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*A Study to Identify the Requirement for*

ACADEMIC EDUCATION  
IN NAVAL ARCHITECTURE  
AND MARINE ENGINEERING



Within Canada's Marine Industries

Aerospace, Marine and Rail Branch  
Department of Industry, Trade and Commerce, Ottawa

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**A Study to Identify the Requirement for  
ACADEMIC EDUCATION IN NAVAL ARCHITECTURE  
AND MARINE ENGINEERING  
Within Canada's Marine Industries**

by  
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This is a study commissioned by the Shipbuilding and Heavy Equipment Branch of the Department of Industry. Any opinions expressed herein are those of the author and should not be attributed to the Government of Canada.

Aerospace, Marine and Rail Branch  
Department of Industry, Trade and Commerce  
Ottawa



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*In framing an ideal we may assume what  
we wish, but should avoid impossibilities*

Aristotle





A Study to Identify the Requirements for  
 NAVAL ARCHITECTURE AND MARINE MECHANICAL ENGINEERING  
 Within Canada's Marine Industries

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## SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS

During the last few decades many important advances in science and technology have been partially responsible for an explosive expansion in most sectors of engineering education. Unfortunately, education in Naval Architecture and Marine Engineering has taken little or no part in this expansion and, at the time of writing, not a single university in Canada offers a sequence of courses which could lead to an academic degree in these disciplines.

The present report arises out of a quantitative and qualitative study and analysis of the educational backgrounds of qualified personnel presently in Canada's marine industries. The report also includes an assessment of the requirements for academic education at the university level in this field. During the investigation many visits were paid to various Departments of Government with responsibility for shipbuilding and shipping matters, shipping agencies, shipyards, shipbuilding consultants, classification societies, and manufacturers of components used in shipbuilding. These bodies together with many others which could not be visited, were asked to provide suitable statistical data giving the numbers, the educational backgrounds and the age groups of their present technical personnel. Information was also obtained about the mode of employment of such technical personnel and an assessment was given by the employers of their requirements for well-trained technical employees over the next few years. The employers also made recommendations regarding the most suitable educational training of future recruits to the industry.

It was found that a total of some 2004 individuals are employed in this field throughout Canada; of these about 939 have an engineering background and can therefore, for the purpose of this study, be classified as engineers, 1035 should more properly be called technicians, while about 30 have an academic education which for various reasons cannot be included in the two larger groups (Table 1, P.23). Estimates by employers indicate that ten years from now there will be a total of about 2222 employed in Canada, of whom 1059 would be in the engineering category, 1133 would be technicians, and there would still be a requirement for around 30 'generalists' (Table 4, P.30).

From the descriptions by the employers of the engineering assignments given to technical personnel in the marine industries, it would appear that technical training, at least of the more advanced staff, should be at the university level, possibly emphasizing management science. An examination of the Canadian educational institutions which presently offer at least some training in marine subjects, showed that such training was quite inadequate to fulfill the needs of the industry for engineering personnel. Indeed almost all the engineering staff at present active in the industry have been educated abroad, the vast majority of them being recent immigrants.

If it is deemed desirable to change this situation and replace immigrants with qualified Canadians then the total Canadian requirement will be some 35 engineers per year for the next 30 years. It is suggested that over the next ten years, or at least until the marine industries can gain some experience and confidence in the quality of

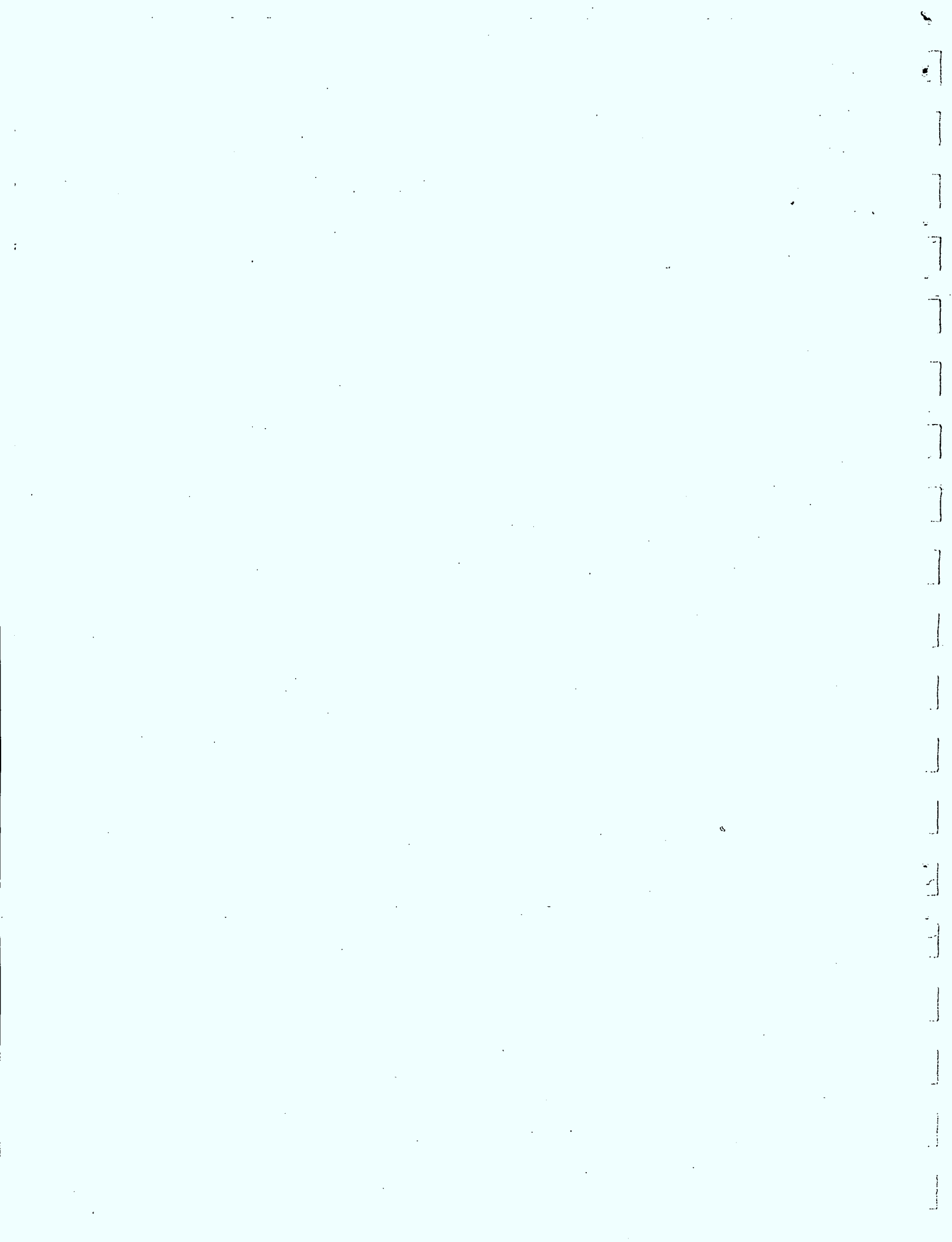
Canadian graduates, the objective should be to provide up to one-third of the annual requirement for engineers from Canadian sources, the remaining two-thirds still being recruited from abroad. There are advantages in training the required personnel in Canada; they would, for example be familiar with environmental problems associated with or unique to Canada and are likely to be more responsive to Canadian requirements than recruits trained elsewhere.

From the educational and technical requirements outlined by the various employers, a detailed curriculum has been worked out and is proposed for incorporation at the undergraduated level at a Canadian university (P. 51). Such a study would lead to a degree in Mechanical Engineering with options in Naval Architecture or in Marine Mechanical Engineering, and in the first instance would be set up in some existing Mechanical Engineering Department. One unusual aspect of the proposed curriculum is that it contains some stress on management science. However, the academic content of the curriculum has been maintained at a high level and some trouble has been taken to have the curriculum examined and approved by experts in the field at the Massachusetts Institute of Technology and the University of Michigan (Tables 7-10, Pp. 56-59, Appendix G. Pp. 85-86. The proposed scheme contains some flexibility. For example, a successful student studying under the scheme would gain a Bachelor of Science degree in Mechanical Engineering and, while he would certainly specialize in naval and marine engineering, his training and experience in the fundamentals of engineering would be such that it would not be difficult for him to find employment in some other branch of mechanical engineering should the marine industries be unable to use his services.

The placing of the disciplines of Naval Architecture and Marine Mechanical Engineering on a sound academic footing by making them available at a Canadian university can provide considerable benefits far beyond the obvious one of securing well-trained engineering personnel. Under the proposed scheme, the particular university chosen could act as an information and communication centre in marine matters and promote research studies in the interests of the Canadian marine industries. Much of this work is presently being done abroad. Such research studies would be further enhanced should the university in question be affiliated with an Industrial Research Centre. This scheme should also bring about an integration of the various levels of education and training in the marine field in Canada, so as to rationalize and improve the present chaotic situation where small inefficient groups across Canada are working in isolation with little or no co-operation, common organization or unified leadership.

**PART I**  
**INTRODUCTION**





## CHAPTER 1

### BACKGROUND TO THE STUDY

#### (1) Introduction

A simple observation of shipping activity on the East and West Coasts of Canada, on the Great Lakes and on the St. Lawrence Seaway would suggest a considerable potential role for the marine industries, especially of shipbuilding, in the Canadian economy.

There exists in Canada a need for the transport of goods by water. The fact that Canada's international trade in dry cargo alone exceeded 135,000,000 tons in imports and exports during 1965, demonstrates that there is such a need. One would therefore expect this need to lead to the growth of shipbuilding. Shipbuilding is a complex industry, being highly dependent for its existence on a wide spectrum of heavy and light industries. A country with a large water front, numerous large lakes and rivers, where the technical skills and supporting industries are available, should provide highly favourable conditions for the development of marine industries. Some constraints on such development may be imposed by economic and social factors, which are liable to change from one decade to the next. An organized society must find solutions for its economic and social problems if it wishes to take full advantage of the natural potential of its environment. In the world of today economic problems are intimately related to technology and management. The degree of sophistication employed in modern technology and management requires a broad educational background. This has been one of the causes of the explosive expansion in university engineering education over the last decade here in North America.

Despite the many opportunities apparently available in Canada an interested outsider would be disappointed to observe that Naval Architecture and Marine Engineering has not kept pace with modern trends in engineering education, and has not as a subject been taught in any university in Canada. In many countries the need for the establishment of academic education in the marine field was realized several decades ago. In some cases their shipbuilding industries were very dependent on foreign investments and on the importation of manufactured products required in the industry.

The general remarks on the situation in other countries will only be cursory, however, will serve as a yardstick by which Canada can gauge its requirement, and as a result of this study a more precise definition will be given to a long felt need which has until recently been largely overlooked.

In 1966 the Marine and Rail Branch of the Department of Industry came to realize that in the field of education as it was related to the shipbuilding industry, very few facts were known, and that while several local studies have been undertaken over the years to determine educational needs, no appraisal of national needs had ever been made. This study was commissioned on 1st May 1967 to rectify this situation.

The case for or against establishing academic education in Naval Architecture and Marine Engineering should be based less on *general opinion*, and more on reliable quantitative and qualitative data about conditions existing at present in the marine industries. Data regarding present and future requirements from employers of Naval Architects and Marine Engineers across the country should constitute a rational criterion for making a judgement on the potential contribution which education can make to the development of the shipbuilding industry.

The present report was written as the result of a detailed investigation of the existing situation in the industry as a whole. It contains specific plans and some more general proposals for the initiation of academic studies in this field at a Canadian university.

## (2) Contribution of Education to the Development of the Shipbuilding Industry.

The Canadian shipbuilding industry is presently going through a period of change. Over the past few years Government has substantially reduced the rate-of shipbuilding subsidy and simultaneously endorsed a policy of competitive procurement for all Government new construction.

The reasons the industry finds itself in this position has been the subject of enquiries in the past, each of these dealing with different aspects of the problem, and each making recommendations for improving the situation.

In a broad sense the present study will attempt to analyse the possible contribution and impact of education to a healthier development of the industry in Canada. The influence of different factors and their interrelations undoubtedly paint a very complex picture and one has to agree to some extent with the findings of the 1965/66 Geddes Committee Report on Shipbuilding in the United Kingdom, which states 'there is no one easy way in which shipbuilding can become competitive. Success can only be achieved by concerted efforts by all those in and associated with the shipbuilding industry'. This conclusion may be no more than a vague expression of hopelessness as long as the shipbuilding industry is deprived of the type and quality of personnel whose education and inventive attitude provide a background to organize and direct such 'concerted efforts' towards definite and attainable goals. The Geddes report further concedes that 'Shipbuilders have remained designers and jobbing contractors'.

The essential contribution of education to shipbuilding resides mainly in the ability to offer to the industry the services of engineering and managerial personnel who can depart from orthodoxy and bring a fresh outlook to the industry's problems and can make use of the tools of present-day technology in an intelligent manner and with some prospect of success. The modern requirements of engineering education are not specific to shipbuilding and not even to Canada. However, a depressed industry relies more on the resourcefulness of its engineering and managerial staff for survival than do many others. The flourishing automobile industry in the U.S.A., for example, can afford to absorb many mediocre engineering personnel who may be indistinguishable from draftsmen, but the shipbuilding industry in Canada would not be expected to survive if its engineering and managerial staff have not a deep appreciation of modern technical developments and the constraints which are imposed by economic factors.

Such personnel are, and should be, the directing and monitoring elements of the shipbuilding industry of today and in the future. Their attitudes, inventiveness and incentives will be largely molded by their educational background.

Education already played an important role in the success of the European industrial revolution when the machine first became dominant, and the shipbuilding industry of that time took full advantage of it. In the second and current industrial revolution in which information, automation, control and systems are clearly becoming dominant, engineers trained in modern schools have generally been the instigators and the main sources of new ideas. In very few countries has shipbuilding kept pace with these trends. In a world where economic power is increasingly identified with the ability to innovate and to exploit new knowledge, high priority must be given to the potential contribution of education, among other factors, to the survival and the growth of shipbuilding.

The basic laws of science do not vary from one locality to another and when properly applied, they are valid for whatever the environment. However, engineering is mainly concerned with the accomplishment of definite objectives in a given geographical, social and economic environment. Because of environmental factors engineering education has to be adapted to meet local geographic, social and economic needs of the community. It is for reasons like this that there are such marked differences in engineering education in the United Kingdom, France, Germany and the United States for each system has grown to meet the needs of the country in question. While the civil engineer in Indonesia, for example, would be taught the same laws of thermodynamics as his counterpart in Canada, the knowledge he has to acquire and the problems he would encounter in the field of road construction, say, would be quite different due to differences in climate, the materials which are available and the type of terrain which exists in the two countries.

At the present time there is no educational institution in Canada which awards a recognized degree in Naval Architecture and Marine engineering. Almost the whole engineering staff and a major proportion of the supporting technical personnel active in the Canadian shipbuilding industry have been educated and trained in the United Kingdom, with a small proportion coming from continental Europe or the United States. It is evident that these engineering personnel have contributed to the demanding technology of the Canadian shipbuilding industry where many new ships have been a new type designed to serve a special purpose. The industry in Europe and Britain mainly relies on relatively low labour costs combined with a high cost of materials; this is to a degree exactly opposite to the state of affairs on the North American continent.

The education systems in different countries may have adjusted to the needs of their own industries. The experience and training of engineers coming from the United Kingdom and Europe will necessarily be governed by the functions, procedures and conditions appropriate to the industry of their country of origin. These engineers usually require a tremendous personal effort, if indeed it can be achieved at all, to change their ideas and outlook in order to adapt to Canadian conditions. It is expected that only a few exceptional individuals can completely overcome this handicap. Even research in shipbuilding is conditioned by the environment. For example, research to

investigate the effects of heavy ice build-up on the stability of fishing boats cannot be a topic of interest in most European countries, although it is of prime concern to Canadian shipbuilding.

## CHAPTER 2

### OBJECTIVES OF THE STUDY

The objectives of the study are:

(1) To examine the existing level of professional education related to the Canadian shipbuilding industry and to enquire into the educational background of individuals active in this field.

(2) To study the present and future needs of the Canadian shipbuilding industry and allied business to obtain the necessary statistical evidence required to assess the requirement for an educational programme.

(3) To estimate the present and future numbers of technical personnel which can and will be employed by the Canadian shipbuilding business. This has been one of the prime concerns of these investigations, for it was thought to be of crucial importance from two points of view:

(i) The number of technical personnel likely to be required is the main criterion to decide whether there is a need to establish an educational institution in this field in Canada. This constitutes the economic justification for the project.

(ii) The deployment of trained technical personnel within different fields of activity in the shipbuilding industry is an important indicator for determining the structure of future education in Naval Architecture and Marine Engineering most suitable to the Canadian environment.

(4) To better gauge the correct emphasis to be placed on various branches of science and technology in any future educational scheme by surveying the future plans of these firms.

(5) To study both qualitatively and quantitatively those Universities and Institutions throughout the world which are offering degrees in Naval Architecture and Marine engineering. This was undertaken to see if it was possible to detect modern trends in education in the field.

(6) To examine the Canadian requirement for marine engineering education.

(7) To prepare a detailed undergraduate curriculum and demonstrate its acceptance and feasibility from an educational point of view, if a Canadian requirement was found to exist.

Beyond the strict terms of the contract the nature of the study brought the investigator into contact with various related problems and potential benefits, and it was felt that several of these should be — at least superficially — defined for future attention:

(i) The potential impact on the industry of ancillary activities which may be instituted at a Canadian university giving undergraduate courses in naval architecture. Specifically, the possibility of the university as an industrial research centre or as an information centre for the industry.

(ii) Simultaneous incorporation of graduate studies in Naval Architecture and Marine Engineering are envisaged and it is important to note that (a) a definite



need appears to exist for such a programme in the Canadian Armed Forces, (b) this would not impose a sizeable financial burden on the University which carries out the undergraduate programme, (c) the prospects of an integrated education system in Naval Architecture and Marine Engineering involving many different levels of education, and extending from vocational schools to graduate studies has been considered, and an all Canada plan has been outlined in broad terms.

### CHAPTER 3

#### THE APPROACH ADOPTED IN THE INVESTIGATION

The method adopted in carrying out this study has some bearing on the findings. When a study of the present kind is conducted by a single investigator, the danger exists that he may unconsciously present his own opinions and prejudices as though they were objective facts. Great care has therefore been taken to avoid as far as possible the incorporation of subjective evaluations in statistical data, since the latter should reflect only the facts.

Whenever it was not possible to obtain statistical data from the employers, the writer preferred to discard completely the particular data concerned instead of going to a doubtful personal assessment; this was done in the belief that a partial but authentic coverage is more reliable than the guess of an outsider. Further, when an evaluation of future needs for technical personnel was required, *the projection of each employer has been relied upon and used* and the investigator has withheld any personal judgement.

(1) Method employed in determining the educational requirement of Canada's marine industries.

In order to obtain some relevant statistical data, five different branches of the Dominion Bureau of Statistics and Department of Manpower and Immigration were consulted. There was no pertinent information from these sources concerning Naval Architects and Marine Engineers, because the majority of such engineers are not registered in the Association of Professional Engineers. The Society of Naval Architects and Marine Engineers was asked to offer a list of Canadian members but they declined to provide the information as the Society has a long standing policy of refusing access to members' records by anyone other than Society officials. The present survey had to rely on its own procedure and findings in order to obtain statistical data concerning the numbers and distribution of Naval Architects and Marine Engineers in the country. Many research visits and interviews were made in order to obtain first hand impressions of the mode of employment and the type of work assigned to or expected from Naval Architects and Marine Engineers. Questionnaires and statistical data tables were used to determine the educational background, age groups and sectors of employment of engineers in this field.

The technical staff involved in the shipbuilding business was divided into four education groups as follows:

- Group 1 Individuals with an academic degree in engineering, such as B.Sc., M.Sc., Dipl. Ing., Ph.D., D.Sc., Dr. Ing., (Appendix F, P. 83).
- Group 2 Individuals with a professional certificate or diploma in engineering like marine engineering, mechanical engineering, ONC, HNC, HND, CD, Dip. Tech (Appendix F, P. 83).
- Group 3 Individuals with a trade school diploma who qualify as technicians.



Group 4 Individuals without any formal diploma but who have been trained in industry and are considered by the company management as technically competent to carry out engineering assignments.

Group 5 Other academic qualifications (B.A., B. Com., etc.).

The management staff, for the purposes of differentiating with those engaged primarily in a technical function, comprised individuals active in Administration, Accounting, Marketing, Purchasing and Sales, etc., and Group 5 was added to ensure full coverage.

The definition of "engineering assignments" or "engineering employment" is quite vague in the industry and depends entirely on the interpretations of individual managers. In order to retain a standard of reference, Groups 1 and 2 have been considered in this study as the "engineering" groups, and 3 and 4 as the "technician" groups. However, it should be conceded that in many cases individuals belonging to the "technician" group carry out what must be regarded as engineering duties. The writer met consultants on the West Coast with no formal education beyond Grade 11 who were involved in the design and related calculations for large fishing boats. The reverse situation is also possible, but much less frequent because usually no company will hire an engineer at high salary and assign him to a job which can be accomplished by less expensive employees. The real demarcation line between engineering and technician groups is, in practice, quite impossible to draw with any confidence. However, the classification described above assures that the diffusion between the two groups cannot introduce an unjustified number of individuals into the engineering group.

A slightly different approach was adopted when dealing respectively with a) The Shipbuilding Industry itself and b) and c) government agencies and businesses which support the shipbuilding industry and shipping.

#### (i) Shipbuilding Industry — Shipyards

It was assumed originally that the shipbuilding industry would be able to specify the qualifications they expect from a Naval Architect and Marine Engineer and that they would also have certain estimates of their own future needs. A few exploratory contacts revealed that the employers would not, possibly could not, express any specific demand and they reversed the question inquiring about the special benefits they could expect to gain from the employment of a graduate from a Canadian institution. In order to avoid a vicious circle in this discussion, the writer henceforth preferred to describe at random the tentative qualification of a future Canadian graduate, sometimes going into unforeseen detail. Reacting to this description, the employers were willing to offer some constructive criticism of the proposed scheme, and this criticism in turn contributed as a feedback to alter the original description of the proposed education system. The deductive and deterministic method of study originally used had to be replaced by a continuous adaptive procedure. This way of communication was certainly more time-consuming, but it surprisingly proved to be more convincing as a better explanation of the purpose of the enquiries to the employers. It was also felt that different kinds of prospective future employment possibilities for Naval Architects and Marine Engineers should be suggested to the employers. During this investigation 14 of the tabulated 17 shipyards were personally visited and during lengthy interviews, an exchange of opinions and criticism took place.



Also during these visits an oral questionnaire of 11 questions (Appendix A, P. 73) was submitted to the representatives of the shipyards and their answers were noted. The purposes of the oral questionnaire were to discover the sectors of activity in which the 'professionals' were employed, the use made of modern techniques within the industry, the degree of collaboration with research institutes, and determine the number of existing educational facilities and upgrading programmes already established by individuals in the various shipyards.

A statistical data table was also left with the shipyards to be completed separately for engineering and managerial staff (Appendix B, P. 75). The first version of this table probably inquired about too much detailed information with the result that the majority of the shipyards were discouraged and did not provide the necessary information. This difficulty was overcome by preparing a more compact statistical table (Appendix C, P. 77); and giving a strong assurance in writing that the statistical data they provided would be strictly confidential and that the information would not be communicated to a third party in any way that it could be identified with a particular shipyard.

With these restrictions and with the vigorous support of the Department of Industry, it was possible to collect and to evaluate the required statistical data from 17 major shipyards in Canada.

In no case were the shipyards prepared to make any assessment of future needs in personnel.

#### (ii) Government Agencies

A shortened statistical data table (Appendix D, P. 79) was sent to the government agencies involved or associated with the shipbuilding and shipping industry. This survey included the Navy Dockyards on both coasts and the Canadian Coast Guard Service. One or more research visits were also made to the following agencies; Department of Industry, National Research Council of Canada, Department of Defence Production, Department of Transport, Board of Steamship Inspection, Department of Mines, Energy and Resources, Department of Fisheries and the Canadian Armed Forces.

#### (iii) Related Industries

The same questionnaire (Appendix D, P. 79) was sent to:

##### (a) Consultants and Classification Societies

A majority of consulting firms and classification societies on both coasts were visited and their opinions and estimates noted.

##### (b) Shipowners and Shipping Companies

Only three major shipping companies on the east coast and one on the west coast were visited. The remainder were merely asked to complete the statistical data table.

(c) Components Manufacturers

The component manufacturers were asked to complete the statistical data table concerning their employment of Naval Architects and Marine Engineers.

(2) Method employed in determining modern educational methods in international education centres

The objectives of this part of the study are outlined in detail in the chapter concerning "International Systems of Education in Naval Architecture and Marine Engineering". The method employed was to contact the institutions of higher learning in different countries offering courses which led to an internationally recognized degree. A correspondence has been maintained with all of them and an appropriate inquiry questionnaire (see Appendix E, P. 81) was sent to 32 institutions of which 28 gave adequate information concerning their systems.

(3) Method employed in determining present education levels and trends in Canada relating to Naval Architecture and Marine Engineering

The extent to which educational institutions in Canada have become involved with subjects relating to Naval Architecture and Marine Engineering has been ascertained and an attempt made to find the extent of their present interests and future plans for development in this field. A large number of these institutions were contacted by letter and several visited. The nature of this part of the investigation did not lend itself to employing a uniform method of analysis. The results obtained are outlined in Chapter 5 "Trends in Canadian Education Related to the Marine Industries".

**PART II**

**ACADEMIC EDUCATION  
IN THE MARINE INDUSTRIES**



THE UNIVERSITY OF CHICAGO  
LIBRARY

## CHAPTER 4

### THE PRESENT SITUATION AND FUTURE REQUIREMENTS

A study of the deployment of technical personnel throughout the Canadian shipbuilding industry and shipping business is a most important part of the present investigation. The decision to recommend or reject a particular pattern of academic studies in a faculty of engineering of a Canadian university, depends largely on the present work being handled by these technical personnel.

It is possible to philosophize on the future significance of the shipbuilding industry and the shipping industry to the economic development of Canada. It is however probably more valid to base this study on the known situation which exists today. Any future academic policy should be based on an analysis of the work being handled by professionals already in the marine industries. The deployment of these people has been both quantitatively and qualitatively examined.

It was the experience of the writer that leading individuals in the field, favoring an education system or rejecting it, based their argument solely on the grounds that the required number of technical personnel was "large", or "small", and yet none of them possessed the information about the existing or projected numbers which have been determined in the present study. The total lack of information led many individuals to make an estimate based on their own feelings, or on the experience gained from their own relatively narrow field of activity. It is hoped that the statistical information contained in this chapter will help enlighten the uninformed and misinformed and possibly serve as a reference for a more rational appraisal of educational requirements in the industry.

A qualitative study of the deployment of technical personnel in the marine field is almost as important as the numerical data collected. Firstly this chapter supplies information about the requirements of the industry concerning the extent and type of knowledge expected from their engineers. Secondly, the qualitative study attempts to appraise the degree of correlation between the present mode of employment and the educational background of technical personnel. The most specific requirements are imposed by the shipyards, therefore, the results of the qualitative study will be outlined under the heading of Shipyards (P. 16).

#### (1) The National Total

The total numbers of technical personnel presently active in Canada in the field of Naval Architecture and Marine Engineering are given in Table 1 (P. 23); this table also gives their age, their education and their activity group. The total number of technical and managerial personnel amounts to 2004 individuals. The engineering group consists of individuals from two quite different educational backgrounds (Education Group 1 and 2, P. 9) and it numbers 939 individuals compared to 1035 of the technician group (Education groups 3 and 4, P. 9). A large number of staff classified in the last group

are carrying out essential assignments. More detailed information about the mode of employment could not be obtained to establish the probable limits of overlap. In Fig. 1 (P. 24), the involvement of personnel with different educational backgrounds is given with a division into age groups. It is worth noting that in the age group between 45 and 65, (a) corresponding largely to senior positions, the number of technical personnel exceeds the number of engineering personnel (19-17). (b) This may be a source of criticism of the marine industry and business that in their senior positions fewer engineering oriented individuals than technicians are employed, whereas in a more progressive industry the reverse would be expected. (c) This trend can also be found in the percentage table Table 2 (P. 25), and from the graphical representation Fig. 2 (P. 26), showing the present distribution of engineering and technical personnel, although here it is less marked.

Future needs in additional personnel in different fields of marine activity have been compiled in Table 3 (P. 27); these were obtained from the projections of the employers. It amounts to 218 individuals. This projection may be accepted as valid for a period spread over ten years so that the considered increase will be of the order of 1% per year. This evaluation cannot be considered an over-estimation for it reflects the present stagnant character of the marine industry.

In Table 4 (P. 30), the present staff and future needs in addition to technical personnel in Naval Architecture and Marine Engineering has been summed up as a national total. It amounts to 2222 individuals with a requirement for 1059 engineering personnel. This future projection of engineering personnel needs presages a growth of 1.28% per year, which is an extremely conservative estimate.

## (2) The Shipbuilding Industry — Shipyards

The shipbuilding industry concentrated in the shipyards employs 1066 individuals as technical and managerial personnel, which represents 53.2% of those qualified to some extent in Naval Architecture and Marine Engineering in Canada. It is not surprising to find this percentage larger than in any other marine activity, however the industry by no means dominates the market for qualified personnel. Shipyards use of personnel must nevertheless be regarded as the decisive factor in appraising the type of Naval Architect and Marine Engineer most suitable to Canadian conditions, not so much because of this large numerical majority in employment, but because of the special type of training and experience the shipyards require from these personnel. The shipping industry, the component manufacturers, even in certain measure the government, may not require from their engineering personnel as much specialized knowledge in the fields of Naval Architecture and Marine Engineering as the shipyards. A more diversified and broader education may be of greater interest in the shipping industry, to component manufacturers and Government, but the extent to which this is desirable should be limited by the compatibility of such education with day to day assignments and responsibilities relating to the industry. In order to attain his optimum solution, a statistical study and qualitative investigation of the situation in shipyards was carried out aimed at including as much detailed information as the shipyards were willing to provide. Complete assurance was given to the majority of shipyards that the statistical data provided would be handled on a strictly confidential



basis and the information would not be communicated to a third party in any way that would make it identifiable with a particular shipyard.

(i) **Statistical data.**

The numbers, age groups and educational background of technical personnel in Naval Architecture and Marine Engineering employed by the shipyards have been compiled. The total amounts to 926 individuals of which 363 are rated as engineering personnel. The representation in Fig. 3 (P. 27), give a spread by age group for each education group. It is worthwhile noting that the technician group (Group 3 and 4) surpasses the engineering group in all age groups: Criticisms for employing poorly qualified personnel can be refuted by the shipyards with the claim that the technician group performs non-engineering assignments, even though in the statistical questionnaire sent to them the numbers of technicians performing engineering assignments was specifically asked for. Since no detailed information about the type of job performed by their staff is available, no decision can be made on this matter. The situation is possibly clearest for management personnel in shipyards and these confidential statistics have been compiled and show that in the whole shipbuilding business there are 56 managers with an engineering education, 54 managers with the background of a technician and 30 with various academic degrees. The spread over age groups (Fig. 4, P. 28), demonstrates that in senior managerial groups, are groups 45 – 65, individuals with a technician background, (Group 4) are in an overwhelming majority. The senior managerial group constitutes effectively the policy and decision-making individuals in the shipbuilding industry; their point of view, therefore, has far-reaching importance, and their influence on the whole industry is the primary drive behind its development. These few leading individuals can easily force their own opinions on the whole organization. Throughout the world the shipbuilding industry is very conservative and resistant to innovation and adoption of new techniques and ideas, although Sweden and Japan are notable exceptions. The industry badly needs enlightened managers to overcome the inertia of orthodoxy, as it has been proved in Sweden and recently by Litton Industries in the U.S.A. The stagnant state of Canadian shipbuilding certainly has various economic and social causes, but also the presumed attitude of the managerial personnel to shipbuilding arising from their educational background may be one of the most important causes.

The individual who is already in a senior managerial position may be inclined to rely on the successes and methods of his past performances, and may in fact resist innovation unless his education has given him an understanding of the meaning of industrial evolution with its implications for technology and social change.

My confidential compilation of Group 5 statistics shows that individuals with academic qualifications other than engineering are holding managerial positions. However it is significant that in the most successful shipyards the managers are mostly individuals with an academic education in engineering, together with a broad interest in administration and economics.



**(ii) Qualitative requirements of shipyards for engineering personnel in Naval Architecture and Marine Engineering**

The mode of employment of Naval Architects and Marine Engineers is well described in a letter dated February 28, 1968, addressed to me by one of the most prominent and successful managers of an important shipyard in Canada. I cannot do better than to quote him:

"We have an original organization here at --- that does not fall easily into the separate divisions you have laid down. There are many overlapping functions which have been built up through operational experience, but which, I can assure you, have welded together a closely knitted team that is extremely flexible and efficient. We dislike the type of organization that incorporates so many specialist departments. This ultimately ends in the employment of large numbers of highly trained men, each having only a very limited range of responsibility.

Our staff is very small in comparison to many other establishments of similar size . . . This includes all our clerical, typing, drawing staff. It is therefore my opinion that the figures that we have stated do not give a true picture of our requirements for qualified persons. Depending on the type of organization, so will the number of qualified persons required vary. Since this survey is to determine the demand for qualified technical people, I feel that this is of extreme importance. Somehow, you must relate these statistics to the tasks being carried out.

As examples, our Estimating function is closely linked with the Design function, and does not have separate supervision; however, it involves not only the senior technical supervision but also the Purchasing function and sometimes certain of our Production personnel.

We have no technically qualified people engaged in Accounting, Purchasing, etc., since these people have commercial qualifications. However, there is always close co-operation between them and the Technical Department. Sales and Marketing are not carried out by specialist departments but are performed jointly by Management and the Technical Department.

In analysing the figures that we are sending to you, I would strongly urge you to bear these points in mind, especially if merged to give a national total".

The description of the administration in one of the most dynamic shipyards stresses very strongly the "flexibility" of the engineering personnel, who are expected to adapt themselves to tasks ranging from design to sales and marketing. This is not a single case, but constitutes almost a consensus of opinion of shipyard managers in Canada. To provide flexibility is exactly the prevailing objective of modern engineering education systems at an undergraduate level, at least in any progressive university today.

The answers obtained to the oral questionnaire reveal a remarkable uniformity in the job definition for engineering personnel in Canadian yards, and indicates that very similar practices in their technical operations are used. General trends can be summarized as follows:

(a) Without exception all shipyards practise a collective system in optimizing decisions in planning and design, in which senior engineering personnel participate on a management team in an advisory capacity.

(b) In general the shipbuilding industry approves, and in most cases practises, the promotion of suitable individuals of the engineering staff into full managerial positions. In some shipyards it is the adopted policy to give first preference to suitable engineering personnel if a vacancy in management arises.

(c) Most of the important shipyards make some use of such modern techniques as critical path scheduling, linear programming, automatic control, reliability analysis, or computer aided fairing.

(d) Almost all shipyards use the services of one or more Towing Tank Laboratories to undertake seakeeping, resistance and propulsion tests and for advice on technical matters relating to stability or vibration, for example. Six of the shipyards interviewed mentioned some contact with the Shipbuilding Laboratory of the National Research Council in Ottawa. A large number of assignments were also from time to time given to the following foreign towing tank establishments: University of Michigan; Danish Towing Tank Laboratory; Wageningen, Holland; Teddington, England; Hamburg, Germany; Vienna, Austria. The shipbuilding industry was completely satisfied with the quality of the work delivered by the Shipbuilding Laboratory of NRC in Ottawa, but it complained bitterly about the long delays required by this institution to supply the required information. The impression was gained that the existing single Canadian Towing Tank was overloaded with work and could not respond adequately to the needs of shipbuilding in Canada.

(e) The shipbuilding industry is in the process of employing an increasing amount of computer aid, sometimes extending as far as computer centres in the U.S.A., Sweden, and Denmark.

(f) Most of the shipyards feel the need to up-grade the knowledge and ability of their existing technical personnel; many yards send them to short courses every few years. One of them even sends a few members of its technical staff regularly to Sweden for upgrading courses.

(g) The majority of the shipbuilding industry believes that as a result of environmental conditions there exists in Canada a need for more study and research to solve associated problems in marine technology.

### (iii) Shipbuilding Industry and Education.

The shipbuilding industry expressed a unanimous interest in the training of technical personnel at apprenticeship and technician levels. A majority of shipyards are attempting to aid the vocational schools in their community in this regard and in some cases themselves offer short courses directed by their own personnel. The reaction of various shipyards to a proposal for incorporating studies in Naval Architecture and Marine Engineering at a university level was not unanimous. Of the 14 shipyards visited, the representatives of 9 were convinced that such an attempt would benefit the shipbuilding industry. The representatives of three shipyards had some mild reservations concerning the type of engineering education to be offered, and stressed the "small" number of employment opportunities in Canada. The representatives of two shipyards were opposed to the project on the grounds that there was no "economic justification" for it, due to the "small" number of individuals involved.

It should be stated here that these consultations took place at a time when the writer and the representatives of the shipyards had no idea of the number of qualified



individuals at present actively engaged in shipbuilding. The discussion took place on an absolutely "intuitive" basis, during which the sole argument of the opponents was based on the belief that the number of Naval Architects and Marine Engineers in Canada was negligibly "small". Therefore the opinions in favour of or against higher education in Canada were solely the expression of a feeling, which at the time could not be substantiated by anything tangible, one way or the other.

### (3) Government

The question of the degree to which Government should concern itself with matters relating to the shipbuilding and shipping industries is an extremely complex one, and cannot be regarded as subject matter for this particular study. However it is relevant to note that economic and industrial development aspects of the marine business are often less than compatible with social or legislative realities, which may include political overtones. In Government itself, federal, provincial and even regional interest may contain mutually antagonistic aspects. At any level the objective of the federal Government resides in the pursuit of the national interest.

Specific objectives like the improvement of the fishing industry or the regulation and control of seaway traffic and safety of life at sea, constitute a now accepted part of governmental responsibility related to the shipping business. It is much more difficult to define the national interest involved in shipbuilding in an economic or a social sense. A pure economist could conceivably note that shipbuilding in Canada is not a profitable business, that it requires heavy subsidies, and he may therefore conclude that the capital investment involved should be shifted from this industry to more profitable businesses.

The proposal to establish an educational programme at a Canadian University found unanimous understanding and support in every department of the Federal Government. The lively interest in the project, as expressed by the Government personnel interviewed, is not accidental; these individuals have a broader view of the present and future role of shipbuilding in the country than the shipbuilders whose primary concern remains an acceptable profit margin in a relatively narrow field of activity.

Government Departments and Agencies visited and included in the following totals are:—National Research Council, Department of Transport, Department of Energy, Mines and Resources, Department of Defence Production, Department of Fisheries, Department of Industry, Department of National Defence and Defence Research Establishment, Atlantic. The education background of present technical personnel employed by the Government in Naval Architecture and Marine Engineering has been summarized (Table 1, P. 23). The projection of the Government for future needs in additional personnel has been included and the projected total increase spread over 10 years is 1.6% of the present enrolment per annum (Table 4, P. 30).

The Government presently employs 314 engineering personnel, the future projection is additional 53 engineers, so the total will amount to 367. The engineering increase alone will be 1.7% annually in Government positions in the next 10 year period.

#### (4) The Supporting Industries and Related Businesses

This group includes the technical personnel of consultants, classification societies, marine component manufacturers, and of shipping companies.

##### (i) Technical personnel of consultants and classification societies.

The majority of consultants and the Lloyd's Register for Shipping have been visited. All of them, with one exception, agreed that the incorporation of Naval Architecture and Marine Engineering into a Canadian university will be of benefit to shipbuilding. The qualification requirements of consultants for an engineering education were the same as those requested by the shipyards.

Consultants and classification societies who responded to my questionnaire and are included in the tabulation are:—Gilmore, German & Milne, Montreal; Commercial Marine Services Ltd., Montreal; G.T.R. Campbell, Montreal; Lloyd's Register for Shipping, Montreal; Jackson-Talbot, Vancouver; Greenwood & McHaffie, Victoria; Grenfell, Vancouver; Allan, Vancouver; W. Reid, Vancouver; John Brandlmayer Ltd., Vancouver; G.A. Whatmough, Toronto; Case Existological Lab., Victoria.

The present technical personnel employed by the consultants and classification societies amount to 137 individuals of which 102 are engineering personnel. The total future technical manpower needs of this group has been estimated by the employers to be 65 representing an annual increase of 4.75% in the next 10 years. The present engineering personnel amount to 102 with a projected increase of 39 (Table 4, P. 30) representing a yearly increase of 3.9% in the next decade. The relatively high rate in the future employment estimates of this group can be attributed mainly to the fact that consultants are also working on design projects of ships which are expected to be built outside Canada.

##### (ii) Marine component manufacturers

The component manufacturers also offer employment possibilities for engineering personnel in Naval Architecture and Marine Engineering. A large number of them were contacted and their response regarding their present employment pattern tabulated. Component manufacturers who responded to my questionnaire and are included in the tabulation, are:— Hall Corp. of Canada, Toronto; MacMillan Bloedel Ltd., Vancouver; Bedard Girard Ltd., Montreal; Garrett Marine, Rexdale; J. Swann Ltd., Vancouver; Beclawat, Montreal; John T. Hepburn Ltd., Toronto; Fleet Manufacturing Ltd., Fort Erie; Robert Morse Corp., Montreal; Peacock Brothers Ltd., Montreal; Marine & Power Eng., Rosemere, Quebec; Sulzer Bros., Montreal; Worthington, Toronto. Employment amounts to 129, of which 83 individuals are engineering personnel. The projected future needs of component manufacturers totals 27 individuals of which 23 are in the engineering group (Table 4, P. 30). The projected total increase is 2.1% per annum and the increase in the engineering group is higher being 2.77% per year in the next 10 years.

The marine component manufacturers do not specify any particular education requirement, although the majority of them prefer to employ marine engineers more

often than naval architects, in the belief that marine engineers may be able to cope with occasional assignments demanding some knowledge of naval architecture.

**(iii) Shipping companies and shipowners**

The employment opportunities for Naval Architects and Marine Engineers are not very numerous in this group. Shipping companies and shipowners who responded to my questionnaire and are included in the tabulation are:— McAllister Towing Ltd., Montreal; Imperial Oil Ltd., Toronto; Clarke Steamship Co. Ltd., Montreal; Saguenay Shipping, Montreal; Papachristidis Co. Ltd., Montreal; Newfoundland-Canada Steamships, Halifax; Hindman Transportation Co., Owen Sound; Quebec-Ontario Transportation, Montreal; Upper Lakes Shipping, Toronto; Canada Steamship Lines, Montreal. The present total technical personnel amounts to 46 of which only 21 have engineering qualifications (Table 4, P. 30). However, it was surprising that even in this group a certain need was felt for additional technical personnel. In their future projection they gave a total number of additional employment possibilities of 24 which corresponds to an annual increase of 4.51%; but their future requirement in engineering personnel was much lower, namely about 1.9% increase per annum in the next ten years.

The shipping business seems to be plagued by the same sort of problem as the shipbuilding industry, but their main complaints were concerned with the lack of legislation protecting Canadian shipping and the excessive financial burden in wages demanded by the seafarer's unions.

The above quantitative and qualitative description of the present situation in the shipbuilding industry, of the interests of the Government and of the supporting industries and businesses were taken into consideration in formulating the recommendations in Chapters 7 and 8 of this report.

**TABLE 1**  
**Education Background of Present Technical Personnel in**  
**NAVAL ARCHITECTURE OR MARINE ENGINEERING IN CANADA**

*Compiled information date: April 8, 1968*

Education Groups *		1			2			3			4			5			
Age groups a) below 25 b) 25–45 c) above 45		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	Total
Number of individuals	Shipyards	7	47	24	36	253	52	47	249	64	52	138	67	—	18	12	1066
	Government	9	100	21	3	112	69	4	72	42	15	118	61	—	—	—	626
	Consultants and Classification societies	1	18	6	8	53	16	3	10	5	2	11	4	—	—	—	137
	Component Manufacturers	7	24	3	12	35	2	7	8	—	1	29	1	—	—	—	129
	Shipping Companies and Shipowners	—	6	—	—	—	5	10	—5	4	5	6	5	—	—	—	46
	Summation by age groups	24	195	54	59	458	149	61	344	115	75	302	138	—	18	12	
	Summation by education groups	273			666			520			515			30			
	Summation by engineering and technical groups	939						1035						30			
TOTAL		2004															2004

- \* 1 Academic Engineering Degree  
 2 Professional Diploma  
 3 Trade School Diploma  
 4 No Diploma, Practical Training  
 5 Other Academic Degrees

EDUCATION BACKGROUND OF PRESENT TECHNICAL  
PERSONNEL IN NAVAL ARCHITECTURE AND MARINE  
ENGINEERING IN CANADA

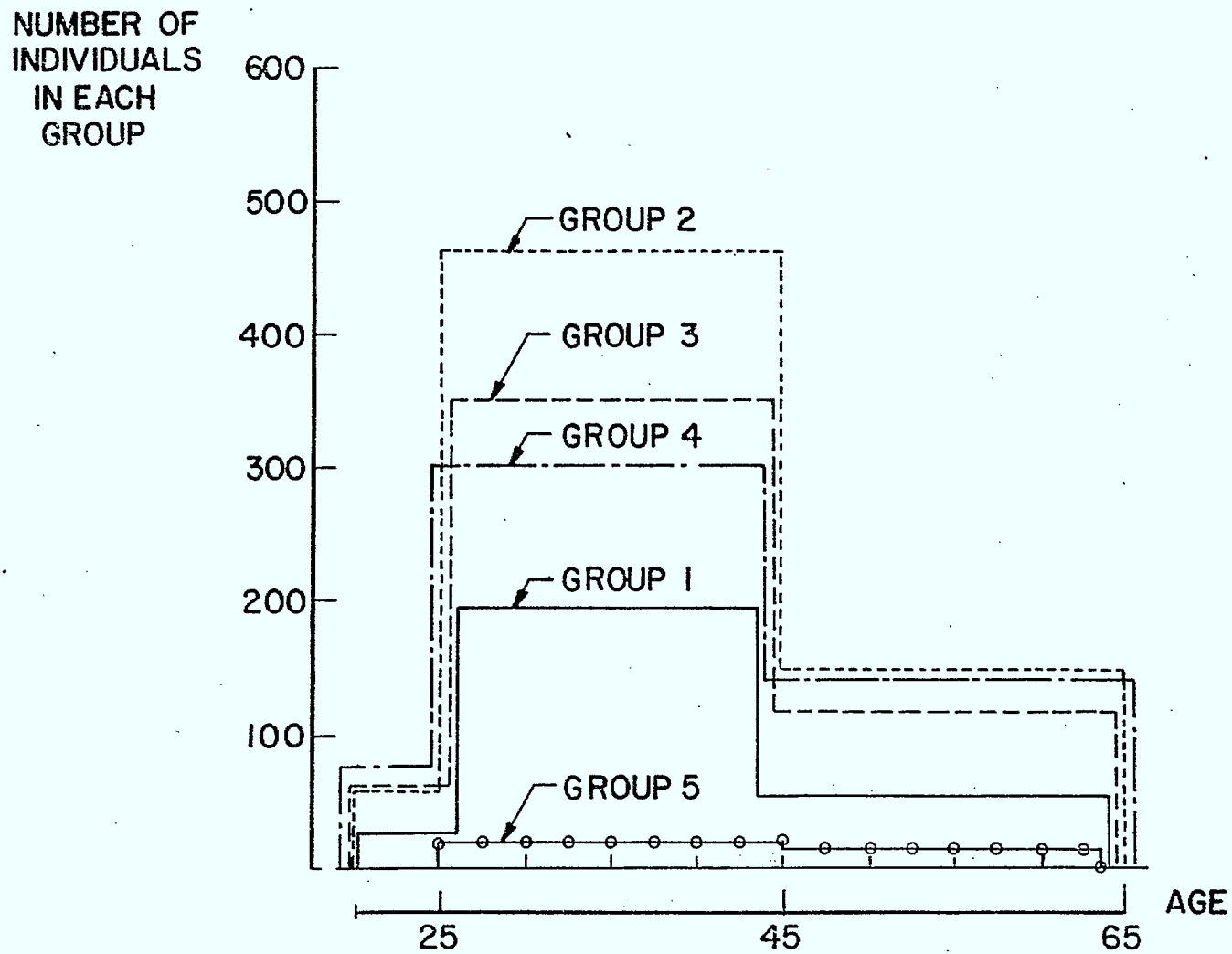


FIGURE 1

TABLE 2

Present Distribution of Engineering and Technician Personnel  
Trained or in Business Associated With

## NAVAL ARCHITECTURE AND MARINE ENGINEERING IN CANADA

Compiled information date: April 8, 1968

	Engin. Pers.		Technical Personnel		Other degrees		Total	
	Groups 1 and 2	Percent of Grand Total %	Groups 3 and 4	Percent of Grand Total %	Group 5	Percent of Grand Total %	For Activity Section	Percent of Grand Total %
Shipyards	419	20.9	617	30.8	30	1.5	1066	53.3
Government	314	15.9	312	15.6	—	—	626	31.3
Consultants and Classification Societies	102	5.1	35	1.7	—	—	137	6.8
Components Manufacturers	83	4.1	46	2.3	—	—	129	6.4
Shipping Co. and Shipowners	21	1.1	25	1.2	—	—	46	2.3
TOTAL	939	46.9	1035	51.6	30	1.5	2004	100%

GRAND TOTAL

PRESENT DISTRIBUTION OF ENGINEERING AND TECHNICAL PERSONNEL  
 TRAINED OR IN BUSINESS ASSOCIATED WITH NAVAL ARCHITECTURE  
 AND MARINE ENGINEERING IN CANADA

Compiled information  
 date : April 1968

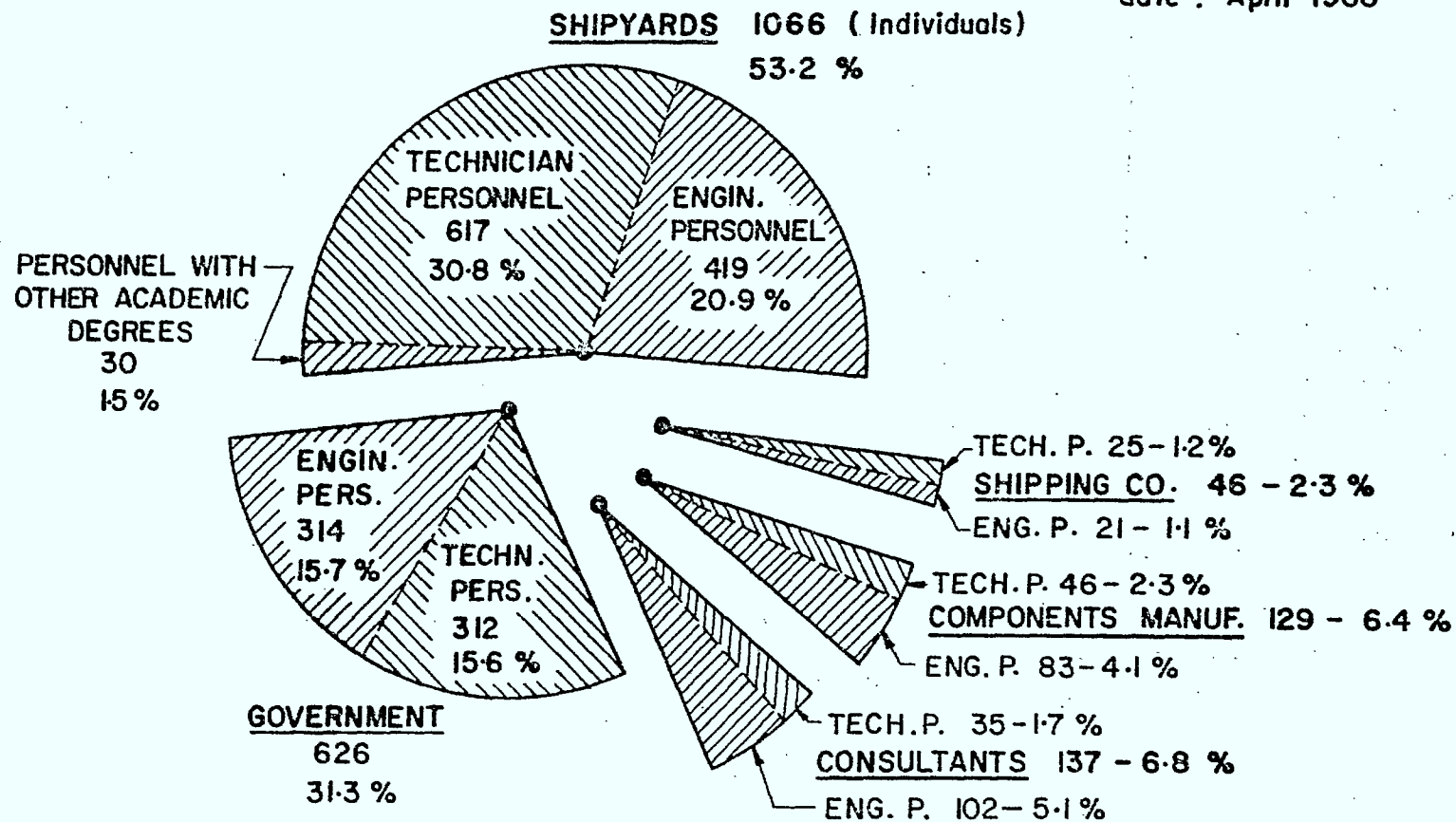


FIGURE 2



# TECHNICAL PERSONNEL OF SHIPYARDS EMPLOYED IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

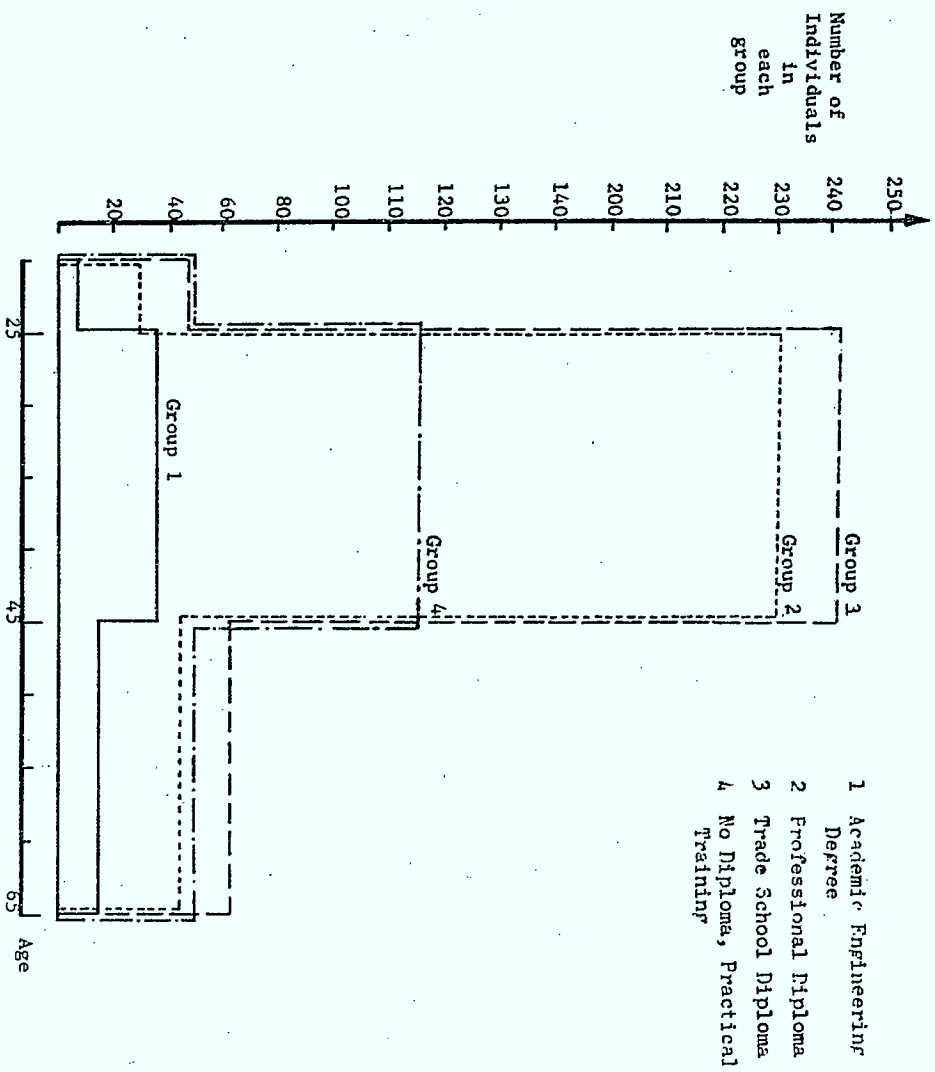


FIGURE 3

## PERSONNEL FULFILLING A MANAGEMENT ROLE IN SHIPYARDS

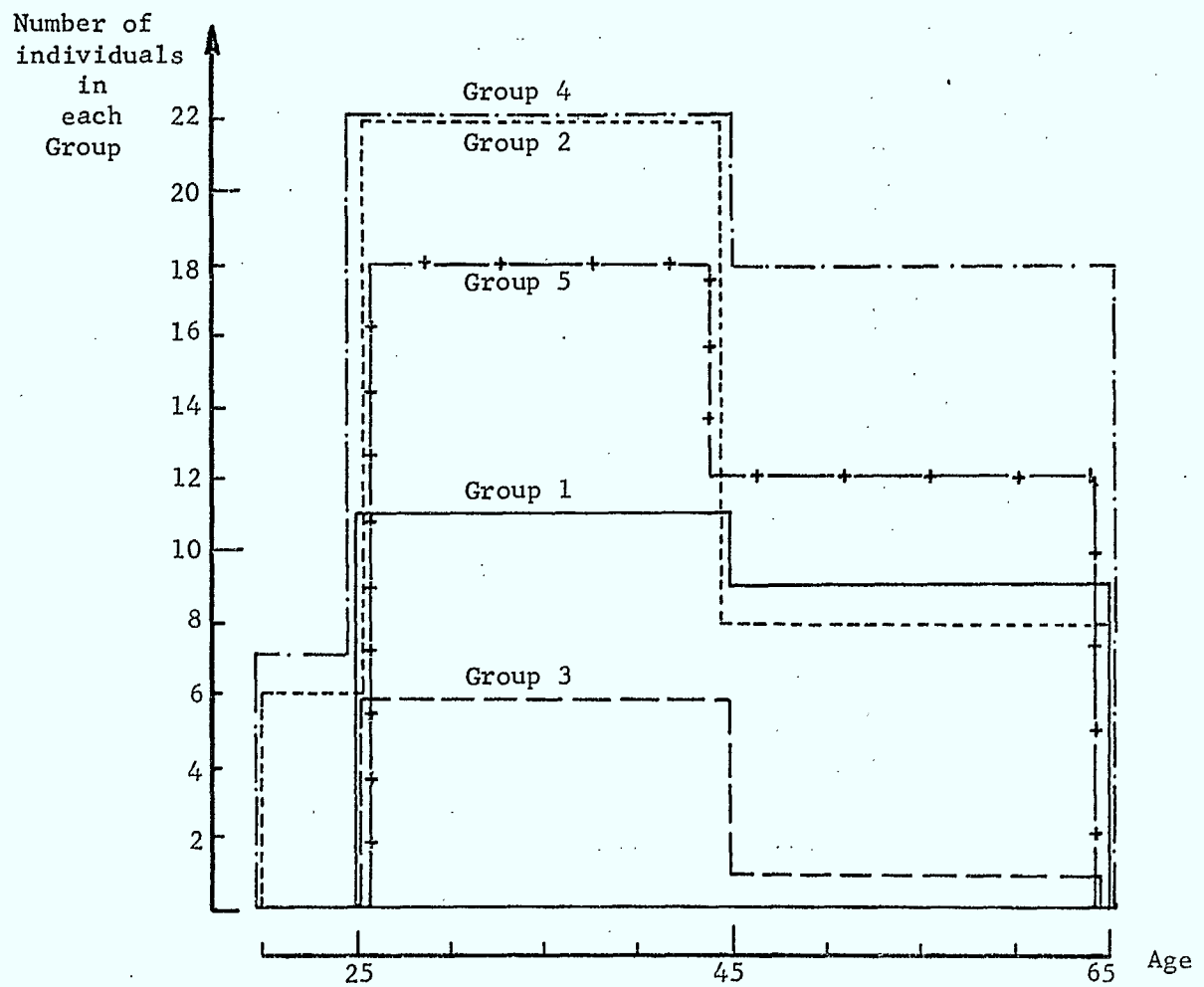


FIGURE 4

**TABLE 3**  
**Future Needs for Additional Personnel Trained in**  
**NAVAL ARCHITECTURE AND MARINE ENGINEERING IN CANADA**

(Based on the projection of employers)

*Compiled information date: April 8, 1968*

Education Groups		1	2	3	4	Tot.
Number of individuals	Shipyards	—	—	—	—	—
	Government	19	34	25	24	102
	Consultants and Classification Societies	14	25	18	8	65
	Component Manufacturers	11	12	4	—	27
	Shipping Companies and Shipowners	4	1	2	17	24
	Summation by education groups	48	72	49	49	
	Summation by engineering and technician groups	120		98		
	TOTAL	218				218

TABLE 4

## Present Staff and Future Needs for Additional Personnel Trained in

## NAVAL ARCHITECTURE AND MARINE ENGINEERING

(Based on present statistical data and the projection of the employers)

Compiled information date: April 8, 1968

Education Groups		1		2		3		4		5		
Number of individuals		Present Staff	Employer's future proj.	Present Staff	Employer's future proj.	Present Staff	Employer's future proj.	Present Staff	Employer's future proj.	Present Staff	Employer's future proj.	Total
	Shipyards	78	—	341	—	360	—	257	—	30	—	1066
	Government	130	19	184	34	118	25	194	24	—	—	728
	Consultant and Classification Societies	25	14	77	25	18	18	17	8	—	—	202
	Component Manufacturers	34	11	49	12	15	4	31	—	—	—	156
	Shipping Companies and Shipowners	6	4	15	1	9	2	16	17	—	—	70
	Summation of present staff and employer's future projection	273	48	666	72	520	49	515	49	30	—	
	Summation by education groups	321		738		569		564		30		
	Summation by engineering and technician groups	1059				1133				30		
	TOTAL	2222										

## CHAPTER 5

### TRENDS IN CANADIAN EDUCATION RELATED TO THE MARINE INDUSTRIES

The need for an institution offering education and training in Naval Architecture and Marine Engineering has been felt in various locations in Canada during the last five years. Efforts have been made to correct this at every level of education. The main motive behind these attempts has been the existence of a local need which was small in scope and readily satisfied by training only a few individuals. The salient character of all these efforts has been a complete lack of co-ordination of the requirements of different localities, even within a single province. Under these circumstances it was to be expected that most of the initiated training programmes, from those of vocational schools up to those of higher learning institution could only last a few years. This was the natural result of the disproportion between the relatively small local requirement for education and training, and the high cost of retaining a qualified staff for this purpose.

The failure of these numerous disseminated efforts created not only disillusion but also, rightly, led to the belief that the scheme was impractical. Indeed this situation will remain with us unless there is a strong co-ordination between the requirements of a large number of localities.

The following paragraphs review the situation existing in Canada today and enumerate all courses relating to marine engineering or naval architectural training, no matter how basic or how tenuous the relationship with accepted professional training.

#### (1) Universities

All Canadian universities which are geographically located in a shipbuilding region have been verbally contacted, or personally visited. The following Universities declared that they have no courses related to shipbuilding: University of Toronto, Universite de Montreal, Ecole Polytechnique, McGill University, Queen's University, Dalhousie University, the University of New Brunswick, Sir George Williams University, University of Western Ontario, University of Windsor, McMaster University, the University of British Columbia, the University of Victoria.

A few universities have expressed a mild interest:

(i) *Universite Laval, Quebec City, P.Q.* Complying with the desire of the Provincial Government this University has for two years contemplated the incorporation of some studies concerning shipbuilding leading possibly to a degree. A standing committee at Universite Laval is still studying the feasibility of the scheme. During an interview with Dean Geoffrion and Vice-Dean Dr. Paul H. Roy on December 6, 1967 the writer was asked to participate in the deliberations of the committee.

(ii) *Nova Scotia Technical College, N.S.* The name of this institution is misleading; its organization and accreditation conform exactly to the standards of a University in Engineering Sciences, and it awards degrees in Engineering at B.Sc. M.Sc. and Ph.D. levels.

At the B.Sc. level the Nova Scotia Technical College offers an Honours Programme including a Ship Design course as a three-term sequence of study related to particular aspects of ship design. The content of the course sequence is flexible and depends on the interest of the participants. It is taught by a single individual who is a lecturer in the Mechanical Engineering Department.

## 2) Technical Colleges and Institutes

Various technical colleges and institutes offer a sequence of courses specified as in Naval Architecture and Marine Engineering. They are reviewed below following their order of success in stabilizing themselves as a learning institution.

(i) *Institut de Technologie Maritime, Quebec City, P.Q.* This institute has been the most successful of different similar institutions. For five years it has offered a regular course in Naval Architecture which lasts three years and it normally admits students from Grade 11 from High Schools. The successful graduate received a diploma; the first graduating class this year contained 12 students. One or two exceptional graduates of the School have been admitted to the University of Glasgow, Scotland, in order to further their studies leading to a degree. The University of Michigan, Ann Arbor, asked the writer for a general recommendation for one graduate of the Institut Maritime this year, who applied for graduate studies. A conditional recommendation was given which stressed the fact that the student may need some additional non-credit courses in order to strengthen his knowledge in the fundamentals of engineering and social sciences.

During a visit to this institute and lengthy interviews with its administrators and students, the impression was gained that they have a very strong professional training in Naval Architecture, comparable to Ordinary National Certificate requirements in Scotland. Graduates of the institute should become excellent technicians in the field, some exceptional individuals may even pursue studies leading to a degree. However, the general trend of the education system is too specialized and too narrow to be properly described as an academic education. The programme lacks depth in fundamental engineering sciences and in non-technical subjects to be at a level comparable with an engineering education at a University. It should also be recognized that the curriculum in Naval Architecture at the Institut Maritime is the most complete in a technical sense available in Canada; and the implementation of this programme has been strictly followed to date.

(ii) *Coast Guard College, Sydney, N.S.* The Coast Guard College admits students from Grade 11 for a three-year course. Their graduates are intended to become marine engineers in the operator sense. Should their programme be applied as it is formulated, the best students in a graduating class may attempt to pursue further studies at the University level.

(iii) *Institut de Marine, Rimouski, P.Q.* This institute is the Quebec counterpart of the Coast Guard College in Sydney, Nova Scotia. The admission and graduation conditions are similar. Personal contacts led to the belief that the implementation of their programme has not been very earnestly followed.

(iv) *School of Fisheries, St. John's, Newfoundland.* The calendar of this school promises an extensive interest in shipbuilding; unfortunately this does not correspond to the existing situation. The school was unable to retain the qualified personnel which



were formerly on the staff and has deteriorated rapidly without having had an opportunity to implement the envisaged programme. According to the calendar, the school admits Grade 11 students for a three and a half year course of study. The publicized small towing-tank is ready but not equipped with instrumentation and is rather badly planned, circumstances which will handicap its future operation. The main activity of the school in shipbuilding seems to be concentrated on wooden construction.

(v) *George Brown College, Toronto, Ontario.* It was the intention of the administrators of this College to start offering regular courses in Naval Architecture this year parallel to their existing Marine Engineering courses. Normally the college admits Grade 12 students for a period of study and practice of four years. The Marine Engineering programme for operators seems to have reached a certain level of perfection. The main interesting feature of the College is their correspondence course in Naval Architecture and Marine Engineering which has been a valuable training tool for some years. The course is designed for technicians and operators, but it is strong enough to form the nucleus of an integrated education system for the whole of Canada in the future.

### (3) Vocational Schools

In vocational schools in almost every maritime locality in Canada some intermittent efforts have been made to introduce Naval Architecture and Marine Engineering. Almost everywhere the activity of a vocational school is closely connected with the training of apprentices from a shipyard in the neighborhood.

On the east and west coasts none of the vocational schools maintain a steady programme because of the limited and fluctuating number of interested students. Wherever the Education Department of provincial governments did not feel they had adequate justification to provide courses in Naval Architecture, the shipyards in many cases attempted to improvise some courses of their own, using their own personnel. The situation is so confused that any interested apprentice student must feel quite discouraged. In vocational schools and in apprenticeship courses, only the techniques temporarily and immediately needed are superficially reviewed for a short period of 4 to 6 weeks, and even this appears to be done to comply only with the requirements of the local shipyard. This system does not provide any essential training which may lead to the development of a special skill. One should not wonder that the apprentices of shipbuilding have a strong tendency to shift to other industries; they have never felt themselves at home in shipbuilding.

Another activity noted is the offering of short courses in a special area like wooden boatbuilding. Such a short course has been offered frequently in Vancouver, B.C. with a successful local shipbuilder as instructor, who is an individual without much formal education but with a good deal of common sense and a highly developed skill. I would like to quote his own words: "I tell them all I know, this is very little. They would like to know more, so would I; to whom should we address ourselves? "

Interest in shipbuilding is so sparsely disseminated over this country that it will never be economical to build strength in each locality, but the total number of

interested people in the field is by no means negligible. Therefore it seems appropriate to make a major effort to establish a scientific information center with high standards which can adequately respond to the various needs of different parts of the country.

## CHAPTER 6

### INTERNATIONAL SYSTEMS OF EDUCATION IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

I have made an extensive qualitative review of the educational methods related to Naval Architecture and Marine Engineering in practically all countries having a minimal amount of marine industry. The educational system of each country adapts itself to the existing social, economic and regional conditions, so that it is impossible to determine exactly similar systems, even between the higher learning institutions of the same country. It would be presumptuous to embark on a detailed analysis of the merits and defects of the systems of these countries, which are actually fulfilling diverse functions. Also, it is not intended to describe and compare the different methods of education which exist. This has been exhaustively performed by Professor R. A. Yagle of the University of Michigan in his recent paper "Naval Architecture Education of Today" (SNAME Nov. 10-11, 1966). Further, the existing system in the United Kingdom has been reviewed in a comprehensive report, "The Higher Education and Training of Naval Architects" prepared for the Council of the Royal Institution of Naval Architects in February 1966 by a committee of 18 members, under the chairmanship of J. H. B. Chapman, C.B.

This chapter has been written for the following three reasons:

(i) To detect any emerging new trends in the education of Naval Architects and Marine Engineering.

(ii) To examine the general but inherent difficulties caused by incorporating Naval Architecture and Marine Engineering in a University, as distinct from environmental difficulties dictated by the economic climate in the Canadian shipbuilding industry.

(iii) To obtain statistical data concerning the duration of formal study, the numbers of students, of Faculty, and of yearly graduating students, in order to evaluate the equivalent needs of a Canadian institution.

These objectives have been pursued by contacting 32 higher learning institutions in different countries offering courses which lead to an internationally recognized degree. The questionnaire (Appendix E, P. 81) has been sent to most of them. Because the economy and technology of Canada are comparatively similar to those of the United States, it was felt that the American methods should be more extensively studied, and several visits were made to the Massachusetts Institute of Technology and to the University of Michigan.

From the 32 institutions contacted, 28 have adequate information concerning their educational systems and the qualitative and quantitative results obtained are summarized in Table 5 (P. 40).

In general, it can be stated that a very small number of Universities consider their present system as satisfactory and well adjusted. Even in countries like Japan and Sweden where shipbuilding is foremost, the established trends seem to have shown some defects. For example, the University of Yokohama states explicitly that they ought to make some changes in their present systems.

### (1) Emerging Trends in the Education of Naval Architects and Marine Engineers

The review of answers obtained from different universities indicates that the most dominant trend in the education of Naval Architects and Marine Engineers is towards a broader educational basis with less emphasis on specialized professional knowledge. Institutions like "Technische Hogeschool, Delft, Holland" and "Webb Institute of Naval Architecture, Glen Cove, U.S.A." adhere still to their established conventional systems, relying on the continuation of their success in the past. However, the number of institutions with this philosophy is very restricted.

A vast majority of learning institutions is aware that the technology is continuously changing and hence are looking forward to implementing a system which will provide the new graduates with the spectrum of knowledge that modern technology requires from them. Admittedly, this spectrum looks entirely different today when compared to the pre-World War II era.

In order to implement a broader education, most of the universities are presently engaged in an exercise which renders their sequence of courses more compact, in the sense that the fundamentals are stressed and hence the professional courses become condensed. The fundamental courses like mathematics, mechanics, fluid mechanics and thermodynamics are taught as extensively as possible. The professional courses like steam turbines, auxiliary machinery of ships, are not developed in much detail at an undergraduate level. The increased stress on fundamental courses has brought the Naval Architecture and Marine Engineering curriculum very close to the curriculum of other engineering departments, specifically Mechanical Engineering. This trend can be followed up in continental Europe, where an integration between both departments at an undergraduate level is taking place. I will quote from a letter addressed to me in July 1967 by the Dean of Chalmers University of Technology, in Sweden: "We are integrating Naval Architecture in the department of Mechanical Engineering, and we no longer accept any student for the first year in Naval Architecture and Marine Engineering".

A second but not so marked trend is also noticeable in the reduction of the duration of studies, especially in continental Europe in institutions which require more than four years for the awarding of their first academic degree.

### (2) Inherent Difficulties in the Establishment of a University Educational System in Naval Architecture and Marine Engineering

Reviewing the enrolment of different universities, one notices that the number of students in Naval Architecture and Marine Engineering is always much smaller than in other fields of engineering, except for Japanese universities. This reflects more or less the ratio of marine activity to the total industrial activity of a country. The shipbuilding and related marine industries represent, generally, a small portion of the total volume of industry in every country. The contribution of marine industry is not even close to the range of chemical, electrical, mechanical or civil engineering. This disproportion in the volume of industries creates an inherent difficulty in the incorporation of Naval Architecture studies in a Faculty of Engineering.

These difficulties can be stated thus:—

(i) The establishment of this course of study for a restricted number of students will require a higher capital and operation cost per capita of students. Although it is not easy to entirely overcome this difficulty, it may be seen from the statistical data (Table 5, P. 40) that in countries such as Belgium, United Kingdom and Sweden, Naval Architecture and Marine Engineering education with an enrolment ranging from 3 to 30 students is regarded as feasible.

(ii) A second but even more severe difficulty is recognized in the high fluctuation in the number of enrolled students. As the volume of business in the shipbuilding industry changes, so any depression immediately affects the enrolment in universities. In sectors of industry with a larger volume, depression periods are not felt by universities quite as severely and it takes a much longer period of time until they may produce a certain marked influence on university enrolment. However, the reverse is also true, and any growth in shipbuilding industry produces a sudden increase in university population in this field. The high fluctuations in the number of students creates one of the biggest difficulties when it is required to project the effects of incorporating courses in Naval Architecture and Marine Engineering at a university. For example, the Technical University of Berlin, which accommodated 158 students in 1965, had enrolment drop to 80 in 1967, a most embarrassing and costly situation for the Department.

The relatively small number of students interested in a prospective Naval Architecture and Marine Engineering option in Canada has been pointed out to me as a specific Canadian problem. I would like to stress the fact that the restrictions and fluctuations in enrolment are definitely not related solely to conditions peculiar to Canada, but rather they are some of the inherent difficulties encountered in any proposal to incorporate Naval Architecture and Marine Engineering into a Faculty of Engineering, anywhere in the world. While it may be dangerous to assume that the continuing existence of these studies in other countries is automatically an endorsement of their success, nevertheless this fact does tend to support the feasibility of providing similar facilities in Canada.

### (3) International Statistical Data Concerning Higher Learning Institutions

The duration of studies, enrolment, numbers of faculty members and total number of graduating students in Naval Architecture and Marine Engineering at higher learning institutions of the world in 1967 have been compiled and presented in Table 5 (P. 40).

The structure of each university being unique, it was a difficult task to bring all the furnished data under a unified basis of comparison. Although utmost care was taken to prevent any mistakes, it is very likely that some minor misunderstanding in correspondence with twenty-eight universities may have slipped into the information gathered. It is quite pointless to strive to make the data more accurate, because during the time spent on gathering the data, the universities were changing their policies and enrolment. The statistics presented in this report represent roughly the state in 1967, as it was evaluated by the individuals in their own universities.

The striking feature of this analysis is that 25% of the existing institutions operate with a student enrolment of less than 35 students and 45% of the institutions have a



yearly graduating class of less than 10 students per year. These numbers are close to the range of operation in the proposal to incorporate Naval Architecture and Marine Engineering, and signifies that if the proposal is carried out, the Canadian university will be classed in the upper level of 71% of the world institutions with respect to enrolment, and in the 57% of world institutions with respect to the number of yearly graduates (see P. 40).

In Table 6 (P. 42) an attempt has been made to obtain the ratio ( $R_1$ ) of total number of students with respect to the number of teaching staff and also to calculate the ratio ( $R_2$ ) of the number of yearly graduating students with respect to the number of teaching staff. As could be expected, these ratios vary in a wide range due to the diversified functions of each university. From the data obtained a world average has been computed to be  $R_1 = 7.8$  and  $R_2 = 1.72$ . It is impossible to consider these statistical averages as an absolute criterion of merit because each institution should be considered on the basis of the extent and type of work in which it is engaged. A university extensively engaged in research work can not be compared on this basis with an institution whose main objective is teaching. However, the world averages  $R_1$  and  $R_2$ , may give an indication of the number of faculty members necessary to integrate an option in Naval Architecture and Marine Engineering as it is outlined in the Canadian proposal.

#### (4) Systems in East European Countries

During this part of the study an effort has been made to obtain statistical data from the Eastern European countries. The only response came from the University of Gdansk, Poland, and the numbers for this institution have been included in the tables. I was assured by Dr. Doust that the Polish education system was a replica of the Russian education system. But, unfortunately continued efforts on my part did not result in firsthand information concerning the Russian educational system. Professor R. Yable gives passing mention in his paper to the Leningrad Shipbuilding Institute, and other Industrial institutes in Gorki, Odessa, Kaliningrad, Vladivostock "and also a new institute in Varna, Bulgaria, with a total teaching staff in Naval Architecture of about thirty professors".

I obtained more recent information through the Blackadder lecture of Professor E. V. Telfer, delivered at the University of Newcastle-upon-Tyne on February 26, 1968 on the subject of "British Shipbuilding in a Changing World". As a matter of interest, I directly quote Professor E. V. Telfer on the subject:

"Quite apart from what the Russian annual tonnage output may be, it is surely staggering to read that the Institute of Shipbuilding, in Leningrad has currently 7500 students. These are housed in an Associated Student Town covering an area of 200.000 M<sup>2</sup>, the actual student hostels consisting of six twelve-storied buildings. The main institute building in the "town" has thirteen stories and houses the shipbuilding and electro-mechanical faculties. Other buildings include a canteen seating 1600 persons, a central hall for 1500 persons and a main library with at least 6000 volumes. Leningrad is moreover not the only shipbuilding centre in Russia. Vladivostock and Odessa have also very ample training facilities."



I do not know the source from which Professor Telfer has obtained this information, but suspect the accuracy of his figure '7500' when discussing the number of students involved. The total enrolment of 4 Japanese universities is 917 in Naval Architecture and Marine Engineering, and one might expect a number around 3000 by simple proportionality of population for the U.S.S.R. The discrepancy may be due to the fact that the definition of Shipbuilding may be much broader in the U.S.S.R. than in the West.

#### (5) Practical Experience

Practical experience as an integral part of technological training is given different emphasis in different countries and institutions. Generally European universities impose a minimum time of practical work as a prerequisite for a degree. The majority of American institutions view practical experience as desirable, and they encourage it, but do not make it compulsory. From the twenty-eight institutions contacted, seventeen require a period of practical training varying from 1-1/2 months to 15 months.

The results obtained in this survey of international systems of education have been given due consideration while formulating the proposal for a Canadian educational system in Naval Architecture and Marine Mechanical Engineering. This is dealt with in Chapters 7 and 8.

**TABLE 5**  
**Naval Architecture and Marine Engineering**  
**at Higher Learning Institutions of the World**

The name of the educational institution	Required number of years	Total number of students NA and Ma Eng.	Number of Faculty Members in NA & Ma E.	Number of Grads with B.Sc. last year	Remarks
U. of Buenos Aires Argentina	6 M.Sc.	130 undergrad	21	3	affiliated with Mech. E
U. de Liege Liege, Belgium	5	4	9	none	lecturers from industry every week
U. of Ghent Belgium	5	3	2	1	affiliated with Fac. Applied Science
U. of Sao Paulo Brazil	5	203 u.g.	16	12 B.Sc.	practical training desirable not compulsory
Danmarks Tekniske Højskole, Copenhagen Denmark	5.5 M.Sc.	—	8	8	12 months practical
U. of Newcastle-upon-Tyne, Dept. of NA and Shipbuilding G.B.	4	84	9	18	Refer to report RIN 1966
U. of Glasgow Dept. of NA G.B.	4	34	6+ add	6	" " "
U. of Strathclyde G.B.	4	25	4	5	Partially co-operative
The Royal Naval College Greenwich G.B.	5	30	3	6	Transferred to Mech. Eng. of University College London 1967
Techn. Universitaet Berlin, W. Germany	4	80	18	15 Dipl. Ing. 2 Dr. Ing.	9 months pract. training-No. of students decreasing
Techn. Hochschule, Aachen Inst. for Shipbuilding W. Germany	5-6 Dipl-Ing	60-70	12	11	9 months pract. training
Techn. Hochschule Hannover, W. Germany	4-5 Dipl. Ing.	132	33	35	8 months pract. train.-decrease in students
U. of Hamburg Hamburg, W. Germany	4-5.5 Dipl. Ing.	50	3 affiliated with Hanover	30	9 mon. practical training
Techn. Hogeschool Delft, Holland	7 M.Sc.	200	13+ 50	9	6 months pract. training
Indian Inst. for Technology, Kharagpur India	5.5-	~60	7+ ad.	B.Sc.	
U. of Naples Napoli, Italy	5	75	17	14	
U. of Tokyo Tokyo, Japan	4	360 u.g. 71 grad	25	80 B.Sc. 20 M.Sc. 1 Ph.D.	1.5 months pract. training

TABLE 5

The name of the educational institution	Required number of years	Total number of students NA and Ma Eng.	Number of Faculty Members in NA & Ma E.	Number of Grads with B.Sc. last year	Remarks
Kyushu University Kyushu, Japan	4	140	16 + 24	35 B.Sc. 9 M.Sc.	2 months pract. training
Yokohama Nat. U. Yokohama, Japan	4	160 u.g. 16 grad	14	34 B.Sc. 3 M.Sc.	~1.5 months changes in curriculum
Osaka University Osaka, Japan	4	140 u.g. 30 grad	10	30 B.Sc. 10 M.Sc. 1 Ph.D.	2 months practical training
Technical U. of Norway Trondheim, Norway	4 1/2	190	15	20 B.Sc.	15 mon. pract. training-revision 1968
U. of Gdansk Gdansk, Poland	5	300	34+.	~50	7 mon. pract. training 3 options
The Royal Inst. of Technology Stockholm, Sweden	4 1/2	25 u.g. 6 grad	5+ 2 pt. time	15 between B.Sc. & M.Sc.	3 mon. pract. training system is to be affiliated with M.E.
Chalmers U. of Tech. Goeteborg, Sweden	4	158 u.g. 13 grad	17	7	6 mon. pract. training system is to be affiliated with M.E.
Mass. Inst. of Tech. Cambridge, Mass. USA	4	20-25 u.g. 120-130 grads	14-17	20 Eng. 15 M.Sc. 3 Ph. D.	practical training encouraged
U. of Michigan Ann Arbor, Mich. USA	4	147 u.g. 30 grad	12+.	35 B.Sc. 14 M.Sc. 1 Ph.D.	3 options
Webb Inst. of Nav. Arch. Glen Cove, N.Y. USA	4	70 u.g. 17 grad	13	9 u.g. 1 grad	8 months practical training
Univ. of Calif. Berkeley Berkeley, Calif. USA	2 M.Sc. after B.Sc.	25	3	13 grad. Deg.	Only Graduate School

TABLE 6

Ratios of Students and Graduates to the Faculties  
in Naval Architecture and Marine Engineering  
at Higher Learning Institutions of the World

The Name of the Educational Institution	Ratio of total number of students to the no. of faculty ( $R_1$ )	Ratio of graduates to the no. of faculty ( $R_2$ )	Remarks
U. of Buenos Aires Argentina	6.2	0.143	
University de Liege Liege, Belgium	0.443	0.00	No graduates
University of Ghent	1.5	0.50	
University of Sao Paulo	12.7	0.75	
Danmarks Tekniske Højskole Copenhagen, Denmark	—	1.0	
U. of Newcastle-upon-Tyne, Dept. of NA and Shipbuild. Great Britain	9.32	2.0	
University of Glasgow Dept. of Naval Archit. Great Britain	5.32	1.0	
U. of Strathclyde Great Britain	6.23	1.25	
The Royal Naval College Greenwich, G.B.	10.0	2.0	
Techn. Universitaet Berling, W. Germany	4.43	0.945	
Techn. Hochschule, Aachen Inst. for Shipbuilding W. Germany	5.84	0.92	
Techn. Hochschule Hanover, W. Germany U. of Hamburg Hamburg, W. Germany	5.05	1.80	Summed up because of co-operation
Techn. Hogeschool Delft, Holland	3.18	0.692	
Indian Inst. for Technology Kharagpur, India	8.55	1.00	
University of Naples	4.41	0.823	
University of Tokyo Tokyo, Japan	17.25	4.05	
Kyushu University Kyushu, Japan	8.75	2.75	
Yokohama Nat. University Yokohama, Japan	12.55	2.65	
Osaka University Osaka, Japan	17	4.1	
Technical U. of Norway Trondheim, Norway	12.66	1.33	
University of Gdansk Gdansk, Poland	7.8	1.47	
The Royal Inst. Of Technology Stockholm, Sweden	6.2	3.00	
Chalmers U. of Techn.	10.0	0.41	
Mass. Inst. of Technology Cambridge, Mass. USA.	8.85	2.24	
University of Michigan Ann Arbor, Mich. USA.	14.75	4.16	
Webb Inst. of Nav. Arch. Glen Cove, N.Y. USA.	6.7	0.77	
Univ. of California Berkeley Berkeley, Calif. USA.	8.33	4.33	Grad. School

**PART III**

**ACADEMIC EDUCATION IN THE  
MARINE INDUSTRIES:  
A PLAN FOR CANADA**



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## CHAPTER 7

### A MEANS OF IMPLEMENTING STUDIES

#### AT A CANADIAN UNIVERSITY

The ultimate aim of the present study has been to formulate either a positive or negative recommendation concerning the establishment of academic studies in shipbuilding in Canada. Earlier chapters have been devoted to summarizing data collected during this study, the necessary prerequisite of a knowledgeable recommendation which must truly reflect the industry's educational requirement.

In Canada there are presently 939 individuals (Groups 1 and 2) having an educational background in engineering and working in the marine industries. It is expected that ten years from now this number will reach 1059 (Table 1, P. 23 and Table 4, P. 30). This fact should not leave any doubt that there exists a definite need for engineering personnel professionally trained in marine matters, and I do not believe that this need can be satisfied by merely substituting individuals with only a technician's background into engineering employment. The fundamental problem resides in the means of supplying engineering personnel to the industry. This supply can either be by importing engineers educated abroad as is now the case, or by establishing an education system within Canada. In shipbuilding circles, there is a dwindling, hard-core minority, who feel that education in Naval Architecture and Marine Engineering is the right and privilege of Britain and they still try to hold on to this tradition.

#### (1) Main Deficiencies of the Existing System of Recruiting Engineering Personnel

In order to give a detailed evaluation of the present British education system, reference should be made to the Geddes report, and also the Chapman Report on "The Higher Education and Training of Naval Architects" (1966). More or less the same type of criticism as occurs in these reports can also be levelled against most European-based education systems in the marine field. An attempt will here be made to explore the problem from the Canadian point of view, to show that the present system of importing personnel trained in Naval Architecture and Marine Engineering is already obsolete, and is likely to deteriorate more rapidly in the future; it may also be highly detrimental to the survival and development of Canadian shipbuilding.

The Canadian need for Naval Architects and Marine Engineers will amount statistically to 1059 as shown in Table 4 (P. 30) in the near future. Let us assume the average age of the presently-engaged engineering personnel to be 35. If they remain active during the next 30 years then at the end of that time the whole population of Naval Architects and Marine Engineers must be completely replaced. This rate of replacement corresponds to an annual addition of about 35 engineers over the next 30 years. Even if the projected increase were completely ignored, the 939 engineers

presently active (Table 1, P. 23) will require an additional 31 individuals annually to maintain the present level of employment.

If the average age had been chosen as 40, the annual requirement for engineering personnel would increase to 42 individuals. By a fairly conservative estimate, therefore the country will require an annual addition of around 35 Naval Architects and Marine Engineers in the immediate future. By the present standards and statistics this rate corresponds to the sum of B.Sc. graduates of the following institutions (Table 5, P. 40):

University of Glasgow	6 B.Sc. graduates
University of Strathclyde	5 " "
The Royal Naval College	6 " "
Technische Hochschule Aachen (Germany)	11 Dipl. Ing.
Chalmers University of Technology (Goeteborg, Sweden)	7 B.Sc. graduates
	35 B.Sc. graduates

Without even considering its desirability, it is highly unlikely that Canada will always be able to attract enough skilled individuals corresponding to the total output of graduates from the above five European institutions.

Further, if the recommendations in various reports for the revival of the British shipbuilding industry are even partially implemented, it must be expected that the flow of immigrants from this main source will be reduced to a mere trickle in the future.

It has already been mentioned that educational training in Europe does not correspond to the needs of this country, because of major differences in the type of industry involved. The European educational system is professionally oriented; Canadian industry requires a much more diversified educational background. The writer would like to refer to the requirements of Canadian shipbuilders (Chap. 4, P. 15) who regard "flexibility" as a major attribute in engineering personnel. Knowledge of the use of modern techniques such as critical path scheduling, computer aided fairing and automatic control have been suggested as educational prerequisites by Canadian industry, but have not been given any great emphasis in most of the European educational institutions giving courses in Naval Architecture and Marine Engineering. One outstanding defect of European-based engineering education is the total discard of the concept of "creativity" in a technical and administrative sense, so that the engineering ideal is more likely to be a safe reproduction of existing designs, than the design of the most functionally efficient and economic product the engineer is able to conceive. The opinion has often been expressed that engineering personnel with backgrounds from various systems of education may induce a fruitful cross-fertilization of ideas. Taken literally, this opinion has a general academic validity. But first hand impressions gained in contact with the shipbuilding industry led the writer to believe that in practice the situation is quite different. The immigrant engineer usually comes into a unfamiliar country in which he has no connections, except the firm which has engaged him at a salary which is usually higher than he was receiving in his country of origin. The novelty of the situation involves a certain feeling of insecurity which makes the new immigrant more a conformist than a critic. Whatever his educational

background, he tries for a period of time to conform to the general trend, imposed usually by a dominant manager, whose favors he tries to attract. If the immigrant engineer is sufficiently bright and capable, after a certain time, say 3 to 5 years, he will try to find a better position in which he may express his own points of view. However, an average man will not attempt to give up the hard won security of his new environment, and will accept the authority with the existing situation and work diligently for its perpetuation. Under these circumstances no substantial contribution and no cross-fertilization of ideas can be expected. Based on his past experience, the writer strongly believes that a Canadian graduate, completely familiar with the environment, and feeling more secure, is likely to act much more freely in expressing and implementing the ideas gained from his more invigorating education.

Both quantitatively and qualitatively the statistics gathered point to a rejection of the existing system which relies solely on the import of skilled manpower for shipbuilding.

Few shipyards in Canada started business on a sound economic footing, and fewer continue to run today as viable economic enterprises. Many continued in business after the war boom in the hope that a grateful Government would view their disregard for economic costing as the price of maintaining employment in depressed areas. The protection which has been given to the industry until recently by subsidy and procurement practices, has in fact endorsed this concept of Government policy, however has left only a legacy of archaic systems of operation, outmoded technology and obsolete management procedures.

A new type of person in management and engineering personnel is urgently required to help the industry adjust technologically and mentally to the more recent Government policy which is obviously aimed at remoulding the industry into a smaller but more efficient organization in response to existing market requirements.

## (2) Recommendations for Incorporating Academic Studies in Naval Architecture and Marine Engineering at a Canadian University

The annual need in engineering personnel of the whole country has been evaluated in the preceding section to amount to, on average, about 35 individuals in the next 10 years. This figure may serve as a basis for formulating recommendations on how to incorporate academic studies in Naval Architecture and Marine Engineering. As in the case of most statistical data, the tabulated information must be used intelligently and with reserve, otherwise impractical conclusions may result. First of all no attempt will be made to define a steady state operation; the development of shipbuilding is expected by the writer to be at best slow with possible intermittent periods of recession. The objective will be to restrict comment to the means of incorporating Naval Architecture and Marine Engineering at a University, and will be geared to meet the foreseeable demands of the next 10 years. The suggested program will attempt to reflect the flexibility required to permit adjustment in response to growth or decline in the shipbuilding business.

The deficiencies of the existing system of recruitment have already been analysed, but there is no doubt that the present system will continue to work, in spite of the criticism contained in this report. Therefore, one can rest assured that a large

proportion of the yearly recruitment for engineering personnel will continue to be procured by immigration. It seems however most likely that by persuasion, seminars, meetings of associations and by personal contact, the shipbuilding and shipping business may be induced to choose at least one-third of their yearly recruitment from graduates of a Canadian university, say in 5 to 10 years from now. This may merely be an over-cautious personal evaluation by the writer; however even this would still require a university population in the marine field geared to produce 12 graduates every year.

Based on recent developments and trends in the education of Naval Architects and Marine Engineers (Chapter 6), it is proposed that at the undergraduate level Naval Architecture and Marine Engineering should be incorporated as two options in the Mechanical Engineering Department of an Engineering Faculty at a Canadian university. In the curriculum of Canadian universities, undergraduates in Mechanical Engineering are allowed to select from five to eight elective courses, depending on the particular University. In the proposed system, any undergraduate student who selects the elective courses in Naval Architecture or in Marine Engineering respectively, will graduate as a Bachelor of Science in Mechanical Engineering with an option in Naval Architecture or Marine Engineering.

The proposed curricula for the two options are outlined in detail in Chapter 8. In the formulation of the curricula great care was taken to maintain high academic standards. The two enclosed letters (Appendix G, P. 85) from the Massachusetts Institute of Technology and from the University of Michigan, respectively, show unanimous agreement on the acceptance of the curricula and point out that the related academic degree would be internationally recognized. The proposed scheme can only be implemented at a university already offering a very strong fundamental engineering course in mechanical engineering; such a course should emphasize modern engineering education along the lines proposed. A practical work period of at least 8 months or its equivalent in the marine industries has also been added as a requirement for graduation.

The immediate and direct benefits of the proposed system are as follows:

(i) From an educational point of view, it is quite efficient, as it covers a broad spectrum of the subject in a classical sense and includes a course in "Shipbuilding and Shipping Management" as a required course and "Economics" as a non-technical elective.

The aim is not to produce general managers. It will depend entirely on the personal capability of each individual, but the main aim is to expose the shipbuilder to the problems of management, in order to give him a different point of view even if he still spends most of his working life as a designer, a planner, or a production controller. The supreme importance of economic factors cannot be ignored today by any active member engaged in the production process.

(ii) The proposed education system is fairly flexible. If naval architecture prospers, the graduates will have an opportunity to be active in this field. But should shipbuilding or related industries be unable to make use of their services, they can very easily shift and find employment as Mechanical Engineers. Graduates should not be a burden to shipbuilding, neither should they have to depend entirely on this one industry for their future livelihood.



(iii) The incorporation of Naval Architecture and Marine Engineering at a university will not create a sizeable financial burden; the proposed elective courses can be taught by 4 or 5 additional faculty members, which will mean an increase of 3% to a fully developed Engineering Faculty already possessing 150 faculty members.

(iv) The proposed scheme acknowledges the possibility of the marine business becoming prosperous in Canada, and by preparing the labour force for such an eventuality can greatly contribute to a possible rapid development of the industry in response to such a future opportunity.

A further sequence of country-wide benefits are closely associated with the incorporation of Naval Architecture and Marine Engineering at a university. The university department could, for example, act as an Information Centre, and could have under its auspices an Industrial Research Institute. It might also provide guidance for a country-wide integrated education scheme in the marine field. These possibilities will be considered again in Chapter 9.

Let us look at the enrolment required to produce these 12 B.Sc. graduates annually. As the proposal is directed primarily at potential mechanical engineers, no courses in the marine options would be offered in the first year. These would start during the second half of the second year, which is found to be one of the critical years in the study of engineering in that it determines the success or otherwise of the prospective candidate. The required 12 graduates in the 4th year corresponds to 12 students in the 3rd year and approximately 16 students in the 2nd year. The total student population at the undergraduate level would therefore be about 40 during the first years of implementation of the proposed system.

### (3) Designation of the Particular Activity Called Naval Architecture and Marine Engineering

The structural and mechanical engineering activity involved in designing, building and performance of transport, defence or research vehicles in or on water, and their related stationary maintenance components and units, has traditionally been called Naval Architecture and Marine Engineering. This designation seems to have given little satisfaction especially in universities and other intellectual circles. During the present study it was suggested to the writer that supposedly more relevant names could be used, such as Shipbuilding Engineering, Maritime Engineering, Technology, Ocean Engineering, Nautical Engineering, Hydronautical Engineering, Water Transportation Engineering. The French names "Génie Maritime" or "Architecture Navale" can also be included in the consideration of an appropriate designation. The name "Shipbuilding Engineering" is exactly the literal translation of the German designation of activity of a Naval Architect. It tends to exclude units like swimming docks, underwater research vehicles, or underwater drilling units; it even omits submarines. The "Maritime" terminology does not correspond entirely to its more general French counterpart, but on this continent brings with it a definite geographical restriction. Terms like "Ocean", "Nautical", "Hydronautical", embrace a much broader field of activity than usually involved in Naval Architecture and Marine Engineering. It should be remarked that, for example, the Massachusetts Institute of Technology has this year innovated an "Ocean Engineering" programme, but its subject is defined as "The



engineering efforts necessary for the efficient conduct of modern ocean sciences, the exploration of ocean resources, and the development of engineering capabilities, engineering products and undersea technology required for the utilization of these resources". Naval Architecture can only be a supporting part of the entire field of activity defined as "Ocean Engineering". "Water Transport" is surely one of the final objectives of Naval Architecture, but it does not adequately describe the design and engineering work specifically involved in Naval Architecture.

After due consideration, the writer recommends the retention of the terminology "Naval Architecture" which is accepted by tradition and it represents probably not the best, but the least equivocal term. Some institutions like the Massachusetts Institute of Technology confer degrees in "Naval Architecture and Marine Engineering" without making any distinction between them; others like the University of Michigan prefer to split it into "Naval Architecture" or "Marine Engineering" as the case may be.

From a purely academic point of view, "Marine Engineering" is only Mechanical Engineering adapted to the marine environment, and it may be dropped for consideration as a special engineering activity. In Canadian industry, specifically in the Canadian Armed Forces and in shipyards, there is a strong tendency to retain the term and to assign definite duties to this category of engineering. In order to delete the term "Marine Engineering" it has been pointed out that Mechanical Engineers can easily adapt themselves to the textile industry, as well as to the paper industry, and indeed may also be able to do so for the marine industry.

From the opinions of industry and the Canadian Armed Forces a certain amount of educational background should be demanded for "Marine Engineering". From an educational point of view no strong objections can be raised to this. The institution which will offer the Naval Architecture option can, without major complication and even without a substantial additional financial burden, may also offer a sequence of courses in Marine Engineering.

The recommendation leading to simultaneous introduction of so-called "Marine Engineering" at university level, brings with it a conflict which should be eliminated from the beginning. It is well-known that university graduates in this field with at least a B.Sc. degree in Engineering are called "Marine Engineers", and unfortunately the same title is used by operators of marine engines. In the last three years this conflict emerged in Canada between the Association of Professional Engineers and the operator group of Marine Engineers. So far it has resulted in the Association of Professional Engineers forbidding use of the title "Marine Engineer" in their activities outside the marine field under penalty of a possible law suit against them.

In order to eliminate any future conflict and misunderstanding, the recommendation is made to designate the university graduates with at least a B.Sc. degree in the option of marine engineering as "Marine Mechanical Engineers" and reserve the name "Marine Engineers" for machine operators. It is understood that under no circumstances can the operator group be called "Mechanical" engineers, because this appropriate terminology is only conferred by a university and ratified by the Association of Professional Engineers.

Summing up, it is recommended that this particular option be designated as "Naval Architecture and Marine Mechanical Engineering",

## CHAPTER 8

### A PROPOSED CURRICULUM

#### (1) Description of the Courses

The Mechanical Engineering curricula of Canadian Universities are not uniform and they differ as the basic philosophy of education, the environmental and temporal demands, and the services required by provincial authorities. In order to avoid giving any suggestion of preferential treatment to any existing University curricula, an attempt has been made to introduce a desirable Core curriculum as a prototype and to demonstrate in detail the feasibility and means of incorporating an option in Naval Architecture and Marine Mechanical Engineering in this prototype.

The assumed prototype curriculum is in essence not very different from existing curricula in Mechanical Engineering Departments in many Canadian Universities and it is presumed that such a department could adopt the assumed curriculum with only minor changes. The proposed system should not be considered absolutely rigid; many valid modifications and alternative proposals in the selection of courses and credit hours can also be examined when the project is activated.

Following the modern trend in engineering education, the prevailing philosophy adopted in preparing the proposed curriculum was to concentrate efforts on fundamental courses such as mathematics, mechanics, fluid mechanics, heat transfer. The key or methodology of solving more complex problems is to be briefly outlined to allow the student to acquire the potential ability to cope with them in his future career should the occasion present itself. Any department of mechanical engineering by adhering to this basic approach to engineering education, can implement the requirements of the proposed option in Naval Architecture and Marine Mechanical Engineering.

Further, the sequence of courses has been adjusted to be within the capabilities of a good student who has graduated from the equivalent of the Grade XIII class of an Ontario High School.

The proposed undergraduate curriculum for an option in Naval Architecture and Marine Mechanical Engineering will be comprised of the following parts:

- (i) *General Engineering Courses*, required by the Faculty of Engineering
- (ii) *Non-Technical Electives* in the field of Humanities and Social Sciences
- (iii) *Departmental Core Courses* required by the Department of Mechanical Engineering
- (iv) *Core and Elective Courses* of the option in Naval Architecture or Marine Mechanical Engineering

In the proposal, a credit hour is defined as one contact hour per week for a nominal 15 week term. The contact hour may be class lecture, design, laboratory or problem session.

*Curriculum***(i) General Engineering Courses**

Required by the Faculty of Engineering:

Mathematics and Science Courses	lecture	other
Algebra and Geometry	3	0
Calculus, elementary	3	0
Physics	6	2
General Chemistry	2	2
Advanced Calculus	3	0
Numerical Analysis and Methods	2	3
Differential Equations	3	0
Applied Analysis	3	0
	<u>25</u>	<u>7</u> Total: 32 hours

**(ii) Non-Technical Electives**

3 non-technical electives from the Faculty of Arts	lecture	other
Recommended electives: History and Philosophy of Science, Economics	9	0
	<u>9</u>	<u>0</u> Total: 9 hours

**(iii) Departmental Core Courses**

Required by the Department of

Mechanical Engineering:

Engineering Graphics	3	2
Mechanics of Solids	2	2
Dynamics and Kinematics	4	3
Science of Materials	4	3
Fluid Mechanics	3	1
Thermodynamics	3	0
Electricity and Magnetism	4	2
Electronics	3	1
System Dynamics and Controls	3	1
Heat Transfer	3	1
Mechanics of Machinery	2	2
Mechanical Design Project	0	10*
	<u>34</u>	<u>28</u> Total: 62 hours

\* Students of the Naval Architecture option registering for "Ship Design and Operation Projects" will be given a shorter Mechanical Engineering Project for 4 credit hours.

Total credit hours from Mechanical Engineering core courses

for Naval Architecture option

56 hours

For Students of Marine Mechanical Engineering, this course will be replaced by "Marine Mechanical Design and Operation Project"

Total credit hours from Mechanical Engineering core courses  
for Marine Mechanical option

52 hours

(iv) Core and Elective Courses

(a) *Core and elective Courses for the option Naval Architecture*

Core Courses:	lecture	other
Fundamentals of Naval Architecture	2	2
Ship Structure	4	0
Hydrodynamics of Ships	4	1
Marine Machinery	3	0
Shipbuilding and Shipping Management	3	0
Ship Design and Operation Project	0	10
	<u>16</u>	<u>13</u>
		Total: 29 hours

Elective Courses:

Vibration of Ships	2-0
Motion of Ships on Waves	2-0
Small commercial Ships	2-0
1 elective required	

2	0
=	=
2	0

Total credit hours for the option of Naval Architecture 31 hours

(b) *Core and elective Courses of the option Marine Mechanical Engineering*

Core Courses:	lecture	other
Fundamentals of Naval Architecture	2	2
Marine Machinery	3	0
Hydrodynamics of Ships	4	1
Shipbuilding and Shipping Management	3	0
Vibration of Ships	2	0
Marine Mechanical Design and Operation Projects	0	10
	<u>14</u>	<u>13</u>
Technical electives from course sequence of other options of the Mechanical Engineering Department	8	0
	<u>22</u>	<u>13</u>

Total credit hours for the option for Marine Mechanical Engineering

35 hours

**Proposed Course Credit Hours Distribution for the Options in  
Naval Architecture and Marine Mechanical Engineering.**

	Nav. Arch.		Mar. Mech.		Eng.	
	Cr. hours	%	Cr. hours	%	Cr. hours	%
General Engineering Courses	32	25	32	25	32	25
Non-Technical Electives	9	7.1	9	7.1	9	7.1
Mechanical Engineering Department						
Core Courses	56	43.7	60	47.0	60	47.0
Pure Option Courses	31	24.2	27	20.9	27	20.9
	128	100	128	100	128	100

Total credit hours for awarding a B. Sc. degree in Mechanical Engineering with options in Naval Architecture and Marine Mechanical Engineering: 128 credit hours.

Below is a description of proposed Courses for options in Naval Architecture and Marine Mechanical Engineering of the Mechanical Engineering Department:

**Fundamentals of Naval Architecture**

Lectures 2 hours – Lab and Design 2 hours

Types of Ships and propulsion systems. Dimensions and coefficients of Ships. Fairing. Buoyancy and Stability, hydrostatic-curves, trim, stability after damage, watertight subdivisions, launching. Use of computers for ship's calculations.

**Ship Structures**

Lectures 4 hours

General and local structural reactions of Ships, Materials of Construction. Beams under action of axial and lateral loads, bulkheads, plating supported by stiffeners, effective width of plating, continuous frames. Consideration will be given to structural configurations, modes of failure, elastic and plastic instability. Rules of Classification societies and analytical optimization of structures.

**Hydrodynamics of Ships**

Lectures 4 hours – Lab or Design 1 hour

Introduction to hydrodynamics of Ships. Review of fluid dynamic concepts. Resistance and propulsion of ships. Theory of model testing. Design of propellers with reference to model propeller testing. Cavitation. Interaction effects between propeller and hull. Ship powering calculations. Motions in a seaway. Manoeuvring.

**Marine Machinery**

Lectures 3 hours

Design and operation requirements of ship's environment on thermal, mechanical, hydraulic and electrical machinery and on their components: Boilers, turbines, motors,

pipng systems, electrical distribution systems, hydraulic and electric control systems, engine room — and deck auxiliaries.

### **Shipbuilding and Shipping Management**

Lectures 3 hours

Evaluation of ships as components of a transportation system. Optimization of the system under consideration of social factors influencing the shipping enterprise. Engineering and economic principles involved in routing, scheduling, selection of dimensions and coefficients of ships. Cost estimates of construction and operation, profitability, contracts, specifications and production planning. Network analysis in shipbuilding and shipping operations.

### **Ship Design and Operation Project**

Report and Design 10 hours

The project can be chosen from different fields:

- Design of hull and arrangements
- Structural design with analytical optimization
- Shipping Operation design

### **Marine Mechanical Design and Operation Project**

Report and Design 10 hours

Any Mechanical Design project with marine adaptability.

- (2) Comparison of the Proposed Curriculum with the Curricula of Massachusetts Institute of Technology and the University of Michigan

The comparison of the proposed curriculum with the curriculum at the Massachusetts Institute of Technology has been summarized in Table 7 (P. 56) and Table 8 (P. 57) on a required credit hour basis and on a Departmental credit hours load distribution basis. A similar comparison has been carried out with curriculum at the University of Michigan in Table 9 (P. 58) and Table 10 (P. 59). A close inspection of these tables leaves no doubt that the standard of the proposed curriculum is comparable to the level of quality of the above-mentioned leading United States institutions, in every respect.

As the study was carried out only by myself, I found it preferable to have extensive deliberations with the faculty members of MIT and the University of Michigan concerning the curriculum in order to avoid omissions, repetitions or redundancies which may have easily slipped into the proposal. I am enclosing the copies of the two letters which the Naval Architecture and Marine Engineering Departments of the two institutions have addressed to me, after reviewing carefully the proposed curriculum. The statements formulated in these two letters show unanimous agreement on the curriculum and point out that the conferred degree will be internationally recognized.



TABLE 7

## COMPARISON OF THE PROPOSED CURRICULUM WITH THE PROGRAM OF THE DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING AT MIT.

(a) on required credit hours basis

		General Engineering Courses required by the Faculty of Engineering			Non-technical electives	Requirement of Mech. Eng. Dept. for option in Nav. Arch. or Marine Mech. Eng.				
		Math.	Chem.	Phys.	Hum. & Soc. Sci.	Core Program	Electives	Lab.	Thesis or Project	Total
Dept. of Nav. Arch. and Marine Eng. MIT approx. present program		8	5	10	24	48	22	6	9	132
Proposal	Proposed ME degree with option in Nav. Arch.	20	4	8	9*	75	2 Nav. Arch.	—	10	128
	Proposed ME degree with option in Marine Mech. Eng.	20	4	8	9*	69	8 Mech. Eng.	—	10	128

\*The Ontario High Schools have a Grade XI11 class, it can be assumed that the students have been adequately exposed to certain subjects in Humanities and Social Sciences.

TABLE 8

**COMPARISON OF THE PROPOSED CURRICULUM WITH THE PROGRAM OF THE  
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING AT MIT.**

**(b) On Departmental credit hours load distribution and percentage basis**

		General Eng. Courses And Humanities	Courses offered by ME Eng. or another Sc. Dept.	Purely Nav. Arch. and Marine Eng. Courses	Total
MIT Naval Architecture and Marine Engineering		47	51	34	132
		35.6%	38.7%	25.7%	100%
Proposal	Proposed: B. Sc. degree in Mech. Eng.	41*	56	31	128
	Option: Naval Architecture	32.1%	43.7%	24.2%	100%
	Proposed: B. Sc. degree in Mech. Eng.	41*	60	27	128
	Option: Marine Mech. Eng.	32.1%	47.0%	20.9%	100%

\*The Ontario High Schools have a Grade X111 class, it can be assumed that the students have been adequately exposed to certain subjects in Humanities and Social Sciences.

TABLE 9

**COMPARISON OF THE PROPOSED CURRICULUM WITH THE PROGRAM OF THE DEPARTMENT OF NAVAL  
ARCHITECTURE AND MARINE ENGINEERING AT THE UNIVERSITY OF MICHIGAN**

(a) On required credit hours basis — curriculum of 1967

		General Engineering Courses re- quired by the Faculty of Engi- neering			Non- technical electives	Requirements of Naval Arch. and Marine Mech. Eng.				Total
		Math.	Chem.	Phys.		Graph. Prog.	Eng. Sci.	Elec- tives	Others Project	
University of Mich.	Mech. Eng. Approx. 1967 program at U. of M.	16+3	8	10	24	6	65	6	—	138
	Nav. Arch. Approx. 1967 program at U. of M.	16+4	8	10	22	5	60	6	4	135
	Proposed program at U. of M. Core Study Com. Report March 29-1967	16+3	4	8	24	4	60	6	3	128
Proposal	Proposed ME degree with option in Nav. Arch.	20	4	8	9*	5	70	2 Nav. Arch.	10	128
	Proposed ME degree with option in Marine ME Eng.	20	4	8	9*	5	64	8 Mech. Eng.	10	128

\*The Ontario High Schools have a Grade X111 class, it can be assumed that the students have been adequately exposed to certain subjects in Humanities and Social Sciences.

TABLE 10

**COMPARISON OF THE PROPOSED CURRICULUM WITH THE OPTIONS OFFERED AT THE  
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING,  
UNIVERSITY OF MICHIGAN.**

**New Undergraduate Curriculum, 13 February 1968**

**(b) On departmental credit hour load distribution and percentage basis**

		General Eng. Courses and Humanities	Courses offered by ME Eng. or another Eng. Science Dept.	Purely Nav. Arch. and Marine Eng. Courses	Total
University of Mich.	University of Michigan Option 1: Naval Architecture	62 48.4%	28 21.9%	38 29.7%	128 100%
	University of Michigan Option 2: Marine Engineering	62 48.4%	39 30.5%	27 21.1%	128 100%
	University of Michigan Option 3: Maritime Eng. Sc.	62 48.4%	49 38.3%	17 13.3%	128 100%
Proposal	Proposed Mech. Eng. degree Option: Naval Architecture	41* 32.1%	56 43.7%	31 24.2%	128 100%
	Proposed Mech. Eng. degree Option: Marine Mech. Eng.	41* 32.1%	60 47.0%	27 20.9%	128 100%

\*The Ontario High Schools have a Grade XIII class, it can be assumed that the students have been adequately exposed to certain subjects in Humanities and Social Sciences.

**(3) Specific Original Aspects of the Proposal for Canada**

The proposal was designed having in mind how to best suit the educational system to the Canadian environment. The effect of this specific requirement is also reflected in the curriculum, which differs from the established conventional systems on two main points:

(i) The statistical data concerning the deployment of present Naval Architects and Marine Engineers in Canada shows that almost one-third of them are engaged purely in managerial or administrative work. Some shipyards require flexibility in their engineering personnel, and often assign them managerial work which involves a certain amount of engineering proficiency. The frequency with which this situation occurs led me to introduce into the curriculum, at the undergraduate level, a compulsory course named "Shipbuilding and Shipping Management", which has been already described in detail. Normally, this type of course is deferred for graduate studies, but it was my

conviction that an urgent need exists in the industry which compels the introduction of it at an undergraduate level, with correspondingly less sophisticated mathematical techniques. All the reviewers of my proposal have agreed on the need for this type of course for undergraduates, and they considered it worthwhile to innovate a similar course in their own institutions.

(ii) The incorporation of Naval Architecture and Marine Mechanical Engineering into a Department of Mechanical Engineering, at the undergraduate level, should not be considered as an "emergency" measure which may be altered later if the shipbuilding industry enjoys a period of growth. If the shipbuilding industry flourishes, from an educational point of view, it will not be necessary to separate Naval Architecture and Marine Mechanical Engineering Departments at the undergraduate level and the educational system will continue to operate most economically as proposed. As will be outlined in Chapter 8 concerning "A Framework for Future Development", the need for a separate Department will arise only at the graduate level, and it is hoped that in the future a manifestation of a more dynamic shipbuilding industry might be a separate graduate Department of "Naval Architecture and Marine Mechanical Engineering" as developed at Berkeley Campus of the University of California.

#### (4) Practical Training

The European and Japanese Universities unanimously require a certain amount of practical training. In the United States it is only considered as "desirable". The Canadian shipbuilders, consultants, shipping companies, Government agencies, Armed Forces, classification companies, and component manufacturers have responded to the question of practical training in different questionnaires and affirmed their belief in the necessity of it by a majority of 98%, which entirely corresponds to my personal point of view.

Therefore, it should be made compulsory for the students to have practical training in the field of shipbuilding and shipping of eight months, or equivalent, for the awarding of a B.Sc. degree in Mechanical Engineering with an option in Naval Architecture or Marine Mechanical Engineering.

Practical training has as an objective the familiarization of the student with the shipbuilding and shipping environment and the techniques in use. However, if the student can demonstrate at his entrance to the University that he has already had an equivalent period of training in the field, he should be given credit for this, allowing him to complete his studies in a shorter period of time.

## CHAPTER 9

### A FRAMEWORK FOR FUTURE DEVELOPMENT

Beyond the terms of the contract, the nature of this research also brought the investigator into contact with various educational problems relating to incorporating these studies at a Canadian university. It is worth including an analysis of these problems.

The aims of a modern university education and the way it relates to industry and to society at large are quite different from the objectives of a professional training school. The latter attempts to "teach" available knowledge to students who should acquire an adequate level of proficiency in the application of the methods and techniques they have learned. In contrast to this, a university education endeavours to reach beyond the teaching functions themselves and to attempt to develop the student's ability to innovate and exploit new knowledge, upon which modern economic power depends. A university is a unique social institution which tries to keep pace with changes in society and technology and to act as a source of new ideas. These aspects of a university's approach to education can in time be reflected in a unique contribution to the country's industrial progress. The benefits for the country in placing Naval Architecture and Marine Mechanical Engineering at a University will eventually reach far beyond the securing of a reliable source of engineering personnel. The many roles a university plays in modern society are becoming increasingly more complex. Members of a university community spend much of their energy in acquiring new knowledge, and this applies no less to the faculty than to the students; they endeavour to impart this knowledge to those who wish to learn; they are at all times the servants of society and, in this capacity, are frequently called upon not only for advice but also for help in shaping major matters of policy and other such acts of leadership; they are sometimes expected to arbitrate between parties in dispute and, as recent events have shown, may even regard themselves as part of the conscience of society. It is not my intention here to expand into the broad implications of the university's many functions, but potential developments which are intimately related to the implementation of the present proposal will be reviewed.

It may be felt that consideration of the various developments which may transpire can be left as a concern of the future, after an initial Bachelor of Science in Engineering programme has been established. In the view of the writer this attitude is erroneous, because if future developments as a whole are not planned before implementation of the proposal, there may be a danger that such developments may be incompatible with the initial programme. This could result in heavy compromises at a later stage with a possible dilution in the quality and an increase in the cost of the project. To avoid this kind of "patching" in future, it is desirable to bring into focus the highlights of the ultimate goals to which such a programme should aim. To use an analogy, if an architect has to design a house, he will not consider his work completed until every detail of the building and surrounding property has been drafted and laid



down; such care will be required for example, in studying the positions of roads and nearby highways, and to landscaping. He would also find it necessary to study the existing regulations regarding the future locations of schools, shopping centres, hospitals and other projected buildings in the community. The most modern and functionally well-designed house would not be good value should it be located in the middle of an isolated wilderness. In the same way, having in mind the mutual influence of different steps of development in establishing a university programme, an attempt will be made in the present problem to review these steps and display their correlation. The possibilities of developing educational courses at many levels will be separately presented, bearing in mind that each course will affect the others, and the educational whole should be regarded as an integrated functional unit, and one of the necessary remedies which can influence positive progress in Canada's shipbuilding industry.

### (1) Graduate Studies

Paradoxical as it may seem, the shipbuilding industry will require sooner than they appear to realize, the services of academic personnel with a higher degree, say, a Master of Engineering. During the course of this study the shipbuilding industry has clearly expressed an interest in engineering personnel with an educational background in modern techniques such as critical path scheduling, linear programming, automatic control, reliability analysis, and computer aided fairing. At the undergraduate level only a general initiation into these methods is usually given. It would be quite wrong to try to develop specialization in these subjects at the undergraduate level because this could only be done by sacrificing fundamental engineering courses. A serious and extensive study of these subjects can only be pursued at the graduate level partly because of lack of time, but also because an undergraduate is not sufficiently well prepared for it. During this study it became apparent to the writer that the shipbuilding industry is developing a sound tendency to consolidate marked by some acquisition of smaller yards by larger companies. The larger groupings will inevitably lead the shipyards to incorporate in their production more sophisticated modern techniques such as inventory control, statistical quality control, queuing theory, etc., knowledge of which can only be acquired at the graduate level.

In many Government sectors it is quite likely that the services of engineers with graduate degrees will also be required soon. Canadian Armed Forces have most clearly indicated an immediate need for the establishment of graduate studies in Naval Architecture and Marine Mechanical Engineering in Canada, having in mind a reduction of the time spent on such studies to two years instead of the usual three years required by universities outside the country. It seems possible to link the programmes of the Royal Military College with the graduate programme of a Canadian university so that the Master's degree can be earned by at most two years of graduate study, as is the case for other engineering subjects.

The shipbuilding laboratory of the National Research Council, the Defence Research Establishment (Atlantic) and similar other scientific institutions can also use the services of engineering personnel with a Master's degree. Furthermore, the Government in general, and to some extent the shipyards, may feel the need for a special type of Naval Architect or Marine Mechanical Engineer with a more extensive

knowledge of Management Sciences and Systems Engineering. All these diversified requirements in the marine field can be met only at graduate level where the course sequence is based on individual requirements and the selection of courses can more readily meet the needs of a student or his employer.

The incorporation of graduate studies at the same university which offers the options of Naval Architecture and Marine Mechanical Engineering at the undergraduate level, will have substantial benefits for the institution without a large added financial burden. The four or five faculty members required for an undergraduate course in Naval Architecture and Marine Mechanical Engineering will also easily carry the load of, say, two graduate students per faculty member. It is usual for faculty members to have three or four graduate students to supervise; in exceptional cases, like the present writer enjoys, it may increase to 7 or 8.

The simultaneous introduction of graduate courses and the establishment of an Industrial Research Institute could serve to attract high quality faculty members, who usually will not consider joining a teaching institution without graduate students, research interests and facilities.

It should again be stressed that the quality of faculty members and the attitude of the university will be a decisive factor in the success of the implementation of the scheme.

## (2) An Integrated Education System

During the study of present Canadian education in Naval Architecture and Marine Engineering, it was found that the financial burden imposed and the personnel requirement were disproportionally large, considering the number of students a small locality needed to train at the technician level. However, the statistics of the present study showed that the total number of technicians active in this field in the whole country amounts to 1035 (Table 1, P. 23). With replacements to meet normal atrophy, it is projected that this number will increase to about 1133 (Table 4, P. 30) in the next ten years. This indicates also that serious attention should be paid to their replacement over the years concurrent with upgrading of technician training in Naval Architecture and Marine Engineering. This problem is further complicated by the fact that some of the more outstanding products of technical schools wish to continue their education with the aim of earning an academic degree. The writer holds without reservation to the principle that any well-qualified student should be given an opportunity to pursue studies to the full extent of his capability, without regard to the school in which he was originally trained. Furthermore, the possibility of allowing partial credits for his previous studies should also be investigated. The present situation is characterized by a complete lack of co-ordination between various institutions, so that it is impossible to establish an equivalence between courses offered. The writer envisages an integrated education system in which a certain amount of equivalence in courses can be settled by prior arrangement with the representatives of each institution. This arrangement would involve a review and an adjustment in the content and sequence of courses at each institution possibly every two years or so. It would serve to establish co-operation between schools at different levels and agreement on specified standards of admission. This scheme is graphically represented in Figure 5 (P. 67) and the

correlation between the programmes has been included with the functions of the university (Figure 6, P. 68). The objectives would be to ensure a continuous relationship between the courses offered in different institutions of the country. Co-operation should be entirely on an academic basis throughout the country and it would not necessarily infringe on the jurisdiction of provincial government.

The scheme would also provide extensive assistance to teaching in technical and vocational schools in every part of the country:

(i) The correspondence course presently offered by George Brown College, Toronto has already reached a certain maturity and it can be used as a reference level for correspondence courses elsewhere. A committee, including representatives of different interested schools under the auspices of the university offering the marine options, may slightly revise and modernize the present course content, or the course content could be subdivided according to the particular interests of schools in different locations and provinces.

(ii) A possible experiment in co-operation could be the formation of a small team of teachers specializing in particular fields of marine technology who would travel to different places to offer short courses and to give assistance and advice to local instructors. The membership of this team could be changed every year and their schedule of visit could be prepared in advance depending on the needs expressed by the various schools in the country. Such periodic visits would not only give support to the local schools but would also substantially enhance interest in shipbuilding. Further, they would establish a means of communication between different centres of activity and the leading university which would be informed of the existence of particular problems in particular areas.

(iii) The integrated education system would also consider the offering of seminars, special short upgrading courses for technicians and operators in the marine field, with laboratory sessions in the university, or in the shipbuilding laboratory of the National Research Council.

(iv) The university implementing the proposed programme should earnestly consider close collaboration with the shipbuilding laboratory of the National Research Council in every phase of education in marine engineering. This institution has an outstandingly well-qualified staff whose co-operation would represent a substantial contribution to education in the field. The contribution of the shipbuilding laboratory need not be restricted to employment of a few students during their summer vacation. The writer envisages that for some particular activities in this laboratory, the undergraduate or graduate student should be able to earn credits for his academic degree. A highly desirable feature might be to introduce special credit courses, presented by the staff of the laboratory during the time spent there by the students.

### (3) The Industrial Research Institute

Modern engineering education is intimately related to research activities, which start at the undergraduate level and are extensively pursued at the graduate level. An institution of higher education exclusively devoted to teaching but cut off from research interests, would be a still-born oddity among modern universities. Research is an integral part of teaching, which develops "creativity" and provides a proficiency in

"innovation", therefore it should be incorporated not as a separate additional entity but as an indispensable ingredient in engineering education.

The expansion and development of shipbuilding in West Germany, Sweden and Holland as well as in several other European countries, owes much to the activities of research centres affiliated with universities.

In the industrial phase of engineering the Canadian shipyards have unanimously agreed that they maintain close connections with research centres inside and outside the country.

The needs of the industry and the requirements of engineering education complement each other and they point directly to the need for establishing a research centre, preferably affiliated to the particular university which would offer the optional courses in Naval Architecture and Marine Mechanical Engineering. The Canadian environment offers a multitude of specific research problems with which the research institute could deal. A few of them might be, for example: breaking of ice, effect of ice build-up on stability and the determination of allowable amount of ice build-up, navigation problems in the Great Lakes, expansion projects for the St. Lawrence Seaway, design requirements of special research vehicles, etc.

The duties and the structure of the Industrial Research Institute could be discussed and enumerated in a separate study, when a consensus of opinion has been reached for its establishment. However, its incorporation and operation as a university function is outlined in Figure 6 (P. 68). It should also be noted that the effectiveness of an industrial research centre, could be greatly enhanced by the availability of a well-equipped computer centre at the same university.

#### (4) The Information and Communication Centre

One of the functions of the university should be the accumulation and dissemination of various types of information relating to Naval Architecture and Marine Mechanical Engineering.

This function could be performed by an information and communication centre, under the direction of one of the faculty members. Communications with research centres, professional societies, Great Lakes Institutes and classification societies should be of a technical nature; some purely statistical communications would also be desirable as provided by the Dominion Bureau of Statistics, Dept. of Manpower and Immigration, Technical Schools, High Schools, etc. The information and communication centre would also be charged with the responsibility of informing the public at large on appropriate occasions about the scope of its activities as they related to the Canadian marine industries. This type of communication would help overcome the inertia imbedded in often repeated, common-place fallacies that Canada is not a "seagoing" nation and there exists "no established potential for shipbuilding in Canada". The development of the industry depends largely on the entrepreneurship and drive of a group of leading individuals.

The outline of an integrated education system, including the proposal, is presented graphically in Figure 6 (P. 68). The usual sequence of study would be for a high school graduate to register in the Mechanical Engineering Department and to graduate in four years as a Bachelor of Science in Mechanical Engineering with an



option in Naval Architecture or Marine Mechanical Engineering. The student could continue his studies at graduate level in the Department of Naval Architecture and Marine Mechanical Engineering, which would be constituted as a separate department only at the graduate level. Normally after two years of graduate study the student would earn the degree of M.Sc. in Naval Architecture or Marine Mechanical Engineering.

In the practical administration of universities, experience has shown that many exceptional cases should be considered, and admission conditions should be as flexible as possible to allow qualified candidates of different provinces the chance of pursuing further studies. On the right side of the graph Figure 6 (P. 68) the projected possibilities have been sketched for students with a background of professional training. The scheme would allow any qualified student of vocational schools, technical colleges and institutes to gain access to the university. On the left side of the graph, the prospective possibilities of entering the marine field for students with an academic background are outlined. Following this scheme students possessing a Bachelor of Science degree in another field of engineering, or a Higher National Certificate, Higher National Diploma or College Diploma, as awarded in Britain, may enter the university for two different purposes. They may choose to follow a one year special adjustment course which would qualify them to work in Naval Architecture or Marine Mechanical Engineering at the Bachelor level. But they could also immediately select a two-year graduate study sequence at the successful termination of which they would gain the degree of Master of Science in Naval Architecture or in Marine Mechanical Engineering. For students coming from outside the country, with a background not included in the scheme, the admission conditions would be arranged individually.

In Figure 6 (P. 68) an attempt has been made to describe the main functions of a university education system in Naval Architecture and Marine Mechanical Engineering.

The establishment of an industry and government advisory council, meeting, for example, twice a year, could exert a great influence on the desirable format of the course design.

This chapter represents only a sketch of potential highlights in future developments. An extensive study is required to establish the feasibility and means of implementing the enumerated topics.

# **PROPOSAL OF AN INTEGRATED EDUCATION SYSTEM IN NAVAL ARCHITECTURE AND MARINE MECHANICAL ENGINEERING**

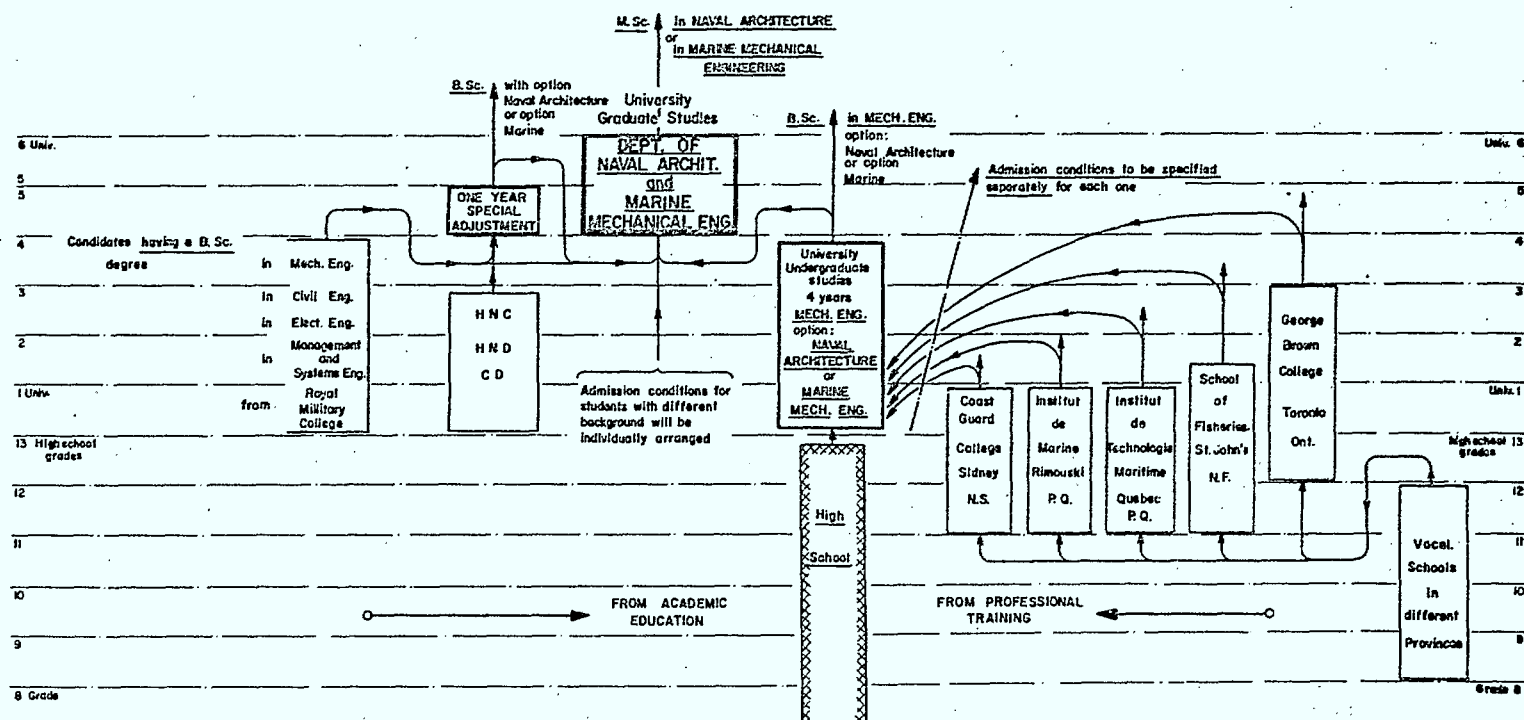


FIGURE 5



# THE FUNCTIONS OF A UNIVERSITY EDUCATION IN NAVAL ARCHITECTURE AND MARINE MECHANICAL ENGINEERING

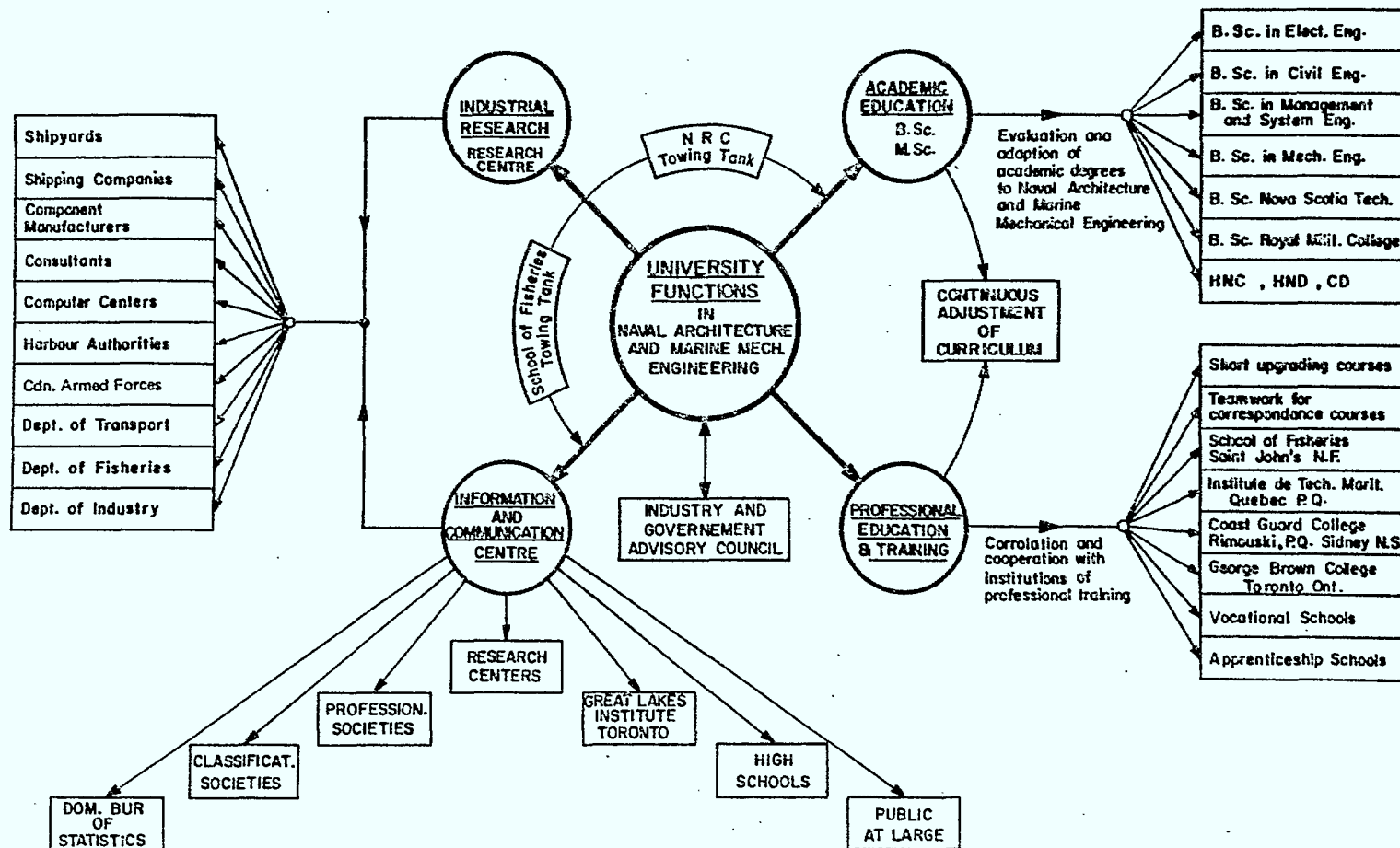


FIGURE 6

## CHAPTER 10

### PLAN OF ACTION

During the conduct of the present studies the writer observed that in the past many attempts have been made to institutionalize studies in Naval Architecture and Marine Engineering. The motive behind these efforts was for the most part a political one, being at best a response to the needs of a restricted region and being confined to a narrow field. This is an appropriate place to urge all interested political and educational authorities as well as the responsible representatives of the marine industries, to implement as soon as possible the proposed scheme of education in which, for the first time, country-wide requirements have been considered and balanced to the best of the ability of the present writer. There are still strong indications that more opportunistic and local schemes of education may be proposed and receive some support, but these will almost inevitably lead to an irrational dissemination of effort and must end in yet another disillusionment. The recommendations for an immediate plan of action are outlined in the following sections.

#### (1) Selection of a University

The selection of the particular university which would be prepared to offer an option in Naval Architecture and Marine Mechanical Engineering in their existing Department of Mechanical Engineering deserved serious consideration. It is well-known that various universities have different attitudes towards education, which may or may not be compatible with the educational requirements of the Canadian marine industry. Further, even among the world's best-known universities, a faculty or even a department may have much lower standards than other departments which have built up the reputation of the institution in question. Several qualitative criteria may be formulated which will serve as a guide in the selection of the most appropriate university.

(i) The university should place proper emphasis on modern engineering education, as has been expressly underlined in the letter of appraisal from the Massachusetts Institute of Technology, a copy of which is included in the Appendix G. The proper emphasis will be reflected by the implementation of a modern curriculum in other fields of engineering and the availability of an adequate number of faculty members of good reputation.

(ii) The university should be prepared to carry out the proposed curriculum with minor changes. The minor changes may include the number of lecture hours as well as changes in the content of courses. But the university should not be allowed to lower the academic standards nor the breadth of the complete sequence of courses. In case of doubt the particular university should be required to submit its alterations for a review and reappraisal.

(iii) It is highly desirable that the particular university should possess adequate computing facilities and audio-visual communication aids.

(iv) It is also desirable that the particular university should have some incentive and experience in dealing with industrial research.

The procedure for selection of the particular university may begin by contacting all the universities located east of a line connecting the cities of Quebec City, Ottawa and Windsor as well as those on the west coast and to inquire about their present interest in offering an option in Naval Architecture and Marine Engineering.

Such an initial contact may eliminate several universities. To the remaining universities expressing an interest a copy or an excerpt from the present report should be sent, with the request that they outline and submit a proposal for incorporation of Naval Architecture and Marine Mechanical Engineering based on the scheme of the report but following their own administrative and academic structure. Further, such interested universities should be asked to provide details of their existing computing facilities, their audio-visual communication aids and their interests in industrial research.

The compiled information would then be presented to a committee which would be asked to recommend a particular university to take on the work. This committee would be composed of the representatives of the Department of Transport, Department of Industry, Armed Forces, Shipbuilding and Shiprepairing Association, as well as Consultants and the Shipping Association. The Deans or Associate Deans of Engineering of two universities from the prairies should also be included as well as the present writer. Should the home university of the writer, the University of Waterloo, be one of the universities considered in the final list the writer should participate in the deliberations only to ensure the proper implementation of the original proposals, but he should be a non-voting member only. The committee may require visits to several of the interested universities before reaching a final recommendation.

## (2) Studies for Future Development

As has been outlined in the previous chapter, a carefully prepared plan for future development is absolutely essential for an efficient and coherent integration between the various functions of a university. In the present report the mode of implementation of academic studies leading to the awarding of a Bachelor of Science degree has been exhaustively considered. The possibilities of implementation of the various enumerated functions of the university also require careful study.

### (i) Graduate studies

Graduate courses and research topics should be selected according to the spectrum of activities encountered in the Canadian shipping industries:

The requirements of the various sectors of marine industries may cover a wide range. It is quite conceivable that the Department of Fisheries for example would require entirely different subjects of specialization than, say, the Armed Forces; also the Shipbuilding Laboratory of NRC may look much more to an analytically sophisticated plan for graduate studies than the shipyards which may, for example,

prefer to see graduates specialized in welding theories and techniques. A study is necessary to put into good order, and to assess priorities relating to, the requirements of all sectors, taking into account the demand of the country as a whole.

### **(ii) An integrated education system**

The sequential integration at each level of education as outlined in the previous chapter can only be achieved if a well-co-ordinated plan of integration has been worked out. It is not sufficient merely to determine how such integration can be reached at a given time; it is just as desirable to draft a dynamic system of procedures which will allow the programme at each learning institution to be adjusted to any necessary changes occurring in another one. The mode of correlation between institutions requires an investigation involving the participation of provincial Departments of Education.

### **(iii) The industrial research institute**

A survey of the type of industrial research supported by Canadian shipyards in the past and mainly given to research institutes outside the country should readily reveal in which direction the proposed industrial research institute should build up its strength. The same survey may also reveal the areas of interest which have been neglected and point out the potential benefits of special research subjects for the marine industry.

### **(iv) The information and communication centre**

The function of the university as an information and communication centre for the marine industries needs to be identified properly from the beginning. The problem of accumulating and disseminating technical information should be analysed and the university considered as a reference centre in marine matters. Another very important part of the same function would be the accumulation of statistical material pertinent to Canadian shipping and shipbuilding in an informative form, which would be accessible to all sectors of the industry. At present the Dominion Bureau of Statistics, Department of Manpower and Immigration are the main sources of statistical information; but they certainly need guidance and formulation of requirements in order that they may compile relevant data. During the conduct of the present study, the writer could have been spared at least 6 months' work if adequately prepared statistics had been available. Up-to-date and well documented statistics would provide the best guidance to any government in making decisions relating to overall educational and industrial policy.

It is worthwhile studying the forms of benefits that the marine industries can obtain from the activities of the Dominion Bureau of Statistics and Dept. of Manpower and Immigration.

The points of interest enumerated above can be best studied as a single entity and the information regarding national and international education systems accumulated

during the present study should be an invaluable assistance in any further investigations.

### **(3) Contribution of Government and Industry**

A plan of action purely related to education per se terminates at this point. However, it is felt that there are some additional remarks of importance for government and industry which should not be omitted at the present time.

#### **(i) Form of aid for initiation of the proposal**

The initiation of the proposal would require financing which should be given careful and sympathetic consideration. A joint financing by government and industry in the form of grants seems to the writer to be the most appropriate procedure. An advisory council of government and industry may deliberate about the feasibility of this proposal.

#### **(ii) Industrial planning**

The national interest of the government in the marine industries has been touched upon in this report. As the government cannot dissociate itself from shipbuilding, it is compelled to provide leadership in planning. The present system of subsidies represents only an aid for survival of the industry. The shipbuilding industry should endeavour to employ more rational means to benefit from such subsidies. It is also felt by the writer that the scope of government planning and assistance, not necessarily in financial form, should be broadened in order to inspire confidence for the future development of the industry and to ensure some economy in future government orders. Unified planning between different sectors of the government, could presumably lead to a more uniform distribution of orders in a temporal and regional sense.

An accurate reappraisal of the cost of shipbuilding to the government may also be necessary, having in mind initiation of ocean shipping, or a revival of lake shipping, or even these two developments combined. This should also take into account any reduction in unemployment benefits to be paid to unemployed individuals to be employed in the development of the industry. Even changes in legislation may be considered, if it can be shown that they may contribute to the economic growth of the shipping and shipbuilding industry.



## APPENDIX A

### Oral Questionnaire Concerning Technical Personnel Engaged in Naval Architecture and Marine Engineering

1. In making technical decisions concerned with design and planning, does your company rely largely on the past experience of individual members of your managerial staff or do you consult with members of your technically trained personnel before making final decisions?
2. Do any of your technical staff take part, or are they consulted, when major decisions have to be made regarding the overall policy of the company?  
It is, of course, realized that such matters vary widely from company to company. Hence, however, the question should be interpreted in its more general sense. A shipping company, for example, may have to decide the most suitable number, size and speed of vessels it should own, or in a shipyard, it may be necessary to decide whether and, if so, how to use computer-aided devices in the design ships.
3. Does your company favour, or practice, or intend to practice, the promotion to managerial positions of some members of your technical staff, whether as full-time managers or to spend some of their time advising managers?
4. In the opinion of your company, should an educational programme designed to meet the needs of the shipping and shipbuilding industry include introductory courses in modern techniques like linear programming or automatic control devices or more recent concepts like methods of reliability analysis, critical path scheduling or queuing theory?  
The question may arise that the inclusion of such topics would extend the time required to complete a degree. On the other hand, the use of modern teaching aids like television for courses in design and graphics have reduced the time required to teach the fundamentals of naval architecture, thus allowing the introduction of more diversified courses.
5. Do you at present use a computer to aid in technical calculations? If so, give details.
6. In your experience do the environmental conditions in Canada present the country's shipbuilding industry with unique problems which require specific study or research, but which would be of little concern to other countries having a major interest in marine matters? For example, ice-breaking equipment is used more in Canada than almost any other country; or, again, navigation on extensive inland waters situated so far north could present special problems to the industry.
7. Do you find it necessary, every few years, to send some of your technical staff on short refresher courses? Please give separate answers, where possible, for the staff you classify as a) Engineers and b) Technicians.
8. When you encounter special technical problems about which you require expert advice, do you contact a University, or some other reputable educational institution, a research institution, an engineering consultant or any other



competent organization? Where possible give examples and your reasons for doing what you do.

9. Do you have, or plan to have, an educational programme in your Company at any of the following levels?
  - a) For apprentices
  - b) At a level suitable for draftsmen, or
  - c) At the technician level.

Please comment briefly on the technical content of your programme, if any, and to which trades they are oriented.

10. Does your company feel the need for an educational programme for technicians in shipbuilding and marine engineering similar to existing programmes designed for technicians in mechanical and civil engineering? Apparently the "Institute de Technologie Maritime" located in Quebec City appears to satisfy a local need for such training.
11. Several shipyards appear to offer training courses in shipbuilding at the apprenticeship level. The technical content, the scope and effectiveness of these courses depend very much on the standards set by the individual instructors. Would you think it advisable to set up an information reference centre serving the whole of Canada to furnish advice and information when requested from shipyards or technical schools? Such a centre could assemble and catalogue relevant technical information and provide information and guidance in planning curricular compatible with higher institutes of learning.
12. Can you supply some quantitative information about your annual turn-over in qualified engineering staff? Figures for the last five or ten years, whichever is more convenient, would be most useful.

## APPENDIX B

**Statistical Data on Technical Personnel  
in Naval Architecture  
and Marine Engineering**

Shipyards

Please classify your present engineering staff as follows:—

1. individuals with an academic degree in engineering B.S., M.Sc., D.Sc., Dr. Ing. (see attached page).
2. individuals with a professional certificate or diploma in engineering like marine, mechanical engineering, ONC, HNC, HND, CD, DIP. TECH. (see attached page).
3. individuals with a trade school diploma who qualify as a technician.
4. individuals without any formal diploma but who have been trained in industry and are considered by the company management as technically competent to carry out engineering assignments.

**A. Engineering Staff**

Technical Personnel		1			2			3			4		
AGE GROUP		a	b	c	a	b	c	a	b	c	a	b	c
a) below 25 b) 25-45 c) above 45													
Number of individuals in	Design Office												
	Planning and Scheduling												
	Production Control												
	Drawing Office												
	Production												
Percentage of Total Payroll							%			%			%

Please comment if any of the above academic degrees are non-engineering.

**B. Administrative Staff**

Engineers who are academically qualified should be classified as above (i.e. 1, 2, 3 or 4)

Other academic qualifications (e.g. C.A.) should be entered in column 5.

		1			2			3			4			5		
		AGE GROUP a) below 25 b) 25-45 c) above 45														
Number of individuals in	Administration	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
	Accounting															
	Sales															
	Marketing, Purchasing															
	Others															
	Percentage of Total Payroll															

C. Hourly Workforce \_\_\_\_% size of Payroll

D. Do you think an educational system consisting of formal instruction alternating with practical work periods in industry to be suitable for the training of Naval Architects and Marine Engineers? Yes ☐ No ☐

## APPENDIX C

## STATISTICAL DATA ON TECHNICAL PERSONNEL

## IN NAVAL ARCHITECTURE

## AND MARINE ENGINEERING

Shipyards

Please classify your present engineering staff as follows:

1. individuals with an academic degree in engineering B.Sc., M.Sc., Dipl. Ing., Ph.D., Dr. Ing. (See attached page).
2. individuals with a professional certificate or diploma in engineering like marine, mechanical engineering, P. Eng., ONC, HNC, HND, CD, DIP. TECH. (See attached page).
3. individuals with a trade school diploma who qualify as a technician, and are considered by the company management as technically competent to carry out engineering assignments.
4. individuals without any formal diploma but who have been trained in industry and are considered by the company management as technically competent to carry out engineering assignments.
5. other academic qualifications (B.A.).

		1			2			3			4			5		
		AGE GROUP														
		a) below 25 b) 25-45 c) above 45			a	b	c	a	b	c	a	b	c	a	b	c
Number of individuals in	Technical Staff*															
	Management Staff**															

\*The technical staff comprises individuals active in Design Office, Planning and Scheduling, Estimating, Production Control, Drawing Office, etc.

\*\*The Management staff comprises individuals active in Administration, Accounting, Sales, Marketing, Purchasing, etc.

Do you think an educational system consisting of formal instruction alternating with practical work periods in industry to be suitable for the training of Naval Architects and Marine Engineers? \*

Yes ☐

No ☐

When completed please return to:

Dr. S.A. Alpay,  
Professor of Mechanical Engineering,  
University of Waterloo,  
Waterloo, Ontario.

Name of the Firm:



**APPENDIX D**  
**STATISTICAL DATA ON TECHNICAL PERSONNEL**  
**IN NAVAL ARCHITECTURE**  
**AND MARINE ENGINEERING**

Shipping—  
 Companies  
 Government  
 Consultants  
 Classification  
 Societies  
 Component  
 Manufacturers

Please classify your present engineering staff as follows:

1. individuals with an academic degree in engineering B.Sc., M.Sc., Dipl. Ing., Ph.D., Dr. Ing. (See attached page).
2. individuals with a professional certificate or diploma in engineering like marine, mechanical engineering, ONC, HNC, HND, CD, DIP. TECH. (See attached page).
3. individuals with a trade school diploma who qualify as a technician
4. individuals without any formal diploma but who have been trained in industry and are considered by the company management as technically competent to carry out engineering assignments.

**A. Engineering Staff**

		1			2			3			4		
		AGE GROUP											
		a) below 25 b) 25-45 c) above 45			a	b	c	a	b	c	a	b	c
Number of Individuals	Present Staff*												
	Projection for future demand												

\*Please comment if any of the above degrees are non-engineering

- B. Do you think an educational system consisting of formal instruction alternating with practical work periods in industry to be suitable for the training of Naval Architects and Marine Engineers?

Yes ☐

No ☐



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**APPENDIX E**  
**INFORMATION CONCERNING**  
**EDUCATION IN NAVAL ARCHITECTURE**  
**AND MARINE ENGINEERING**

1. Is Naval Architecture and Marine Engineering a distinct Department or Faculty in your institution? Or is it incorporated in another Department, like Mechanical Engineering, Hydronautics or Astronautics?
2. Minimum number of years, or semesters, or terms, required for the first academic degree in Naval Architecture and Marine Engineering, like the Bachelor of Science in Engineering.
3. Could you send me the programme, the schedule and course content of the Naval Architecture and Marine Engineering education?
4. Number of students in Naval Architecture and Marine Engineering

undergraduates.....

graduates.....

5. Number of Faculty members and persons actively engaged in the teaching of Naval Architecture and Marine Engineering.
6. Number of graduates in last academic year and their degrees.
7. Has the Naval Architecture and Marine Engineering department access to towing tanks, ship structure laboratories, propeller tunnels, computer centers?
8. Do you consider your educational system as satisfactory, or do you intend or want to make changes in it in the next future?

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## APPENDIX F

## ABBREVIATIONS OF ENGINEERING GROUP

## Education Group 1 – Individuals with an academic degree

B. Sc.	Bachelor of Science in engineering as awarded by most North American and U.K. Universities.
M. Sc.	Master of Science in engineering as awarded by most North American and U.K. Universities.
Dipl. Ing.	Diplom-Ingenieur, as awarded by German and most American and U.K. Universities.
D. Sc.	Doctor of Science as awarded by a few North American Universities.
Ph. D.	Doctor of Philosophy as awarded by most North American and U.K. Universities.
Dr. Ing.	Doctor Ingenieur, as awarded by a few North American Universities.
P. Eng.	Professional engineer in Canada.  The graduates of "Ecole Nationale Superieure due Genie Maritime" in Paris–France.

## Education Group 2 – Individuals with a professional certificate or diploma

O N C	Ordinary National Certificate as awarded in U.K.
H N C	Higher National Certificate as awarded in U.K.
H N D	Higher National Diploma as awarded in mechanical engineering in U.K.
C D	College Diploma as awarded by Sunderland Technical College.
Dip. Tech.	Diploma in Technology as awarded in England.

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## APPENDIX G

## THE UNIVERSITY OF MICHIGAN

March 26, 1968

Professor Saip Alpay  
University of Waterloo  
Waterloo, Ontario  
Canada

Dear Professor Alpay:

Professor Yagle and I have carefully studied your curricula for mechanical engineering options in naval architecture and marine mechanical engineering. Your proposal show conscientious work, and Professor Yagle and I agree that we would have arrived at much the same sequence of courses and selection of topics.

Any student graduating from either option with a B average or above would be eligible for our graduate program at The University of Michigan in naval architecture and marine engineering.

We have a continuing flow of Canadian students in our department as well as a continuing demand from Canadian companies for our graduates. We are, therefore, convinced of the wisdom of initiating your proposed program. We should welcome the chance to maintain liaison with such an activity in Canada and to furnish whatever assistance and advice that we can.

Sincerely,

Harry Benford  
Chairman

HB:ef

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of the Original



APPENDIX G

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT OF NAVAL ARCHITECTURE  
AND MARINE ENGINEERING  
CAMBRIDGE, MASS. 02139

12 March 1968

Dr. S.A. Alpay  
Professor of Mechanical Engineering  
University of Waterloo  
Waterloo, Ontario, Canada

Dear Dr. Alpay:

I reviewed the curriculum which you proposed and which would lead in Canada to awarding of a B. Sc. degree in Mechanical Engineering with option in Naval Architecture or in Marine Mechanical Engineering.

The proposed curriculum represents a well thought out combination of depth and breath of engineering education for Naval Architects and Marine Engineers on the undergraduate level.

If this proposed program is to be implemented, I recommend that it be by a university which places proper emphasis on modern engineering education and along the lines proposed.

I am of the opinion that graduates with sufficiently high standing graduated from this program (implemented as recommended in the preceding paragraph) would be well qualified for graduate studies in the Department of Naval Architecture and Marine Engineering at MIT.

I am also of the opinion that graduates of this program will have an engineering background and a motivation which are essential for the development of a forward-looking maritime industry.

Sincerely yours,

A. H. KEIL  
Head of Department

AHK:map

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of the Original

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