The Canadian Development of VDS

As successful export markets reveal, Canada has established itself as an expert in Variable Depth Sonar (VDS) towed systems. However, aside from training manuals and evaluation reports, there is no historical documentation of this major Canadian ASW development. The recollections of sailors and scientists associated with the system provide us with a rare insight into development that began with research by HMCS NEW LISKEARD in November 1947.

The Problem

The history of the Battle of the Atlantic testified that some factor was seriously affecting the Asdic efficiency of RCN ships operating in Eastern Canadian waters. In 1944, some 22 ships were sunk in the Gulf of St. Lawrence, despite the presence of convoy escort vessels. In one case, the submarine's periscope was sighted, but no Asdic contact could be made. A preliminary bathythermograph (temperature vs depth) survey of the Gulf of St. Lawrence waters disclosed a strong negative temperature gradient under a shallow isothermal (equal temperature) layer at the surface. Sound ray plots showed that this gradient refracted the sound beam so greatly that submarines below it were detectable only at very short ranges by a hull mounted Asdic. Later surveys showed that this gradient extended for eight months of the year over the entire Atlantic seaboard area covered by the Labrador Current and into the Gulf of St. Lawrence.

It was evident that, if submarines below this strong gradient were to be detected at A/S operational ranges, it would be necessary to place the Asdic devices below the gradient.

First Steps

Naval Research Establishment (NRE) conducted trials, correlating water conditions and sonar ranges, using the hull mounted Asdic Type 144 of HMCS NEW LISKEARD. The first of these trials took place in the Grand Manan Channel in November 1947 utilizing HMCS HAIDA, HM Submarine ARTEMIS and a six foot steel triplane as targets. A major program of trials took place in St. Margaret's Bay from 5 July to mid-October 1948 using HMCS NEW LISKEARD, under the command of LCdr Ian Morrow, and HMC Diving Tender No. 1 (DT. 1). The after cabin of the diving tender was fitted with sound measuring and recording equipment. Much of the equipment was designed and built by Bill Dingle and Oscar Sandoz of NRE.

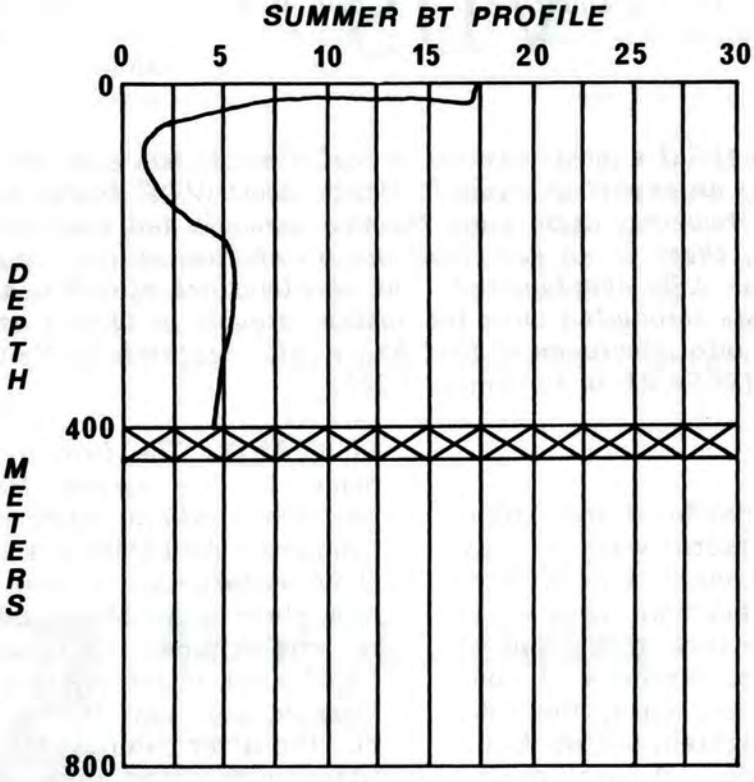
Commodore Morrow recalls these events of 1948:

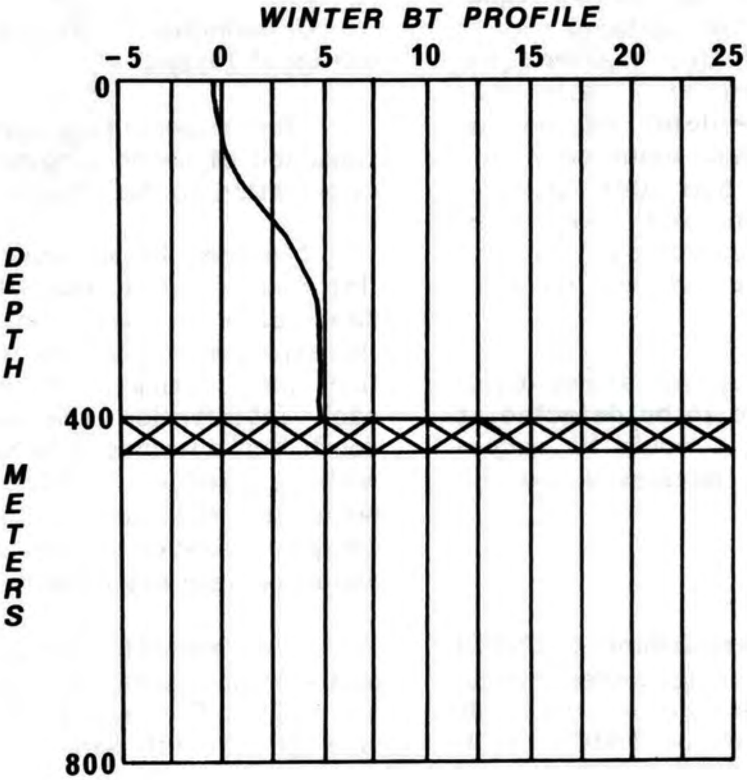
"The experiments carried out onboard consisted of sound ranging and collection of information on the effects of ambient noise.

"An area in St. Margaret's Bay, with a flat sandy bottom and relatively consistent depth of water, was chosen as the site for the experiments. A grid was developed with lines intersecting at 50 yard intervals. At each intersection the ship recorded the depth and obtained a sample of the bottom with a bottom grab. This tedious but necessary work took a number of weeks to complete, because calm weather and good visibility were essential to achieving success.

"The research equipment consisted of a mini-portable sonar set designed and built in the NRE. The transducer was roughly the size of a thumb nail. It was fitted to the

ENVIRONMENTAL PROFILE DATA
GULF OF ST LAWRENCE





end of a waterproof cable which could be lowered and raised by hand.

"Ranging experiments were carried out using USS DOGFISH (Fleet Class submarine) hovering at pre-arranged depths, with a considerable amount of time at periscope depth. NEW LISKEARD was required to approach at very slow speed with the transducer positioned over the bow, to a point 100 yards on the beam of DOGFISH and then back off again for another run. The COs of both units had the con continuously during the trials which were conducted over a period of ten days. To ensure safety during each approach to DOGFISH at periscope depth, NEW LISKEARD's starboard engine was not used, but reserved for full speed astern. As an added precaution the ERA Of The Watch was instructed in writing that regardless of what order he received on the Starboard telegraph, other than Stop, the engine was to be put full speed astern. A telephone line was also kept open between the ERA Of The Watch and the Second Officer Of The Watch.

"These somewhat nerve wracking manoeuvres kept all hands alert for hours on end. Eventually, it was necessary to reduce to 30 yards the distance between the transducer and DOGFISH . Fifty runs were made against her, and sonar ranges were short, 200-300 yards."

Commodore Morrow continues: "The next requirement was to measure the effect of ambient noise. Two vessels were needed for this phase; one stationary and the other floating free but able to move silently, at controlled speed away from and towards the stationary consort. The success of the phase depended on the elimination of noise emanating from either vessel.

"On each suitable day NEW LISKEARD was secured by the stern to a mooring buoy provided by HMC Dockyard and reverted to 'silent operation' which included shutting down all machinery that could be safely eliminated and stopping work which would create noise. In order to provide a silent yet a manoeuvrable platform, Diving Tender No. 1 (DT 1) was rigged with five whaler sails. DT 1 could then be sailed downwind at a constant speed (with Lt Charles Bourque or Lt Bill Rickley in charge) controlled from the bow of NEW LISKEARD by a mile long two inch grass rope manned by the duty watch. When she had completed the 'run out' she was then retrieved at a constant speed, by hand with the rope.

"Both NEW LISKEARD and DT 1 were fitted with transducers and measuring equipment which proved successful. The equipment was manned by personnel from the Naval Research Establishment, who were responsible for the scientific aspects of the task.

"Weather was the governing factor throughout the task. Nothing could be accomplished if the visibility was limited or if the wind was too strong. Calm days during the ambient noise measurement phase were non-productive. External noise from the boats of curious fishermen or aircraft piloted by naval aviators testing their close-in skills caused considerable rage and indignation and, of course, loss of precious time. Frustration caused by equipment malfunction or theories found wanting in practice placed a considerable strain on the NRE scientific staff who were faced with the extreme urgency of the entire project. However, success was achieved. It was most gratifying to see the first VDS 'A' frame fitted to NEW LISKEARD during her next refit and conversion.

"It is unfortunate that the Fleet did not benefit operationally until over ten years later," Commodore Morrow notes.

The Aim

These findings were reported to the RCN and in April 1949 a staff project for a towed variable depth Asdic was laid down by the Defence Research Board. NRE was given the responsibililty for research and development in meeting this requirement. Work on this new equipment became known as Project DUNKER.

NEW LISKEARD

DT–I

Project DUNKER

In December 1948, at a Defence Research Board symposium, John Longard of NRE noted that, in summer, much of the water on the Scotian Shelf was found to be in three layers: a warm surface layer, a cold intermediate layer and a warmer bottom layer. It was postulated that "the cold intermediate layer between two warm layers would form a sound channel. An Asdic dome, which could be lowered to this depth from a ship or carried there by a submarine, might have good ranges on a target in this layer."

At the suggestion of LCdr Bob Welland, a Harbour Defence Asdic capsule was fitted with a bridle and 300 feet of connecting electrical cable for lowering from a stopped ship. It was known as the HOT DOG and had a transducer of the same type and frequency as the hull mounted unit in HMCS NEW LISKEARD, so the two could be operated interchangeably. When lowered over the stern, a line running from the unit to the bow kept it on the same heading as the ship.

The trials, carried out on 7 and 8 September 1949 showed the possibility of achieving unusually long ranges with standard Asdic gear by lowering the transducer to the vertex of a sound channel. While maximum ranges (9400 yards) occurred as expected with transducer and target (HMS TALLY-HO) at the vertex, the movement of both to the upper limit of the sound channel reduced the detection range to 4200 yards, with intermediate ranges as target or transducer approached the vertex.

Other trials followed on the Scotian Shelf. It was shown that a submarine at sound channel depth, whose echo was firmly held on the HOT DOG, was undetectable by the hull mounted system. This, of course, caused serious concern.

In October 1952, the RCN requested top priority for the project. A Project DUNKER team, drawn from the Engineering and Underwater Physics Group, was formed.

Towing Development

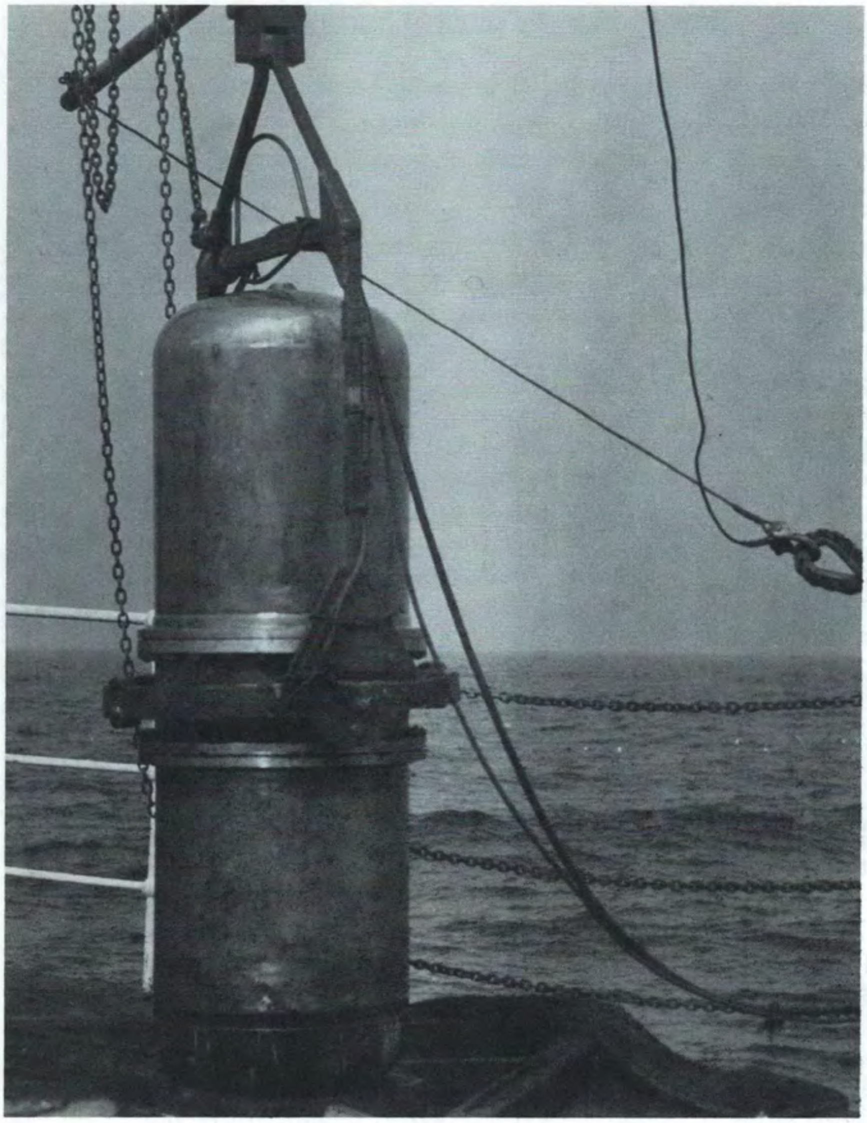
The first objectives were to construct a dummy body of the approximate weight and dimensions envisioned for an operational unit, which would be stable under towing speeds of 15 to 20 knots, and to determine the type of tow cable required. A suitable body took about six years to develop, and tow cables still present problems.

A study of the theory and practice of towing bodies in water was initiated. Experimental work was begun in October 1949 under the direction of Captain A.F. Peers on the construction of a mock-up body known as TOBY. The body chosen was an ordinary torpedo with shortened centre section and enlarged fins, to which the tow cable was attached by means of a pivoted towing arm. Towing trials in January 1950 gave rough measurements of towing tension, depth and pitch of the body. Essentially these trials confirmed the theory that for practical lengths of tow cable, the towing depths of the body were much less than desired.

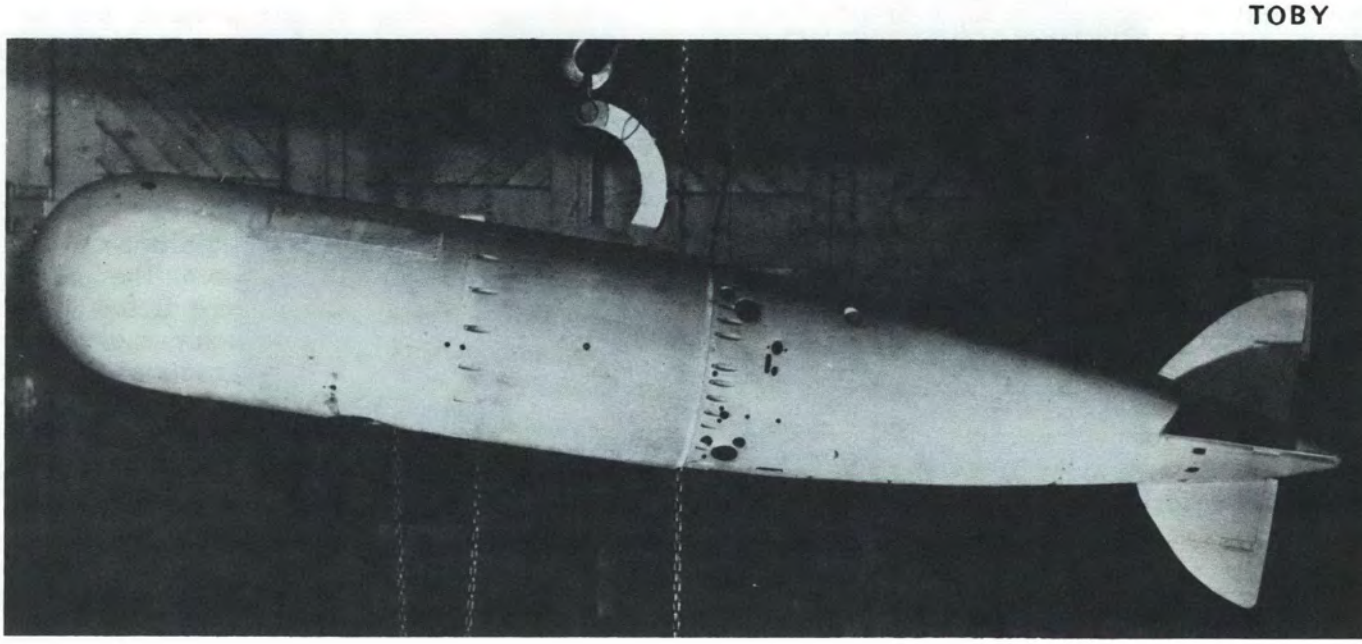
The preliminary towing trials made apparent the need for the procurement of faired cable and of a towed body better adapted than TOBY to the housing of a transducer and recording instruments. Also, the need for better shipboard equipment for handling towed bodies and determining towing characteristics was indicated.

The next stage in the project was to test various towed bodies. The first TOBY was lost at sea, so a second torpedo body, TOBY II, was built and fitted with an aluminum nose to house a fixed Type 144 Asdic transducer. As an interim measure, two WHATS (Winged Housed Air Towed Sonar) bodies, developed for US blimp-towed systems, were purchased from the EDO Corporation in 1950. They were fitted with stub wings, as depressors to achieve greater depths, and an untrainable transducer in the nose. To measure towing characteristics of cables, an Oropesa Float, normally used for minesweeping, was ballasted to represent both the TOBY II and the WHATS bodies.

HOTDOG



TOBY



The WHATS bodies showed that hydrodynamic depressing was unsuitable for ship towing because the light weight of the body could not compensate for ship's pitching. A mathematical study which followed indicated that ballast had advantages over wings at speeds under 20 knots.

NRE itself then entered the business of designing bodies, chiefly under the direction of Captain Peers. A contract was let to Fairey Aviation to build a body, known as CANBY (Canadian Body). It was to house a Type 144 Asdic transducer similar to the one fitted on NEW LISKEARD. The delivery date for this body was revised from February to August 1952. The first trials were held in October 1953.

Because of the long period required for delivery of these bodies, preliminary specifications were prepared for a body to follow CANBY, which was to be named TRILBY. Its shape was radically different from CANBY, to permit the housing of a larger, more powerful transducer which could be trained all round. It was initially intended to follow a design by the David Taylor Model Basin in Washington for a USN towed sonar project. However, trials in the US showed some doubt of its stability, so a new body was designed by Mr. Mike Eames of NRE, based on the RN 100 inch sonar dome and DTMB information. TRILBY towing trials were conducted by HMCS CRUSADER in 1955.

Meanwhile, tests were underway on several types of cable fairing to eliminate serious tow-off problems, sometimes so extensive that the body surfaced. Delivery of equipment was very slow because of the re-armament program, associated with the start of the Cold War and the Korean Conflict. Not until the spring of 1952 was there enough equipment on hand to start trials with faired cable. The tow-off problem was finally solved in early 1953 by a complete re-design of the fairing. During these trials, it was resolved that over-the-stern towing was entirely satisfactory and was simpler than over-the-side towing, then being pursued by the USN, despite the greater vertical movement due to pitching. Eventually, a patent was granted on the recovery system.

Acoustic Development

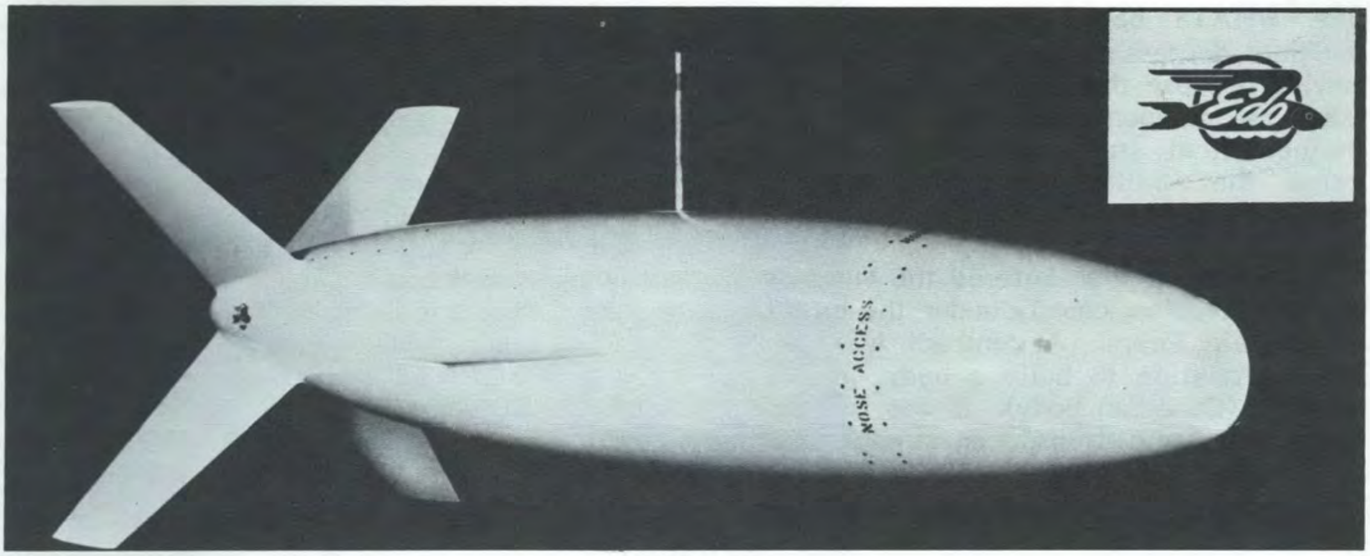
As predicted, the necessity for a towed Asdic system to give effective A/S coverage in East Coast Canadian waters was borne out by actual trials. Trials using HOT DOG were conducted with HM Submarines ASTUTE and ANDREW in 1950 and THULE in 1951. CANBY trials aboard HMCS NEW LISKEARD were conducted in 1953 with HM Submarine AURIGA and USS DIABLO. USS COBBLER served as a target in 1954.

The TRILBY body, equipped with a CAST/1 research transducer and electronics including a split beam direction finding (SPBF) system, was designated CAST/1/R. NEW LISKEARD conducted trials with this system in the Bermuda area with HMS ALDERNEY in December 1955. A similar system, with a modified CANBY handling gear and an experimental version of the CAST/1 electronics, which operated on a 'train - ping - listen' sequence, was designated CAST/1/X. The X version, completed and installed in HMCS CRUSADER in June 1956, had its first submarine target trials in September 1956, followed by trials against HMS ASTUTE off Bermuda in November. All trials were successful.

NRE scientists involved in the design of the operational transducer included Mr. W.H. Dingle, Dr. D. Schofield, Mr. R.F. Brown and Mr. B. Fanning. Mr. F.A.A. Fergusson, Dr. C.R. Mann and Dr. J.G. Retallack eventually received a patent on the towed body design. Mr. Ian Wright worked on the project at the Department of Mines and Technical Surveys. The electronics circuitry and display equipment were manufactured by Cossor (Canada) Ltd.

A Change In The Aim

The initial requirement for towed sonar was based on the unique water conditions existing off the Eastern Canadian Coast. The concern then was submarine detection, mainly in the shallow water areas of the Gulf of St. Lawrence and off Halifax



WHATS

CANBY

TRILBY

Harbour. By 1953, however, the view had shifted to an urgent need for the longest possible initial detection ranges, i.e. early warning. Locating the transducer at the best possible depth was seen as one method of improving the performance of any Asdic, with the case no longer dependent only on the occurrence of some peculiar sound channel over the Scotian Shelf.

This change in orientation was reflected in the 1954 RCN Staff Requirement whose objective was "to develop a towed sonar of substantially increased acoustic performance over conventional hull mounted sets, and which is capable of being operated at variable depth". A subtle, but important change from the 1949 requirement.

The Operational Evaluation of CAST/1/X

Cdr J.F. Watson, RCN (Ret'd), currently Maritime Program Coordinator in NDHQ, outlines the RCN operational evaluation trials: "In March 1958, the experimental system, developed by NRE (now DREA) and consisting of CAST/1/X electronics, TRILBY Mark V body, and over-the-stern towing arrangements, as fitted in HMCS CRUSADER, was turned over to the RCN.

"Although this was an experimental system, an operational evaluation was considered necessary in order to ascertain whether Canada was on the right track and whether this system could meet the staff requirement. Both the scientific community and the Navy were concerned that those carrying out the development may have a biased view of its capability and future potential. In addition, the Navy considered that the requirement for VDS was urgent. It was decided to proceed with an operational evaluation while acknowledging that numerous difficulties might be encountered due to the experimental nature of the components.

"For this reason, the official turnover had little effect on NRE and the RCN Operational Evaluation Team. They had initiated their close cooperation several months earlier, in order to familiarize the team with the operation of the equipment, and they continued this joint effort throughout the trial period.

"The evaluation consisted of two Phases - Phase I in April 1958 in the Bermuda area and Phase II in May and June in the New London, Connecticut operating area, on the Scotian Shelf, and in the Gulf of St. Lawrence. The results far exceeded most people's expectations and in many respects surpassed the Staff Requirement. To an operator, the first reaction to CAST/1/X was the superb quality of the echo - it was obvious when you were in contact. The characteristic which continued to excite all those involved was the maximum ranges consistently achieved throughout the evaluation. The CAST/1/X outranged the fleet-fit Type 144 by a factor of five. Alterations of course and speed, and the use of decoys by the submarine targets, were ineffectual in breaking contact. Other aspects of the evaluation such as range and bearing accuracy, the handling gear and towing cable, and console operation were all satisfactory."

Ranges, Bearings and Balloons

Cdr Watson continues: "That is not to say that problems did not arise. They did, constantly. NRE technicians, evaluation team members and ship's company worked long hours to ensure the availability of the system. Many ideas for conduct of the evaluation itself either did not work or were found to be unnecessary. Among the most frustrating were the many options for evaluating range and bearing accuracy. In addition to the VDS range and bearing, records were maintained on Type 144 sonar, Type 175 gunnery radar and Sperry. Visual bearings from the submarine periscope and from the ship employing an ex-German Alidade on the pelorus, as well as ship and submarine track charts were also employed. To facilitate radar ranges and bearings, and visual bearings of the submarine, it was decided to procure two Barrage Balloons MK VI from the Admiralty. Without going into detail, this bright idea turned into a massive headache. The first balloon broke adrift by parting the towing wire, creating a problem for the North American Air Defence

Command. The second balloon was promptly returned to stores.

"The COMOPVAL Report on this project recommended that the experimental CAST/1/X sonar be re-engineered to the required standards as the AN/SQS 504, and accepted for service use. The report put great emphasis on the advantages of VDS and proposed that the production and fitting to all escort vessels be expedited.

"As a result, the mid-life modernization of the ST. LAURENT Class, in addition to facilities for the Sea King helicopter, included the SQS 504 VDS and SQA 501 handling gear."

Royal Navy Comparisons and History

Cdr Watson adds: "The Staff Requirement against which the CAST/1/X was evaluated was a Joint RN/RCN document. The Royal Navy were anxious to carry out comparative trials between the CAST/1/X and their Asdic Type 192X. They considered it essential to assess the advantages of the high power, complex, and low frequency Type 192 as compared to the CAST/1/X. The trials were scheduled for the Gilbraltar area during August and September 1958.

"During the last two weeks of August, HMCS CRUSADER and HMS BROCKLESBY participated in side-by-side comparison trials in the Gilbraltar operating areas. On completion, CRUSADER returned to the UK for three days of trials in the Londonderry operating areas against the high speed, hydrogen peroxide powered submarine HMS EXCALIBUR.

"As a result of the trials, the RN concluded that there was no significant difference in the detection performance of the two sonars and therefore the additional complexity and cost of the Type 192X was not justified. Further, they concluded that the production version of the CAST/1/X could be fitted into most of the existing ships 'which will form the bulk of the RN/RCN anti-submarine craft for the next ten years'.

"In due course, the RN did fit the Canadian system as far as electronics, display and body were concerned, but developed a unique handling system. In later years, the RAN also fitted four RN versions of this Canadian Variable Depth Sonar system."

HMCS CRESCENT and the VDS

The development program did not end with acceptance into the RCN inventory. VDS trials continued and advances in sonar, handling gear and related systems gave us today's systems. Highlights of personal accounts of the trials aboard HMCS CRESCENT, development of the second generation VDS and subsequent evaluations aboard HMCS TERRA NOVA provide glimpses of the following twenty-five years.

Hank Baker recalls: "In 1959, I was the Dockyard Electronics Officer on staff of MEE. Cdr Carl Ross, eventually Admiral Ross, was MEE. At that time HMCS CRESCENT was in refit and the CAST/1/X Variable Depth Sonar was being transferred to her from HMCS CRUSADER.

"Early in 1960 I was appointed to CRESCENT as the Electrical Officer. Cdr Ross stated that VDS was going to become one of our major sonar systems and a good knowledge of the technology could stand a person in good stead. In many ways he was more prophetic than he knew. The system has had a great effect on my life; I'm still working to develop new and much improved systems.

"Capt Murdock was in command of CRESCENT at the time I joined her. The last of the VDS installation work was being completed and alongside trials commenced shortly after I took over the Electrical Department. It soon became apparent that one of our major tasks was to carry out a series of VDS trials."

Handling Gear

Mr. Baker continues: "The handling gear was completely home built from parts salvaged from old DREA experiments and from Dockyard stock. The saddle was much the same as you see on the present AN/SQA-501 today. The topping winch consisted of a Dodge truck rear end with a pair of small cable drums substituted for wheels and driven by a 15 horsepower electrical DC motor. The gear system of the rear end equalized the topping cable tensions in the same manner as the AN/SQA-501 hydraulic system does. The brakes were hydraulically controlled and supplied from a small hydraulic pump driven by a 5 horsepower motor. The topping winch cables were flexible steel cables, each capable of holding 45 tons. There was no lack of safety factor.

"There was one peculiarity in the winch drive system. In the shaft of the pinion gear, driving the main winch drive gear, was a small clutch that was supposed to slip at about 18,000 lbs cable strain. Apparently, when CRUSADER was towing, something had snagged the cable or body. The cable was strong enough to overcome the winch brake system and pulled body and cable off the drum. The gear box blew apart from centrifugal force, with shrapnel landing all over the quarter deck. This clutch was in the line to disconnect the drum from the gear box if such a happening ever occurred again. The cable and drum were sacrificial in this case.

"This particular loss had its effects on the AN/SQA-501 design. In the production system, a slipping clutch was also designed into the winch drive. The clutch was intended to slip somewhere in the range of 50,000 to 70,000 lbs. This clutch never was activated out of necessity, but it did have its effects.

"The CAST/1/X control systems for the two drive motors were five step contactor arrangements, similar to that used on the old street car systems. The contactors were in the tiller flat tight against the after bulkhead. Control rods extended up through the quarter deck to handles sited on a tray. This tray was tight against the after guard rails on the port side of the quarter deck, just clear of the port topping winch sheave. In addition to the control handles, the system power switches were sited on the tray, all in the open.

"Much of this activity and input took place in the early 1950's to 1960. From DREA, Dr. Schofield (present CRAD), Mr. F. Fergusson (present Chief DREA), Mr. Barny Barnard, Mr. Wilf Armstrong, Mr. Carmichiel, Mr. Mike Eames, Dr. Retallic, Mr. W. Dingle, Mr. C.R. Mann, Mr. W. Gibson and others were involved. From the Navy side, Captain Peers provided support and encouragement."

According to Mr. Baker, "During launch, the parallel mechanism would work fine. During recovery, however, the pinion would try to push the rack away, squeezing out the grease and causing a great deal of friction between the rack and the rack retaining pad. This resulted, far too often, in the rack becoming jammed, the paralleling arms becoming bent and twisted and the body being banged up. After several such failures someone came up with a model of the paralleling mechanism in use today on both the AN/SQA-501 and 502 systems."

Protective Housing

"Shortly after an incident where I was nearly washed overboard during a launching, the construction of a protective house on the quarter deck was started. When I asked to have glass put in the windows I was told to forget it, I was lucky to get the house.

"As the summer of 1960 wore on, we were at sea exercising VDS almost constantly. We were having trouble with cross talk and noise generated by ground loops, and were busy trying to beat this problem. Then something else started to completely jam the receiver and was finally traced to tail flutter. New tail fins of different materials, metal sandwiches and all sorts of ideas were tried, without success. Finally, Mr. Barnard of DREA tried sharpening the after edge of the fins to knife sharpness. This worked beautifully, but we had to put wooden guards on the after edge of the fins when the body was inboard so that no one would get hurt."

Heavy Weather Recovery

"During the winter of 1960-61, we continued to tow regardless of weather conditions. On one particular stormy day, it was decided that the body should be recovered so the ship could enter harbour. It was sea state 7 and obvious that there was going to be serious body damage if we tried to recover heading up sea. After some discussion with the bridge, it was decided that we would try a down sea course. Because of the speed of the seas it was necessary to make about 20 knots to prevent broaching or riding a wave. As we reached the proper course, it became very steady back aft and the recovery was as good as if we were in sea state two. We now knew how to recover in heavy sea states and have carried out this routine many times since, with both the AN/SQA-504 and 505 VDS systems.

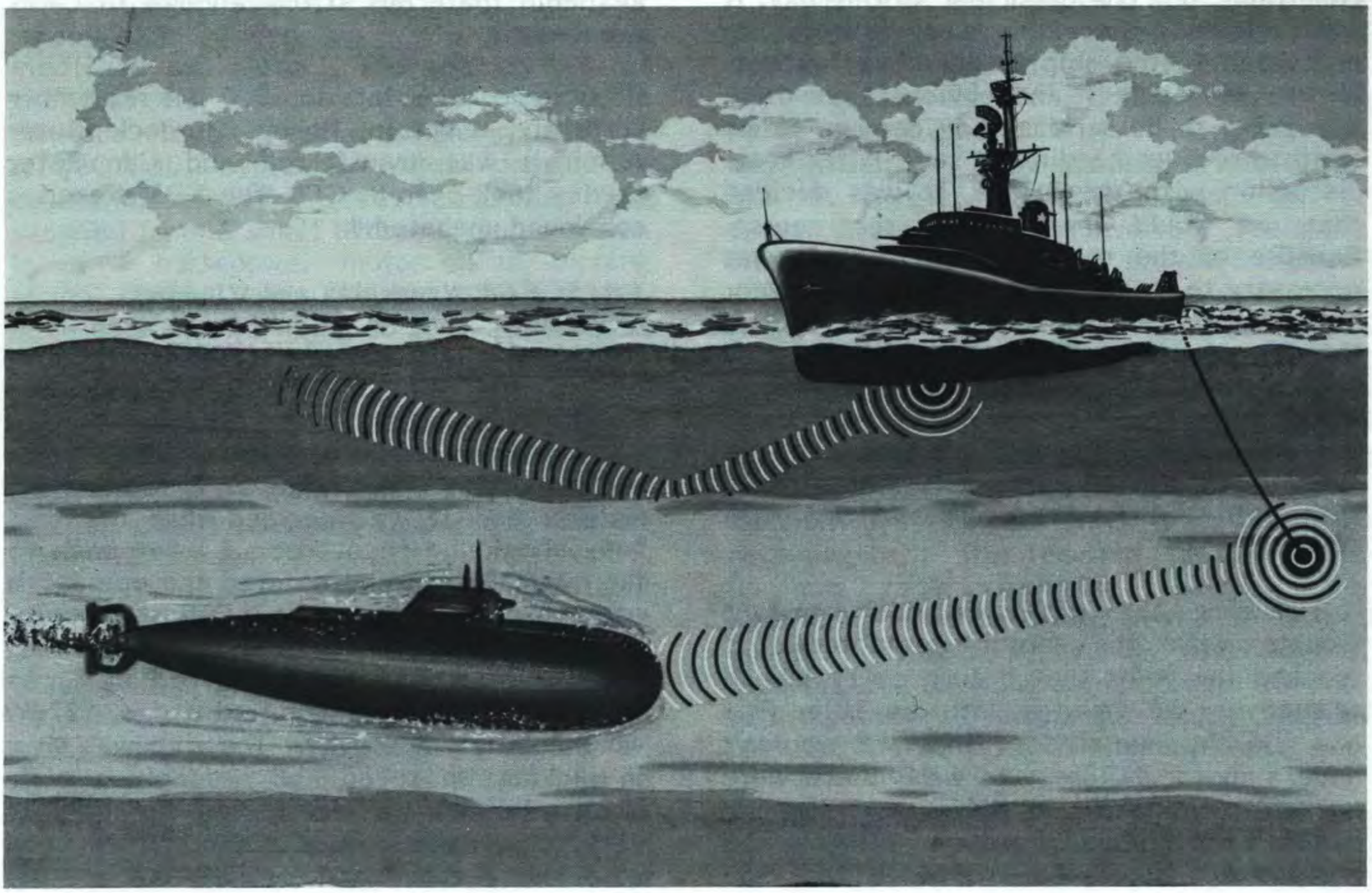
"During the trials we had constant trouble with the motor contactors. It reached the point that before every launch or recovery we would go into the Tiller Flat and file the contacts so that we wouldn't have a motor failure. As well, there were no safety interlocks in the system and one had to be particularly alert in bringing the equipment inboard, so as not to tear the system apart. After a number of mishaps that required dockyard assistance, and a number of meetings and discussions, several interlock and warning light circuits were devised and installed. Most of this work was carried out by the dockyard with Mr. Van Zutphen of MEE doing the circuit designs. With these modifications, the equipment became much safer to operate.

"On another occasion, during a rough recovery, it was noticed that the body was hanging in the saddle with the bottom tilted to port. As the body was lowered to the cradle and the tension removed from the cable, the starboard side plate fell apart. The strength member to which the yoke was pinned had broken and only a fragile aluminum side plate was taking the load on the starboard side of the yoke. This mishap led to the redesigning of the strength member with stainless steel. Up to this point, steel in the body had been avoided because of the possibility of upsetting the magnetic flux gate compass. Stainless steel was considered the least magnetic of the available materials strong enough to carry the loads.

"Some time, late in 1960 if I remember correctly, Captain Bobby Murdock (later Admiral) was transferred and Cdr Peter Cayley took over as CO. The VDS exercises continued unabated."

CRESCENT Wrenching and Windows

Mr. Baker continues: "During the winter of 1961-62, Commander Cayley was appointed to NDHQ and LCdr Red Wilkes, who had been the XO, took over as CO. On a stormy winter night, we were approaching Halifax and it was decided that the VDS body should be recovered. I went back to the quarter deck and entered the operator's compartment, closing the 1/8th steel plate door after me. I requested and received a down sea course. For some reason I was wearing a brand new cap and badge, $27.50 worth of new headgear. The ship was slow in picking up speed and suddenly a huge swell overtook us and buried the quarter deck. The water rushed in through the open windows, grabbed and swirled me around, completely filling the compartment. As the wave receded I saw my new cap float out the after window. I figured that I had better get out of there so I turned, took a firm hold on the latch and opened the door. Just at that moment the ship rolled hard to port and the heavy steel door flung me out of the compartment before I could let go of the latch. The quarter deck was covered with ice and I went skidding on the seat of my pants to the port guard rail. I found myself hanging onto the centre rail with my feet outboard and the water completely covering and pushing me aft against a stanchion. The ship rolled to starboard and as I came out of the water I rolled over onto my hands and knees to scramble inboard. I then managed to scramble forward on hands and knees til I was sheltered by the towing winch. There I got to my feet and went into the after instrument space to tell the bridge that there would be a slight delay in the



Pictured above is an artist's conception of the new Variable Depth Sonar (VDS) to be used by the Royal Canadian Navy for submarine detection. Fitted in HMCS CRESCENT, VDS is the result of more than ten years' research and development by Defence Research Board scientists of the Naval Research Establishment, Halifax, and the Royal Canadian Navy.

The gear enables warships to lower sonar through the ocean's thermal layers, thereby reducing a submarine's ability to escape detection in or below the layers. The drawing shows sonar gear lowered from a typical RCN destroyer escort detecting a submarine "hiding" in a thermal layer while the sonar beam from the conventional transmitter is deflected back to the surface.

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body recovery. I went forward, had a shower and changed clothes, then aft again and recovered the body.

"The next morning, as soon as I was sure the Commodore of the Dockyard was in, I went to tell him my story. That afternoon the Dockyard people were down fitting glass in the windows. And that is how we got a safe operator's compartment."

VDS Get Well Team

"In 1964 I was sent for by Admiral Landymore to become a member of a 'VDS Get Well' team. This team was headed up by LCdr Percy Buzza and consisted of Percy, myself and a CI ERA. This team was set up because of complaints from sea that the AN/SQS-504 system was useless, that it couldn't even be launched without serious damage.

"The complaints had real substance. For example, almost every body was too wide to fit between the saddle arms and as a consequence, they were crushed when pulled into the saddle. The hole in the yoke was only a couple of thousandths of an inch larger than the pin. The pin hydraulics were underpowered and if there was a burr on the pin it wouldn't enter the yoke staff. The saddle block was too massive. Much of the hydraulics were improperly designed. It seemed to us that the system had not been designed to fit together. The 'Get-Well' Team spent the year, with no funds or project manhours, modifying the system by stealing manhours from other projects and rabbiting supplies and parts from stores and shops.

"During the remainder of my time in the Navy, we had the usual run of problems that are common to all equipments. A lack of spares, too little theoretical training, misjudgement on the part of ships' staffs regarding sea state, a couple of collisions with submarines who got out of position and in one case, a cable collision with a six foot shark. When the ship went to recover the VDS, the shark was between the VDS body and the saddle. The various handling problems resulted in my writing the first MARCORD for launching, towing and recovering VDS."

Developments of the 60's

In about 1964, the Design Authority decided to develop the AN/SQS-505 sonar and the AN/SQA-502 Hoist Group system. Cdr. Joe Stachon, DMCS3, led the development team.

Commander Stachon describes the developments of the 60's with personal pride and satisfaction: "Our systematic evaluation and updating of each and every facet of the sonar technology of the time utilizing state of the art techniques, terms of performance, kept it all within the same physical envelope, and entailed only a modest cost increase. By maintaining technical control, we substantially reduced overall system costs and permitted a much broader spectrum of Canadian industrial talent to be applied. As a result, this was an entirely Canadian effort, though some ideas had been borrowed from offshore sources. Inclusion of these ideas generated considerable offshore sales of the system or its parts. In terms of the weapon integration aspect of the system, we succeeded in providing the first Canadian shipborne digital computer fire control system. With respect to VDS technology, we succeeded in going deeper and faster than ever before while at the same time increasing the search capability of VDS some twenty-fold over its predecessors. The 'can do' spirit which this development engendered converted Canada from a manufacturer of obsolescent, British sonar designs in the 50's to a designer and manufacturer of the most up to date sonar equipment anywhere."

Appointed to Headquarters, Cdr Stachon directed the efforts of the newly formed Sonar Section. His mandate was to determine where the RCN stood in sonar development and where it should go. The review of transmitter, transducer, display and sonar design led to an ambitious development program for a new scanning sonar.

Commander Stachon continues: "Some time in late 1962 to early 1963, it became apparent that we should take a close look at the variable depth aspect of our sonar program. We were well aware that the SQS-504 currently fitted in ships was essentially a post World War II directional sonar placed in a VDS body.

"In retrospect, I'm certain that the development problems of hydrodynamics were of sufficient complexity that the people involved did not want to further jeopardize the project by being too venturesome in the development of the sonar itself.

"Sometime in 1963 we undertook a major development program on the hull mounted sonar. Joe Elson was responsible for receiver development, essentially his own original idea expanded to cover the whole 360° periphery; Jim Miles was responsible for transducer and transmitter development; Dennis Pratt was responsible for development of displays; and Robin Fjarlie was handling the dome development. Earnie Gummer worried about contracts, treasury board approvals, staff submissions, etc. My own involvement essentially was riding herd on them.

"When we took a good look at the VDS system, we decided that there were compelling arguments for making the system compatible to the ship mounted system. Maximum compatibility could be achieved by transferring the four foot diameter by four foot deep cylindrical hull mounted transducer into a towed body and making all other aspects of the system similar to the hull mounted system. Unfortunately this would make for a much larger towed body which could generate a whole series of problems on its own. However, at the time, the advantages both in terms of system performance as well as simplified shipboard maintenance and training plus longer manufacturing runs outweighed the disadvantages of developing a larger towed body. Fleet Manufacturing, who were responsible for the new dome development, took over the engineering and fabrication of the unit under Robin Fjarlie's immediate direction. We were aware that it would not be practical to utilize tuned double wall construction for the new body. This was a body of revolution and had no plenar curved faces, as was the case for sonar domes and the SQS-504 towed body. We felt the intrinsic strength of the skin in the compound curvature required for the new body would be sufficient even in a thickness that would be acoustically transparent. The body design specifications were written accordingly."

New Handling Gear and Boom Bobbing

"Obviously a new towed body with such a major increase in size over the existing SQS-504 body would require new handling gear. We examined our experience with the SQS-501 handling gear, pros and cons, to come up with a new design. We eliminated the transition from winch tow cable lift to hydraulic push, which was a feature of the previous design in the lifting sequence. The new handling gear would utilize straight hydraulic lift throughout the lifting cycle. We also eliminated the electric winch and provided a hydraulically driven winch.

"A larger towed body would impose considerably higher snap loads on the towing cable in the event of serious ship pitching. The new hydraulic lift arrangement incorporated nitrogen filled accumulators in the boom hydraulics. This lifted the towing arm of the VDS gear when the cable went slack and absorbed the tension when the stern lifted (boom bobbing). This became an integral part of the initial design," according to Cdr Stachon.

Cables and Fairings

"Previous to this time the cable for the VDS was fitted with a continuous rubber fairing. Though the fairing was quite efficient in reducing drag and minimizing tow off, there was considerable difficulty in repairing it aboard ship because of its continuous nature. Repair was primarily a Dockyard job. Also, because of the new multi-receiver design, it was apparent that more conductors would be required in a new scanning sonar VDS than with the directional sonar. To meet the requirement for more conductors, while maintaining a small overall cable diameter, a new cable was developed. This was based upon data which I had acquired from the French Navy while on a NATO trip to Paris in 1964. This cable design encased the required number of twisted telephone pairs in an extremely strong stainless steel outer cable sheath. The development under Robin Fjarlie's direction went to Canada Wire and Cable of Toronto. To go with the new cable design we also examined the possibility of changing our fairing system, in conjunction with NRC, Montreal Road. We took the cue from some American work and went to a segmented plastic type of fairing which had the distinct advantage of being able to be repaired aboard ship, as each segment was individually replaceable.

"Apart from the development of the hydrodynamic form, there was a limit to the test tank work at NRC. The problems of hoisting the body, marrying it to the ship, particularly that touchy stage where the body becomes firmly attached to the VDS lifting gear could not be solved without shipboard trials.

"Through a tremendous amount of effort and cooperation on the staff side, we were eventually successful in getting the services of HMCS CRESCENT to do some initial tow work with the old VDS system using a new tow cable and fairing. The first small cable used 400,000 psi tensile steel and was very small in diameter. Unfortunately it could not withstand the environment and was abandoned because of corrosion problems. Subsequent cables were more conventional, using 200,000 psi steel with improved insulation and the twisted quads, a Canadian Wire and Cable development. This was followed by new dummy body trials in TERRA NOVA.

"During the years 64 and 65, our concept of the ship installation evolved from one attack sonar and two scanning sonars to two identical scanning sonars; one VDS mounted and one hull mounted. The attack function was built in, utilizing either scanning source. Since ASROC was soon to be purchased as the new long range weapon for VDS destroyers, we also embarked on the development of a completely new digital fire control system for the ASROC, to work in conjunction with these new scanning sonars."

Computer Firsts

Cdr Stachon recalls: "In order to incorporate this development, our group purchased and installed the Navy's first shipborne digital computer. This original computer was purchased from Computing Devides of Canada in Ottawa and the initial ASROC control programming was done by Lt Jerry Smuck. We took this rather bold step in order to eliminate the problems suffered in the GUNAR system during the 1950's. In our view the ASROC control system which the Americans would have liked to have us purchase was virtually an underwater version of the GUNAR system.

"Recollections of the program would not be complete without some indication of the costs. The total development cost for the entire shipborne system, the VDS system and the VDS components subsequently added to complete the system were something of the order of 2-1/2 to 3 million dollars spread over a period of approximately three years.

"In late spring of 1965, the development model of the sonar in the hull borne version was brought together at the Edo test site in the St. Lawrence River at Cornwall. In spite of a tremendous amount of concern, these initial trials went very smoothly. After some two months we were ready to transfer the system to TERRA NOVA for the first ship trials. Around this time, LCdr Fred Jardine joined our group upon graduation from Post Graduate School in Monterey, California, and was placed in charge of coordinating the system trials, and feeding back information to the group for incorporation into production specifications. Cdr Chuck Leighton was the captain of the TERRA NOVA at the time, and he and Fred Jardine became intimately involved with the trial program over the next two years.

"At this stage, we were still dealing essentially with the hull borne sonar. I remember Fred telling me that when the ship was alongside - this was before having gone to sea for the first time - they were trying out the transmitter and received some very irate phone calls. Submarines alongside in Halifax Harbour asked them to cut out that terrible noise coming through the water and banging on their hulls. This was rather direct evidence of the increased power output from the sonar by virtue of the new transducer and transmitter design.

"I vividly remember the first time the system went to sea on trial. Their first submarine contact was achieved at a range of 27,500 yards. When you compare this with the typical 5-7000 yard performance of the sonar it was replacing the success of this development really comes into sharp focus. I recalled the discussions that Capt Dennis Pratt and I had some two years before on display scaling. I had felt that 2, 4, 8 and 16 thousand yard display scales would be quite adequate, for if we doubled current ranges we would be most fortunate. He had convinced me to put in a 32 thousand yard scale just in case. Here, on the first real ping, we had damned near gone off the largest scale. As the trials progressed, I was extremely gratified to learn that for the first time we could see through the stern both in the VDS and the hull mounted versions. This was an eloquent testimony to the effectiveness of the development of both the receiver, in its noise rejection characteristics, and the dome and towed body in terms of construction to minimize sound opacity.

"In order to provide a heading reference in the towed body, we adapted and fitted a gyrocompass within the VDS towed body housed within the hollow transducer core. The VDS handling gear development took a long time because much of the transition work between sea and ship had to be done in actual sea trials which tended to be slow. Fitting of the handling gear and any modifications required extensive ship alterations, causing further delays.

"Unlike the 1980's practice of contracting out even the thinking and planning for a project, we were firmly committed to all planning and system engineering in-house. There was no prime contractor in the program, and all segments were awarded to various contractors on a competitive basis. The receiver and transmitter went to Westinghouse Canada, the display system went to Sperry Montreal, and the transducer went to Edo in Cornwall, who were then producing the existing SQS-503 scanning sonar for the Navy. The work on the new dome went to Fleet Engineering in Fort Erie, since they were the suppliers of the existing dome and started the engineering on that project."

DIANA and MOTEF

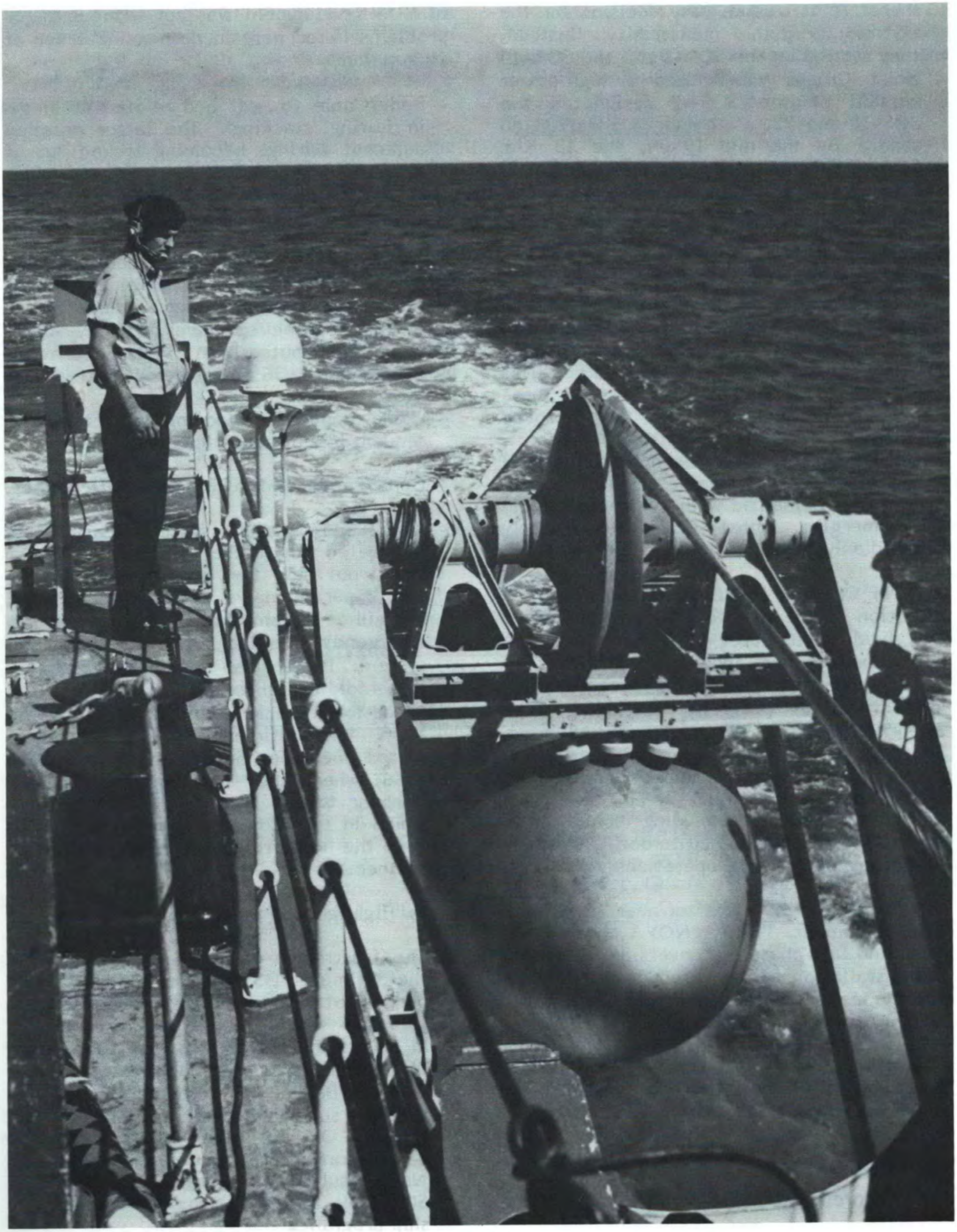
The follow-on evaluations were observed closely by the Maritime Operational Test and Evaluation Force, headed by LCdr Max Reid [now Capt(N)(R)]. He describes the program: "Several factors combined to formulate the requirement for a state of the art, or second generation, VDS. This program was subsequently designated the SQA-502 Hoist Group. The SQA-502 would utilize the 'DIANA' towed body, a National Research Council design, and would house the SQS-505 sonar then under development. The factors were -

* Operational limitations of the 'searchlight' sonar used in the earlier SQA-501/ SQS-504.

* Trends toward lower frequency and higher power. It was then assumed that 'brute force' would automatically increase detection ranges. (It has taken decades to understand that the sea environment does not necessarily follow the laws of physics.)

* Technology improvements which included solid state electronics and higher efficiency transducer ceramics.

* US Navy development of the large SQA-11/ SQS-23 VDS. This was a 5 KHz/ 244 db/micropascal sonar with a design capability for Bottom Bounce and hopefully Convergence Zone operation. Neither was operationally achieved,



SQS 505

therefore it was an easy decision for the USN to scrap this 'monstrosity'. Instead, they settled on the SQA-8 and the SQA-10 Hoist Groups which used a high-power version of the SQS-4, designated the SQS-31 and 32, a 12 and 14 KHz/230 db sonar. By the mid 1960's, the 13 Khz SQA-13/SQS-35 Independent VDS (IVDS) was introduced.

The SQA-502/SQS-505 represented a quantum increase in equipment size and sonar capability.

"By 1966, the Service Test Model had been designed, fabricated and installed in HMCS TERRA NOVA (DDE 259). This installation was part of the first of three conversion phases to produce the Improved Restigouche Class destroyer escort. Although the intent had been to convert all seven ships of the class, severe defence budget cuts combined with cost over-runs in the emerging Tribal Class subsequently allowed only four ships to be converted.

"In October 1968, under the technical direction of the Maritime Operational Test and Evaluation Force (MOTEF), the ship began nearly two and one half years of evaluation. This evaluation covered some 40 different projects, including the SQA-502/SQS-505 VDS and entailed some 305 days at sea while steaming over 65000 miles. As a result the ship participated in nearly all National and NATO exercises during the period, including some three MARCOTS while attached to both Destroyer Squadrons and 'private' operations.

"By mid 1971, and after nearly a decade of development, TERRA NOVA entered her third and last phase of conversion. This saw the installation of the production SQS-505 and the last of nearly seven years as a Trials Ship. At about this time, MOTEF, which was the successor to COMOPVAL (Commander Operational Evaluation) also faded away and with it some two decades of naval sea-going evaluation."

Problems

According to Capt Reid, "This decade of VDS development was not without major problems listed here in descending order of frustration:

- Body/Cable tow-off and related problems in fairing 'stacking'. The latter entailed adjacent fairings becoming locked out of alignment, thereby causing a rudder action on the cable system with subsequent tow-off.

- Understanding the severe 'shock loading' of the cable caused by vertical accelerations of the ship's stern in sea states over 5. Three of the VDS body losses were attributed to cable tensions exceeding the 36 tonne breaking strain.

- Cable connector flooding with the subsequent loss of acoustic capability.

- Upper saddle and towing yoke deficiencies.

- Winch and hydraulic system. Early tests illustrated that the Emergency Brake would not hold the system when towing and experiencing a power loss. If the hydraulic system failed, there was no emergency method of recovering the system. It was also demonstrated that a three-fold purchase pulley system and 'clear lower decks' could not recover the body. This deficiency was clearly illustrated one quiet Sunday morning in late 1966 when the ship entered Halifax Harbour towing the body at 'short stay', which in turn towed a manned whaler to keep the body from rotating until the ship berthed.

"Highlights of that decade included:

* The frustration of not being able to use the optimum VDS body depth during trials because of submarine safety restrictions.

* In an attempt to demonstrate the system to the Federal German Navy in the Western Baltic, we were not able to detect the submarine, even at pitifully short ranges. On the other hand, successful demonstrations to the Royal Netherlands Navy resulted in the sale of some twenty SQS-505's to the Dutch and Belgian new ship programs.

* While steaming off Nova Scotia on a non-ASW passage, but operating VDS, an unalerted detection was made against a submerged "O" Class submarine at some 15 miles.

"The IRE ASW system gave the Canadian Navy a medium/long range active sonar, the first Canadian naval digital computer and an all-weather/ immediate response stand-off weapon."

To some degree, this quantum increase in ASW capability was almost overshadowed by the higher profile helicopter/destroyer marriage and the arrival of the DDH 280 Tribal Class destroyers. This new class was also fitted with both hull mounted and VDS 505. Once operational, their superior noise quietening contributed significantly to the SQS 505 acoustic performance.

Historical Reflection

Until now security and a lack of collation have prevented a full under- standing of the Canadian group who invented VDS. The collection of personal memories used in this article give an enlightening account of the frustration, trials and successes of the people directly involved. Few may have realized the vital role Canadians played in the development of VDS systems and our continuing expertise.

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