Guide

The *Journal* welcomes **unclassified** submissions, in English or French, on subjects that meet any of the stated objectives. To avoid duplication of effort and to ensure suitability of subject matter, prospective contributors are strongly advised to contact **the Editor, Maritime Engineering Journal, DMEE, National Defence Headquarters, Ottawa, Ontario, K1A 0K2, Tel.(819) 997-9355**, before submitting material. Final selection of articles for publication is made by the *Journal*'s editorial committee.

As a general rule, article submissions should not exceed 12 double-spaced pages of text. The preferred format is WordPerfect on five-and-a-quarter-inch diskette, accompanied by one copy of the typescript. The author's name, title, address and telephone number should appear on the first page. The last page should contain complete figure captions for all photographs and illustrations accompanying the article. Photos and other artwork should not be incorporated with the typescript, but should be protected and inserted loose in the mailing envelope. A photograph of the author would be appreciated.

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

Yugoslavia — A MARE joins Operation Bolster

Coming up in our next issue