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04a HISTORY OF OPERATIONAL RESEARCH IN THE ROYAL CANADIAN NAVY.

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ABSTRACT

This short history of operational research in the Royal Canadian Navy covers the period from the early days of World War II up to the time of the reorganization of the military operational research services (1 Feb 1965) following the integration of the Canadian Armed Services in July 1964. It presents details of the beginnings of military operational research in Canada and of the growth and development of operational research in the Royal Canadian Navy. A brief account is given of the organization and working relations of operational research in the Royal Canadian Navy, together with a condensed description of the main activities and types of studies undertaken, with passing reference to some of the many scientists and naval officers who contributed to the development and application of operational research in the Royal Canadian Navy. This history has been prepared in three parts. Volume 1 contains the main text and Volumes II and III, under separate covers, consist of the supporting annexes and appendices.

RESUME

Ce bref historique de la recherche opérationnelle effectuée par la Marine royale du Canada couvre la période du début de la Seconde Guerre mondiale jusqu'au moment de la réorganisation des services de la recherche opérationnelle militaire (le 1er février 1965), à la suite de l'intégration des Forces armées canadiennes en juillet 1964. Il présente des détails de la mise sur pied de la recherche opérationnelle militaire au Canada de même que sa croissance et son expansion au sein de la Marine royale du Canada. En plus de décrire brièvement l'organisation de la recherche opérationnelle dans la Marine royal de Canada et ses rapports avec d'autres organismes de recherche, l'historique retrace rapidement les activités principales et les divers genres d'études entreprises en mentionnant certains chercheurs et officiers de la Marine qui ont contribué à son adaptation et à son application à la Marine royale du Canada. Ce récit est en trois parties. Le Tome I contient le texte principal et les tomes II et III contiennent les annexes et les appendices.

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FOREWORD

The period covered in this history of operational research in the Royal Canadian Navy extends from the early days of World War II up to the time of the reorganization of the military operational research services (1 Feb 1965) shortly after the integration of the Canadian Armed Services in July 1964. To complete the account of some important maritime operational research work, details of relevant activity up to 1966 have been included. A brief description of the post-integration organization of operational research within the Department of National Defence is also presented.

Several aspects of the story of the development, growth, and achievements of operational research in the Royal Canadian Navy deserve more attention and emphasis than has been given them in this paper. Such aspects include the impact of the findings of operational research studies on naval planning and procurement, the relations between naval operational research and maritime air operational research, and the influence of naval operational research on the development of operational research in Canada generally. These matters and others await the preparation of a more comprehensive study. This paper has had a more modest aim, that of presenting some of the highlights and facts pertinent to the development and growth of operational research in the Royal Canadian Navy before all the early participators leave the active scene.

This history of Operational Research in the Royal Canadian Navy has been prepared in three parts. This part, Volume I, contains the main text and Volumes II and III, under separate covers, consist of the supporting annexes and appendices.

ABBREVIATIONS

AA - Anti Aircraft
ACNS(A&W) - Assistant Chief of Naval Staff (Air and Warfare)
AOC - Air Officer Commanding
A/S - Anti-Submarine
ASDIC - Anti-Submarine Detection Investigation Committee
ASW - Anti-Submarine Warfare
ASWORG - Anti-Submarine Warfare Operations Research Group
ASW/ORT - Anti-Submarine Warfare Operational Research Team
CANFLAGLANT - Canadian Flag Officer Atlantic Coast
CAORE - The Canadian Army Operational Research Establishment
CCPP - Contact Correlation Program Package
CDRB - Chairman Defence Research Board
CDS - Chief of the Defence Staff
CNS - Chief of the Naval Staff
COMANSEC - The Computation and Analysis Section
COMMARPAC - Maritime Commander Pacific
COMMARLANT - Maritime Commander Atlantic
COMOPVAL - Commander Operational Evaluation Organization
COR/DRB - Chief of Operational Research, Defence Research Board
CUSSAT - Canadian-United States Scientific Advisory Team
CVE - Carrier Vessel Escort
DATA-O - Data Analysis and Threat Assessment Officer
DDE - Destroyer Escort
DGORD - Director General Operational Research Division
DMOR - Director of Maritime Operational Research
DMWOR - Director of Maritime Warfare Operational Research
DND - Department of National Defence
DNOR - Directorate of Naval Operational Requirements
DNT - Director of Naval Training
D Ops R - Directorate of Operational Research

DOR - Director of Operational Research
DOR(A) - Directorate of Operational Research Admiralty
DOR(N) - Director(ate) of Operational Research Navy
DRB - Defence Research Board
DREP - Defence Research Establishment Pacific
DSAG - Defence Systems Analysis Group
DSE - Directorate of Systems Evaluation
DSS - Director of Scientific Services
DUSW - Director of Under-Sea Warfare
DWT - Directorate of Weapons and Tactics
FOAC - Flag Officer Atlantic Coast
JORC - Joint Operational Research Committee
JMWS - Joint Maritime Warfare School
JSORT - Joint Services Operational Research Team
MAC - Maritime Air Command
MARPAC - Maritime Command Pacific
MC/ORB - Maritime Command Operational Research Branch
MOTEF - Maritime Operational Test and Evaluation Force
MP&EU - Maritime Proving and Evaluation Unit
MWS - Maritime Warfare School
NDHQ - National Defence Headquarters
NRC - National Research Council
NRE - Naval Research Establishment
NS - Nova Scotia
NSHQ - Naval Services Headquarters
OEG - Operations Evaluation Group
OEPC - Operational Evaluation Project Committee
OPVAL - Operational Evaluation Organization
OR - Operational Research
ORC - Operational Research Corps
ORD - Operational Research Division
ORG - Operational Research Group
ORO - Operational Research Officer
PNL - Pacific Naval Laboratory
RAF - Royal Air Force

RCAF - Royal Canadian Air Force
RCN - Royal Canadian Navy
SA/CNS - Scientific Advisor to the Chief of the Naval Staff
SACLANT - Supreme Allied Command Atlantic
SOOR - Staff Officer Operational Research
SSO(OR) - Senior Staff Officer Operational Research
SORG - Superintendent Operational Research Group DRB
SORO - Senior Operational Research Officer
TAS - Torpedo and Anti-Submarine
UK - United Kingdom
USA - United States of America
VCDS - Vice Chief of the Defence Staff
VCNS - Vice Chief of Naval Staff
VDS - Variable Depth Sonar
VLF - Very Low Frequency

OPERATIONAL RESEARCH IN THE ROYAL CANADIAN NAVY

INTRODUCTION

THE ORIGIN OF MILITARY OPERATIONAL RESEARCH

1. The term "Operational Research" originated in the United Kingdom (UK) during the Second World War to describe the activities of a small group of scientists attached to the Royal Air Force (RAF) Fighter Command Headquarters located at Stanmore. This first military operational research team was formed in September 1939. Detailed information about the beginning of operational research in the RAF is given in Ref 1.

2. From the beginning the team concerned itself with the general effectiveness of the operations of the fighter aircraft at Stanmore. It studied radar detection of enemy aircraft and the system of ground control interception in action. Its analysis of and reports on all phases of night fighter operations formed the pattern for many later analyses of other military operations. After the United States of America (USA) entered the war it was not long before this type of research work spread in the military organizations of the USA where it became known as Operations Research.

3. Shortly after the first operational research team had been organized at Stanmore, a similar unit was set up at Anti-Aircraft (AA) Command Headquarters in the UK and was concerned with the operation and coordination of radar equipment at gun sites.

Subsequently another team was organized by Coastal Command to study the problems associated with the detection of submarines by radar and other means.

4. At about the same time the Admiralty in the UK began employing scientists in the investigation of anti-submarine warfare problems. Thus, soon after the beginning of World War II operational research sections had been set up in all of the British Armed Forces. Developments in operational research in the USA soon followed, particularly in the United States Air Force.

5. The first operational research (OR) group formed by the United States Navy was set up in 1942. It concerned itself, in the beginning, with anti-submarine warfare (ASW) only and was called the Anti-Submarine Warfare Operations Research Group (ASWORG). However, it expanded very rapidly and at the end of the Japanese war consisted of about seventy scientists grouped in five main divisions, dealing with almost every phase of naval and naval-air warfare. This group was directed by Dr Philip M Morse and a second one organized soon after was called the Mine Warfare Operational Research Group. Its leader was Cdr F Bitter, United States Navy, Reserve.

DEVELOPMENT OF CANADIAN MILITARY OPERATIONAL RESEARCH - WORLD WAR II

6. The first operational research facility in Canada was set up in the Royal Canadian Air Force (RCAF) in 1942, some three years after the first official institution in the UK. The late Professor JO Wilhelm headed this small group in Air Force Headquarters. The Royal Canadian Navy (RCN) and the Canadian Army followed suit with the beginnings of similar organizations. The present report traces the history and development of operational research in the RCN but it may be mentioned in passing that in 1944 the Canadian Army established a Directorate of Operational

Research at Army Headquarters in Ottawa, and a field organization known as the Canadian Army Operational Research Group. A short history of OR in the Canadian Army is given in Ref 2.

7. During the period 1942 to 1945 the Canadian Services employed some 60 civilian scientists and officers on OR duties. By the end of the war OR had been fairly well established and accepted in all three Armed Forces. However, at the close of hostilities most of the scientists involved returned to the universities to help cope with the flood of post-war students and within a year very few of these were left.

DEVELOPMENT OF OPERATIONAL RESEARCH IN THE ROYAL CANADIAN NAVY - WORLD WAR II

8. Depending on how one defines OR the beginning of the activity in the RCN might be traced to 20 Feb 1940 when Captain (later Vice Admiral) HE Reid, Commanding Officer Atlantic Coast called in Professors JHL Johnstone and GH Henderson of the Physics Department of Dalhousie University and requested their help. Every effort was needed to install protective devices on ships on this side of the Atlantic before entering the mined waters of the British Isles. The information available was extremely scanty, being to the effect that a degree of protection would be obtained by a coil of wire around the perimeter of the ship energized by direct current, with the ampere turns given by a rough and ready rule.

9. There was no information available as to the type of measuring instrument (magnetometer) suitable for the purpose, so one was developed from first principles. The method adopted involved the use of a rotating coil. The components were contained in a water-tight box which was dragged underneath a ship at anchor by "keelhauling". The first model was developed in time to test out satisfactorily the first ship coiled (or "degaussed") in Canada, HMCS "Fleur de Lys" on 21 March 1940.

10. At about this time arrangements were made by the acting President of the National Research Council (NRC) Dean CJ Mackenzie, for Professors Johnstone and Henderson to become members of the Research Council Staff with joint responsibility for the conduct of naval research at Halifax. These arrangements proved invaluable, allowing the formation of a staff and financial arrangements for securing necessary equipment.

11. This work continued vigorously under Dr Johnstone and much other research was conducted into such areas as magnetic minesweeping, calibration of ships, defence against magnetic and acoustic torpedoes, and the development of noise makers for use in acoustic minesweeping.

12. By the middle of 1942 the NRC staff at Halifax had grown to about thirty, most of whom were young physicists and engineers recently graduated from Canadian universities. Naval scientific research was continued at Halifax by the Naval Research Establishment (NRE) under the direct control of the RCN and official connection with NRC terminated in January 1944. Needless to say, the Establishment continued to have available the advice and assistance of the NRC when required, on a contract basis.

13. Whether or not this valuable research work should be called operational research is not vital to the present treatise. It is sufficient to note that it involved Dr JHL Johnstone and Dr GH Henderson who later formed the nucleus of the first OR unit that worked with the RCN. By 1943 Dr Johnstone was the joint superintendent of the Naval Research Establishment, Halifax, and on 1 July 1943 was appointed Director of Operational Research (DOR) and charged with organizing an operational research group for the RCN.

14. As a first step Dr Johnstone made a visit to the Department of the United States Navy (USN), Washington where the organization and operating methods of ASWORG were studied. He spent the month of August 1943 at the UK Admiralty where he acquired familiarity with the Royal Navy OR organization and its method of working. In addition arrangements were made for the new Canadian unit to receive reports of naval OR work done in the UK and USA. For example in September 1943 some thirteen OR papers were forwarded to Naval Services Headquarters by the Naval member in Washington and three more in January 1944. Access to such papers played an important part in developing military OR capability in Canada. A second visit was made by Dr Johnstone to ASWORG in early January and to the Massachusetts Institute of Technology on 15 January 1944 to learn more about various anti-submarine problems. Such exchanges of information and visits have continued down to the present. They have been very valuable particularly to the Canadian OR workers.

15. On his return Dr Johnstone set about organizing staff and a program of work for them. The RCN operational research staff, as finally established consisted of:

Director of Operational Research - Dr JHL Johnstone,
Professor of Physics,
Dalhousie University.

Operational Research Staff Officer - Dr GH Henderson,
Atlantic Command
Professor of Physics,
Dalhousie University.

Operational Research Advisers:

WR Christmas, B.SC., F.A.S., Sun Life Assurance Co.

A McKellar, Ph.D., Astrophysicist, Dominion Astrophysical Observatory.

RM Petrie, Ph.D., Astrophysicist, Dominion Astrophysical Observatory.

HL Welsh, Ph.D., Assistant Professor Physics, University of Toronto.

BN Moyls, B.A., Mathematician.

EB MacNaughton, B.A., physicist.

One officer, Lt. B Sutton, WRCNS and one secretary stenographer, Miss M Sarazin, completed the group.

16. For the greater part of the time there were five scientists (including the Director) stationed at Naval Services Headquarters (NSHQ) and three at Atlantic Command Headquarters, Halifax. This appeared to be a satisfactory distribution, but a larger staff at both places would have been required to handle the volume of work adequately. Occasional visits, only, were possible to St. John's, Newfoundland. A larger staff would have made it possible to have at least one scientist continually stationed at this important focal-point of North Atlantic operations.

17. It was found that suitable liaison with the OR groups at Admiralty and with the USN was most important both in stimulating the activity of the RCN group and in making the results of the other groups available to the RCN and vice versa. From January, 1945, until the end of the Japanese war, a Canadian scientist was stationed in the Directorate of Naval Operational Research at Admiralty, UK. The benefits of this arrangement were considerable and, if they could have been foreseen, would have justified the continuous existence of this form of liaison from the beginning. Operational records, even of RCN ships, were always more complete and up-to-date at Admiralty than at NSHQ, and the

presence of a Canadian scientist at Admiralty meant that these records as well as much other operational information were then available to the Canadian group with a minimum of delay.

18. Liaison with ASWORG in Washington, DC was on the whole very satisfactory, and was maintained by monthly visits of varying duration by different members of the RCN groups at Ottawa and Halifax. By this means much information was exchanged, not only on OR matters, but also on technical subjects. It would have been of considerable advantage to have a Canadian scientist continually stationed in ASWORG but the shortage of personnel made this impossible. It might be pointed out that such an arrangement would have been welcomed by the USN authorities.

19. During the period from August 1, 1943 to August 31, 1945 OR reports and memoranda on a wide variety of subjects were prepared and circulated to the operational authorities at NSHQ and Atlantic Command. A list of reports and memoranda is given in Appendix 1 to Annex A, Vol II which is a copy of Dr Johnstone's final report. This list represents in reality only a portion of the work of the group. Much advice was given to operational staffs conversationally or as minutes on files and did not require formal reports or memoranda. It may be of interest to note that the first Anti-Submarine OR report dealt with the analysis of 49 hunts by anti-submarine (A/S) ships in the Atlantic Coast Command in 1942.

20. A summary of the more important topics with which the Directorate dealt at more or less greater length is given below:

a. Analyses of anti-U-Boat operations in Canadian coastal waters. These analyses were carried out mostly by the Halifax group and were useful in indicating how future operations could be improved.

b. Statistics of the factors affecting the success of anti-U-Boat activities of the RCN for the period 1940-44.

c. Countermeasures to the acoustic torpedo. In association with NRE at Dartmouth, NS, successful countermeasures were developed shortly after the advent of this torpedo.

d. Countermeasures to the German Type XXI U-Boat with high underwater speed. This boat was a grave threat but never became an actual danger to Allied shipping, because the enemy was unable to bring Type XXI into operation to any extent before the end of the war.

e. Estimation of the improvement in the RCN A/S effectiveness if certain new weapons were introduced. Thus, the installation of Squid in RCN ships, stabilization of Hedgehog mounting, and the use of Carrier Vessels Escorts (CVEs) in Canadian coastal waters were studied.

f. Since the ships of RCN were used to a great extent for convoy protection this phase of operations was given full attention in operational research. The reports included the effect of weather on North Atlantic convoys, the effectiveness of convoy radar screens, the value of middle-ocean escorts in saving merchant ships, etc.

g. Possible countermeasures to schnorkels.

h. After the collapse of Germany, assistance in the interrogation of prisoners of war from U-889 was given and a technical examination of the U-Boat was made. During this immediate post-war period, DOR's representative in Admiralty was able to transmit to NSHQ with a minimum delay much information on captured German weapons and devices.

21. At the end of World War II the RCN operational research unit was disbanded and in October 1945 Dr Johnstone prepared a final report on its activities. Because of its historic interest the report has been reproduced as Annex A, Vol II. Much

of the information presented in this section is based on that report. From this report and the preceding summary of topics, it is clear that the OR units under Dr Johnstone were of great assistance to the naval staff during the three years that they were serving the RCN. In the light of later events it is interesting to note that Dr Johnstone's report reads in part, "Even in peacetime one or more operational research scientists would be found very useful to the Navy".

22. It was not until after the Defence Research Board was established in 1947 that OR staff again became available to the RCN. An account of how OR was provided to the RCN and the other Canadian Armed Services is described briefly in the following section.

DEVELOPMENT OF CANADIAN MILITARY OPERATIONAL RESEARCH - POST WORLD WAR II

GENERAL

23. In 1947 provision was made in the Canadian Department of National Defence (DND) for a unified research element known as the Defence Research Board (DRB), intended to serve all three Armed Services. An agreement was reached among the Board and the three Armed Services that an OR team would be set up in each Service and within the Board, and that these would be staffed largely by DRB scientists, with provision for assignment of qualified Service officers at the discretion of each service. DRB, through an establishment specially set up for the purpose, known as the Operational Research Group (ORG), was to give general technical supervision and support to the work of the Service Sections and plan individual postings and careers of the civilian scientists. The program of each of the four units was the responsibility of the RCN, Army, RCAF, and DRB respectively, but a committee called the Joint Operational Research Committee (JORC) reviewed programs periodically with a view to balance of effort, avoidance of duplication, and a reasonable apportionment of resources relative to need.

24. An extract from the 409th Chief of Staff Committee Meeting held 22 Dec 1947 reads as follows:

"The Chairman, Defence Research Board, observed that, when the Defence Research Board had been formed, it had been agreed with the Service Chiefs of Staff that operational research in the Services would be a Service rather than a Defence Research responsibility. Service operational research sections had,

however, been discontinued and their reconstitution was now needed. It was proposed, therefore, that operational research sections be established in each of the Services and the Defence Research Board, and that the section in the Defence Research Board be responsible for recruiting scientific staffs for all groups, for doing certain operational research of inter-Service interest, and for supplying the secretariat of a coordinating and advisory committee(JORC). The sections in each Service would be responsible to that Service and would consist of scientists seconded from the Defence Research Board and of serving officers."

25. The JORC approved the organization of operational research sections on the basis outlined with the understanding that the Chairman, Defence Research Board, (CDRB) was to collaborate with the three Armed Forces in organizing these OR sections.

26. It was some time however before OR units were organized in the three Services, but within two years an organization was developed by DRB to provide the necessary staff and facilities. A description of the organization and how it changed is outlined in the following paragraphs.

27. Within Headquarters DRB the Directorate of Operational Research was established on 14 January 1949 and incorporated the following sections: Arctic Research, General Operational Research, and Psychological Research.

28. The General Operational Research Section was to advise upon and coordinate operational research activities, including those of detached Service operational research units comprising research officers seconded to and working with Service personnel under direction of the respective Armed Services. The Director of Operational Research (D Ops R) appointed at that time was Dr NW Morton.

29. This arrangement was of short duration and within a few months the Directorate consisted of two sections only: one concerned with operational research and one with psychological research. Dr Morton continued as Director and Mr (later Dr) Craig M Mooney headed the psychological research section.

30. As mentioned above it had been agreed that a coordinating committee for operational research would be established, the secretariat for which would be provided by the Defence Research Board. Later by agreement the Coordinating Committee for Operational Research consisted of one representative from each Service and DRB, and the DRB member acted as Chairman. Dr NW Morton was appointed to serve as DRB member.

31. The chief purposes of this committee were:

a. To consider each Service program from the standpoint of possible economies that could be effected by joint work and avoidance of duplication of effort.

b. To consider and make recommendations upon procedures to be followed in defining and describing research projects, reporting, means of effecting liaison with other operational research bodies, etc.

c. To exchange views upon operational research methods and techniques.

32. On 19 July 1949 the Vice Chief of Naval Staff (VCNS) appointed Captain (later Rear Admiral) EP Tisdall as RCN representative to the Coordinating Committee for Operational Research.

OPERATIONAL RESEARCH IN THE ROYAL CANADIAN NAVY - POST WORLD WAR II

33. On 20 January 1949 the Vice Chairman DRB notified the Chief of the Naval Staff (CNS) that DRB was prepared to assign civilian OR officers to the three Armed Services who would be retained on DRB strength and their employment coordinated by it. At the same time it was suggested that a suitable RCN officer should be allocated to work with the OR staff to be provided for the RCN and assist in the definition of OR problems.

34. The reply to this notification was that Naval Board approved in principle the setting up of a Director of Operational Research under the Vice Chief of the Naval Staff (VCNS) and that a scientist rather than a Naval officer should head this Directorate. A RCN officer was not specially allocated at the time. It was considered that the OR unit might come under the immediate direction of the Scientific Advisor to the Chief of the Naval Staff (SA/CNS) but it was decided that a Directorate of Operational Research be set up under the VCNS.

35. The Director of Scientific Services (DSS) for the RCN (JS Johnson, a senior DRB scientist) inquired within RCN Headquarters about problems that the OR Directorate might undertake. A consolidated reply was made on 21 March 1949. A copy of the reply is presented in Annex B, Vol II. It provides a good picture of the type and variety of problems thought to be important at the time.

36. At a Naval Staff Meeting on 13 September 1949 the following organization of operational research in the RCN proposed by Dr GS Field, SA/CNS was approved:

a. Scientists engaged in operational research for the Navy are appointed by the Defence Research Board and are seconded to the Navy for duty;

b. When a sufficiently senior scientific officer can be found to direct operational research, he should be made "Director Operational Research". He should report to VCNS and be a member of Naval Staff;

c. Pending the appointment referred to in b, the most senior of the scientists engaged in Operational Research for the Navy will be known as the "Operational Research Officer" (ORO) and will be in charge of the Operational Research Group;

d. The Operational Research Officer will report to VCNS through the Directorate of Weapons and Tactics (DWT);

e. Research programs undertaken by ORO will be prepared in consultation with the DSS and will be referred by DWT to Staff;

f. Liaison between ORO and DRB will be effected through DSS.

g. The RCN representative on the inter-service committee for coordination of OR will be DWT with DSS as alternate.

37. This organization of OR in the RCN was approved by the Naval Staff and confirmed by CNS on 13 Sept 1949.

38. Work had started in the Operational Research Group, RCN in March 1949, when one scientist, Dr JAH Duffie was made available to the unit. He spent some time reviewing the work done by the Directorate of Operational Research, RCN during the Second World War and later RCN Directorates turned over a number of problems for solution.

39. The first problem undertaken by Dr Duffie was the construction of a chart which gave a pilot information as to his actual speed when he had data available on indicated air speed, temperature and elevation. This chart was reproduced and copies were distributed to the Director of Naval Air.

40. In June 1949 two summer workers were added to the Operational Research Group (one of whom was Dr JS Vigder) and the three workers undertook two more problems:

a. A study of all factors relating to the anti-submarine situation;

b. An analysis of the probability of a hit given a certain type of gun and projectile and a moving target.

41. In accordance with DRB policy a report on progress of OR in the RCN was requested for the DRB annual report in Sept 1949. Despite the short life of OR in the RCN at the time a report up to 31 Oct was prepared. It is of some historical interest to note this report; it has been reproduced as Annex C.

42. In Sept 1950 two papers dealing with two types of convoy patrol to afford protection against submarines were issued by the OR unit. They were titled Patrol Easton and Rattlesnake Patrol Mathematical Evaluation and were prepared by SA Kushneriuv, a summer employee.

43. In October 1950 the Department of the Army United States of America extended invitations to attend the Tripartite Conference on Operational Research. A representative of the RCN from the Canadian Joint Staff Washington was nominated to attend. He was Commander PFX Russell who from that time until he went on retirement leave as Commodore in December 1969 was a staunch supporter of OR in the RCN.

44. There was no OR activity in the RCN after the summer of 1950 until the next DRB scientist to work on OR problems at NSHQ Mr Henry Montgomery reported for continuing employment early in May 1951. He was joined by Dr JS Vigder on 15 May 1951, for summer employment only, and by Mr EL Leese on the 15 June, 1951 as a permanent employee. Both Montgomery and Leese remained with DRB and Dr Vigder subsequently joined DRB (in July 1952) to remain till the end of his active career. In August 1951 he published a report on the effectiveness of the Mark 32 A/S Homing Torpedo. Mr Leese was an experienced OR analyst having worked with the London Passenger Transport Board and in military operational research with the Admiralty during World War II. An outstanding applied mathematician and competent analyst he contributed a great deal to operational research in both the RCN and the RCAF after joining DRB in 1951. He was one of several experienced OR scientists who came from the UK and did much to establish military OR in the Canadian Armed Services. Others were: H Larnder, IH Cole, PB Wilson, JL Hudson, GD Kaye, FJ Cripwell, DHJ Norman, RP Hypher, WJ Jones, and Harry Poole.

45. At a meeting on 15 June 1951 the Naval Staff recommended approval for the establishment of priorities for OR projects as follows:

Priority A

a. An evaluation of current and immediate future anti-submarine detection investigation committee (ASDIC) and associated detection equipment capabilities when employed in Canadian coastal waters.

b. Evaluation of anti-submarine weapon capabilities with a view to determining the advantages and disadvantages, hit probabilities and lethality under stated conditions. The weapons to include Limbo, Squid, Torpedoes Mk.32, Mk.35, Mk.27 Bidder and Dealer B.

c. Evaluation of anti-aircraft protection afforded the DDE 205 class when fitted with:

1. 2 in number 3" 50 mountings
2. 1 in number 3" 50 mountings
   1 in number 3" 70 mountings

d. Evaluation of seaward defences with regard to the relative efficiency of mortars as opposed to controlled minefields.

e. An evaluation of the threat to Canadian Atlantic ports from enemy mining.

Priority B

a. A study of the feasibility and factors involved in flooding the Canadian Coastal Zone by radar transmissions.

b. An evaluation of the tactical capabilities of Magnetic Airborne Detection Equipment.

c. An evaluation of the relative tactical capabilities of Blimps, Helicopters and Hydrofoil craft for use as the A/S vehicle in Canadian coastal waters.

46. This set of priorities for OR projects was prepared by DWT after consultation with Dr JW Abrams who at that time was deputy director of operational research at Headquarters DRB under Dr NW Morton.

47. In a report made in January 1952 by EL Leese Head of the Operational Research Group of the RCN (as the unit was then called) it was noted that the following work had been completed in 1951:

a. Comparison of effectiveness of 3"/50 and 3"/70 guns;

b. Comparison of gunnery effectiveness of the ships MICMAC and HAIDA;

c. Comparison of gunnery effectiveness of destroyer escorts (DDE 205) with aft - and forward-mounted 3"/70;

d. Comparison of effectiveness of 5"/54 single, 3"/70 twin, and 4" Mark 16 twin;

e. A series of some half-dozen smaller problems, assigned by DWT;

f. Criticism of five draft reports of Air Defence Command Operational Research Section.

48. The report also listed five projects not yet started (Trials of GFCS Mk 63 Mod 13 at OPDEVFOR, use of Limbo as an anti-torpedo weapon, use of helicopter dunked sonobuoys, magnetic field of minesweepers, and prediction of motion of carrier decks) and made the following recommendations:

a. The staff of ORG should be increased from 2 to 4, by the provision of one more research scientist and one computer.

b. The OR Group should be kept constantly aware of current thought in Naval Staff Directorates on all matters of policy involving weapons, tactics, or plans. This should be implemented by allowing the attendance of OR staff at Naval Staff meetings in an advisory capability.

c. The OR Group should be encouraged, as in the past, to visit Schools, Establishments and Universities in order to maintain first-hand knowledge of the current state of technical and scientific progress in all matters affecting naval warfare.

d. The OR Group should be allowed, subject to the approval of VCNS, to initiate scientific research on general problems which, while having no direct application to current projects, may be of assistance in future work.

e. When the OR Group has attained the necessary all-round experience, it should be divorced from DWT and reconstituted as a separate Directorate reporting to VCNS.

OPERATIONAL RESEARCH AT NAVAL SERVICES HEADQUARTERS

GENERAL

49. Operational research work continued at Naval Services Headquarters on a variety of problems despite the rather few scientists available to undertake studies. There were changes in the Naval Services organization at National Defence Headquarters (NDHQ) and changes in OR staff from time to time. One noteworthy change was in the appointment of the head of the OR unit. In 1952 the unit became known as the Directorate of Operational Research (Navy) and the senior OR scientist was designated Director of Operational Research (Navy) (DOR(N)). He attended meetings of the Naval Staff and frequently presented findings by OR studies at these meetings as well as discussing agenda items as appropriate. The names and periods of service of these directors from then until the time of integration were:

1952 - 1955	PB Wilson
1955 - 1958	JW Mayne
1958 - 1965	Dr JS Vigder

THE PERIOD 1952 - 1955

50. In July 1952 there was a substantial change in the personnel of the staff of the RCN Operational Research Group. The number of scientists was increased from 2 to 3. The senior OR officer Mr. Leese was posted to the OR Group of DRB to undertake a special air defence weapons system study, Dr JS Vigder joined the staff, and Mr PB Wilson, Head of the Air Defence Section, Directorate of Operational Research, Admiralty (DOR(A)) UK was made available to DRB for a two year period and became the senior OR officer. As it turned out Wilson remained in Canada and with DRB until 1957 when he joined the staff of the Canadian National Railways.

51. Dr Vigder was a wartime member of the Canadian Army Operational Research Group and served in Canada and with the Australian Army in the South West Pacific Area. As already noted he had been engaged in OR with the RCN at Ottawa and Halifax during the summers of 1949 and 1951. He later became the third and last Director of Operational Research at Naval Services Headquarters.

52. At the end of April 1952 the third Tripartite Conference Army Operational Research was held in Kingston, Ontario under the Chairmanship of Dr OM Solandt, CDRB. The Deputy Chairman was Col CM Carrie, Scientific Advisor to the Chief of the General Staff. On the Naval side it was attended by EC Williams, Director of Operational Research, the Admiralty, Messrs Leese and Montgomery of the RCN OR Section, Capt MA Medland DWT, and Capt AHG Storrs. Two junior RCN officers attended sessions for specific papers. This was the first time that Canada hosted the conference and it was a very successful one.

53. The Coordinating Committee on Operational Research met from time to time under the Chairmanship of Dr NW Morton, DOR, DRB. These meetings served as a means of sorting out inter-service matters related to operational research and reporting on progress by the OR units.

54. Early in Jan 1953 the RCN Operational Research Group published its Annual Report 1951-52. By that time as noted above the Group had been made a separate Directorate (DOR(N)) and came under the Assistant Chief of Naval Staff (Air and Warfare) (ACNS(A&W)).

55. A good idea of the work accomplished during the year can be had from the titles of the main sections of that annual report. These were:

a. Air Threat to Atlantic Shipping

b. Anti-Submarine Warfare
   (i) ASDIC Conditions in Canadian Coastal Waters
   (ii) Evaluation of Anti-Submarine Weapons
   (iii) Evaluation of Helicopter Dipped Sonobuoys

c. Defence Against Enemy Mining
   (i) Magnetic Safe Depths for Canadian Minesweepers

d. Gunnery Assessment
   i. Trials of GFCS Mark 63, Mod 13 in HMCS "IROQUOIS"
   ii. AA Effectiveness of 3"/70, 4" and 5"/54 Gun Mountings
   iii. Evaluation of Gunnery Effectiveness of (Destroyer Escort) DDE 205
   iv. Effectiveness of Gunnery Armaments in "MICMAC" and "HAIDA"
   v. A Comparison of the Effectiveness of NATO AA Guns.

56. DOR(N) and its predecessor had always received strong backing and help from the SA/CNS (Dr GS Field SA/CNS Jan 1948-Sept 1954 Dr FH Sanders Oct 55 - Apr 57) and the Directors of Scientific Services (DSS), RCN. Mr JS Johnson was DSS from Jan 1948 - Aug 1953 and Mr DP Hoyt Acting DSS from Oct 1955 to Apr 1957. Both were cooperative and strong supporters of DOR(N) and its activities. This support and cooperation continued when Mr Hoyt later became DSS from Oct 1960 - May 1962 and during the tenure of Dr WM Cameron as DSS and Deputy SA/CNS circa 1956.

57. In April 1953 DRB received an invitation to present a series of papers outlining Canadian work in military operational research before the US Joint Operations Research Group. This body included representatives from the Operations Evaluation Group (OEG) USN, Office of Operations Research US Army, Operations Analysis Division USAF, the RAND Corporation, and the Weapons Systems Evaluation Group of the Joint Chiefs of Staff.

58. The invitation was accepted and the meeting held on 11 May 1953 in Washington, D.C. Each of the Canadian OR units with the Armed Services and DRBHQ presented a paper. The DOR(N) paper was titled "Anti-Submarine Requirements Against Modern Submarines" and was presented by Mr. PB Wilson, DOR(N).

59. During the period 1952 - 1955 it became clear that there was a need for more OR support at Naval Services Headquarters. The story was largely one of formal requests for more OR staff by the RCN (and the two other Services) and a reply of regrets from DRB due to shortage of staff and promises to attempt to remedy the situation. Indeed progress was made and by 1955 DOR(N) had a total of 6 scientists, one of whom was detached with the Operational Evaluation Organization in Halifax.

60. The nature of projects undertaken by DOR(N) varied according to the tasking received from the Naval Service HQ's Directorates. These projects were regularly recorded as Research and Development projects with the DND Program Control Centre. A listing of such DOR(N) projects for 1955 with their aims is set forth below:

a. Comparison of Naval A.A. Guns
   Aim: To determine the most effective gunnery armament for the new DDE's under construction.

b. Improvement of F2H3 (Banshee) Air-to-Air Armament
   Aim: To provide a numerical estimate of the chance of carrying out a successful interception with the Banshee aircraft with various types of armament against representative enemy aircraft.

c. Air Defence of Atlantic Shipping
   Aim: To assess the threat to Atlantic shipping from enemy aircraft and review the methods by which the necessary protection can be provided.

d. Evaluation of Anti-Submarine Weapons
   Aim: To assess the probability that certain anti-submarine weapons will cause lethal damage to a submarine.

e. Techniques and Applied Studies
   Aim: To assess the relative merits of minesweeping and minehunting.

f. Radio Warfare in the RCN
   Aim: To assess the maritime threat from recent Soviet developments in electronics, and arrive at appropriate counters to this threat.

g. Optimum Utilization of Merchant Ships

Aim: To determine the effect of frequency of convoy sailings and choice of convoy routes on the utilization of merchant ships.

61. In early 1954 DRB appointed an advisor to the Director of Naval Training (DNT) to be responsible for advising on training aids and techniques including audio and visual communication. The first and only incumbent was Mr FH Morrow who joined the DOR(N) staff in this capacity on 30 Apr 1954.

62. By the autumn of 1955 when PB Wilson was posted out of DOR(N) the Directorate was well established and had proven its value to the RCN. This success was due in large measure to the ability and dedication of Mr Wilson who built up a competent staff and enjoyed the confidence and support of the Naval officers with whom he served. Operational research in the RCN owes much to his leadership and professional competence.

63. As a remark of interest concerning the good working relations between the OR scientific staff and the Naval officers with and for whom they worked, the author recalls Peter Wilson saying just as he left DOR(N) that he found his period of service with DOR(N) the best and most pleasant years of his professional life. He also predicted that his successor would have a similar experience. This prediction proved to be accurate.

THE PERIOD 1955 - 1958

64. Because of requirements for senior OR staff for the Canadian-United States Advisory Team (CUSSAT) in Washington and elsewhere in the summer of 1955, it was decided to post Mr PB Wilson to the CUSSAT staff and phase out the Joint Services Operational Research Team (JSORT) in Edmonton, Alberta. This Team had been working with Western Army Command and Tactical Air Command and consisted of three OR scientists.

65. As it turned out Wilson did not go to CUSSAT but became Director of the Canadian Army Operational Research Establishment (1956 - 1957) and JW Mayne who had been head of JSORT succeeded him as DOR(N). Mr. Mayne had been employed in DRB as an operational research scientist since April 1951 and like Peter Wilson later became Director of the Canadian Army Operational Research Establishment.

66. One of the most important investigations underway at the time was the development of the characteristics for a new class of destroyers referred to as the Improved Restigouche Class. Considerable time and effort was devoted to the study group on this subject by DOR(N) and his staff. Another investigation to which the DOR(N) staff made valuable contributions was the development of tactics for defeating ballistic missile launching submarines by using available maritime forces. Concepts and tactics for this purpose were developed from theoretical considerations and tried out in exercises.

67. One of the major undertakings early in this period was a comparison of medium and close range AA guns to be fitted to the various classes of destroyers. Another was the determination of the requirements of a missile system for convoy defence. These projects were completed satisfactorily and in timely fashion.

68. A study of the estimated effectiveness of various force systems in support of an anti-submarine barrier was completed in July 1957. The report was a comprehensive cost/effectiveness analysis involving some twelve detection systems and various force systems providing the barrier. Another major study conducted later was the determination of the air defence requirements of the fleet on a study group basis which was done in conjunction with naval air staff officers. A statistical analysis and summary was made of the probable effects of weather and sea conditions on maritime operations in the North Atlantic. The results have been

widely used in planning exercises and operations and in determining the sea and weather conditions under which helicopters can be safely accepted on the decks of destroyer escort vessels.

69. Other studies that were conducted in this period were concerned with such topics as force requirements for the support of submarine detection systems, future requirements for A/S ammunition, torpedo armament for RCN fixed and rotary wing aircraft, effectiveness of support systems in support of an anti-submarine barrier, effectiveness and requirements for air defence systems for the RCN, and the analyses of a super-sonic interceptor with an infra-red homing air-to-air missile. Still other subjects that were studied included early warning requirements and radio warfare aspects of the air defence of shipping, radar silence policies in the defence of shipping, and the possible use of radars mounted on transatlantic commercial and military aircraft as an anti-submarine confusion device, bearing accuracy requirements of shipborne sonars used with medium and long range attack systems, and the effectiveness of Mk 44 torpedoes used by surface ships. Toward the end of the period much work was done with the naval staff in developing and analyzing the concept of operating A/S helicopters from the decks of Canadian frigates and destroyer escort vessels.

70. Findings and conclusions of such studies were reported to the RCN authorities in the usual fashion, i.e. in written form, at briefings, and at Naval Staff meetings, which DOR(N) attended regularly, and in informal discussions with Naval Staff officers. As DOR(N) was physically located with the ACNS(A&W) staff there was continual discussion and exchange of ideas between the DOR(N) staff and the Naval officers whom they served. This close daily contact with military staff and sponsors was subsequently lost when the OR resources at NDHQ became centrally located.

71. At this time DOR(N) did not publish regular monthly or annual activity reports. Indeed with the passage of time it has not been possible to determine all the papers that were published by DOR(N) during any particular period. A listing of the various papers prepared by OR staff at Naval Services Headquarters that have been traced is presented in Annex D, Vol III showing authors and dates. This list reflects the variety and scope of the tasks undertaken for the RCN.

72. During this period the Armed Services became interested in bringing to the attention of the ORC, at an early stage, all human resources and OR projects raised within any part of DRB's operations. As a result of this interest an advisor on personnel and training was appointed in the three Services. In the RCN the appointee was Mr FH Morrow who had been working as advisor to the Director of Naval Training since May 1954 and was already on the DOR(N) staff. He continued in this capacity with DOR(N) until 1957 when he became a member of the Biosciences Research Section of the Chief Scientist's Branch, DRB. He still carried on as training advisor to DNT until the early 1960's.

73. It is of interest to note the type of studies that were requested of DOR(N) from time to time. In June 1958 the Director of Under-Sea Warfare (DUSW) at NSHQ, Captain PFX Russell submitted the following list to DOR(N):

Title	Priority
Sonar Mutual Inteference	1
A Review of the Usefulness of Limbo in 1960 in St Laurent and Later Ships	2
An Investigation of the Detection, Navigation and Attack System of CS2F Aircraft	3
An Estimation of the Probable Effectiveness of Ship-launched Wire Guided Torpedoes	4

A Comparison of the Values of Various Improvements in the Characteristics of Variable Depth Sonar (VDS)	5
Evaluation of Anti-Submarine Weapon and Detection Systems	6
Assessment of Very Low Frequency Submarine Detection Equipments and Weapon Systems Required for Their Support	7
Investigation of Hydroacoustic Countermeasures	8

74. Accompanying this submission were individual enclosures for each study providing background, aim, and factors affecting the particular study. This approach was developed by DUSW and DOR(N) and emphasizes the close working relationship which had evolved. Captain (later Commodore) Russell, DUSW had long appreciated the value of OR in naval studies and made heavy use of OR services in the several appointments that he held throughout his naval career.

75. A useful training practice that began earlier was continued and extended during this period. This procedure involved having the DOR(N) scientists attend courses in ASW Tactics for Naval Officers given at the Joint Maritime Warfare School (JMWS). In addition these scientists participated in regular ASW exercises and got practical knowledge of the experience in naval exercises at sea. The benefits derived from such courses and exercise participation were substantial and served to cement good working relations with naval officers. In addition DOR(N) staff attended meetings and conferences (e.g. Torpedo Anti-Submarine (TAS) conferences) as appropriate.

76. It perhaps should be noted that in the latter part of this period the Directorate of Systems Evaluation (DSE), one of the two OR directorates working with the RCAF Headquarters in Ottawa, became interested in the operations of maritime aircraft in the ASW role. Related OR work had of course, been going on at Maritime Air Command (MAC) and Maritime Command in Halifax, NS and at the RCAF base in Greenwood, NS. A particular concept that

was developed with the help of DSE was based on a field of free-floating air-dropped buoys which were equipped to listen to underwater sounds, record them on a recorder, and then broadcast them when triggered by a monitoring aircraft. DOR(N) staff cooperated with DSE in the development of this concept and in testing it. Similarly, somewhat later, DOR(N) and its successor the Directorate of Maritime Operational Research (DMOR) cooperated with the Maritime Air Command OR Branch in developing and conducting tests of a field of moored buoys in a set of sea experiments called the Ocean Series.

77. Based on an assessment made by DOR(N) (Annex E, Vol II) in May 1958 CNS in June 1958 requested that OR staff in the RCN be increased by 2 scientists for DOR(N) and 1 for the OR Team with the RCN in Halifax (for projects of specific Naval interest). The DRB reply in June mentioned that the combined requirements considerably exceeded the resources under the "present total DRB complement of scientists". By March 1960, however, CDRB informed the Service Chiefs that the complement of scientists for operational research in DRB was raised from 58 to 78 to meet the increases requested by the Services. However, it was not until many years later that the complement of OR staff approached the 78 figure.

78. Relations with naval operational research scientists in the UK and USA were maintained at a satisfactory level during this period. The Director and members of the DOR(N) staff visited the Directorate of Operational Research, Admiralty (DOR(A)) and the US Navy OEG in the Pentagon as occasion demanded. As suggested earlier military operational research in Canada benefited greatly from the help and encouragement of OR scientists in the UK and USA. In particular DOR(N) during this period was indebted to Mr HC Calpine at DOR(A) and his staff and to Dr Jacinto Steinhardt and his staff at OEG, Washington.

79. As the preceding outline indicates DOR(N) increased in number of staff in the 1955-1958 period and in range of projects undertaken. The staff improved its capabilities and grew in confidence and in its ability to respond quickly and effectively to the many demands for studies and investigations. The naval staff was learning how to make better use of the OR potential and turned to DOR(N) for assistance and advice on a day-to-day basis as well as for studies and projects related to both planning and operational matters.

80. DOR(N) was responsible to ACNS(A&W) at this time. In the 1955-1958 period the post was held first by Commodore KL Dyer and latterly by Commodore AHG Storrs. Both these officers were strong supporters of operational research and made good use of the services of the DOR(N) staff. Encouragement and support were also given by the two Vice Chiefs of the Naval Staff RAdms HN Lay and EP Tisdall, by Capts TC Pullen, JC O'Brien, CP Nixon, GC Edwards and Commander HA Porter and by Dr FH Sanders SA/CNS (Oct 54 - July 59).

81. It has not been possible to find the names of all the staff members of DOR(N) and the earlier units doing OR for the RCN, and of the OR staff at Naval Commands. An attempt has been made to find the names and dates of employment of all such personnel and the results are set forth (with apologies to the missing persons) in Annex F, Vol II. At the end of this period (July 1958) the staff of DOR(N) consisted of Dr AC Lauriston, DM Murray, J Langis, RD Wilmot, HL Seymour, FH Morrow, and the Director JW Mayne. As noted elsewhere Mr. Murray was attached to the Joint Maritime Warfare School for duty but was carried on the strength of DOR(N).

THE PERIOD 1958-1965

82. During this period the Director of DOR(N) was Dr JS Vigder whose name has appeared previously in this paper. He was a competent mathematician and an experienced OR scientist who had recently been Deputy Director CAORE (1957-58). He succeeded JW Mayne in July 1958 on the latter's posting to the SHAPE Air Defence Technical Center.

83. Following up on earlier negotiations Dr Vigder, in cooperation with Mr HC Calpine (DOR(A)) and Dr Jacinto Steinhardt, Director OEG, was successful in arranging a series of tripartite operational research symposia on naval problems. In March 1959 the first one was held in Key West at which time it was agreed that they should be held at intervals of about two years. The theme of this symposium was Anti-Submarine Warfare. It was attended by twelve Canadians of whom five were Service Officers (Naval and Air) and four were OR scientists. The latter presented five papers at the symposium. The second one was held at the Royal Naval College in Greenwich 17-21 April 1962. The main theme was Naval Operational Research Problems in Limited Wars. It was attended by seven representatives from Canada including 3 OR scientists. At this symposium four papers were presented by the Canadian delegates.

84. The Third Tripartite Operational Research Symposium on Naval matters was held at the Canadian Services College Royal Roads, Victoria B.C. in June 1963. The general theme of this symposium was problems involved in long range predictions. Twelve Canadians participated in this symposium and presented eight papers. The symposium was opened by Rear Admiral WM Landymore, Maritime Commander, Pacific. The general Chairman was Dr JS Vigder, the symposium coordinator was JED McCord and the symposium editor was RS Keir. The theme of the fourth and the last symposium was the use of exercise data in operations research. It was attended

by 14 Canadian representatives, 9 of them active in OR. Five papers were presented by the Canadians and Dr JS Vigder made closing comments at the symposium.

85. DOR(N) staff also participated in several Supreme Allied Commander Atlantic (SACLANT) ASW Symposia and presented papers at the meetings. These symposia emphasized ASW in the NATO environment and were of great interest and value to DOR(N).

86. Examples of the type of work being done by DOR(N) in the late 1950's were three studies completed in the fall of 1958 by Mr J Langis under the direction of Dr Vigder, DOR(N), on fitting frigates with helicopters, fitting St. Laurent class destroyers with helicopters and long range sonar, and on the modernization of SIOUX and CRUSADER. A further specific study requested in August 1958 by Captain Russell DUSW concerned the usefulness of ASW helicopters operated from escort vessels.

87. Other OR work conducted during the latter part of the 1950-1960 decade included studies in the following areas: modernization of the CS2F Tracker aircraft; the use of homing torpedoes rather than depth charges; the RCN requirement for submarines; the air defence of escort vessels; equipment for escort vessels; the possible use of hydrofoils in ASW; and the potential of ship-borne sonobuoys. The nature and scope of other studies can be had from the titles of the publications given in Annex D, Vol III.

88. In 1960 Commodore JV Brock, ACNS(A&W) felt that there should be a more close-knit organization in Naval Staff, and was instrumental in forming a combined military-DRB group to study future requirements. To accomplish this aim he created a Directorate of Naval Operational Requirements (DNOR) under a Captain and after some discussion with DRB arranged to have the DOR(N) group do most of their work in this directorate. DOR(N)

continued to exist and was responsible for providing operational research assistance to other parts of the Navy including the Operational Evaluation Organization and VX10 the Fixed Wing Experimental Squadron. The individual holding the appointment of Director, DOR(N) was also named Assistant DNOR (Analysis and Evaluation), and acted as deputy DNOR. At the same time the old Gunnery, Torpedo Anti-submarine (TAS) and Action Information and Electronic Warfare (AI&EW) Directorates were combined into the Directorate of Naval Fighting Equipment Requirements.

89. During 1960, a major change of organization took place in military operational research. Formerly, the Operational Research Group (ORG) functioned as an Establishment under the direction of a Superintendent. One of the major tasks was to establish and demonstrate the usefulness of techniques of operational research within the services. This required close liaison between the Superintendent and the Services, and with the Service operational research teams for which he acted as an advisor and referee.

90. With the increasing acceptance and use of operational research by the Services and also with the increased competence and experience of operational research staffs, the teams became more closely concerned with Service plans and policy. Consequently, it was decided that each of the service teams should be set up as an autonomous group within its service headquarters.

91. In April 1960, the ORG and the position of Superintendent ORG ceased to exist. The ORG staff who were members of ORG were regarded as constituting an Operational Research Corps (ORC), although they were posted to Service directorates. However, the responsibility for their assignments, the scientific caliber of their work, and their training rested with the Director of the Service OR team in which they were employed. In each of the three

Armed Services, the Scientific Adviser of each Chief of Staff consulted with the Director and Service agencies concerned regarding the program in that Service.

92. In place of the position of Superintendent ORG, the position of Chief of Operational Research, DRB(COR/DRB) was created. COR/DRB continued to advise the DRB Director of Personnel on recruitment, transfer, promotion, posting and careers of personnel in the ORC. COR/DRB reported to the Chief Scientist, DRB.

93. In April 1960 Dr W Petrie was appointed Chief Operational Research (COR/DRB). He had been Superintendent ORG since 1958. At the same time (Ref 3) DOR(N) was reorganized as the single OR directorate at Naval Services HQ and the official holding unit for OR staff employed elsewhere with the RCN.

94. As re-organized, the operational research teams were as follows:

In DRB Headquarters:

COMANSEC - The Computation and Analysis Section, reporting to COR/DRB.

DSAG - The Defence Systems Analysis Group, reporting to VC/DRB.

In Naval Headquarters:

DOR(N) - The Directorate of Operational Research (Navy).

In Army Headquarters:

CAORE - The Canadian Army Operational Research Establishment

In Air Force Headquarters:

DORS(Air) - The Directorate of Operational Research Services (Air) reporting to Chief of Operations.

DSE - The Directorate of Systems Evaluation, reporting to Chief of Operational Requirements.

95. At that time the naval operational research program fell into four main parts: studies of future operational requirements; effectiveness of present and proposed equipments and systems; tactical studies and analyses of operations; and scientific support for the operational group that evaluated new equipments.

96. About half of DRB operational research staff in Naval Headquarters was engaged in studying systems to meet long-term requirements. This group worked in the analysis and evaluation division of the DNOR. Because future roles cannot be predicted with certainty, a broad range of requirements had to be examined. Some unconventional systems were being studied, with a view to obtaining the best cost-effective results for a number of specific roles.

97. The remainder of the staff worked in the weapons requirements division of the DNOR. This group was engaged in evaluating present systems and proposals for new weapons. Most of this work was in the anti-submarine field, and an extensive study of the effectiveness of modern escorts was done. Other studies included airborne systems, harbour defence, and the capabilities of the 3"/70 guns.

98. In 1961 Rear Admiral Brock (now promoted and appointed VCNS), after much discussion with DRB arranged to have the Anti-Submarine Operational Research Team in Halifax report to

HQ through DOR(N). At this time it was arranged that each field section reported through a HQ OR directorate rather than directly to the Superintendent of the Operational Research Group.

99. It is of interest to note that in 1962 it was officially recognized that DOR(N) reported to ACNS(A&W) and that field personnel from DOR(N) were attached to the Maritime Commander, Atlantic, the Commander Operational Evaluation Group, (COMOPVAL) and the Joint Maritime Warfare School (Ref 4). This relationship came about as a result of a reorganization of OR services and a change in the role of the Chief of Operational Research, DRB (COR/DRB). The revised functions and terms of reference of COR/DRB and the reorganized form of the ORC were defined in Ref 4 which is reproduced as Annex G.

100. In the latter part of the period of this review (1963 - 1965) the activities in naval OR work at NDHQ ranged over a great variety of projects. Several of the more important or interesting of these are described briefly in the following paragraphs.

101. It had been decided to investigate the possible use of war gaming ASW operations. Initial work on this project was done by HL Seymour and RS Keir. The war game facility was used to investigate several problems; one of the earlier uses was the study of the effectiveness of various combinations of maritime weapons systems. Other areas investigated by this method were general ocean surveillance and maritime force structure. The latter involved much work and new approaches and led to a continuing project on the composition of future maritime forces. Later this development was ably advanced by Dr NJ Hopkins when effort and money were successfully devoted to automating the maritime war game.

102. Work was done on planning exercises for testing the use of moored sonobuoys. This work was pursued in conjunction with

DSE, staff at Maritime and Maritime Air Commands, and the Maritime forces. Further account of this development is given later in this review in the section dealing with OR at Maritime Command Atlantic.

103. The desirability of providing the FHE400 Hydrofoil with the capability to launch and monitor sonobuoy systems was investigated. A large project that was undertaken on a joint basis with OR scientists and military staff at NDHQ and Halifax, was the study of maritime command and control requirements. A comprehensive report on this project was issued.

104. Other areas of investigation included the study of towed ultra deep sonar, ammunition requirements, maritime requirements for peacekeeping, the analysis of moored buoy data, and ASW in the Arctic.

105. During this period the DOR(N) staff participated in a number of important studies on a joint or contributory basis. In April 1961 a re-examination of naval objectives to determine whether existing activities and future plans were adequate was undertaken under the Chairmanship of Rear Admiral JV Brock. Although DOR(N) was not represented on the Ad Hoc Committee set up to report on Naval Objectives, DOR(N) staff members contributed considerable analysis to the work of the Committee.

106. At the request of the Minister of National Defence a study was done in 1963 with the aim of setting forth the composition and cost of a mobile force. This force was envisaged as basically an air transportable fighting unit deployable and employable in any part of the world. Dr. JS Vigder was a member of the Planning Group and he and his staff again made significant contributions to the study.

107. In September 1963 a study committee was set up with the aim of recommending the size and shape of the RCN for the period 1964-1974. The Chairman was Commodore HG Burchell and DOR(N) staff were contributors to the committee in a number of studies. The committee made its report in January 1964.

108. In July 1964 the Maritime Systems Studies Group which had been set up to define and compare the major alternatives which were available to Canada in the field of Maritime Warfare Systems during the next decade (1964-1974) made its report. Again the DOR(N) staff contributed to the work of this group by providing analyses and participating in discussions.

109. In concluding this review of the OR work it is informative to present a short summary of OR activity for the RCN as prepared for the DRB Annual Report 1964. This submission as prepared by COR/DRB is given in the following four paragraphs.

110. Operational research on behalf of the RCN was conducted during 1964 at Headquarters, within the Directorate of Naval Operational Requirements, (DNOR), and at field units, by the staffs of the Maritime Commander Atlantic, (COMMARLANT), the Joint Maritime Warfare School, (JMWS), and the Commander Operational Evaluation Organization Force (COMOPVAL). In August an operational research scientist was posted to the staff of the Maritime Commander Pacific, (COMMARPAC). Activities of these groups have covered a wide spectrum, ranging from the tactical use of systems in being to the study of future force structure.

111. One major study concerned the possible use of an airborne submarine detection system in surface ships. Trials of this system were conducted by COMOPVAL to determine operational ranges against specific targets, to measure the accuracy of target bearings, and to assess the interference from surface ships. Results of the trials showed that the general performance figures

obtained from aircraft operations are applicable to shipborne systems. Studies were also conducted in DNOR regarding the tactical advantages to be gained by projecting sonobuoys a substantial distance. This study suggested that quite major gains might be realized in some tactical situations, e.g. in support of other sound surveillance systems. Such gains, if attainable in practice, would be very worthwhile.

112. Work of the Anti-Submarine Warfare Operational Research Team at COMMARLANT was concentrated on the performance of equipment in service with the object of attempting to devise more effective tactics and procedures. Many studies were carried out concerning the variation in system effectiveness with time and circumstance as well as studies of the operating characteristics of possible targets. Through the analysis of exercise data a tendency towards non-randomness or periodicity, both in the effectiveness of detection systems and in the occurrence of opportunities for detection, has been discovered. Some progress has been made in predicting this periodicity, and in devising appropriate tactics and procedures.

113. A large part of the work carried out in Naval Headquarters was concerned with means of increasing the mobility of Canadian maritime forces and with the provision of sea lift to Canadian forces including those engaged in peace-keeping operations. One very striking conclusion was that the addition of one underway replenishment ship on the East Coast could result in very nearly doubling the effective time on station of the destroyer force under a wide range of plausible circumstances.

114. The record shows that the authorized establishment of DOR(N) in 1962 was eight DRB scientists and no naval officers. But the RCN always provided officers to assist with the special studies on an as and when required basis. However, the number of OR scientists on strength even in 1964 was only seven including

the Director. In November 1964, the DOR(N) staff members were: Dr JS Vigder (Director), JED McCord, Dr AC Lauriston, JG Jones, RD Wilmot, RS Keir, and WSP Ward.

DEFENCE SYSTEMS ANALYSIS GROUP

115. This account of OR at NSHQ would not be complete without some reference to work done on maritime operations by the Defence Systems Analysis Group (DSAG). This was the group of OR scientists set up by DRB for the purpose of undertaking special studies required by the Chiefs of Staff on particular problems of joint service defence systems. It was organized in 1960 and consisted of a director and two sections each headed by a senior OR project leader. Some work related to maritime operations was performed by both of these sections.

116. One of these sections headed by JW Mayne, formerly DOR(N), undertook a project concerned with the expected pay-offs occurring from extending various parameters that were functions of ASW effectiveness. Such parameters included speed of vehicle, detection range of sensor, kill probability of weapon, etc. The overall aim of the project was to provide guidance development of ASW equipment and systems. Considerable work was done on this project with respect to vehicle speed and sensor range including extended ranges of magnetic anomaly detection equipment, but on the posting of the project leader to become Director of the Canadian Army Operational Research Establishment in Nov 1963 work on the project ceased. However several relevant papers had been produced (Annex D, Vol III). Other naval OR done by the section included the study of data handling problems and the potential of sonobuoy type systems used against submarines.

117. The other DSAG section under GD Kaye carried out a study of the air defence of Canadian destroyer escorts and contributed to the work of the Maritime Systems Study Group.

118. Personnel of DSAG who worked on naval OR problems included AJ Looker, JD McRuer, JW Mayne, GD Kaye, and Norwegian Military Officer E Reine who was working at DSAG under a DRB NATO fellowship.

CONTRIBUTION TO THE ANTI-SUBMARINE WARFARE RESEARCH CENTRE, LA SPEZIA, ITALY

119. Canadian OR scientists made significant contributions to the research work of the Supreme Allied Commander Atlantic (SACLANT) Anti-Submarine Warfare Centre at La Spezia, Italy. This Centre had been operated in the interests of NATO and SACLANT by the Societa Internazionale Ricerca Marine but on 1 February 1963 it came under International Military Headquarters management.

120. The first Canadian OR scientist to be posted to this Centre was Dr GR Lindsey in September 1961. He joined as Group Leader for Operational Research and Analysis and remained in that position till the summer of 1964. He was followed by Mr J Langis of DOR(N) as an OR analyst who served there from 25 Aug 1964 to 31 May 1967. He in turn was succeeded by Mr RP Hypher in 1970. All three of these scientists were experienced OR analysts who contributed much to the research program of the Centre.

OPERATIONAL RESEARCH AT MARITIME COMMAND ATLANTIC

INTRODUCTION

121. On 1 October 1950 a school of maritime warfare was formed at HMCS Stadacona, Halifax, NS. This RCN/RCAF school was reorganized with effect from 1 November 1951. Functional control of the school was to be exercised jointly by the Flag Officer Atlantic Coast (FOAC) and the Group Commander, Maritime (Air) Group through two directors of equal status; one representing the RCN, the other the RCAF. Oddly, administrative direction was the responsibility of the Commodore, RCN Barracks Halifax who outranked the Joint Directors.

122. The functions of the school (at that time referred to as the Maritime Warfare School (MWS)) were as follows:

a. To train ship command teams and aircraft crews to work together.

b. To assist Naval and Air Commanders to organize (but not necessarily to control) joint sea/air exercises when requested to do so.

c. To conduct courses as required for:

(i) Senior officers destined for staff posts or command of ships; with emphasis on the strategic implications of anti-submarine warfare, and the importance of inter-service cooperation;

(ii) Junior officers, as a general introduction to advanced joint anti-submarine warfare tactics.

d. To study and recommend joint anti-submarine warfare tactics for areas in which Canadian forces are likely to operate.

e. To propose operational requirements for equipment and weapons, and advise on the tactical requirements in the design of ships and aircraft, insofar as these concern advanced joint anti-submarine tactics.

123. The nature of these functions indicates clearly that operational research could make valuable contributions to the activities of the MWS which was soon renamed the Joint Maritime Warfare School (JMWS). Consideration was given to establishing an OR team to work with the MWS but it was not until December 1952 that a team of two scientists was actually in being; the first of these arrived in June 1952. A copy of the original terms of reference of the team called the Anti-Submarine Warfare Operational Research Team (ASW/ORT) is given in Annex H, Vol II. These terms of reference were approved at the 12th Meeting of the Sea/Air Warfare Committee in May 1952. This document shows very distinctly the joint character and responsibilities of the team in relation to the two Services.

124. As often happens these original terms of reference did not prove entirely satisfactory and by March 1956 we find a new set being proposed. A copy of the revised terms of reference is given in Annex I, Vol II. The main change was in defining a procedure for the initiation of projects for the Team. The terms of reference were revised several times during subsequent years. The association with JMWS continued and ASW/ORT remained at JMWS for office quarters and motor transport.

THE ANTI-SUBMARINE WARFARE OPERATIONAL RESEARCH TEAM

125. The first head of ASW/ORT was WJ (Bill) Jones who was from the Admiralty Joint Anti-Submarine School in Londonderry. He reported for duty in the summer of 1952. He was on loan from the UK and played an important role in starting operational research work with the RCN in Halifax. A very important contribution was the training and direction given to less experienced Canadian operational research scientists. He was joined in December 1952 by Mr JF Ruddell who had been doing operational research for Maritime Air Command at Greenwood, NS since June 1950.

126. It should be observed that the members of ASW/ORT were officially members of the DOR(N) staff. The arrangement was that DRB allotted a pool of scientists to DOR(N) to meet all naval requirements for operational research, including any Joint Command or Service for which the CNS was the executive agent. DOR(N) was responsible to CDRB for ensuring that these scientists were properly employed, and assigned them duties in consultation with ACNS (A&W) who was the Naval Member of the Joint Operational Research Committee. This procedure was in conformity with the extant terms of reference of ASW/ORT.

127. During the period covered by this review the several OR teams or units engaged in a great variety of studies. The major part of the work of the ASW/ORT was concerned with ASW exercises. This work involved assistance in the design of such exercises but concentrated mainly on exercise analysis and on ways and means of improving anti-submarine actions. Each year three or four major exercise reports (Canada/USA, Canadian, and NATO) were produced and were highly regarded by the international ASW community.

128. Canadian maritime forces were active during the early 1950's in developing and testing new ASW equipments and tactics for their employment. These equipments included new sonars (eg. VDS, AN/SQS-504), explosive echo ranging with air-dropping passive sonobuoys, ASW helicopters, and new acoustic detection systems.

129. In all this work the ASW/ORT participated in various stages by providing technical, statistical, and operational research skills to assist naval planners and operators in devising the necessary exercises and testing procedures. In this participation the team evidenced ingenuity and innovativeness, and contributed much hard work.

130. A particular aspect of related work was the study of procedures and methods for the selection and training of sonar operators which led to improvements in these important areas. To assist the team in this work Dr TW Cook and DA Grant were posted to ASW/ORT by DRB in 1953, and JA Easterbrook in 1956.

131. The names and dates of tenure of the Senior Operational Research Officers (SORO) of ASW/ORT were:

WJ Jones	1952 - 1954
JED McCord	1954 - 1957
RL Baglow	1957 - 1957
Dr NJ Hopkins	1957 - 1961
MF Coffey	1961 - 1966

132. In addition to the work on exercise analysis and the other activities already mentioned, work was done by the OR team in the mid-fifties on the operational performance of an intercept receiver - the UPD 501, on the limiting lines of submerged submarine approach to a convoy, on the capability of the APS 20 radar in detecting snorkelling submarines, on the passive detection of schnorkel exhaust, and on the analysis of various types of data.

133. During Mr McCord's tenure as SORO/ASW/ORT several new investigations were conducted by the Team. Among these were the testing of airborne sonobuoy equipment, the study of the capability of various acoustic devices, electronic counter measures policies for ships and aircraft, and the development of tactics for the use of airborne sonobuoy equipment. A description of some of this work is given in the following paragraphs.

134. During World War II it was noted that the sound from explosive charges, set off in the ocean, would travel for considerable distances. It was not until the mid-1950's, however, that experiments aimed at a possible operational application were undertaken. Some of the early experiments were initiated by Flight Lieutenant EA DeLong of MAC, and designed and analysed by Mr JED McCord and Mr RL Baglow of ASW/ORT. These experiments which took place in 1955 and 1956 would not have been possible without the assistance of the Maritime Proving and Evaluation Unit (MP&EU) of Maritime Air Command. The air-launched sonobuoy which was being developed and used to obtain passive aural detection of submarines was also an essential feature of the explosive echo ranging concept. As the experiments progressed it was determined that relatively small charges (one ounce) would produce satisfactory results.

135. When the Canadian experiments were in their early stages the ASW/ORT staff became aware of parallel work being sponsored by the US Navy (at Daystrom Inc), and a cooperative exchange of information and test results continued until explosive echo ranging became an operational system. By 1956 explosive echo ranging had become popularly known as "Julie". The technique was named after a favorite strip tease artist in Washington DC who, as the saying went, "made passive buoys active". In scientific circles the term for explosive echo ranging was more commonly quoted as EER or E^2R. Operational use of echo ranging was successfully accomplished on a squadron training exercise

at Guantanamo 1957, within two years of the early experiments. This accomplishment must be some sort of record with respect to the origin of a concept to its successful operational implementation!

136. A passive acoustic anti-submarine detection and classification project designed for use in maritime aircraft was undertaken largely through the initiative of officers in MAC. Flight Lieutenant EA DeLong and Flight Lieutenant RH Hicks with assistance from Mr RL Baglow and later Flight Lieutenant JR Hudson, Mr RP Hypher and others of ASW/ORT, conducted numerous experiments beginning in 1957; these continued through the 1960's. In doing so they were ably supported by the MP&EU and its facilities.

137. The first airborne experiments in support of the new concept were flown by a Neptune aircraft of MP&EU. Close cooperation between the Canadian Forces, the USN, and Bell Telephone Laboratories resulted in the use of an operational airborne sonobuoy system within three years of the early Canadian experiments. Implementation of the new system was accelerated by a convenient, but unofficial exchange between MAC and the USN. The Canadians had a large quantity of passive aural sonobuoys available, and these were traded for the USN - Bell Telephone sonobuoy recording equipment.

138. Operational research personnel in Halifax continued to assist in the improvement of the system as it progressed in operational use in aircraft and ships through the 1960's.

139. The Directors of the JMWS regularly submitted quarterly status reports of analyses and investigations to the Naval Secretary and other interested agencies. In general ASW/ORT staff produced independent reports and a listing of these is given in Annex J, Vol III. An example of joint work and publication reads in part: Project AI-9/55 - The Effect of Long Range Sonar on Current NATO Doctrine for Anti-Submarine Ships.

Status: Distributed by JMWS under MWC 1670-1128 dated 15 March, 1957 and Anti-Submarine Warfare/Operational Research Team Memorandum 6165 on 11 March 1957.

The title of the ASW/ORT paper was "A Study of the Effect of the Use of Long-Range Sonar on ASW Tactics" (by AJ Tingley, JED McCord).

140. Initially the ASW/ORT tended to be heavily involved in naval studies and surface trials but under McCord and Baglow close working relations were developed with MAC. Office space was assigned in MACHQ on South Street, Halifax and OR personnel worked there on MAC problems. A little later Mr RP Hypher who joined the ASW/ORT team in 1957 was assigned full time to MACHQ although he remained a member of ASW/ORT. He was given the title of SORO at MACHQ. Thereafter there was extensive cooperation in the OR work being conducted for the Flag Officer Atlantic Coast (FOAC) and for the Maritime and Maritime Air Commanders. The SOROs at MACHQ were:

RP Hypher	1957 - 1961
AG Staflund	1961 - 1962
DA Grant	1962 - 1966

141. The OR staff at ASW/ORT developed good working relations with the Defence Research Board's Naval Research Establishment (NRE) across the harbor in Dartmouth. NRE staff provided the OR scientists with scientific and technical advice in conjunction with trials and projects. As well, technical equipment was made available by NRE and there were frequent consultations and discussions on various aspects of the OR work. Mention should also be made of the help and support provided to ASW/ORT (and to Maritime Command Operational Research Branch as it was called later) by the several NRE scientists who held the appointment of Scientific Advisor to the Maritime Commander.

142. The proximity and good working relations between NRE and ASW/ORT were responsible, in large measure, for three NRE staff members deciding to enter operational research. The first of these was FG Millar who joined ASW/ORT in July 1960 and finished his career in OR work in December 1973. The two others were GJ Hutton who made the change in April, 1968, and NO Fothergill who did so in August, 1970. The exchange of personnel was not entirely one way as Dr AC Lauriston, one of the earlier OR scientists, served a tour of duty at NRE (Defence Research Establishment Atlantic with effect from July 1967) from December 1965 to July 1970.

143. It is interesting to note that during the early years of ASW/ORT, the old Admiralty House was the Naval Mess. Facilities were not considered adequate and the new HMC Stadacona Mess was built. ASW/ORT personnel claimed that they found the atmosphere and fellowship at the Admiralty House more cheerful and desirable under the crowded conditions that obtained there, than they were in the new mess.

144. A further revision in the terms of reference of ASW/ORT approved by the Joint Operational Research Committee on 4 Sept 1958 made the team responsible to the Maritime Commander rather than to FOAC and the Air Officer Commanding (AOC) Maritime Air Command as had been the case with effect from 21 Mar 1956 as per an earlier version of the terms of reference. Some of the changes in the terms of reference were made to reflect changes in command structure and working relations between the staff of the FOAC and Air Officer Commanding MAC.

145. It may be noted that according to the 1958 terms of reference projects for the Team could be proposed by NSHQ, Air Force Headquarters, and the Defence Research Board. Later, changes were made in this understanding to the effect that the sole tasking authority was the Maritime Commander although work could and was done at the request of NSHQ or DOR(N) at NSHQ. Working relations between ASW/ORT and the Director of Naval OR at Naval Service Headquarters were always congenial and cooperative.

146. ASW/ORT remained with the JMWS until 1960 when it moved into the Maritime Headquarters in the Dockyard. This move was made to bring it more directly into day-to-day contact with the staff of the new headquarters which was fully in operation by that time having taken over many of the functions of the old Naval and Maritime Air Headquarters. Admiral HJ Pullen, Commodore WM Landymore, and Group Captain RA Gordon were primarily responsible for this relocation of the Team. At that time the senior operational staff officer, Dr NJ Hopkins, became a full member of the staff of Maritime Command Headquarters. In addition to the main body of the team, individual members were attached to the JMWS, MAC, and COMOPVAL. Close working relations were also established with the Scientific Advisor to the Maritime Commander and NRE, Dartmouth.

147. To provide OR assistance for the JMWS after ASW/ORT moved out of the School one OR scientist of the ASW/ORT staff was assigned to the JMWS on a full-time basis. The first of these was DM Murray formerly with DOR(N) at Naval Services Headquarters. He had joined ASW/ORT in 1957 and remained at JMWS for the period Sept 1961 - 1966 after which he was posted to what had become Canadian Forces Headquarters in Ottawa on the staff of the Director of Maritime Operational Research (DMOR).

148. Among the many projects successfully undertaken by Mr Murray while at JMWS ans ASW/ORT his contributions to the development of shipborne sonobuoys were particularly noteworthy. He spent much time at sea developing and adapting the system. Some outstanding results were achieved and the concept was adopted by the navies of the USA and other nations. Shipborne sonobuoy equipment was acquired as operational fitting for Canadian ships.

MARITIME COMMAND OPERATIONAL RESEARCH BRANCH

149. In April 1966 the name of the Anti-Submarine Warfare Operational Research team was changed to the Maritime Command Operational Research Branch (MC/ORB). The directors after this change were:

MF Coffey	1966 - 1968
DA Grant	1968 - 1973
DM Murray	1973 -

150. In conjunction with MAC, DSE and DOR(N), OR scientists at MAC and ASW/ORT carried out a lengthy series of studies of the performance and capabilities of low frequency air-dropped surveillance sonobuoys. The first stage of this work involved the use of standard free-floating buoys to evaluate the detection and tracking capabilities of fields of free-floating buoys. The performance of these fields provided data on the possible capability of fields of moored buoys. It was based on the use of moored sonobuoys fitted with hydrophones, a tape recorder, and a highspeed play back transmitter device that could be triggered by a signal from a monitoring aircraft which then recorded the transmission, analyzed it on board or returned it to a shore base. Extensive trials proved the practicality and value of the system for providing information on submarines transitting the areas in which the buoys had been dropped.

151. The development and testing of the new concept involved much work and many people. Among those who contributed a great deal to the work, mention should be made of Mr DA Grant, SORO at MACHQ, and Mr Arthur Levin of EMI Cossor, Ltd. The sea trials of the concept were concluded over a period of time (1962-1966) in a series of experiments which were called Ocean I, II, III, and IV.

152. A major contribution by ASW/ORT due to MF Coffey and other members of the staff was made in the field of command and control. A procedure called the DATA-O (Data Analysis and Threat Assessment Officer) System based on a well organized collation of available information and the use of statistical techniques was devised which produced a marked increase in command and control effectiveness. It made possible more accurate predictions and projections of the positions and tracks of 'enemy' submarines than had been possible without it. As a result available forces could be more effectively employed in ASW than heretofore.

153. The development and use of the DATA-O concept deserve some recording. By the time of the Cuban crisis in 1963 it became apparent that the introduction of new sensors as well as improvements in current ones was resulting in a flow of information which at times threatened to swamp the headquarters, especially since there was no basic system for collating and correlating the information. The high number of false contacts in addition complicated the problem (a ratio of about 10% valid 90% false). During the Cuban crisis ASW/ORT had hurriedly pulled together a very primitive system for coping with the information flow, and by the time the operation was over it could plainly be seen what the requirement was.

154. Under Coffey's direction the ASW/ORT staff, particularly Messrs HL Seymour, FG Millar, and AJ Looker, began to attack the problem. Graham Millar had developed the first crude forecast concept whereby he tried to assign values to events and correlate these and produce strategic estimates of where the targets were moving; he had some success.

155. It was agreed that there were three requirements. First, a systematic way of recording the information on the events, and its storage and retrieval; secondly, a technique for assigning worth or probability of validity to events; and finally, a technique for incorporating the assigned events and their values so that probabilistic estimates could be made of the tracks of the intruder and their intentions.

156. A computer with a video display was the solution to the first problem but use had to be made of a simpler punch card and knitting needle approach with overlays and coloured symbols. This set-up was surprisingly satisfactory except that the first military officer to operate the system turned out to be a service rarity, in that he was colour blind.

157. After considerable work, and despite pessimistic forecasts from most of the people in the business, Seymour, Millar and Looker, each contributing a share of the solution, came up with the first model, which Seymour molded together into a workable concept. Briefly the model, using field detection data, could assign probabilities of validity to some 5,000 different events and combinations of events. Treatments were arranged so that from these, probabilities of validity of tracks could be developed. With this arrangement a logic control operated in which the human operator's input and the projections were incorporated producing estimates of target location.

158. The first runs of the system were done by the ASW/ORT staff, with Mr CLR Unwin of the Operational Evaluation Organization and staff from DOR(N) and MAC all contributing. Quite an effort was involved since an attempt was made to run the system 18 hours a day during a large exercise, but scientific curiosity kept the group going. The results were most encouraging especially when the DATA-O estimates were compared with those obtained using

the Operations Room current system. A few improvements were built in, the probabilities were expanded a bit, and on the next exercise, military officers ran the system with the ASW/ORT staff keeping the system going with help from other staff.

159. At the end of the exercise a team came up to Halifax from the US Anti-Submarine Warfare Force Atlantic and took back with them all the DATA-O material. It was tested by the USN, adopted in principle, computerized, and put in use at various USN stations. The DATA-O system underwent various improvements in Canada and later under DA Grant's direction it was automated to a large degree and called the Contact Correlation Program Package (CCPP).

PERSONNEL

160. From the early days of ASW/ORT it was the custom to employ students and professors to undertake OR work during the summer months. These temporary staff members made valuable contributions to the work of the team. Among those particularly worthy of mention were AJ Tingley, G Cross, R Boorne, RG Cassidy, HM Bradford, and a little later WP Cherry, MJ Kirby, and O Cochkanoff.

161. An attempt has been made to list the names of the personnel who were on the staff of ASW/ORT during the period covered by this paper (1952-1966). The names are included in Annex F along with those on the staff of DOR(N).

162. This rather brief account of OR at Maritime Command Atlantic indicates some of the work and accomplishments of the ASW/ORT and its successor, the MC/ORB. It does not, however, convey the high degree of success that the OR staff had in working with the naval staff. Working relations were close and cooperative

and the OR staff got involved in all major problems of the Command in which their services could be of use. The ASW/ORT and MC/ORB have long been considered one of the most productive and useful elements of military OR in Canada. That it has been so considered is due to the ability, initiative, and high professional quality of its staff and senior officers.

OPERATIONAL RESEARCH AND THE OPERATIONAL EVALUATION ORGANIZATION

INTRODUCTION

163. The Operational Evaluation Group of the RCN was formed in August 1955 as the result of a decision by Naval Board. Later called the Operational Evaluation Organization (OPVAL) this unit was commanded by a LCdr called COMOPVAL and originally had one other junior Naval Officer on the permanent staff, the first of whom joined the staff in January 1956. In view of the operational testing and the evaluating nature of the work involved, DRB agreed to appoint an operational research scientist to COMOPVAL to assist in the planning, design, conduct, and analysis of the evaluation projects.

164. The unit was located in Halifax but was under the direction and control of NSHQ and responsible to the Canadian Flag Officer Atlantic Coast (CANFLAGLANT) for administration. The DRB member remained on the staff of DOR(N) in Ottawa but was located with OPVAL in Halifax. A screening committee was established at Naval HQ to review each request for evaluation, decide on its merits, and allocate priority. It was called the Operational Evaluation Project Committee (OEPC) and was formed to provide direction and control of COMOPVAL's program. It came under ACNS(A&W) and was chaired originally by the Director of Training and Staff Duties.

165. The scope of the operational evaluation organization included:

a. Ship-fitted operational equipment

b. Aircraft fitted operational equipment concerned with ASW

c. Operational shore installations

d. Operational training devices

166. The Terms of Reference for COMOPVAL were as follows:

a. To coordinate and supervise all operational evaluations carried out in HMC Ships or Establishments as directed and subject to priorities from Naval HQ.

b. To process and record data derived from such evaluations and produce the pertinent COMOPVAL reports.

c. To make recommendations for alterations to ships or equipment arising out of the evaluations.

d. To recommend new tactical doctrines arising from equipment evaluations to the Joint Maritime Warfare School.

167. These terms of reference give ample evidence of the wide scope of activities for which COMOPVAL was responsible under the direction of the Naval Headquarters Committee. They also indicate that the associated activities were such that OR could contribute much to them.

168. The types of evaluations with which OPVAL was concerned were called operational and technical evaluations. An operational evaluation was the test and analysis of a specific item or system, insofar as practicable under service operating conditions in order to determine whether quantity production and procurement was warranted, considering;

a. the increase in military effectiveness to be gained and,

b. its effectiveness as compared with currently available items or systems.

Consideration was also given to:

c. personnel capabilities to maintain and operate the equipment,

d. size, weight, and location,

e. procurement, installation and maintenance costs, and

f. foreign capabilities in the field.

169. A technical evaluation was the study and investigation by a research or development authority to determine the technical suitability of material or various components of an equipment or system for use in the military service.

170. The first Commander of OPVAL was LCdr CJ Benoit. The first DRB scientist was Mr Keith R Kavanagh who reported for duty 1 Aug 1955. He had been with DRB since 1 Apr 1954 as a member of the staff of the RCAF OR Section under the Chief of Air Operations. Mr Kavanagh remained with OPVAL for 3 years and contributed a great deal to the design and analysis of the many evaluations that took place during this period.

171. Arrangements for personnel administration and scientific responsibility for the DRB member of OPVAL were that Superintendent/ ORG (S/ORG) would be responsible for all personnel administration for the DRB representative with OPVAL and a direct channel of communication was authorized for this purpose; the DRB representative would be responsible to COMOPVAL for work on OPVAL projects;

in addition to normal OPVAL channels of communication, direct liaison links were authorized on scientific matters between the DRB representative at OPVAL and DOR(N) and SORO ASW/ORT.

EARLY WORK AND PROJECTS

172. On 13 October 1955, the Operational Evaluation Project Committee held its first meeting to assign initial projects to COMOPVAL. The projects assigned covered a wide variety of equipments and involved several different ships. Brief details of seven of these are given below:

Project	Anticipated Commencement Date
The evaluation of the:	
a. Bird Class Patrol Vessel - HMCS LOON	3 Jan 1956
b. 27 foot LCP	7 Nov 1955
c. Electro-magnetic Log	1 Feb 1956
d. AN/UPD 501 SHF/DF Equipment	15 Dec 1955
e. Auto-Follow System for Mk. 6 Director	3 Jan 1956
f. Simulated Radiac Meter (Technical Assist Project)	2 Nov 1955
g. Detection Capabilities of Radar AN/SPS12 Against Low Flying Aircraft	- - -

173. In Oct 1955 the first assignment of work was forwarded to COMOPVAL and consisted of eight projects. In addition, there were approximately six further projects which were ready for evaluation during the opening months of 1956. In carrying out each project a Project Officer was seconded to COMOPVAL but he had normal duties to perform and it turned out that due to the large number of projects that were assigned there was always a large backlog of projects to be undertaken.

174. An electrical officer joined the OPVAL staff in January 1956 and later in the year a civilian technician was added. Five additional projects were added at about that time and from April 1956 to January 1957 sixteen more projects were assigned. Eight of the projects had been completed before an additional officer was added to the staff. The first project completed was the evaluation of the Detection Capabilities of the AN/SPS12 Radar.

175. In the conduct of each project, the responsibility of COMOPVAL (and the small full-time OPVAL staff) was:

a. To arrange for the necessary ship time through CANFLAGLANT;

b. To arrange for the secondment of a Project Officer to COMOPVAL staff part-time, or in some cases full-time for large projects;

c. To arrange through the Dockyard for the installation of the particular equipment and for technical support, if required;

d. To advise and assist the Project Officer in all stages of the evaluation including:

(1) preparation of the Project Plan;

(2) design and conduct of the evaluation;

(3) collection and analysis of data;

(4) preparation of the evaluation report.

176. By June 1956 the borne complement of OPVAL consisted of one Executive Lieutenant Commander as Officer-in-Charge, one Lieutenant, one DRB representative, and one Stenographer Grade 3.

177. With this small full-time staff COMOPVAL was unable to keep up with the volume of projects assigned and a request was made for the addition of an executive LCdr or senior lieutenant. But additional staff was not readily available. It is surprising that COMOPVAL accomplished as much as it did with such small manpower resources.

178. During the period 1955-58, some of the more important projects completed by COMOPVAL included ship-borne radar trials, SHF/DF evaluation, comparative trials of AN/APN-59 and AN/APS-38A radars in CS2F aircraft, CAST IX Experimental VDS evaluation, Decca navigation systems for minesweepers and helicopters, feasibility trials of helicopters operating from frigates and DDEs, and a wide variety of smaller projects.

PERSONNEL

179. After serving with COMOPVAL for three years, Mr Kavanagh was succeeded on 1 Aug 1958 by Mr AJ Looker who had been with DRB for some six years latterly with CAORE. He had good background in engineering, mathematics, and statistics, and served with OPVAL for two years. Among the several evaluations that Mr Looker assisted with, two in particular deserve mention. These were the sea trials and evaluations of the 3"/70 anti-aircraft guns and the electro-magnetic ship's log. The latter was installed in the Canadian destroyer escort Restigouche, the first surface ship to be fitted with the device which was designed for use with USN submarines.

180. On 4 Sep 1958 LCdr Benoit was succeeded as COMOPVAL by LCdr RC Thurber who later served as RCN liaison officer with both NRE and as senior military officer with DMOR at NDHQ, retiring from there as Commander at the end of the year 1973. He served as COMOPVAL till 15 Aug 1960 and was succeeded by LCdr JJ Coates who remained in the post until 3 Apr 1964. He in turn was succeeded by LCdr L. Speight.

181. In 1960 Mr Looker was posted out of OPVAL and was replaced by Mr MF Coffey a former Army Officer who had become an experienced operational research scientist. He had been active in northern operational research on a variety of projects associated with the Mobile Striking Force.

182. It is of interest to note an example of the type of work performed by OPVAL and the assistance provided by the attached OR scientist as described by Mr MF Coffey: "I well remember the feeling of utter confusion, when less than an hour before the start of my first Maritime trial, I was advised that the COMOPVAL officer who was to conduct the operation (for which I had drawn up a statistical design) was unwell and the responsibility for running the operation had been passed on to me. This test involved the evaluation of four or five experimental sonobuoy models in the Julie mode. We launched at dawn from Summerside in a P2V and in a short while I discovered myself with an A class submarine, A Bird Class auxiliary vessel, a diving tender, a CS2F Tracker, and an Argus aircraft, all thrashing about, plus a limitless expanse of ocean, and a limited number of hand constructed sonobuoys. Thanks to the Forces who came to my help and cooperated magnificently, we completed the trial, and in fact introduced a new technique in sonobuoy evaluation which was called high speed Julie Candle (the submarine launched a candle or flare every 10 minutes, a new batch of buoys was dropped on the candle and bombed rapidly by all hands giving a high data sampling rate). I was greatly relieved when the operation was over. However, with this behind me most subsequent trials were a "piece of cake"."

183. In 1961 Coffey was appointed SORO/ASW/ORT and was succeeded by Mr CLR Unwin who had been on the DOR(N) staff for one year. Unwin remained in the post until 1965 when Mr WSP Ward was posted to OPVAL.

ACTIVITIES 1961-1965

184. During the period 1961-1965 COMOPVAL conducted trials on many small items of equipment and several major ones. The task was diverse and the OR man found himself involved in precision navigation equipment, safety gear, rocket flares, electro-magnetic ship's logs, air defence radar, and several kinds of sonar and sonobuoys. The latter two comprised the bulk of the work. In both areas Canada was doing pioneering work and faced problems not encountered elsewhere.

185. The Variable Depth Sonar (VDS) AN/SQS-504 had just reached the pre-production stage and was being put under trial aboard the ASW destroyer HMCS Crescent. The sonar was towed from the stern of the ship by several hundred feet of cable to put it below the near-surface layers which limit detection range. The solution of this problem gave rise to other problems associated with body motion and bearing accuracy. The latter was the object of weeks of trials in which the VDS sonar bearings were compared to ship's gunnery radar bearings taken off the masts of snorkelling submarines in various manoeuvres. It was the OR man's task to sleuth out the factors contributing to bearing inaccuracy from mounds of automatically recorded data. Among the factors were faulty (reverse) compensation for towing distance astern of the ship and, apparently, the magnetic influence of the ship upon the compass in the VDS body.

186. In another project involving the monitoring of sonobuoys from a destroyer, the treatment required was a statistical analysis of the probability of detection of an event, compensating or normalizing the data for known influences.

187. From an operational research point of view it may be of interest to note that in 1961 Mr J Langis DOR(N) assisted OPVAL in the evaluation of the AN/SQS/504 VDS System over a period of 10 months. This cooperation is indicative of the close working relations that existed between DOR(N) and the OR scientists at OPVAL and ASW/ORT.

188. Throughout the entire life of OPVAL in the RCN, the OR scientist with OPVAL worked as a member of the COMOPVAL staff and participated in all trials and evaluations. Due to the nature of the work independent OR papers were not published; the OR contributions appeared as integral parts of the COMOPVAL project reports.

189. In closing this section on operational research at OPVAL it may be appropriate to mention that OPVAL ceased to exist shortly after the integration of the Canadian Armed Forces (July 1964). Its role and functions were assumed by an integrated organization called MOTEF, the Maritime Operational Test and Evaluation Force.

OPERATIONAL RESEARCH IN MARITIME COMMAND PACIFIC

INTRODUCTION

190. During the early 1960's, the need was felt by the Commander and staff of the Maritime Command Pacific (MARPAC) for an operational research team at MARPAC Headquarters in Esquimalt, B.C. Recognition of this requirement led to a series of letters from MARPAC to Naval Headquarters in Ottawa.

191. The first of these was submitted by the Maritime Commander Pacific (RAdm EW Finch-Noyes) in Sep 1960. This requirement for operational research assistance was recognized in Ottawa by the Interservices Establishment Committee in March 1961 and exploratory correspondence was exchanged regarding the feasibility of providing personnel. However, OR staff was not available and the request was re-submitted in Dec 1962 by Rear Admiral WM Landymore, Maritime Commander Pacific.

192. It is interesting to note that Dr WN English, Acting Superintendent Pacific Naval Laboratory (PNL) in response to a memorandum from DRBHQ in the spring of 1960 concerning the proposed expansion of OR, suggested to the Maritime Commander Pacific that he request the setting up of an OR team in Pacific Maritime Command.

193. In March 1963 the Chief of the Naval Staff, Vice Admiral HS Rayner, forwarded a request to DRB that consideration be given to the provision of an operational research team in Maritime Headquarters Pacific. Sufficient work in anti-submarine warfare operations, exercise analysis, program evaluation, tactical trials, and operational and exercise planning was thought to be available

to employ two scientists gainfully. Further correspondence on the matter was continued by RAdm WM Landymore and in January 1964 the RCAF concurred in the recommendation.

194. In March 1964 the Maritime Commander Pacific advised that office space and equipment had been reserved for the OR team and that stenographic and clerical support would also be available. These facilities were reserved starting in July 1964.

195. Due to a staff shortage DRB was unable to fulfill this request until August 1964 when one OR scientist was provided to MARPAC. Mr Keith R Kavanagh reported for duty on 15 August and his appointment was as Senior Operational Research Officer. Mr Kavanagh had joined DRB in 1954, worked in three previous OR assignments with the RCAF HQ OR Section (1954-1955), COMOPVAL (1955-1958), and DOR(N) (1958-1960), followed by a four-year laboratory assignment at the DRB Suffield Experimental Station. Efforts by DRB to recruit a second scientist for the team were unsuccessful in 1964. However, the team reached its planned establishment of two a year later with the arrival of Mr CLR Unwin on 16 August 1965. Mr Unwin had gained considerable experience in Maritime OR and evaluation with DOR(N) 1960-1961, and with COMOPVAL 1961-1965.

ACTIVITIES AND WORKING RELATIONS

196. The general requirement described by RAdm Landymore in 1962 provides an accurate outline of the main fields of work for the new team, i.e. operational research studies and scientific advice on ASW operations, exercise analysis, evaluation programs, tactical trials, and operational planning.

197. As was customary for the various OR units with the Canadian Armed Forces, terms of reference for the MARPAC OR team were developed. A copy of an early version of these is presented in Annex K, Vol II. These terms of reference define the duties and responsibilities of the senior staff officer operational research (SSO(OR)) and the staff officer operational research (SO(OR)) as the two were designated.

198. The MARPAC OR Team prepared reports on their activities on a regular basis for the information of the Maritime Commander Pacific and his staff, DOR(N), and ASW/ORT. They also issued reports on studies and investigations. A listing of those up to the end of 1966 is given in Annex L, Vol III. This list indicates exercise analysis and testing new procedures and equipment formed a major part of their work.

199. The Team enjoyed the confidence and support of the Naval staff and working relations were congenial and stimulating. Among the many strong supporters RAdms WM Landymore, MG Stirling, and JA Charles should be mentioned. The MARPAC OR Team originally reported to the Deputy Maritime Commander, Pacific (Aug 1964 - Jan 1966), Air Commodore RC Weston. When he became Chief of Staff for Operations (Jan 1966 - Aug 1966) the Team continued to report to him and later to the Deputy Chief of Staff for Operations, Capt AD McPhee after Aug 1966.

200. The MARPAC OR Team also enjoyed good working relations with the staff of the Pacific Naval Laboratory (PNL) (later Defence Research Establishment Pacific (DREP)). The Superintendents of PNL (Dr FH Sanders (1964-1966) and RF Chinnick (1966-1969) were strong supporters of the OR Team and encouraged collaboration and cooperation with the PNL Staff. In addition PNL Staff provided scientific and technical advice and help in various studies,

trials, and investigations. They also welcomed the OR scientists to their seminars and made their library facilities available to them. An important function that the Team performed was the improvement of liaison between the staff of MARPAC and PNL (later DREP).

PERSONNEL

201. Since the Team was initiated in August 1964 there were only two members who served with it during the period of this history. These were Mr KR Kavanagh (15 Aug 1964 - 12 July 1968) and Mr CLR Unwin (16 Aug 1965 - 28 June 1969). Subsequently Mr SLW Mann became SSO(OR) in July 1968, and Mr JG Jones joined the Team as SO(OR) in Aug 1969 and remained with the Team until Aug 1973. Mr HL Seymour became SSO(OR) in Aug 1971.

REORGANIZATION ON INTEGRATION OF CANADIAN ARMED FORCES

INTRODUCTION

202. Although this short history is intended to deal with OR in the RCN it seems worthwhile to give some account of changes in the provision of military OR services following the integration of the Canadian Armed Forces. The formal date of integration was 1 July 1964 but it was not until 1 Feb 65 that the reorganization of the OR services was effected.

203. Consideration was given in 1964 to ways and means whereby DRB could best provide OR services to the integrated armed forces at National Defence HQ and to the Field Commands. In October 1964 a document was prepared by the Chief Operational Research (Dr RJ Sutherland) in consultation with DRB for submissions to a Chief of Defence Staff (CDS) meeting. This document described the former policy regarding the provision of OR to the Services and DRB and the assignment of staff as of 1 July 1964, proposed a new policy and an interim organization and program, and made four recommendations. A copy of this submission is presented in Annex M, Vol II.

204. The four recommendations may be summarized as follows:

a. CDRB should be responsible for recruiting, professional direction, and career management of civilian scientists supplied to CFHQ for OR duties, and for OR in matters of direct concern to CDRB; CDS should be responsible for the approval of major projects and the establishment of priorities;

b. The organization shown in Appendix 1 to Annex M, Vol II. be approved for the interim period;

c. All existing work in the fields of maritime warfare, air defence, and trials design and analysis respectively, should be redistributed between three new OR directorates (the Directorate of Maritime Warfare Studies, Strategic Weapons and Air Defence Studies, Mathematics and Statistics) and that a sorting out operation should be performed between the new Directorates of Land/Air Warfare and Systems Studies, and that program definition should be carried out with respect to a major study on tactical air which had recently been approved by the Chief of the General Staff and the Chief of the Air Staff.

d. The Chief of Operational Research be directed to prepare a comprehensive review of existing programs and priorities by 1 Mar 1965.

205. At the Chief of Defence Staff Meeting 9/65 on 28 October 1964 these recommendations were approved. Other relevant decisions taken at this meeting were:

a. Arrangements are to be made to include appropriate Assistant Deputy Minister involvement in the actions which are being initiated in executing the review of all research programs;

b. The current ratio between Service and DRB operational research staff at CFHQ is to be continued for the time being;

c. The Chief of Operational Research is to become a member of the Vice Chief of the Defence Staff (VCDS) Weekly Coordinating Conference;

d. Military personnel will not be seconded to DRB but will be assigned to DRB for duty.

THE NEW ORGANIZATION

206. Action was then taken to implement these decisions and reorganize the OR services accordingly. While these agreements formed the base for the new OR organization it turned out in practice that certain minor changes apppeared warranted and were put into effect. The main features of the new organization and its working relations are described below. The new unit was called the Operational Research Division (ORD); it was manned by DRB scientists, Canadian Forces officers, and civilian and military support staff.

207. The effective date for the integration of the OR services was 1 February 1965. The role of CFHQ/ORD was to:

a. Undertake OR projects within the approved program;

b. Collect, collate, and disseminate all information of CFHQ interest arising from operational research and other relevant studies in Canada and abroad.

208. The Head of ORD was designated Director General Operational Research Division (DGORD) and was appointed by the CDRB with the concurrence of CDS. DGORD was responsible to the Vice Chief of Defence Staff (VCDS) for the consolidation of operational research projects requested by the various DND staffs. This consolidated

program was to be screened by VCDS in conjunction with the Chief Scientist (Physics and Engineering) DRB and approved by VCDS on behalf of CDS. The execution of the approved program was the responsibility of DGORD in accordance with priorities approved by VCDS.

209. The first DGORD appointed by CDRB and CDS was Dr RJ Sutherland. As noted above he had been holding the position of Chief of Operational Research, DRB under the former organization. For purposes of personnel administration the civilian component (scientific and support) of the Division was organized into the Defence Operational Research Establishment, one of the several DRB establishments. With this reorganization the two positions Director General Operational Research Division, and Chief Operational Research Establishment were both held by Dr Sutherland.

210. At the time of integration it was agreed that the ORD would be manned by 59 DRB scientists, 25 military officers, and eight other ranks, and a clerical staff of 17.

211. The newly approved organization made provision for a Chief and two Deputy Chiefs of Operational Research. One of the Deputies was to be responsible for programs and one for administration. The five operational units were originally designated as groups. It turned out that the two deputy chief positions were not filled and in their place an assistant to the Chief was appointed as a military officer in the rank of Lieutenant Colonel and the other position became known as Senior Operational Research Scientist (SORS). A few years later the position of a single Deputy Chief in the rank of Brigadier General was approved and the position filled. Soon, also, the OR Groups were re-designated Directorates Their names became Land/Air Warfare, Strategic Weapons and Air Defence, Mathematics and Statistics, and Special Studies. The OR units at the Service Commands remained unchanged in name, numbers, and locations.

NEW TERMS OF REFERENCE FOR DIRECTOR MARITIME OPERATIONAL RESEARCH

212. The general terms of reference for the new Director of Maritime Warfare Operational Research (DMWOR) were as follows:

a. DMWOR will be responsible for the execution by his staff of allotted projects. These will be in the field of maritime warfare, although certain specific projects belonging to this general field, such as air defence of ships, may be placed with other Directorates.

b. DMWOR is responsible to DGORD for matters concerning the work assignments of personnel in his group. For specific projects he may be directed to report to an officer in the requesting agency, or to undertake the direction of the work of additional personnel assigned by the requesting agency.

c. DMWOR will be responsible for the support from Ottawa of the Operational Research Sections at Maritime Command Atlantic (MARLANT), Maritime Command Pacific (MARPAC), Maritime Air Command (MAC), and Joint Maritime Warfare School (JMWS).

CONCLUDING REMARKS

213. The value and productivity of any organization depends critically on the quality and ability of its personnel and on the environment within which it functions. In both these respects the OR units working with the RCN were fortunate. The DRB scientists assigned for duty with these units were selected with care and they always found themselves well received, encouraged, and supported by the Naval staff with whom they were employed. Working relations with naval officers of all ranks were congenial and the OR directors and staff were never kept out of any planning or thinking that related to their responsibilities and tasks. They were readily accepted as members of the team and responded accordingly. Their successes and accomplishments were due in large measure to the cooperative milieu in which they carried out their work. Many of them, particularly in the earlier days, were ex-servicemen who were not unacquainted with Service and Naval matters and operations, but those who were new to the naval scene soon became acquainted with naval life and developed loyalty to the 'Senior Service' and the OR unit with whom they were working. All of them took pride in their output and accomplishments and in those of the unit and the RCN as a whole. The names of some of the OR scientists and references to their contributions have been cited in the preceding text. Many others warrant mention but space and time have not permitted. The names, appointments, and tenures of most of the OR staff who worked with RCN during the period covered in this history have been listed in Annex F. The author apologizes for omissions and errors in this listing.

214. Operational research in the RCN could not have been organized, developed, and extended in application, scope, and influence without the active encouragement and support of senior naval and DRB officers. Mention has been made of some of these

but the contributions of others should also be recognized. First, on the DRB side Dr OM Solandt CDRB, was always a strong supporter of military OR and did much to ensure that qualified OR staff was made available to all the Armed Services. Incidentally, Dr Solandt had been head of the Army Operational Research Group in the U.K. during part of WWII. This policy was continued by successive chairmen of DRB. The several SA's/CNS and DSS's of the period always provided support and encouragement as did the Superintendents and staffs of NRE and PNL. As well the Superintendents (or Chiefs) of the ORG in DRB were always helpful and were careful to appoint well qualified DRB scientists to the Naval OR units. To mention all the Naval officers who helped and supported the OR units would require considerable time and space and it may not be necessary to do so for the purposes of this history. A few of the more prominent of these, however, should be noted.

215. In the early days of World War II Admiral HE Reid was instrumental in getting OR-type work started in the RCN with the cooperation and support of other senior officers and civilians. Following the War both the Chiefs and Vice-Chiefs of the Naval Staff encouraged the re-introduction of OR in the RCN. These included Vice Admirals ER Mainguy, HS Rayner, HG DeWolf, HN Lay, EP Tisdall, and JV Brock. Other senior naval officers that were more closely associated with using and promoting OR in the RCN were Vice Admirals JC O'Brien, HA Porter, Rear Admirals EW Finch-Noyes, WM Landymore, KL Dyer, HF Pullen, Commodores PFX Russell, N Cogden, IBB Morrow, GC Edwards, RH Falls, RW Murdock, RP Welland, and Captains TC Pullen, and AD McPhee. To these officers, those mentioned earlier, and numerous others, senior and junior, much is owed for their assistance to and support of operational research in the Royal Canadian Navy.

REFERENCES

1. The Origins and Development of Operational Research in the Royal Air Force - Air Ministry Air Publication 3368. Her Majesty's Stationery Office, 1963, London (Unclassified)

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3. Defence Research Board Organization Letter No. 7/60 dated 20 April 1960. (Unclassified)

4. Defence Research Board Organization Letter No. 3/62 dated 19 March 1962 (Unclassified)