Canadian Naval Contribution to Tactical Data Systems and Data Link Development

While Canadian developments in Variable Depth Sonars (VDS) and the ship/helicopter marriage have been fairly well advertised, the story of the development of Canadian Tactical Data Systems (TDS) has been almost lost with the passage of time. The purpose of this article is to provide an historical background to Canadian Tactical Data Systems and Link Systems, and to demonstrate Canada's early and continuing leadership in the TDS/Data Link world.

At the beginning, it is necessary to underline the difference between a Tactical Data System (TDS) and a Link (such as Link 11 or 14) system. Simply stated, a Tactical Data System is used to receive, process and display information within a single unit. A Link system, such as 11 or 14, is a communications method of exchanging processed tactical data between the TDS's of two or more units. As will be seen, experience has shown both systems to be interdependent. It is of significance to note that, within Canada, the development of Link systems frequently served as the catalyst to promote further interest and development in Tactical Data Systems.

In The Beginning

In the 60's and early 70's, briefings on the need for Tactical Data Systems to solve current Action Information Organization (AIO) problems of maritime warfare usually included a somewhat corney joke at the expense of a famous statement, by an equally famous US Naval hero, to illustrate an important point. It goes, "After the battle between HMS SERAPHIS and USS BONHOMME RICHARD had been raging for some 15 minutes, Captain John Paul Jones staggered topside from his cabin and delivered the immortal statement - 'I have not yet begun to fight.' A marine crouched with musket in the rigging turned to a cutlass carrying sailor on deck and rejoined, 'there's always 10% that doesn't get the word'."

Simply stated, that was the problem facing the Action Information Organization at the close of WW II. The War had demonstrated the requirement for rapid processing and display of tactical information for the Command both at sea and ashore. While American experience in the Pacific emphasized the necessity for high speed data handling in attack carrier warfare, British and Canadian experience in the North Atlantic highlighted the complexities of modern ASW with its demands for decisions based on up-to-date accurate track information and complete picture compilation from all available sources.

The basic AIO problem was saturation - the inability of systems to accept, analyse and correlate target data, assign weapons, and calculate fire control solutions in sufficient time to achieve all objectives. Technical developments produced many solutions to this AIO problem. Servo attachments were added to surface and subsurface plots to speed the tracking of present target positions from sonar and radar indicators. However, this still required manual calculations of course and speed. Servo inputs from visual sights supplied target information directly to fire control equipment and radar assisted auto-tracking fire control systems were introduced to control servo-driven weapons. Plans were developed to place electronic symbols on a radar screen from underwater sensors as an aid to controlling ASW helicopter operations. Other

technicians were devising methods of projecting a real radar picture on the horizontal plots to achieve real time integration of primary and secondary tactical data. Still, time delays were too great and the period from initial target detection to attack from hostile targets was decreasing rapidly. Operations Room plots were tending to become "after-the-fact" displays.

After months of study in 1949, the following solution was recommended: "Radar, sonar and electronic warfare must be integrated on the same plot which must need no human plotters. Radio links have to be integrated into the equipment in such a way that data exchanges are automatic but under human control for orders and addressing. The equipment must not introduce 'cross-talk' among the sources and must be capable of storing tactical data for fairly long periods and must take over as many as possible of the routine tasks of calculating courses and speeds and dead-reckoning of positions. Above all, the delays in the system must be sufficiently short that Command can view the integrated situation as it is happening in 'real time'." Thus, the general prescription for the modern TDS was defined.

During the late 1940's, there occurred a period of concurrent TDS development within Canada, the US and the UK.

The earliest RN/USN TDS models were based upon analogue systems and were designed for fitment in major combatants - aircraft carriers and cruiser/destroyer leaders. The RN initiated two systems in the late 1940's: the Comprehensive Display System (CDS) for AAW; and the Cambria System for ASW applications. The USN began the design of a system called the Electronic Display System. Of particular note is the fact that both the RN and USN systems were based on own-ship inputs only; there were no provisions made for these systems to receive off-board data.

Early Canadian Naval Developments

Two names stand at the forefront of the history of RCN digital development: Mr. Stan Knights, a communications engineer who had been employed with Canadian Marconi; and Lt(L) Jim Belyea (later Cdr) who served on the staff of the Electrical Engineer-in-Chief at Naval Headquarters in Ottawa during the late 1940's and early 1950's. Both men had been experimenting with the combination of digital computation and shipboard plots. They foresaw that these plots would receive raw information from radar, sonar, other sensors, as well as outside units; process and display this information, and transmit the processed information to ships in company, thereby allowing each ship to maintain a similar plot. Digital data processing was preferred, as it would overcome two major problems of analogue systems: the ambiguity that arises at short ranges between targets; and the continuing difficulty of keeping analogue systems tuned so as to minimize this ambiguity problem. Thus, Canadian technicians foresaw from the beginning the requirement for a data system which was based upon digital technology and which would receive off-board inputs (i.e. data link). The application of digital techniques to information displays was to follow two paths:

- a project to design a Tactical Trainer; and
- the development of a Tactical Data Management System.

A contract let to EMI Cossor of Dartmouth, NS, for a digital trainer resulted in the analogue Torpedo and Anti-Submarine Trainer (TAST) of late 1949. It appears the company then had little expertise in digital systems, and therefore produced the trainer as an Electro-Mechanical Analogue System! Further contracts were let in 1950 and 1951 to Computing Devices of Canada (CDC) for a digital Tactical Trainer - to be called the Canadian Radar Action Trainer (CRAT), and to Ferranti Canada for the development of a Tactical Management System - to be called Digital Automatic Training and Remoting (DATAR). At this point, although Mr. Knights and Lt(L) Belyea worked together in developing the applications of these new technologies, their views on how to do so began to drive a wedge between them. While Jim

Belyea remained dedicated to his attack on the basic problem of conventional AIO by building simulators to improve training, Stan Knights, more and more, leaned to the view that what was required was the introduction of more capable and accurate hardware into the Operations Room itself, complete with a capability to automatically exchange information between ships by means of radio. To the extent that they could, they cooperated in the use of a common technological base, but it became inevitable that they should part company to pursue separate paths. They were both right! The successful development of digital naval warfare trainers is a Canadian story of great importance in the development of real time trainers and simulators. However, this is not the story which we shall recount here. The remainder of this article will trace the story of DATAR and its successors.

First Digital TDS/Link Demonstration

The world's first Digital Data Link was demonstrated by Stan Knights in Ottawa in 1950. Utilizing Ferranti (Canada) designed target generating equipment, a Computing Devices of Canada (CDC) Projection Display Unit and HF radio equipment, target positions were digitally generated in Toronto and displayed on an automatic plot at the Canadian Naval Electronic Laboratory (CNEL) in Ottawa. The display unit consisted of a six foot by six foot vertical screen with digital facilities for offset and scale expansion. The HF data circuit itself required a 4 channel teletype and a data transfer rate of 500 binary digits per second. In 1950, this represented the state of the art.

One should bear in mind the technological background of the period. The transistor was not yet commercially available and existing computers consisted of huge numbers of vacuum tubes and carbon core cells. To perform digital computations, Mr. Knights had to design and manufacture his own, "FLIP-FLOPS", "AND GATES", "OR GATES", etc.

The 1950 demonstration failed to impress its foreign observers. Most spectators simply failed to understand the system and grasp its operational usefulness. Both the USN and RN claimed that digital equipment would be too complex for shipborne use and continued with their analogue systems. There is some speculation that the RN actually hoped to sell the CDS system to the Americans. The USAF did show some interest in the Canadian project, but at that time they were involved with the Massachusetts Institute of Technology (MIT) in the development of the Whirlwind 1 digital computer. This computer would undergo two generations of improvement to become the heart of the Semi-Automatic Ground Environment (SAGE) system, a component of the North American Air Defence System.

DATAR

Despite, or perhaps because of, the lack of foreign enthusiasm shown for the 1950 Data Link demonstration, work continued in Canada on the applications of digital technology to shipborne Action Information Systems. By late 1951, DATAR project officers had been appointed - Cdr Dan Hanington as Operational Project Manager, Mr. Stan Knights as Technical Manager, and Lt(L) Mac Davison as overall Administrator. Cdr(L) J.E. Roué joined the staff in the summer of 1953. Dr. Arthur Porter was the Ferranti Chief Project Officer. This Project technically came under the jurisdiction of the Defence Research Board (DRB) which was then responsible for financial estimates, contracts, funding, etc. Overall management for DATAR became the duty of the DATAR Policy Committee (DPC) chaired by the Scientific Advisor to the Chief of Naval Staff - a member of the DRB.

Much early technical support for DATAR came from the Canadian Naval Electrical Laboratory (CNEL) - much to the chagrin of the DRB as CNEL was not a Research Board Facility!

As developed, DATAR relied upon magnetic storage - not on tape, but on Deltamax and Orthonic magnetic drums. Scores of these new drums were designed by the team to support the digital circuitry. As

software was not available during these early years, the DATAR console was hard-wired as an integrated system; sensor inputs, reception, storage and signal processing were all integral functions. As well, UHF TDZ/RDZ transceivers were included to fulfil the Data Link function. From the beginning, navigation was a problem because DECCA receivers were not widely available, and LORAN A was not sufficiently accurate for the link picture. Thus, relating units to a common reference point when out of radar contact with one another was to prove a real headache.

DATAR was submitted to its first field test in the summer of 1953 utilizing the National Research Council facilities in Scarborough, Ontario, and the Bangor Class minesweepers DIGBY and GRANBY "at sea" in Lake Ontario. For these tests, the shore exchange equipment utilized a sonar simulator, a USN multi-target generator, and a specifically designed DATAR display and control console.

The control console displayed data generated in the sonar simulator, various types of target and tracking symbology and regenerated raw data from a Sperry HDWS radar. The radar data was picked off a VK-3 radar repeater by means of an ingenious device known as the "ball tracker" which was developed by Mr. Knights and manufactured by Ferranti. The ball tracker (in use in TDS systems NATO-wide today) consisted of a bowling ball floating on air in a hemispherical cavity with mechanical-optical pick-offs at the cardinal points. Movement of the ball activated perforated discs placed at right angles to the tangent at the four quadrental points and so interrupted a light beam which was then translated by a digital correcter into "X" and "Y" coordinates indicating North/South and East/West movement from the datum. Utilizing the ball tracker, the operator could strobe and "hook" a selected target. By this means, the target could be tracked, or referenced for information; i.e. receive digitized information on range, bearing, course and speed. The system capacity allowed for 64 targets in a tactical area of 80 x 80 miles with a $\pm$ 40 yard resolution.

The shore/ship UHF data link was received via a 3 element discone, omni-directional antennae. Unfortunately, these antennae could not be mounted at the mast-head of the ships and this resulted in significantly reduced operational ranges. At this time the ship made no attempt to input raw data from ships' sensors to the exchange, although log and gyro inputs were accepted to establish a fixed coordinate geographic plot. So, although it was designed for two-way exchange of data, the trial exercised a one-way shore to ship link, inputting targets to the ship system which, when matched with the ship's gyro and log inputs, allowed for the assessment of "rate assisted dead reckoning" - i.e. a test of the accuracy of shipboard plots given the log and gyro inputs into the system.

As to be expected - the DATAR ship-board fit was huge, occupying nearly the entire after-end of each minesweeper. Although Philco was working on a surface barrier transistor at this time, the Company could not promise delivery until 1953. A main element of all DATAR circuitry was the 12AT7 vacuum tube - a large tube used in early television sets. Some 3800 of these tubes were installed in each of the minesweepers. Overheating of the equipment was a distinct problem. There simply wasn't enough power available to provide all the extra ventilation and cooling required!! One engineer even suggested a ninety foot pipe over the ship's side to draw up cold water for cooling the equipment. The DATAR equipment itself has been described as a "power-hungry beast", further increasing the power supply problem.

The demonstrations were organized over an eight week testing period in August and September 1953. Forty observers came each week for a week's duration. The tests consisted of simple, usually single threat, scenarios. They attracted considerable international attention from very senior USN, RN and RCN officers, scientists and politicians, and generated a vast range of responses from its spectators. Some were overjoyed with the successful demonstration of a real time TDS which had proven the absolute requirement for Tactical Data Sys-

tems in future construction. Other observers, reacting as they had after the 1950 demonstration, continued to feel this "mass of electronic junkery" had no place in military operations. By and large, however, the 1953 trials did meet with foreign approval and acclaim - particularly from the USN and RN. They served their purpose well in that they demonstrated that a real time tactical data system was both possible and manageable. They also served to highlight the popular selling points of the DATAR type system: it was small - frigate or destroyer sized; it was digitized, and it possessed a data link which could receive off-board inputs. While these demonstrations did not generate any foreign sales for DATAR, they did have considerable influence on foreign approaches to the TDS problem.

With all its successes, two problems were noted during the 1953 DATAR trials. Due to time constraints placed upon Ferranti prior to the trials, there was little coordination in the engineering and design of the various system components and the engineers involved were given a virtually free-hand in design and construction - so long as the parameters of the parts they produced were compatible with the system!! The other problem concerned sensor accuracy. Although individual sensors might provide target information of an acceptable accuracy, once processed and transmitted the data could gain errors of unacceptable accuracy. It was of critical importance that a single target did not become a multiple, inaccurate and invalid target after processing and transmission.

After the trials and a series of on-site demonstrations during the fall of 1953, the DATAR equipment was moved to Building 97 at RCAF Station Rockcliffe - a location from which it never re-emerged. Although contractor briefings and demonstrations were held during 1954 and 1955 for the next phase of DATAR development, the funds to allow further testing and development were never made available. And so this very Canadian project which had aptly demonstrated its credibility and potential came to a stand still in 1955.

The Lean Years - <u>The Big Shift: Analogue to Digital</u>

The 1954-1958 period marked a significant milestone in Tactical Data Systems/ Data Link Development. From a purely technical point of view it saw the beginning of the shift from analogue to digital systems. Both the UK and the US were convinced that with the development of the semi conductor, digital AIO would become a reality. Without doubt what they saw during the DATAR demonstrations had considerable influence on their thinking regarding the shape of things to come. DATAR was the right idea at an awkward time. During this watershed period vacuum tubes were no longer popular, but transistors and programmable software were still just around the corner. Therefore, further system development would soon require a major redesign. It was only a matter of time - for Canada time <u>and</u> money. This period thus represented something of a hiatus in the progression of Tactical Data Systems development as the UK and US, like Canada, struggled with the problem of whether to "go digital" or not and what form the new systems should take.

In 1954 the UK stopped work on their massive analogue system CDS, as well as project CAMBRIA, and embarked upon the design of a hard wired system employing digital techniques which would become known as Action Data Automation (ADA). This AAW system, which was based on the centralized approach of CDS, could receive information from a variety of internal sources, mainly radar, and then broadcast it via normal communications to ships in company. ADA received approval for fitment in RN aircraft carriers in 1955. It subsequently underwent numerous changes to incorporate the developments of Data Links 14 and 11 later in the 50's and 60's, and was eventually produced in a modified and more general purpose form known as ADAWS for DLG types.

By 1955 the USN had also abandoned work on analogue TDS and was working on the design of a digital system at the Fleet Programming Centre in San Diego. This

Project COSMOS would result in a centralized AAW system known as the Naval Tactical Data System (NTDS) - the backbone of USN tactical data systems ever since. NTDS was designed for USN carriers and DLGs and would incorporate Link 14 and eventually Link 11. It was heavily influenced by DATAR and particularly the technology and foresight contributed by Mr. Stan Knights who, at the commissioning of USS KING (DLG) in 1960, was acknowledged by the USN to be "the father of Naval Tactical Data Systems".

While at this time NTDS was completing shore testing, it would not receive its operational evaluation at sea until 1961. However, the USAF SAGE system, also heavily influenced by DATAR, was nearing completion as early as 1956.

In the latter part of 1956, a design based on DATAR was sketched out for Litton Industries. This was the beginning of the USN Air Tactical Data System (ATDS) an early Airborne Early Warning system fitted in Grumman El Tracer carrier-borne aircraft, some of which may still be in operational use today.

Thus, DATAR did play an important part in the evolution of Tactical Data Systems of the decade. It is interesting to note that in the 1954-1958 period only Canada, through DATAR, was doing anything to help small ships with their AIO/tactical problems, especially in the most difficult area - anti-submarine warfare. It is also ironical to note that during this period while the RN and USN were pursuing development of digital TDS that would be at sea by the end of the decade, Canada was still waffling. The prevailing National Defence/Defence Production departmental attitude towards Canadian naval projects could be summed up by saying; "If the RN or the USN are not sponsoring similar development, there is no need for it to be done. If, however, they are sponsoring such development then there is no need for the RCN to duplicate it". This, in effect, was a Catch 22 situation. Not surprisingly, in 1955 a DATAR System proposed for the DDE 205 St. Laurent Class and HMCS BONAVENTURE was turned down. One story says that around 1952, Mr. Stan Knights obtained a number of new fangled devices called transistors from a friend of his who worked for Bell Laboratories where they were then being developed. From these he built a small digital 1K byte memory computer which, it is said, would have formed the heart of the DATAR system proposed for the St. Laurent Class and BONAVENTURE. Again, in 1958, a DATAR proposal for the second batch of DDEs, the 257 Restigouche Class, was turned down.

So DATAR died as a project. But it left a most valuable legacy for the RCN and Canada:

- it showed that realtime tactical data systems were possible and established the RCN in this field;
- it got Canada quickly into an Automatic Data Processing Information Exchange Program with the USN and RN, a field on which we had never before been consulted;
- it provided an experience in technical developments and applications associated with TDS and data links, many of which were Canadian in origin; and
- it gave birth to the integrated systems approach to TDS based upon the utilization of all internal sources of action information and a data exchange system where each ship so fitted would, at intervals, in turn, broadcast information to all other ships in company via a radio link.

As we shall see, though DATAR itself did not get to sea, it formed the conceptional basis for those Canadian Naval systems which eventually did.

Data Links - The Continuity Factor

One area which did continue to develop on all fronts during the 1954-1958 period was data links. Stan Knights' HF data link demonstration in 1950 and his UHF link used in the DATAR demonstrations had clearly shown that unless a way was found to enable

ships of Canada, the US and UK to automatically exchange tactical data among each other, their respective TDS developments would only succeed in overcoming half of the AIO problem. To do this they needed a radio data link with common features and data structure.

In 1954 a CANUKUS group, known as the Naval Data Transmission Working Group (NDTWG), was formed and work began in earnest on two fronts:

- the design of an intership data link terminal; and
- the design of a standard data link message format.

Stan Knights and Cdr John Roué were regular Canadian representatives at the deliberations of this Working Group, which rotated its meetings among the three capitals. Work proceeded towards establishing the length and composition of a standard information message. Target number, position, course and speed, heights, depths, identity, and numerous other data - were combined and rearranged in an infinite variety of forms - in an effort to achieve unanimous agreement. By 1956 the Kineplex modulation technique was adopted, and it still is the basis for computer to computer links. The definitions of other link specifications followed. Finally, at a meeting held in Ottawa in late November 1957, after two days of intense effort, the proposal was ratified by all members. The link would use a 30 bit message format comprised of data and error detection and correction codes. It was also at this meeting chaired by Cdr(L) Mac Davison, RCN, that the RN proposed a name for the new link - Tactical International Data Exchange or TIDE. Stan Knights later confessed that they agreed on the name of a well known laundry soap as an acronym in order to capitalize on its universal acceptance. This TIDE link was later to become NATO Link 11.

Meanwhile the USN was readying NTDS for sea trials. This system called for a fast HF data link and a teletype one-way link. These were to become NATO Link 11 and 14 respectively. Canada's contribution to data link development was, and would continue to be, important. The TIDE Committee met at frequent intervals over the next 3 years, and the Ottawa agreement of 1957 and individual components of the message structure were modified just as frequently.

In 1959 a CANUS Working Party had produced a study of "Proposed Characteristics of a Small Ship Combat Direction System". Inter alia it set forth the data transmission requirements for inter ship links to improve the overworked and inadequate AIO/CIO facilities of RCN and USN ASW ships. In May 1960, the NATO Naval Steering Group invited Canada to give a presentation of this proposed system as soon as possible. A presentation covering the complete system was given the following month and was enthusiastically received by the nations present. It was decided that discussion of the data transmission requirements should be deferred until the 1961 meeting of NATO's Electronic Data Transmission Working Party (ELDATRAWP). The meeting concluded with a need to define a NATO "Basic Military Requirement for Data Handling Equipment for Small Ships". More will be said about this in the next section.

During the winter of 1960-61, the still incomplete TIDE agreement for an HF automatic Data Link was re-edited into the form of a NATO Standard Agreement (STANAG) for presentation to the NATO Navies through ELDATRAWP. At the ensuing ELDATRAWP meeting, the STANAG was reviewed paragraph by paragraph; necessary editorial changes were incorporated and certain Link terminology current in the old TIDE agreement was changed to conform with the numbering scheme begun in NATO for the Supreme Headquarters Allied Powers Europe (SHAPE) Air Defence Links. Radio links between ships at sea would emerge as:

- Link 11: fast HF automatic link
- Link 12: fast UHF automatic link
- Link 13: slower (cheaper) HF automatic link
- Link 14: slow HF/UHF semi-automatic link

Link numbering for circuits between ships and land terminals, including buffer stations were also specified.

Thus from 1961 on, the work of the TIDE Committee was taken over by ELDATRAWP with participation by many more nations than before. Sub Group 1 of ELDATRAWP was to provide overall national policy input and act as the decision-making body. It had two subordinate working groups: the Link 11 Technical Standards Working Group, and the Message Standards Working Group. During the next 25 years as Military ADP applications within NATO Commands and member nations rapidly expanded so the various Committees, sub-groups and working parties of NATO underwent many changes and iterations. However, the Message Standards Working Group continued to function as before, and still does, though the name has changed to the Military Command and Control Information System Working Group (MCCISWG). It carries forward with it two important principles of 1960:

- universal recognition by NATO of the need for tactical data exchange in Naval Command and Control systems; and

- the need for strictly controlled, standard message formats for such data exchange to work.

In Search of A Vehicle - The San Diego Connection

With the 60's, we began to see the diverse TDS design ideas of the 50's crystalize into a more disciplined systems approach. Large ship AAW systems like NTDS and ADA were now entering service at sea in both the RN and the USN. In the early 60's, attention turned once again to the need for small ship ASW/general purpose systems.

In Canada the close of the 50's saw the RCN at work on the design of DD 270 - the General Purpose Frigate. Associated with this project was a 1960 study for a TDS called Action Data and Control System (ADACS). Also in 1960, renewed interest in hydrofoil and hovercraft development resulted in the formation of a CANUKUS "tripartite" group to study these hull forms.

During 1960, Stan Knights and LCdr Bryan Judd, Data Link Project Officer at Naval Headquarters Ottawa, continued their work towards a Small Ship Combat Direction System which they had begun with the USN during a two month study at the US Naval Electronics Laboratory (NEL) in San Diego in 1959. In 1961 Judd and LCdr (L) Wally Lockwood moved to NEL to work full time towards this "common design" ASW oriented system which would, hopefully, meet the NATO Basic Military Requirement for a data handling system for small ships of destroyer/frigate size. This work continued into mid 1963 when, after much frustration, it was finally scrapped. The main stumbling block had proven to be the fact that the USN and RCN wanted to build bigger and more highly automated ships - Project Seahawk in the case of the US, and the GP Frigate in the case of Canada, neither of which were within the state of the art nor fitted the "small ship system" category. Ironically, both of these projects came to an end the next year - Seahawk petered out, and the GP Frigate was cancelled in 1964 by the Canadian Government.

Software Development and Programming

By this time ADACS had not progressed much beyond the study/definition stage. Little is known about ADACS itself, nor is it certain whether there was to be a data link. Rumour at the time said that while ADACS had received project approval, Link 11 had not. At any rate ADACS did cause the RCN to ponder its philosophy regarding centralized CPU systems approach. It also focused attention on the problems of software development; how and by whom it would be accomplished. In early 1963 three RCN officers: LCdr (TAS) John Belcher; Lieut (Weapons) Mack Whitman and Lieut Doch Macgillivray were posted to the Basic Operational Programming Course at the Naval Training Centre, San Diego, thence for the advanced programming course and on-the-job training at NEL.

Observers in Ottawa and LCdr Judd, the RCN Liaison Officer at NEL, had noted the difficulties the USN were experiencing with NTDS software. The US approach had been to contract out initial software programming to a civilian firm, then use Naval

Officers and senior enlisted men to maintain both the software and the system hardware. In those days, programmers enjoyed few luxuries in the way of today's packaged programs, compilers and assemblers. Those that did exist were basically machine code methods and it wasn't until the early 60's when FORTRAN I, COBAL and CORAL hit the industry that military compilers such as CS-1, JOVIAL and NELIAC were introduced. NTDS program documentation consisted of about 50 volumes - all in object code (machine language) in octal base. It is not surprising that USN programmers had terrible problems understanding and translating NTDS software to a sufficient degree to modify or improve it. This USN method of initial software development was also very costly and for the reasons recounted above it proved necessary to keep a portion of the contractor's staff on at the programming centre for years after delivery.

The RN approach was not much better. They used a team of Naval Officers of various specialties - TAS, gunnery, air direction, communications, etc., known as the Admiralty Rule-Writing Group. Their job was to set forth software specifications for ADA in sufficient detail and clarity to enable contractors' engineers/programmers and RN "boffins", to translate them into operational programs. This turned out to be a most laborious process which involved months of "de-bugging" and reprogramming before desired results could be achieved. Even then, it remained an inflexible method and costly to maintain.

It was with some justification, therefore, that the RCN opted to teach operationally experienced Naval Officers how to write software specifications and program computers rather than attempt to cram civilian programmers with enough knowledge of platforms, weapons, sensors and tactical doctrine to enable them to do a proper job of translating specifications into operational software. As we shall see, this system has worked very well - up to today.

TDS Maintenance

In the summer of 1963, NDHQ also wisely anticipated the need for training digital systems technicians, and posted three RCN Petty Officers; Ralph Knowles, Art Gill and John Lawson to undergo the NTDS Maintenance Course at Mare Island, California. Upon completion of training in 1964, POs Gill and Lawson received OJT at the Fleet Anti-Air Warfare/Fleet Programming Centre in San Diego (across the street from NEL) while PO Knowles went to the East Coast counterpart, FAAWTC/ FPC at Dam Neck, Virginia. These three Petty officers had mixed backgrounds of Electronics Technician and Radar Plotter, and their skills and professionalism drew much praise from the USN. PO Lawson was to leave the service in 1966, but Gill and Knowles continued through the Hydrofoil AIS 240 project, CCS 280 and ADLIPS. Both retired as Chiefs and are still with Director Maritime Combat Systems (DMCS) today. These three were the forerunners of a long line of outstanding systems technicians whose collective skills and knowledge in the development and application of maintenance and diagnostic programs and routines for RCN real time TDS represent a superb contribution over the years.

The Small Ship Combat Data System (SSCDS)

In 1961-62 NTDS went to sea for operational evaluation in USS ORISKANY (CVA) and the DDGs KING and MAHAN. In 1962, the USN had embarked upon a project "to investigate the application of the NTDS systems approach to a general purpose TDS suitable for fitment in small fleet units". This project was named the Small Ship Combat Data System (SSCDS), and was undertaken in the Anti-Submarine Development and Experimental Centre (ASDEC) of NEL. Much of the concept for this system was drawn from the earlier CANUS Small Ship Combat Direction System study in 1959. The development model of SSCDS consisted of: a single Univac USQ20A 64K 30 bit word computer; 6 SYA3 digital radar displays (expandable in number depending upon the ultimate ship type) fulfilling the functions of radar detector; tracker-track management; ship's weapons coordinator, command/ops coordinator, and remote plat-

form coordinator; and would have Links 11 and 14 and, perhaps, a third UHF Link (envisaged as Link 12). SSCDS provided a central processor system with inputs from radar, sonar, EW data and data link sources inputted/outputted through converter "black boxes".

The "stimulus" for these simulated inputs would come from a Support System comprised of a Univac USQ17 32K memory computer and six Hazeltine digital radar displays which would be connected to the SSCDS by a jungle of coaxial cables. SSCDS would also be interfaced with a system called SPADE, which was a digital processor being developed at NEL to filter, detect and track sonar targets handed off by the SQS26/SQQ23 sonar systems. There was also a first generation electronic warfare data processing system called SINEWS, under development.

By 1963, SSCDS system design and software specifications had been completed, and active programming was underway. LCdrs Judd and Lockwood and Stan Knights had been involved in the former of these activities, and by this time Canada and the US had decided to jointly trial the system in a "live" environment. This was to be accomplished by using a three station data link. One of these stations would be a St Laurent Class Conversion (ISL), the second a Fram I USN destroyer, and the third ASDEC itself. Tactical data would be exchanged among the three stations via a simple UHF "round robin" data link. Each station would have one dedicated time slot for transmission and two time slots for receiving. These RX and TX modes would be controlled by a clock. Sound familiar? Actually there was a good deal about SSCDS which was "déjà vu" and, not surprisingly, when one recalls the influence which DATAR had on NTDS - hence the systems approach for SSCDS. The ball tracker, hook and strobing techniques plus many other features were all present (though in updated form) in the SSCDS digital displays. And Data Link 11 was a more developed version of the CANUKUS TIDE Link. SSCDS, son of DATAR, would eventually become the grandfather of CCS 280.

It was to SSCDS that the three RCN programmers applied their newly acquired skills in real time tactical data systems software development. LCdr John Belcher became software project manager; Lt Mack Whitman tackled the tracking algorithms, variable intercepts and other "problem" areas; and Lt Doch Macgillivray undertook data link programs, auxiliary readouts, and the communications mode.

By the time the GP Frigate was cancelled in 1964, SSCDS had entered its "in house" ASDEC testing phase at NEL. By that time is was also known that, for various reasons, SSCDS would not be jointly tested at sea. Thus the "raison d'etre" for RCN programmers being at NEL was rapidly disappearing.

Fortunately the USN, spurred by renewed interest in ASW among the "black shoe" Admirals in the Pentagon, and encouraged by the potential offered by SSCDS's testing, decided to continue development of an ASW system for operational trial at sea. Washington asked Ottawa to leave the three RCN programmers at NEL to head up the software specification and data design development for what was to become Anti-Submarine Warfare Command and Control System (ASWCCS). All was well with the world again! ASWCCS would end up being more of a mini NTDS than a pure ASW System. Its main software development took place during 1965 and 1966. The second batch of RCN programmers, LCdr Bill Marchant and Lt Ian Bouch, played key roles in that development, and in the testing period which followed. ASWCCS went to sea in the ASW carrier, USS WASP, and the destroyers KOELSCH and VOGE in early 1967. Though the program subsequently underwent many changes, it has served as the basis for subsequent ASW oriented TDS in the USN ever since.

It was also in 1964 that the RCN programmers at NEL lent a hand with the definition of the ANEWS Tactical Data System destined for the ORION Maritime Patrol aircraft, which would be developed at the Naval Air Training Centre in Johnsville, Pa. LCdr(P) George Marlowe was the RCN liaison officer for that program.

FHE 400 Action Information System (AIS 240)

The CANUKUS group formed in 1960 had decided that the US and Canada would concentrate their efforts on military hydrofoil design (submerged foil in the case of the US; and surface piercing foil for Canada) and the UK would tackle development of the hovercraft for military purposes.

By 1961, the Canadian design team had begun its work and De Havilland Aircraft of Canada was granted a contract for an engineering and feasibility study of the craft. Model tests and computer simulation together with extensive design study confirmed the craft feasibility and by the spring of 1963 the hydrofoil Operational Equipment Requirement (OER) had received approval and design was contracted to De Havilland.

Concurrently, Naval Staff had studied the requirements for the craft and its weapons systems. These included a report by Cdr(L) Hal Smith (later to be Project Manager) on an automated Action Information System (AIS). In April 1963 the RCN contracted with Canadian Westinghouse Company, Hamilton for a design study leading to the specification of the fighting equipment for FHE 400. CWC would look to its American parent (WEC Baltimore) for help with much of the AIS 240 equipment and software engineering support. It would, however, retain overall contract responsibility including the provision of a Program Generation Centre (PGC) at its Aero-Space and Electronics Division in Hamilton, Ontario.

During the winter and spring of 1964 as the overall fighting equipment plan began to take shape, the RCN programmers at NEL became increasingly involved in discussions with the Contractor regarding both the hardware and software design for AIS 240. By that summer, and for the next year, in addition to their responsibilities with ASW CCS, the RCN officers and Petty Officers formed a mini software project team at NEL to assist Westinghouse engineers and software consultants from both Hamilton and Baltimore in the following areas of AIS design:

- system definition
- specification for an RCN compiler based on NELIAC
- data design of the operational software and its general specification
- design of diagnostic and maintenance software
- simulation software design

As the FHE 400 was to be an ASW vehicle, the principle craft requirements were to have the most effective ASW detection and weapons and to have a centralized AIS (Command and Control System) since the entire ship's crew was to number only 19 Officers and men. The ship system also was to be compatible with other action information systems via data links. To achieve this, the design aims of the AIS were set to:

- be compatible with increased speeds of action of submarine and hydrofoil
- provide remote control of sensors and weapons
- eliminate voice or manual plotting
- keep own ship track and that of consort and 64 other tracks
- be capable of changing scales and off-centering plots

Although the AIS 240 software design approach was to be very similar to that developed for SSCDS the small physical size of the hydrofoil and its unique performance characteristics demanded innovation in all areas of systems design. In a nutshell this mini real-time TDS would consist of a central processor, a rapid access data storage device, and three digital data operator displays. It would receive inputs from radar, sonar, log, gyro and navigation devices. It would input and output Link 11 and output Link 14. Choice of displays came first. As specifications called for input of sonar, as well as radar and descriptive symbology, a CRT type digital

display was required. The Hughes SYA4 was chosen. One of three displays would require modifications to enable selection of either raw radar or raw sonar; otherwise these displays were very similar to those used by SSCDS. They would facilitate the functions of Ship Weapons Coordinator (with radar/sonar detection functions), Command/Operations Coordinator, and Remote Platform Coordinator/Track Management. This allowed the definition of the computer tasks to proceed and the Westinghouse 2402 16K 24 bit word, 4 I/O channel machine was eventually the CPU chosen. Mass storage would be achieved by an IBM 1311 militarized disk file, which could access, locate and read out data quickly enough to satisfy the real-time AIS 240 requirements. Other vital components such as symbol generators, azimuth analogue to digital converters and peripheral equipments were then identified.

A second, support system to be utilized for software generation, simulation and system testing would consist of a rented IBM 360/30 computer, 2311 disk file and peripheral equipments. A single SYA4 Hughes display, CWC computer to computer interface, symbol generator, and a small analogue computer to simulate ship response completed this system.

These two systems - the ship's system, and the support system - were to be housed in separate, adjoining rooms of the PGC at Westinghouse. They were designed to function back to back connected by an array of coaxial cables running between "black box" converters. The 2402 system would play the FHE 400 AIS functioning as it would at sea. The 360/30 system would do the compiling of the software programs for the 2402 and itself. In addition, it would simulate other ships, helicopters, MPA, submarines, torpedoes, missiles, etc., by means of synthetic video which it could control. It would also pose as "other units" for simulation and testing of the data links. The overall system's design and flexibility would enable it to fully test and "de-bug" the operational software for the AIS 240.

If and when it was decided to fit this system in the FHE 400 for operations at sea, it was envisaged that the 360/30 support system would be housed in a van or hut near the hydrofoil jetty, where it would function as a software generation/maintenance system, passing updated programs to the craft via coaxial cable. The other function of this "umbilical" would be to transfer the on-board data "history" files from shipborne AIS 240 to the support system for post mission analysis.

As mentioned earlier this system was weight/space limited - more like the design of an airborne TDS than for a surface unit. The programmers at NEL estimated that the generation of software for the operational program would take 24 man years. They didn't count on the fact that the system definition and choice of computers and other equipments vital to the "design" phase of the software would be slow, and in some cases up to a year late. Other problems cropped up. For example the WEC 2402 was a "first off" computer and the IBM 360/30 was the second delivered in Canada. Both had teething problems. The 2402 was a 24 bit word length/octal coding machine and required the modification of one I/O channel to accommodate Link 11. The IBM 360 computer used hexadecimal coding with a 32 bit word length. This meant that the compiler which was being developed by software experts at WEC Baltimore had to be "bilingual" in order to meet the requirement to run in the 360/30 and translate software written by the programmers in RCN NELIAC into object code for both the 2402 and 360/30 use. This was a very advanced concept and consequently a pioneering effort in software/compiler design. Another software challenge was that created by the first use of a rapid access Disk File. Normally, high priority segments of software had been core resident, i.e. readily accessible in the CPU. However because of the small amount of memory available in the 2402 computer (16K for what would be a 65K operational program plus diagnostic and "red tape" programs), the majority of these programs would be stored on disk and read into a special working area of the computer for execution as required. This led again to "pioneering" in software design to ensure that such critical programs could be lo-

Rear Admiral J.C. O'Brien joyfully accepts
Maritime Command Tactical Data System (MARTADS)
- 4 July 1968

cated, read in, and executed within the rather stringent time limitations imposed by the system.

In the late spring of 1965 the original 3 RCN programmers, plus a USN exchange programmer and Petty Officers Gill and Lawson moved to the PGC in Hamilton. Ralph Knowles (now a CPO) joined the team from Dam Neck and over the next two years the ranks of the staff grew to full compliment with the addition of LCdr Peter VanFleet, Lts Ron Binnie, Jim Bishop and David Gurr; Commissioned Officers John Chute and Vern Schwager; Lt Ian Bouch; and Petty Officers Baines, Snider and Zipfell.

By the spring of 1966 the PGC was in full operation. Cdr Jock Allan had taken over as AIS 240 Project Manager. During the wait for late equipment arrivals a large portion of the software had been "dry" programmed. On opening day of the PGC, while some normal "de-bugging" problems were experienced, most pre-programmed software modules, including the tactical programs and those controlling Links 11 and 14, worked on their first run. The experience and skills developed at NEL had paid off! It was indeed a busy afternoon for Paddy's Pub on King Street.

This software generation had taken only 18 man years! A year later AIS 240 system testing was almost finished and the documentation phase was well in hand. It was during this timeframe that the RCN ran its first computer programming course in Canada - at the PGC in Hamilton - instructed by LCdr Mack Whitman and Lt Bill Herron, USN.

The fire suffered by FHE 400 in 1966 and structural problems with the main foil would delay its expected delivery date to Halifax until 1968. In the fall of 1967, with work virtually completed, it was necessary to decide what to do with the AIS 240. At NDHQ Ottawa design work on the DDH 280 Class had been underway for several years, as well as work on the definition of what would constitute the Restigouche Class mid-life conversion. Both of these projects clearly pointed to the fact that digital systems would be making a major debut in the eight fleet units due to enter or re-enter service in the early 1970's. Thus while the ultimate disposal of AIS 240 would not be known until the government studied FHE 400's forthcoming sea trial results, it seemed prudent, indeed highly desirable, to ship the system to the Maritime Warfare School in Halifax, where it could be utilized as a TDS training and development system. This decision was taken in November 1967, following a late night and very informal discussion in the Hamilton Holiday Inn among Captain(N) Carl Ross (DMCS); Cdr Fred Crickard (Fleet School Halifax); LCdrs Ernie Ball, Doch Macgillivray, Mack Whitman, Cam McIntyre, Frank Costin; and many others.

On 4 July 1968, AIS 240 was renamed Maritime Command Tactical Data System (MARTADS) and formally accepted from CWC by Rear Admiral J.C. O'Brien, Commander Maritime Command. LCdr Jim Bishop was OIC MARTADS supported by a team comprised of LCDR Herm Hanson, LCdr Des Nugent, Lt John Chute, and Petty Officers Baines and Snider. CPO Forsythe was assigned by the Fleet School as Digital Training Coordinator, a function he would carry through to the CCS 280 system in the Combined Support Division in 1970. MARTADS served as a vehicle for software development, for training of tactical programmers and digital system technicians up until the Combined Support Division of the Fleet School was in commission. The 360/30 portion of the system was also used by Operational Research staffs in the Command. As we know, AIS 240 never did get to sea, but it played a vital part in paving the way for the next big step, CCS 280.

Command and Control System 280 (CCS 280)

The DDH 280 and its Command and Control System are contemporary, hence fairly well known. However, there are aspects of its evolution and basic philosophy which, from an historical viewpoint, need to be recorded here.

The DDH 280 was not a follow-on of the General Purpose Frigate. Design for what was to become DDH 280 began in 1964 after the GP Frigate cancellation. Initially

it was intended to be a repeat of the Annapolis Class. In the following years extensive studies into fighting equipment suites, propulsion systems, etc., began to produce a clearer idea of the components that would comprise the DDH 280 Class.

Inter alia, the OER of 1965 called for a ship: whose primary role would be ASW; would be able to defend itself against close range air attack; would be able to destroy lightly armed surface targets; and have a bombardment support capability. This, translated into real terms, called for a DDH type hull and propulsion system; hull mounted and VDS sonars, torpedoes, mortar; surface 5" gun, point defence AA missile system and associated fire control; electronic warfare system, chaff and jammer; communications and data links; a navigation system, and requisite surface and air warning radars. Essentially these divided into three sub-systems: underwater; surface and air; and electronic warfare.

In the TDS area the operational requirement stated that "the ship was to have a command and control system adequate to provide for data exchange". As we shall see, this simplistic requirement was eventually defined as a total Command and Control System. However the interesting point about this statement of requirement is that throughout the evolution of Canadian Tactical Data Systems, while to the "workers" the importance of the data exchange facility to a complete TDS was obvious, it was certainly not fully understood by senior decision makers. In Canada, preoccupation with the DATAR application to AIO problems had left development of data exchange to international groups such as TIDE. Hence, while projects always called for a TDS, the data exchange requirement was often vague. ADACS was a case in point. Happily for CCS 280, the reverse was true.

The Combat System (CCS 280) philosophy in the overall DDH 280 design was that of a central Command and Control System interfacing with autonomous weapons and ship control sub-systems. If the CCS 280 became unserviceable the sub-systems could operate, albeit on a less effective basis, though external data exchange via data link would not be possible. If a subsystem were to fail, CCS 280 and other subsystems would be essentially unaffected, except for the loss of the casualty subsystem. In this sense CCS 280 would be a "modular", rather than a totally integrated, system. CCS 280 was also intended to be a "two echelon" system - to satisfy the normal C^3 requirements of a single ship, as well as those of an embarked Officer in Tactical Command (OTC) or Group Commander.

This new approach would provide an element of redundancy and, at the same time, facilitate "graceful degradation", a popular concept in NATO circles, if the System suffered action damage or other forms of failure. While this overall modular philosophy represented a major departure from the Canadian approach to TDS design, in practical terms the function of the CCS itself and the content of its operational software would not be all that different than AIS 240 or SSCDS. "Interfacing" the control and sub-systems would prove another matter.

Contract for design and execution of the CCS 280 was awarded to Litton Systems (Canada) in September 1966. Selection of hardware which would comprise the system included: the Litton L304F 40K-80K 32 bit word central processor; a multi functional digital Situation Display Console (SDC) - designed to the RCN's specifications and to be produced by Litton's plant in Rexdale, Ontario; a high speed magnetic tape drive, and the accompanying high speed printers, I/O devices, converters, symbol generators, etc. Litton would also be responsible for providing the assembler/compiler (RCN NELIAC), diagnostic software, and "red tape" software such as math library, CCS interface software for other systems, etc., and a Program Generation Centre for the development, testing and evaluation of the operational software. The work on the latter was begun in early 1967 at the Litton, Woodward Ave location in Ottawa. Computer Center Manager was to be LCdr - now Mr. - John Belcher.

NDHQ Ottawa was a mighty busy place

in late 1967. Among other things, it was going through the labour pains of Unification and the endless reorganization that entailed. Individuals and whole Directorates changed offices, even buildings, frequently and with lightning speed. The Navy was currently in the final stages of the FHE 400 program; and was juggling two new construction Projects - 4 DDH 280s, and the 2 Protecteur Class AORs - and the mid-life conversion of 4 Restigouche Class (IRE). Hence there were many Project Offices in being at the time. LCdr Ernie Ball and his colleagues in DMCS were winding up their part in AIS 240 and looking for new challenges. They had been joined by other refugees from the Project, among them, Cdr Jock Allan and LCdr Mack Whitman. The former became head of the section responsible for CCS 280 - DMCS (Action Information); the latter became head of a new Software Section (DMCS-8). Stan Knights would work with both on the hardware and software specifications for CCS 280.

One of the thorniest problems that emerged at this time was the realization that a total Systems Definition, describing how CCS 280 and the other sub-systems were to work together, was lacking. The Underwater Combat System (UCS 280) - led by Cdr Denny Pratt - had been under definition for some time; the Surface and Air Warfare System (SAWS) - led by Cdrs Frank Boyle/ Ron Capern - had been decided upon; and the Electronic Warfare System (EWIS 280) - led by Cdrs Lorne Manogue/ Harry Palmer - was being assembled. The problem lay in the fact that there was no overall blueprint for how control of these systems by the Command would be accomplished.

The means to that solution lay in one of the many studies done in the 1964-65 period. This one, known as Design Study #14, was a complete study of the complex inter-relationships of all the weapon/sensor/ communication/and other internal and external sub-systems functioning within a "model" Command and Control System, including the Command function itself. The work was painstakingly accomplished by a team comprised of such names as LCdr(L) Art Baxter, LCdr(TAS) Dan Mainguy, LCdr (G) Wilf Stebbings, LCdr Peter Traves, LCdr (L) Wally Lockwood, LCdr(C) Russ Wilcox, LCdr(L) Larry Wilkins (later PSE 280), and LCdr(D) Howie Markle. It used a system of operational sequence diagrams (OSDs) to trace the functional inter-relationships and identify the positions and associated roles and duties of all personnel in the system.

Engineers and "operators" alike on 280 Project Staffs at NDHQ used Design Study #14 extensively. From it, they gained a first hand insight as to how the various parts of the CCS 280 system would inter-relate. In late 1965 it was used as a basis for briefings to the Director of Naval Fighting Equipment Requirements, Captain Peter Cayley and his staff, on the software architecture envisaged for CCS 280 by the RCN programmers at Westinghouse. It was used again by LCdrs Ernie Ball and Neil Barrett, Mr. Keefie and Stan Knights of DMCS-AI between 1967 and 1970 to set up a "role acting" OSD process for defining the interface requirements between CCS 280 and the three major weapon/sensor sub-systems. This, in turn, facilitated another set of tests where a simulator for each sub-system was used with CCS 280 to see if the correct interface I/O would work. The reverse process was then carried out in the contractor's plants by using a CCS 280 simulator with each sub-system. Again Stan Knights was very much involved, in many cases showing the companies how to do the actual design. The lesson learned from all of this was - never again should an overall system design come after the fact.

By the winter of 1967/68, LCdr Mack Whitman (DMCS 8) and his band of AIS 240 ex-patriots had the software specifications for CCS 280 well in hand. This group included LCdrs Ron Binnie, Hugh Ellis and Peter VanFleet; Lt David Gurr; and CPOs Knowles and Gill. That July, they took up residence at the PGC on Woodward Ave. Upon its official opening in September, Mack Whitman became the OIC PGC 280, and Ron Binnie the Senior Programmer. They were shortly joined by LCdrs Bob George, Kerry Burgess and Des Nugent; and

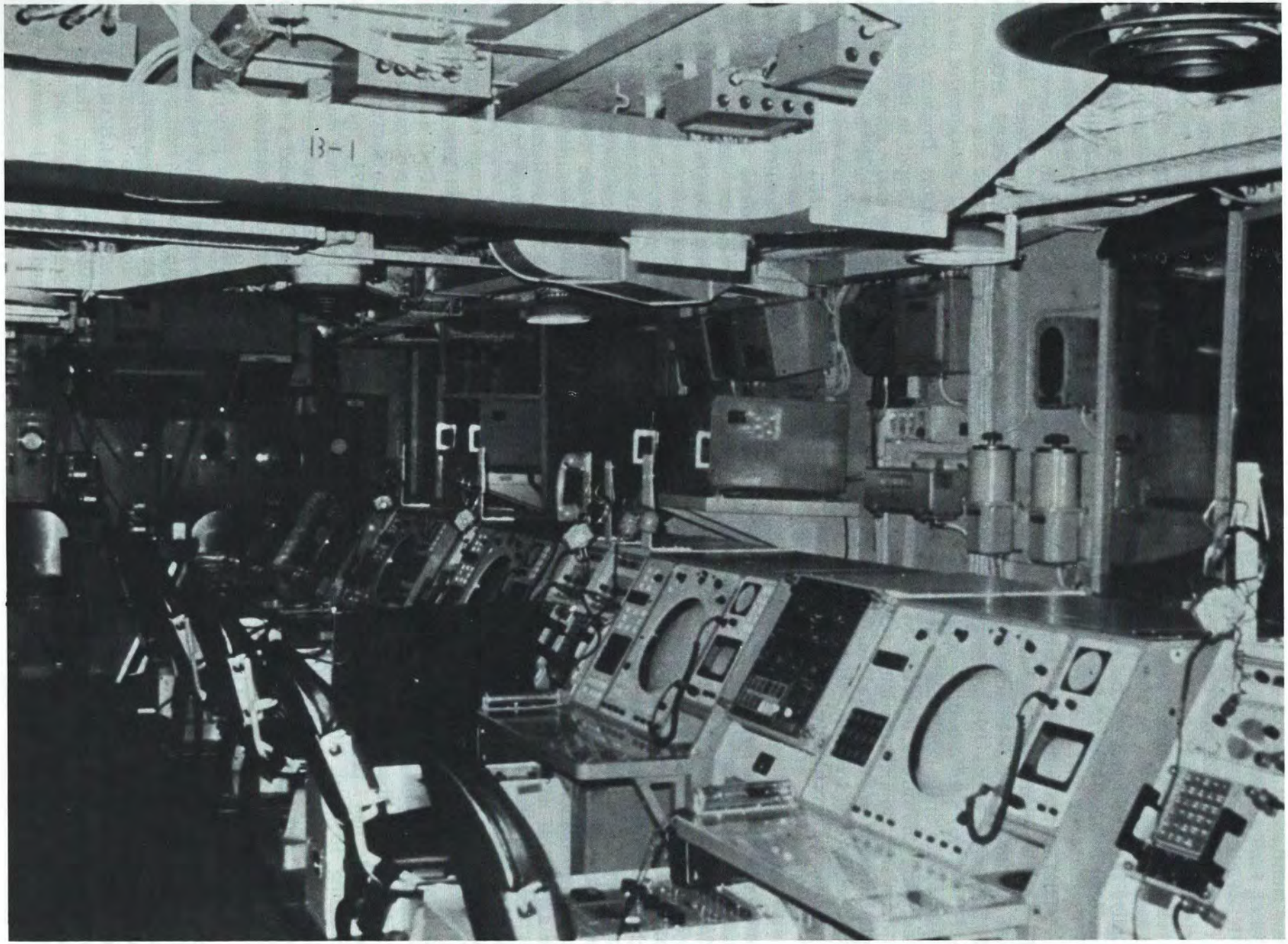
Lts Rolly Burton and Earl MacLaughlin. LCdr Neil Barrett and Lt Bob Mustard were assigned special technical responsibilities with the PGC and liaison duties with the Contractor.

The new PGC was a spacious facility, well designed for the task at hand. Like its predecessor in Hamilton, the System was designed for the generation of operational and diagnostic programs and their testing and evaluation. Again the "back to back" approach was used with one complete system representing the operational system and components of another system acting in support to provide compiling/assembling functions, simulation and testing. It was, however, a much less complicated system than the one at Westinghouse, and all of the components of both systems were either destined for eventual service in a DDH 280 or the Combined Support Division Halifax.

By fall 1968, Cdr Ernie Ball had taken over DMCS 7 from Jock Allan, who went west to command HMCS QU'APPELLE. Cdr Doch Macgillivray had returned from sea command to take charge of the new Command and Control Section (DERMS-5) at NDHQ. The "roll over" process from project to project was applying itself to the human resources as well as hardware and software aspects of CCS 280!

The Data Link side of CCS 280 had been addressed by the OER requirement for NATO Links 11 and 14. Over the years, Canada had been very active in the NATO Message Standards Working Group since its formation in 1960. Stan Knights had, of course, kept a keen eye on the technical side of developments, and never lost interest in his pet area - the error detection and correction feature of Link 11. On the Message Standards side, Canada had made excellent progress during the AIS 240 development period (1965-68), getting ASW messages defined to our satisfaction - as well as Special Points such as lines and other symbols associated with ASW probability areas, search patterns, etc. With our Navy's first TDS due to go to sea in the early 70's, it was important to Canada that the NATO Message Standards STANAG be agreed to by all participating nations. These now comprised Canada, Denmark, Federal Republic of Germany, France, Italy, Netherlands, Norway, UK and USA. Canada's first order of priority was to work in the NATO forum to get the Link 11 STANAG ratified, and the Link operating in as many NATO Navies as possible. This would benefit Canada in two ways: it would support the way we were going with DDH 280, and would guarantee that we would be able to continue going with that Link in future systems - i.e. the Argus Replacement and Ship Replacement Programs. To change at this point would be impossibly costly. Two problems were looming on the horizon: a US study into national interoperability among their Army, Air Force, Marine Corps and Navy systems, which was delaying final ratification on their part; and a move by the UK and Netherlands towards a different, more simple data link known then as Link XRay (now Link 10) which threatened to drive a wedge into the Link 11 community. Canada fought almost single handedly against the latter up to 1970 - and lost. However, in the end, we were proven right. Both the UK and NL eventually returned to the Link 11 camp.

In 1968, a Fleet Operations Study identified the problems of tactical communications and data plotting for operations between ships of the DDH 280 Class and other ships of the Fleet not fitted with a TDS/Link. This problem had been gnawing at the back of Canadian C^3 systems developers' minds for some time. Link 14 was originally designed to fulfil this type of requirement but, from the beginning, it was only useful in large ocean area applications and AAW environments - not close ASW work. Going to a simple system like that proposed by the RN and Netherlands was a solution, but it posed a Link problem. Link 11 was very expensive, too expensive for a simple system. Going to a cheaper Link meant a change in modem design, and so the loss of interoperability with Link 11 achieved thus far within NATO and Nationally in our own DDH 280 Class. 1970 brought the solution. The Collins Radio Corporation franchise on the Link 11 terminal equipment expired, and within



DDH 280 – Ops Room

a few months half a dozen competitors were offering Link 11 for half the price. In 1971, an NDHQ Research and Development project was initiated for the design and development of an automated Data Link plotting system for ships not fitted with a TDS. This eventually resulted in ADLIPS. Thus, happily, it turned out to be practical and affordable to have Link 11 and a mini-TDS.

Whilst on the subject of Data Links - in 1969 the Operational Equipment Requirement for the Argus Replacement Program got underway. The Naval Requirements Staff (DERMS) was asked by Maritime Air Requirements Staff (DERMA) to lend a hand in defining the areas devoted to Tactical Systems and Communications. Compelling arguments for an interoperable, integrated TDS complete with Data Links 11 and 14 were made and eventually accepted.

By 1969, colateral development of the Underwater Combat Systems and Electronic Warfare Information Systems was well underway for both DDH 280 and the IRE projects. Money had been allocated for a Training Centre in Halifax for the new IRE Fighting Equipments. This work was spearheaded by LCdr Rene LaRoche at Halifax and LCdr Cam McIntyre in Ottawa. Through good luck, good management and a fair amount of mutual back scratching, the two Projects struck a deal to pool their resources and produce a Combined Support Division to meet both the training needs and software maintenance requirements of the two Classes. This farsighted solution had far reaching implications for the successful introduction of these new systems to the fleet, and has proven instrumental in continuing to bowl out systems problems, such as those mentioned earlier concerning interfaces and overall systems definition and design.

In the spring of 1970, software specifications for CCS 280 were frozen by DERMS-5. By July that year the addition of Lts John Anderson, Dale Gibb and Ray Steele to the staff at PGC, Ottawa, brought the programming effort for CCS 280 to full strength. Testing of the operational software began that winter and was to continue up until mid-1972.

In November 1970, IROQUOIS and ATHABASKAN were launched at Marine Industries and Davies Shipyards respectively, and commenced fitting-out. The plan called for the fighting equipments - including CCS 280 - to be installed in each of the four ships at an appropriate time before the ships steamed to Halifax. In the case of CCS 280, the equipments would go to the shipyards via the PGC Ottawa, where they would be tested in situ with the operational and diagnostic software. These systems would not be set-to-work until after the ships arrived in Halifax.

The Combined Support Division (CSD) at the Naval Armament Depot in Dartmouth had been rapidly taking shape since 1969. It would provide training and maintenance support for all digital sub-systems associated with the DDH 280 fighting equipment package. In the case of the CCS 280, in addition to training facilities for systems operators and maintainers, it would offer training for programmers, and provide the Program Generation Centre [PGC(H)] to keep the operational software package up-to-date in future years. These functions would be accomplished in classrooms and in a CCS 280 equipment room where a full ship set of CCS 280 hardware would provide hands-on operator and maintainer training and also act as the "Operational System" in a back-to-back arrangement similar to the PGC in Ottawa.

In July 1970, the first ship set of CCS 280 hardware arrived at CSD accompanied by some of the naval maintainers from PGC(O), and several contractors' representatives. On 7 May 1971, the CSD was officially opened. Later that summer the majority of the Naval programmers moved from PGC(O) to the CSD, and a few months later, PGC(H) was in full operation.

On 29 July 1972, HMCS IROQUOIS, the first-of-class, was named and commissioned at Marine Industries, Sorel, Her Excellency Norah Michener acting as Sponsor. ATHABASKAN would follow two months later, HURON in December and ALGONQUIN in November the following year. During the fall of 1972, CCS 280 was fully set to work in IROQUOIS and Link 11 testing was

commenced with the CSD. In February 1973 ATHABASKAN, during passage south for sea trials in the Caribbean, maintained a firm link with the CSD and IROQUOIS (alongside in Halifax) until she was well south of Bermuda. In September of that year IROQUOIS, while enroute to Norfolk, Va, following systems trials in Puerto Rico and Charleston, S.C. areas, established a Link 11 net with the USS AMERICA. Within minutes they were joined by a DLG alongside in Norfolk, a P3 Orion, and an E2B Hawkeye airborne in the vicinity. This constituted the first Canadian participation in an international Link 11 exchange at sea.

Epilogue

Thus, what began in 1949 as a prescription for a modern TDS to solve the AIO problems of the day had, for the Canadian Navy, finally come to pass. It took four iterations between DATAR and CCS 280 to reach fruition. At the time of its entry into operational service, CCS 280 represented the state-of-the-art in system design, hardware and software among Western Navies. It had the benefits of a rich heritage derived from 33 years worth of accumulated ingenuity, imagination, perseverence, and the plain ordinary sweat of a multitude of persons, naval and civilian. CCS 280 is, itself, 20 years old now and, by present day system standards, due for updating. Thus, while this particular story has ended, it is by no means the end of the story. The research and development for more technically efficient, new ways to do these things is a continuous process. As one system is being developed, another is being designed, while yet another is being born in concept.

Two common threads have strung together the events of our story of Canadian contributions to Tactical Data Systems and Data Links. One of these was the Data Link itself. Whenever a hiatus appeared in TDS development, somehow the work on data exchange managed to survive and continue over the years, finally bringing TDS development along with it. The second thread, or continuity factor, was the "Father of the Data Link", and many other elements of TDS, the late Stanley Frederick Knights.

Stan's foresight and tenacity were present at every twist and turn of this story. He was, in truth, the guru of his profession and he had the unbelievable flexibility and adaptability to be able to harmonize the essence of what he foresaw with the times and the environment. As one naval colleague stated, "it is regrettable (for the Navy) that Stan Knights was so far ahead of his time that he was constantly fighting against those who could not see the nose on their face." On 7 May 1971, during the official opening of the Combined Support Division, a plate made available by Litton Systems (Canada) Limited, was presented by Commodore(E) Bill Christie, RCN, for permanent mounting in the CSD, to honour the contributions and services of this remarkable man. It reads:

On the occasion of the official acceptance of
the Command and Control Equipment fitted in this
DDH 280 Operations Room in the Combined Support Division,
this plaque is fixed in honour of,
STANLEY FREDERICK KNIGHTS, Professional Engineer
His pioneering genius, foresight, dedication and determination
devoted over twenty years to the development and application of digital technology in
the field of Command and Control Systems for Her Majesty's Canadian Ships, is a
lasting inspiration to his military and civilian associates, national and international.

This article was written and researched by Capt(N) D.N. Macgillivray, the Commandant of CFMWS, and Lt(N) G. Switzer, a Staff Officer at CFMWS. Contributors included:

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