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Proposal for the establishment of marine hydrodynamic facilities

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A PROPOSAL FOR THE ESTABLISHMENT OF MARINE HYDRODYNAMIC FACILITIES AT UTM, SKUDAI, JOHOR DARUL TAQZIM

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The contents of this paper reflect the author's own personnel views and are not necessarily endorsed by the university.

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Abstract

This thesis discusses the maritime education and training of marine technologists in Malaysia, especially at University of Technology, Malaysia (UTM). It focuses on the reasons for setting up the marine hydrodynamic laboratory (model basin) facilities at the new UTM Skudai campus in the state of Johor Darul Taqzim. Justification for its establishment and an outline for ways to utilize the model basin facilities are provided.

The establishment of these facilities is in line with the aim of initiating the Marine Technology course. This course, at both Diploma and Degree level, has been included in the Faculty of Mechanical Engineering UTM, since the academic year 1981/82. Instilled from the beginning, it is clear that this course will not be a duplication of that which already exists, especially at Ungku Omar Polytechnic (PUO), Ipoh Perak and Malaysian Maritime Academy (ALAM) at Malacca.

Thus, the proposed establishment of the UTM hydrodynamic facilities will be a good teaching and research tool. The availability of a good marine hydrodynamic facility will help to enhance the students' level of confidence and increase their value as shore-based marine technologists. The development of research work will enhance a closer rapport between UTM and the marine industries in Malaysia.

Discussions and recommendations include (1) The national consideration and its objectives; (2) The cost estimate for the proposed marine technology laboratory; and (3) The impact upon the nation.

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In ending, I uphold my deep thanks and gratitudes to the Almighty God to whom I submit my work and for whose sake I finished it. From Almighty God, the cherisher and sustainer of the worlds, will be the reward.

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Abbreviations

AIP - Akademi Ilmu Pelayaran / Indonesia Maritime Acad.
ALAM - Akademi Laut Malaysia/ Malaysian Maritime Academy
ASEAN - Association of South East Asian Nations
CAD - Computer Aided Design
CAM - Computer Aided Manufacture
DTRC - David Taylor Research Center
EEZ - Exclusive Economic Zone
EOI - Export Oriented Industrialisation
GDP - Gross Domestic Product
GNP - Gross National Product
HICOM - Heavy Industries Corporation of Malaysia Bhd.
HLL - Hong Leong-Lurssen Shipyard
IMP - Industrial Master Plan
ISI - Input Substitution Industrialisation
ITI - Industrial Training Institute
ITM - Institut Teknologi Mara / Mara Institute of Tech.
JICA - Japan International Corporation Agency
KTM - Kereta Api Tanah Melayu / Malayan Railway
MARDI - Malaysia Agriculture Research & Development Inst.
MATES - Malaysian Training and Education of Seamen
MASK - Manoeuvring & Seakeeping Facility
MHF - Marine Hydrodynamic Facility
MISC - Malaysian International Shipping Corporation Bhd.
MSE - Malaysian Shipyard and Engineering
MSC - Malaysia Shipping Corporation
MVA - Manufactured Value Added
NEP - New Economic Policy
NIC - Newly Industrialised Country
NPV - Net Present Value
NCSRD - National Council for Scientific Research and Dev.
PETRONAS-Petroleum Nasional / National Petroleum

PNSL - Pernas National Shipping Lines
PPC - Penang Port Commision
PROTON - Perusahaan Otomobil Nasional/ National Auto. Ind.
PUO - Politeknik Ungku Omar / Ungku Omar Polytechnic
PWD - Public Works Department
RMN - Royal Malaysian Navy
RMP - Royal Malaysian Police
RRI - Rubber Research Institute
RTA - Reversible Trunk & Airflow
SEA - South East Asia
SHP - Shaft Horsepower
SP - Singapore Polytechnic
ULCC - Ultra Large Crude Carrier
UNDP - United Nations Development Programmes
UNESCO - United Nations Educational,Scientific & Cultural Organization
UTM - Universiti Teknologi Malaysia / Technological University of Malaysia.
VLCC - Very Large Crude Carrier
WMU - World Maritime University
ZOPFAN - Zone of Peace, Freedom and Neutrality

PART 1

POLICY CONSIDERATIONS

AND OBJECTIVES

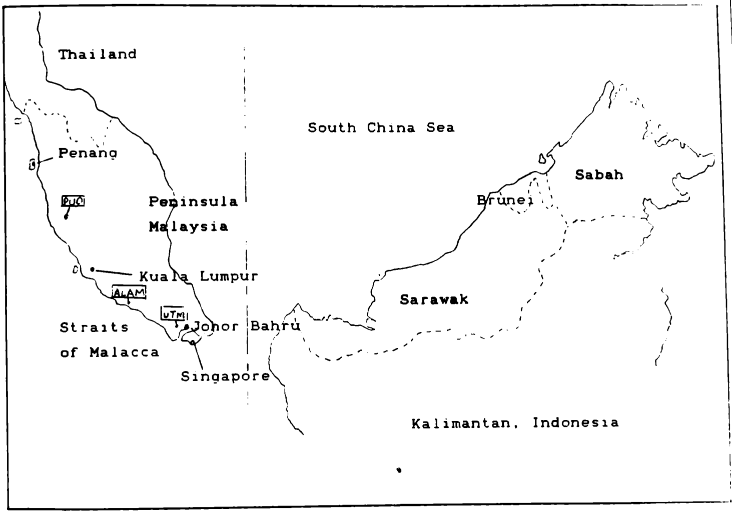
CHAPTER ONE: INTRODUCTION

1.1 GENERAL BACKGROUND

The federation of Malaysia , comprising thirteen states, is separated by 664 kilometers of South China Sea into two distinct geographic regions. The western part, a peninsula consisting of eleven states, stretches from the Isthmus of Kra, Thailand. The peninsula runs parallel to the island of Sumatra to its west, and in between them is the famous and historical Straits of Malacca. Its southern tip is just above the equator after the island state of Singapore. The eastern part consists of two big states of Sabah and Sarawak which border with the state of Brunei and Kalimantan of Indonesia, in the big island of Borneo. The total land area of Malaysia is approximately 336,700 sq. km. of which the peninsula occupies 134,680 sq. km. (5). (Refer to **Figure 1**, page I-2).

Thus, Malaysia is fortunate to have a vast stretch of coastline. The sea has traditionally provided a source of food and link of sea trade with other nations. The awareness to properly manage the sea around us has never been greater, especially with the discovery of oil and gas in the early seventies, along the coast of Sarawak in East Malaysia and off the coast of Trėngganu in West Malaysia. There is also an increasing demand for protein from the sea to feed the growing population. Recreational activities are booming to attract tourists to sunny and beautiful beaches and natural underwater coral reefs. Lately the proclamation of the 200 nautical mile Exclusive Economic Zone (EEZ) will make this maritime sector more vibrant and a rapidly expanding industry in Malaysia.

FIGURE 1: The Map of Malaysia



1.2 PROCLAMATION OF EXCLUSIVE ECONOMIC ZONE

Malaysia views the seas and oceans as the new frontiers of mankind. In the international arena, we realise that there is always a lag between international law and political action. Like many developing countries, we are uneasy about the developed countries' ability to exploit the seabed and about their naval power in the high seas. Instead, we would like to see such resources become the 'common heritage of mankind' and to see international control of the military uses of the high seas (17).

Thus, to safeguard the national interest, Malaysia unilaterally demanded exclusive jurisdiction over its continental shelf "Continental Shelf Act" on 28 July 1966. The "Emergency (Territorial Waters) Ordinance" (Number 7 of 2nd August 1969) was called the " Emergency (Essential Powers) Ordinance". It was only in 1969 and 1971 that the "Territorial Waters Act" was passed, enabling Malaysia to extend its territorial sea to 12 nautical miles. The Exclusive Economic Zone (EEZ) was proclaimed on the 25 of April 1980. All these proclamations also apply to Sarawak and Sabah, the two states in East Malaysia (12). This Exclusive Economic Zone (EEZ) occupies an area of 454,000 sq.km. This (EEZ) area actually amounts to an additional jurisdiction of almost 12 times the previous territorial water (5).

This development opens up vast opportunities for exploitation of the sea's living and non-living natural resources, both in the seabed and the adjacent continental shelf. Thus, this development heralds bright prospects for the nation's growth in manpower development and training.

Education plays an important role in the nation's growth and development. Research is another key area to which a nation must be devoted in order to acquire scientific and technological advancement. These in-house activities will help to create a pool of local experts.

At this moment, there are approximately 12 registered shipyards operating in the country, of which two could handle repair and construction of up to 10,000 deadweight tonnage vessels (Refer to **Table I-1**, page I-5). The biggest shipyard, which was established in 1976, Malaysian Shipyard and Engineering (MSE), could handle ULCC and VLCC up to 400,000 deadweight. There are in existence two major national shipping lines, the Malaysian International Shipping Corporation (MISC) and Pernas National Shipping Lines (PNSL). The third major shipping company, Malaysian Shipping Corporation (MSC), has also recently been established (20). There are also many smaller private owned shipping companies.

This upsurge of great participation since the 1980's, especially in coastal shipping, is largely due to the government's Cabotage policy. Under this new ruling, only Malaysian registered vessels are allowed to operate, and employment of at least 75% local crewmen is required. Presently, the two national shipping lines and other Malaysian private shipping lines are actively involved in the liner services within the several affiliated international conferences. They also compete for tramping services internationally.

These indicate that marine industry, which includes shipping in one sector, and shipbuilding and ship repairing in another sector,has a great future in Malaysia (19).

Table I-1

Major Shipyards in Malaysia

Shipyard	Location	Max.size(DWT)
1) Malaysia Shipyard & Engineering Sdn. Bhd.	Pasir Gudang, Johor.	400,000
2) Sabah Shipyard Sdn. Bhd.	Labuan, Sabah.	12,000
3) Penang Shipbuilding Corporation Sdn. Bhd.	Pulau Jerejak, Penang.	8,000
4) Hong Leong-Lurssen Sdn. Bhd.	Butterworth, Penang.	2,000
5) Limbongan Timur Sdn.Bhd.	Kuala Trengganu.	1,000
6) Brooke Dockyard & Engineering Sdn. Bhd.	Kuching, Sarawak.	3,000
7) Ironwoods Shipyard S.Bhd.	Kuching,Sarawak.	5,000
8) Ocean Shipyard Co.S.Bhd.	Sibu, Sarawak.	2,000
9) Sykt. Sarawak Slipways	Miri, Sarawak.	2,000
10) Yong Hing Shipyard	Sibu, Sarawak.	2,000
11) Far East Shipyard S.Bhd.	Sibu, Sarawak.	2,000
12) Jasib Shipyard & Eng.	P. Klang, Selangor.	1,000

1.3 DEVELOPMENT IN MARINE INDUSTRY

Emphasis in industrial development policy in Malaysia shifted from import substitution industrialisation (ISI) in the late 1950s to the mid-1960s, to export-oriented industrialisation (EOI) since the late 1960s (32). Since the early 1980s massive public investments have gone into selected heavy industrialisation programmes, and marine industry is one of them. In the marine industry, the key area is in steel production, and shipbuilding and ship repairing activities.

The shipbuilding and ship repairing industry's contribution to the GDP and manufacturing value added (MVA) in 1981 was 0.35% and 2.1% respectively (Refer to **Table** I-2, page I-7). This percentage contribution is quite similar to that in Japan and South Korea, the premier shipbuilding nations of the world . The industry's share in GDP and MVA in neighbouring Singapore was very much higher, being 3.66% and 10.04 % respectively in 1980. It must be noted that a substantial portion of this contribution came from ship repairing (21).

There are a number of positive factors which favour the promotion of a healthy shipbuilding and ship repairing industry, as well as a steel industry in Malaysia. Aside from being able to support the expansion of the national merchant marine, these industries can also generate the following economic benefits :-

(i) Although substantial capital investments are necessary initially, shipbuilding and ship repairing activities are relatively labour-intensive. Furthermore, shipbuilding and ship repairing activities not only

Table I-2: Size of the Shipbuilding and Ship-Repairing Industry in Malaysia and Selected Countries.

(Unit: millions)

		Malaysia 1981	Singapore 1980	S.Korea 1979	Japan 1980
Output Amount	M$	409.1			
	US$	177.5	776.2	874.0	11,127.3
Value Added Amount	M$	197.4			
	US$	85.7	402.1	278.1	4,097.2
% Cont. to GDP		0.35	3.66	0.46	0.39
% Cont. to Manuf.Sector		2.1	10.04	1.46	1.25
Employment					
Number		6,200	22,300	42,300	135,000
% Cont. to Nat.Employ.		0.12	2.08	0.31	0.24
% Cont. to Manuf.Sector		1.07	7.76	2.00	1.31

Source: 1) Census of Manufacturing Industries 1981, Department of Statistics, Malaysia.
2) Yearbook of Industrial Statistics 1980, UN.

provide additional employment opportunities but also help to improve the skills of the nation's workforce.

(ii) A healthy shipbuilding and ship repairing indust -ry generates demand for a wider range of manufactured inputs. Examples of these are iron and steel, engineering products, electrical products, chemical products and assorted specialised services. It also provides a good rationale for the improvement of telecommunication, financial, and port facilities.

(iii) Finally, under appropriate market conditions and subject to proper government guidance and encouragement, the industry can establish an internationally competitive position in shipbuilding, ship repairing and fabrication of offshore structures. These can contribute significantly to the nation's foreign exchange earnings.

All these economic benefits will not be achieved unless they are being supported by an effective maritime policy. The adoption of a comprehensive maritime policy is a prerequisite for fostering the development of a healthy shipbuilding and ship repairing industry. None of the countries among the most advanced in shipping and shipbuilding activities could have attained their present domination positions without a firm commitment on the part of their governments to provide assistance and protection to the industry. In view of the many difficulties facing the local shipyards and the highly competitive world market for new ship construction and ship repairing activities , the establishment of a firm maritime policy is all the more pressing for the nation. The policy to be highlighted is the education and training of maritime personnel which are to be fed into the industry.

1.4 DEVELOPMENT IN MARITIME EDUCATION AND TRAINING

The development path for Malaysia over the last quart-er century was one of great success. It is moving into the ranks of those countries which are on the threshold of becoming industrialised. This nation is well endowed with natural resources and after 32 years released from a colonial status, it still maintains relatively high levels of infrastructure and human capital. The essential ingredient for its success would have been its overall economic environment and its policy packages, especially in raising the level of education among the masses.

Malaysia's education system was, generally speaking, one of the best in South-East Asia and the developing world. Not only were enrollment and retention rates through the primary and secondary cycles high, but compar-ed with other developing countries, teacher quality was high and the system was well organized as well as fairly well equipped. While the formal education system was generally considered to be quite good, the level of vocational education might seem to have been rather poor since only very limited school facilities for technical and vocational training were provided in the Federation (29).

The problems regarding the vocational training were true during the early 1970s. Since the end of the 1970s and early 1980s, these problems had been tackled seriously by the government. Presently, we have polytechnics and vocational schools in most major states in the country. This development has been very encouraging, but still a lot has to be done in improving the teaching facilities in the higher institutions and universities.

Education plays an important role in the nation's growth. Inculcating important spiritual and physical values in the education curriculum will ascertain a well balanced student development. In the marine related area, education and training are being provided by three major institutions. The three national institutions are namely Ungku Omar Polytechnic (PUO), Malaysia Maritime Academy (ALAM) and University of Technology Malaysia (UTM). These institutions provide the necessary shore-based and sea-going semi-professional and professional man-power required to ensure proper management of marine affairs activities in Malaysia. While ALAM, undertakes training of ratings as well.

As for the development of skilled man power for the marine industry, it is not wholly monitered by the government. At present, the local shipyards, especially those located in Sabah and Sarawak of East Malaysia and the East Coast of Peninsular Malaysia, experience shortage of peronnel with the required technical skills. In-house or on-the-job training is done by the existing shipyards to improve the skills of their production personnel. Some of the larger shipyards have also sent their employees to local training institutes such as Institute of Technology Mara (ITM), Industrial Training Institute (ITI), Polytechnics and Mara Training Centre. Overseas training, however , is available only to supervisors and senior management staff of major shipyards which have technical tie-ups with foreign companies (21).

Producing enough skilled workers and senior managers in marine industry does not ensure that we could reach new heights in technological advancement unless it is coupled with more extensive marine research activities (25).

1.5 RESEARCH AND DEVELOPMENT IN MALAYSIA

Malaysian universities are primarily undergraduate teaching institutions. There are few research activities, although a number of academic staff are active on individual and group projects. This phenomena is improving, with most of the 7 local universities encouraging staff members to participate in reseach activities. Particularly, to supervise many master's and doctorate's research programmes. At the same time, a number of local industry and government bodies do rely on the available expertise and testing facilities from the universities.

However, there are a number of bodies outside the education system undertaking large scale research programmes of international renown. Those include the Institute for Medical Research, Malaysian Agricultural Research and Development Corporation (MARDI) and the Rubber Research Institute (RRI). RRI has been well established, it has a large budget raised through a levy on rubber producers with which it conducts fundamental and applied research into the production, properties and uses of rubber (10).

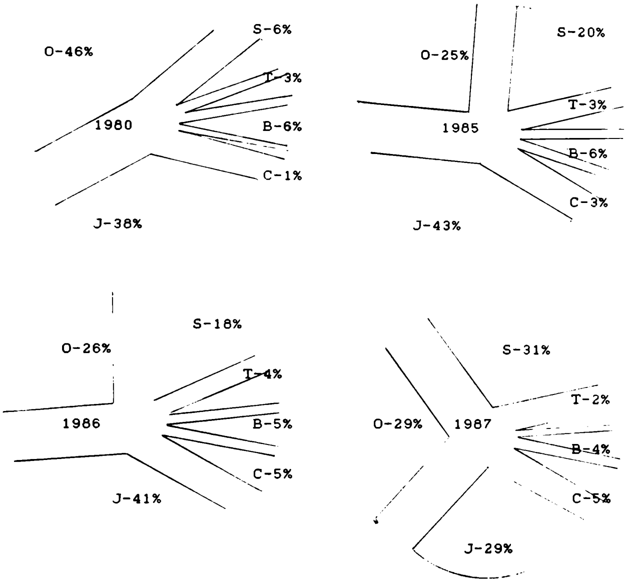
As regards to maritime research, there are some marine scientific research programmes going on between the Agriculture University in Serdang Selangor and Japanese counterparts. In the Sun Expedition (Ekspedisi Matahari) both in 1985 and 1987, they made studies on the fish potentials in the offshore water of the Malaysian EEZ (2). But, as regards to marine technological research work within the nation, there is none, the main reason being that there are no facilities available in the country to undertake such tasks. It seems that government agencies are only interested in the end products, the number of ships or boats required for their department or agencies. Perhaps research work on sophisticated national flag ships and the latest oil platform installations have been done overseas. The acute and unfortunate facts are that not much information is being transmitted back for our own analysis or future references.

Based on these facts, it is sensible that University Technological of Malaysia, which conducts the marine technology should be given greater roles to include research work in marine technology. The Malaysian's policy makers should support the idea of establishing a marine model basin facility in Malaysia. Let this facility be the only one and the best possible to withstand the test of time. Money spent on this facility will not be wasted. Instead, it will create other chain or cyclic reactions to vitalise the industry and the human resources.

To reflect over that proposal, a case in point is Japan, an island nation which is surrounded by sea. It has all the disadvantages that we could possibly think off. But, in a matter of a decade after the Second World War, she emerged to be one of the most advanced and industrial nations in the East. Certainly, it is due to the assistance of post-war aids, coupled with the strong will of the people which propelled them forward.

Japan is heavily dependent on marine research to be in the forefront in shipbuilding and ship repairing. Although, now they are eclipsed by South Korea (Refer **Table I-3**, page I-13) in shipbuilding, they still conduct much marine reseach work (30). The marine research methodology is very much the same as that for automobile or aeronautic -al research. So, the establishment of a marine model basin facility will be an invaluable asset to a nation.

Table I-3: Market Share of New Building Ships ; A Comparison between South Korea and Japan.



* J - Japan; T - Taiwan; S - South Korea
  C - China; B - Brazil; O - Others

Source: World Shipping Statistics 1989;A graphical analysis of the marine industry;FISYS Fairplay Info.Sys.

1.6 MARINE MODEL BASIN FACILITIES

Accordingly, there are about 58 institutions and research centers in Japan doing research work on various ranges of marine activities (7). Each institute or research center has one or more of the following marine hydrodynamic (laboratory) facilities, namely:-

1) Towing Tank
2) Circulating Water Channel
3) Seakeeping and Manoeuvring Basin
4) Rolling Tank
5) Wind Tunnel
6) Cavitation Tunnel
7) Oscillating Tank
8) Offshore Structure Experimental Basin
9) Ice Model Basin
10) Wave Channel
11) Smoke Tunnel
12) Ship Manoeuvring Simulator
13) Wave and Current Flume
14) Rotating-Arm Tank
15) Water Impact Testing Channel
16) Depressurized Circulating Water Channel
17) Wave Tank and Wind Tunnel

These marine model basin facilities, as stated above, vary in size depending on the experiment or research to be undertaken. An interesting fact noted is that most of the institute and research centers have at least a towing tank and some other combination of equipment.

As for the proposed Marine Technology Laboratory (Marine Hydrodynamic Facilities) at UTM Skudai, Johor

Darul Taqzim, the facilities that we plan to install are confined to a space area of (37 x 73) metres. This space area was allocated in the initial deliberations with the UTM authority. Within this restricted space area a Towing Tank, a Seakeeping and Manoeuvring Basin, a Cavitation Tunnel and a Model Making Workshop are to be constructed. That space area is not adequate. If we take into consider-tion the future expansion of those facilities an area of twice that size is required.

In this respect, the establishment of Marine Technology course at University of Technology, Malaysia (UTM) will make an important contribution towards this end by providing knowledgable marine technologists to support the heavily expanding Malaysian industries.

The proposed laboratory at UTM, Skudai, Johor Darul Taqzim, will help to assimilate knowledge and develop awareness to produce well-designed ships, first and foremost for local uses and perhaps later, for other neighbour-ing ASEAN countries demands. Its establishment will also meet the national objectives, as stated in the Industrial Master Plan, August 1985 Report, as regard to development in the shipbuilding and ship repairing industries (21).

So, the phrase normally lauded as "A Newly Emerging Maritime and Industrial Nation" or "The Second Wave of NICs" will only be just another gimmick unless more positive action is taken seriously by the policy-makers in assisting to raise funds to build it. Funds should be provided for not only the development of the industrial infrastructure but also for research facilities and on-going activities.

CHAPTER TWO: MALAYSIAN MARITIME EDUCATIONAL FRAMEWORK

2.1 NATIONAL EDUCATION POLICY

The education policy of Malaysia is largely based on the Education Act of 1961, which established a national system of education which is aimed at satisfying the needs of the nation. This is achieved by promoting cultural, social economic, and political development. Progressive development is also made in having the national language, Bahasa Malaysia, be the main medium of instruction in all government assisted schools and universities (10).

The continuing objectives of educational policy at the school level are:

(1) to provide a minimum of nine years general education to all who wish to attend

(2) to preserve and sustain the languages and cultures of each community

(3) to unite the various races and create a national identity

Educational development plans are drawn up as part of the national five-year development plan. An example is the Third Malaysia Plan (TMP) 1976-1980, which outlines the implementation of the New Economic Policy (NEP). The objectives of the education and training programmes under this TMP still carry an enormous bearing on the nation. They are:

(1) Consolidation of the education system to promote national integration and unity through:

a) the phased implementation of the national language as the main medium of instruction in schools

b) closing the gap in educational opportunities among regions and races

c) the eventual integration of the education system of the states of Sabah and Sarawak with the national educational system

(2) Orientation and expansion of the education and training programme towards meeting the manpower needs of the country through:

a) improved coordination of these programmes

b) a sharper definition of their objectives and methods

c) expansion in areas of critical manpower needs

(3) Improvement of the quality of education and increased effectiveness for nation building (22), through:

a) reduction in wastage rates

b) more intensive evaluation

c) improvements of curricula, teaching methods, and teacher/ pupil ratios

(4) Improvement of the research, planning and implementat-ion capacity to meet the above objectives.

Besides the 1961 Act and the various five-year plans, there have been a number of other reports and reviews which have affected education policy In the 1980s, we see the implementation of many of the Cabinet Review Committee's recommendations. Whilst these recommendations fore-shadow a big expansion in vocational education and teacher training and a substantial revision of curricula, the main objectives of education and the highly centralized structure of the education system are still unchanged (10).

2.2 MARITIME EDUCATION AND TRAINING

The demand for qualified marine personnel has been on the rise since the end of the 1960's and the early 1970's. During this period, a new government policy was introduced . This reduced or curbed expenditure in the government and semi-government agencies and encouraged greater participat -ion by private industries. The implementation of 'Malays-ian Incorporated' privatisation concept in shipping indust -ry goes back since 1969, when the Malaysian International Shipping Corporation (MISC), first established its liner operation. But now, MISC has grown into a large shipping conglomerate with diversified operations. It is also listed in the Kuala Lumpur Stock Exchange (KLSE). In ship -building and heavy industry, Malaysian Shipyard and Engineering (MSE) is a good example. MSE started off in 1974, as a joint venture project with Sumitomo Shipyard of Japan. Apart from doing ship construction and repairing, it has diversified into construction of offshore modules, railway coaches and other mechanical constructions.

The above two examples indicate that the marine related industry is still flourishing and booming. Qualified marine engineers and technicians are in greater demand to cope with the growing sophistication and stringent regulation adopted in the marine industry throughout the world. This is to ensure that a proper safety standard is maintained and implemented.

Marine related education and training in Malaysia began with the establishment of a marine engineering course at Ungku Omar Polytechnic (PUO), Ipoh, Perak in 1972. This course is jointly assisted by UNESCO, World Bank and the Japanese Government under its Colombo Plan to train Malaysian sea-going marine engineers.

Before 1972, personnel in the marine engineering sectors were either trained through an in-house training or apprenticeship programme. These in-house or apprenticeship training programmes are planned to meet the immediate manpower requirement of the respective company. The company or government department that does have such training apprenticeship programmes are MISC, PNSL, MSE, PPC, HLL, RMN, RMP and others. Even then, it was found that the demand for qualified marine engineers, as well as navigation officers, was still greater.

As a member of the Association of South-east Asia Nations (ASEAN) country, Malaysia participates fully in its effort to promote friendship and cooperation within this region. The cooperation in marine related education is well received, as it is universal and international in nature.

In promoting education, there was a mutual agreement between the government of Malaysia with some ASEAN governments to set aside some places of study for Malaysians in marine and nautical studies especially at Akademi Ilmu Pelayaran (AIP), Bandung, Indonesia, and Singapore Polytechnic, Singapore. While at the same time, there are just as many students who went to the United Kingdom and other advanced Commonwealth countries to pursue their studies under government or private company scholarships. There are also a few who pursued studies in the United States of America.

Thus, the manpower development and training has been very rapid, to keep pace with the demand of qualified personnel both on-shore and off-shore of the marine related industries. Later, two other marine related institutions were established to accommodate for the specialization in education and training. Akademi Laut Malaysia (ALAM) in Kuala Sungai Baru, Malacca and Marine Technology course under the Faculty of Mechanical Engineering at UTM, Skudai, Johor Darul Taqzim (moved since July 1989).

In summary, the technical manpower needed to support these diversified maritime and marine technology related activities in Malaysia, can be broadly classified into the following three categories:-

- **1st. category** --- Seafarers both engine and deck.
- **2nd. category** --- Shore-based Marine Engineers & Technicians.
- **3rd. category** --- Shore-based Marine Technologists.

The institutions of higher learning in Malaysia which are involved in the education and training of the above categories of manpower are as follows:-

- **1st. category** --- Ungku Omar Polytechnic (PUO) in Ipoh, Perak and Maritime Academy Malaysia (ALAM) in Malacca.
- **2nd. category** --- PUO and University of Technology Malaysia (UTM) in Skudai.
- **3rd. category** --- UTM in Skudai, Johor Darul Taqzim

The natures of the education and training programme conducted by each of the above mentioned institutions of higher learning are different from one another. It is relevent here to clarify their differences.

2.3 UNGKU OMAR POLYTECHNIC (PUO), IPOH, PERAK.

The rapid development of the Malaysian shipping line, MISC and lately PNSL and other smaller companies have led to a greater demand for qualified technical personnel to man these ships. For this reason, the year 1972 saw the commencement of the first Marine Engineering Course (15).

(i) Marine Engineering Course

The purpose of the marine engineering training project at PUO is to bring up marine engineers for foreign going ships with the Certificate of Competency for the First and Second Class Engineers.

At Ungku Omar Polytechnic, the Marine Engineering Department offers only a Diploma in Marine Engineering. While the Mechanical Department offers several courses but only up to Technician level.

The course in Marine Engineering has been set up with the assistance of the Japanese government under the Colombo plan (JICA). Under that mutual agreement of assistance, the Japanese government provided the equipment and adviser-s, while the Malaysian government provided the workshops, local teaching staff, additional equipment and operating cost. It is also important to note that the establishment of the Polytechnic in 1969 is through the assistance of the United Nations Educational, Scientific and Cultural Organization (UNESCO). At present, the course is totally conducted by local staff.

Marine Engineering, which is closely related to Mechanical Engineering, emphasises the operation and maintenance of the ship, marine power plants, and associated equipment as well as ship construction and naval architecture.

The students who succeed in this course with sufficient credits and after sufficient sea-experience are exempted from Part A of Class I and Class II of the Certificate of Competency for the Foreign Going Ship Examination. These Certificate of Competency examinations are conducted by the Marine Department. The students are required to sit for only certain papers in the part B of the Class I and II marine engineers examinations.

(ii) Course Structure

The Marine Engineering course is a four year sandwich course which includes sea training and shipyard training. This is as shown below, in five phases:-

Phase I	First Year (at Polytechnic)	12 months
Phase II	Industrial / Shipyard Training	6 months
Phase III	Second Year (at Polytechnic)	9 months
Phase IV	Sea Training as cadet engineer	12 months
Phase V	Final Year (at Polytechnic)	9 months
		48 months

(iii) Marine Workshop Practice, Cutter Training & Correspondance Course.

Since the basic aim of PUO is to train operating marine engineers, the marine workshop practice curriculum focuses on a set of lectures and laboratory experiments exercises. Examples are procedures for starting of main diesel engines and steam power plants, and also trouble shooting and overhauling works.

Regular cutter training and sailing practice are held and made compulsory for all second year and final year students. The training is held twice in a term.

Students undergoing sea training on board ships are required to follow a correspondance course. This course is conducted by the Polytechnic with the co-operation of the national shipping companies.

(iv) Modular Courses

In addition, arrangements are made with Malaysian Maritime Academy (ALAM), Malaysian Red Crescent Association and also sponsors to conduct Modular courses for the final year students.

The modular courses are as follows:-

1) Basic Fire Fighting at sea
2) Advanced First Aid

The above courses are necessary requirements for holders of Fourth Engineer Certificates and above. Graduates of PUO are eligible to sit for the Fourth Engineer Certificate of Competency (oral examination).

(v) Curriculum

The curriculum for the first, second and fourth year are as shown in the (**Table II-1, page II-9**).

Table II-1: Curriculum for First, Second and Fourth Year.

First Year	-	English Language
		Islamic Education
		Mathematics
		Engineering Science
		Engineering Drawing
		Workshop Technology I
		Electrical Technology I
		Heat & Fluid Technology
		Marine Engineering Practice
		Naval Architecture I
Second Year	-	Islamic Civilization
		Strength of Materials
		Mechanics of Machines
		Steam Engineering I
		Auxiliary Engineering
		Marine Control Systems Technology
		Marine Workshop Technology
		Naval Architecture II
		Electrical Technology II
		Internal Combustion Engineering I
Fourth Year	-	Mechanical Technology
		Internal Combustion Engineering II
		Advanced Mathematics
		Drafting and Design
		Steam Engineering II
		Naval Architecture III
		Marine Eng. Practice & Legislation
		Control Engineering
		Applied Electronic & Electrotechnology
		Materials Technology
		Auxiliary Machinery

2.4 MALAYSIAN MARITIME ACADEMY (ALAM), MALACCA.

Initiated in 1976, as a Malaysian Training and Education of Seamen (MATES) Centre. MATES Foundation is run and supported by MISC, Kuok Foundation, International Maritime Carriers and the Malaysian Ministry of Transport. The government realises its importance. In August, 1981 it was announced as the Malaysian Maritime Academy (ALAM). In doing so the government is committed to play a much bigger role in promoting the advancement of training of seafarers in the country (23).

At present ALAM provides four type of courses,namely:

i) Pre-sea Courses
ii) Post sea Courses (Nautical)
iii) Post sea Courses (Engineering)
iv) Modules Courses

For the purpose of this thesis, I will concentrate only on engineering officers and ratings training programmes at ALAM.

(A) Rating Training, Engineering Department

Under the pre-sea training as mentioned above, six courses have been offered at ALAM. The courses include the training of two cadets courses and four ratings courses. The basic courses for Ratings are in the Deck, Engine and Catering Department. The General Purpose (GP) Rating course which forms the fourth type of course was started in 1977. This GP rating was expected to work both on deck and in the engine room. Unfortunately, due to some difficuities in their job specification and promotion-wise the GP training course was scrapped in 1983.

In the Engine Department training, candidates will be given a 14 weeks course in Basic Engine Room Rating. It provides the ratings with the insight into their duties and responsibilities when they proceed on board ship. The Document of Guidance 1975 are used as the basic guidelines for the course, which stresses safe working practices as well as familiarity with the tools of their profession. At least three such courses are conducted in a year.

(B) Marine Engineer Officers, Education and Training.

Most of the Malaysian candidates who work for the national or local shipping company are sponsored while studying at ALAM. About one third finance their own study.

(i) Second Class Engineering Part B (Motor).

The Academy has been conducting a 14 weeks preparatory course for the Second Class engineering part B as from November 1983. The subjects are as follows:-

a) Mathematics
b) Applied Mechanics
c) Heat Engines
d) Engineering Drawings
e) Electrical Technology
f) Naval Architechture
g) Engineering Knowledge I/II/oral
h) Basic Engineering Science
i) General Engineering Science I/II.

(ii) Second Class Engineering Part A.

Part A of the examination also commenced as early as

November 1983. It covers a period of 14 weeks. Candidates from Ungku Omar Polytechnic will be exempted from this examination, in view of the previous 5 years of studies and cadetship. Later, the duration of studies was reduced to 4 years. So, this part of the examination caters more to those who go through the apprenticeship programmes and engineering ratings who managed to pass the First Engine Driver examinations and want to pursue further.

(iii) **First Class Engineering Part A & Part B**

This course has been conducted since 1985 and has been running smoothly. The period of study is 14 weeks. Just as is the Second Class preparatory course, it is primarily directed for Motor candidates. There are moves in preparing candidates for the Steam Certificate of Competency, for both Second and First, recognizing the fact that MISC have five Liquid Natural Gas (LNG) vessels.

(C) Additional Supplementary Courses

For each grade of qualification there are requirements for attendance, examinations and proper certification in Additional Supplementary Courses. The requirements vary with the level of competency and qualification being sought by the candidates. At present, the Academy provides for the following Additional Supplementary Courses:-

1) Proficiency in Survival Craft
2) Basic Fire Fighting
3) Basic First Aid
4) Restricted Radio Telephony
5) Personal Survival at Sea
6) Automatic Radar Plotting Aid (ARPA)

At an advanced stage of planning are the following courses which will be conducted in the vary near future:-

1) Radar Operation
2) Radar Observation
3) Electronic Navaids Operation
4) Advanced Fire Fighting
5) Ships Captain's Medical Training
6) Radar Simulator

Also being planned are the following courses:-

1) Ship Management
2) Bridge Teamwork
3) Tanker Safety
4) Liquified Natural Gas (LNG) Carrier Safety
5) Crude Oil Washing (COW)
6) Inert Gas
7) Carriage of Dangerous Goods

ALAM has the facilities to conduct the courses mentioned above. The academy has also installed a Life Boat Module with all the landing facilities in Malacca. They have converted the Smoke House formerly belonging to the Fire Department of Malacca, to simulate fire and smoke within an enclosed space for the fire fighting course.

At the end of each course, the academy (ALAM) shall issue a certificate of attendance to a student who has completed the course of study to the satisfaction of ALAM. The academy then shall recommend to the Ministry of Transport (MOT) for the issuing of the Certificate of Competency to the qualified candidates.

2.5 UNIVERSITY OF TECHNOLOGY, MALAYSIA (UTM).

(A) Brief History

The University of Technology, Malaysia was established on 14th. March, 1972 under the name of National Institute of Technology. But on 1st. April 1975, it's name was changed to "Universiti Teknologi Malaysia (UTM)".

UTM is considered to be the oldest higher institution in Malaysia and was started way back in 1925, as a technical school. This technical school at that time was managed by The Public Works Department (PWD), Survey Department and Malayan Railway (KTM). In 1930, the technical school was extended and resited at Bandar Road, Kuala Lumpur.

Due to the advancement in the level of education, in 1941, Kuala Lumpur Technical School was suggested to be elevated to a Technical College. However, that idea was shelved for some time with the disruption by the Second World War. It was only in the year 1946, after the war, that Kuala Lumpur Technical College was finally established at Gurney Road (now Jalan Semarak) in Kuala Lumpur. The construction of these new buildings started in 1951 and was officially opened in March 1955. That is now the present site of UTM Kuala Lumpur branch.

In the beginning, all the courses conducted were only meant for semi professionals. In 1960's, the Technical College started to conduct courses leading to professional engineers examinations. These courses are tailored in accordance with the requirements of the Institute of Civil Engineers, Institute of Mechanical Engineers and Institute of Electrical Engineers in the United Kingdom.

All these courses were recognised as equivalent to university degree level.

As the result of the outstanding achievements of its graduates. in 1967 the committee on planning for Higher Education agree to eleviate the Technical College into a Technical Institute. In 1969, its status was raised to a University (8).

(B) Marine Technology Course

The Marine Technology course at both Diploma and Degree levels was introduced in the Faculty of Mechanical Engineering since the academic year of 1981/82 session. At present, there are approximately 150 students in total enrolled for the Marine Technology course. Upon satisfactorily completing the courses, students are awarded a Diploma or Degree in Mechanical Engineering (Marine Technology).

In connection with developing the Marine Technology course, UTM has made a study of the manpower requirement in shore-based marine industries in Malaysia. UTM was also fortunate to get expert advice and services from the Ship Research Institute of Japan and the University of Newcastle Upon Tyne, United Kingdom regarding the establishment of the Marine Technology course.

The Marine Technology courses offered by UTM, in contrast to the courses offered by PUO and ALAM, are designed to cater primarily to the needs of the shore-based marine industries in Malaysia. The details of the courses in UTM are elaborated below.

(i) Course Structure

The diploma and degree programmes are completely independent from one another and their durations are 3 and 5 years respectively. The entry qualifications are exactly the same as those for Mechanical Engineering programmes. For the degree students they are required to submit a thesis for the fulfillment of the course.

(a) Diploma in Mechanical Engineering (Marine Technology)

In the Diploma programme, the students are offered mainly mechanical engineering subjects in the first and second year. In the final year, the subjects are mainly Marine Technology. The subjects offered are as follows:-

1) Marine Engineering Materials
2) Ship Calculation and Stability
3) Ship Structure
4) Ship Drawing and Ship Design
5) Construction, Repair and Conversion of Ships
6) Outline of Ocean Engineering and Offshores Structures

(b) Degree in Mechanical Engiheering (Marine Technology)

In the Degree programme, the students are offered mechanical engineering subjects in the first three years, except Basic Ship Drawing in the first year. In the fourth and fifth year the marine technology subjects offered are as follows:-

1) Marine Engineering Materials
2) Naval Architecture
3) Shipbuilding & Ship Repair Practice
4) Ship Structure & Ship Vibration
5) Applied Hydrodynamics
6) Ship Resistance & Propulsion
7) Ship Drawing
8) Ship Design Practice
9) Marine Power Plant
10) Marine Electrical Engineering Practice
11) Dynamics of Marine Vehicles
12) Design & Construction of Offshore Structure
13) Sea Transportation Practice

For further details, breakdown on the curriculum for both Diploma and Degree programmes is given in **Appendix A**.

Both the Diploma and Degree students are required to undergo six months of practical training. Two months are normally done in-house doing welding, machining, and fitting, while the remaining four months are done in the shipyard. This training is normally done during the semester break. It is part of the requirement for successfully completing the course.

(ii) Workshop and Laboratory Facilities

Since the Marine Technology programme is strongly integrated with the mechanical engineering programme, the workshop and laboratory facilities developed for mechanical engineering are fully utilized. Some of the exercises and training include machining, auxiliary machinary operation, analysis of refrigeration and steam systems and experiments on materials.

In addition, some exclusive facilities such as a ship stability dynamometer, circulating water channel, cavitation tunnel, manuevering tank, towing tank, ship design and lofting facilities are being proposed.

The proposal for the establishment of this marine hydrodynamic facilities at UTM is the main thrust of this thesis.

(iii) Teaching Staff

UTM is fortunate to have a sufficient number of teaching staff for the Marine Technology courses. The staff members are being sent overseas for higher education and training in specific areas such as Naval Architecture, Marine Engineering, Maritime Transport, Ship Production Technology, Offshore Engineering, Marine Technology and others. This will provide a wider blend of experience as they are being sent not only to United Kingdom, but also to USA, Sweden and Japan.

(iv) Recognition

The degree programme leading to the award of Bachelor of Mechanical Engineering (Marine Technology) meets the academic requirement of the Board of Engineers Malaysia as well as the Institution of Engineers Malaysia for the status of Professional Engineer.

Efforts are also being made to obtain accreditation from the Royal Institution of Naval Architects and the Institute of Marine Engineers of the United Kingdom. This is to ascertain that the Marine Technology degree option is widely recognized both at home and abroad.

(C) UTM at Skudai, Johor Darul Taqzim

Presently, there are nine faculties in UTM. The present location, at the heart of the capital city is considered ideal. Due to its rapid expansion, in terms of courses offered and greater resurgence in manpower and facilities development, it is found that the existing site is too small. The government decided to relocate it to Skudai, Johor Darul Taqzim. This new site of 380 hectres was given by the Johor State Government to UTM for the relocation. It is about 400 kilometers to the south of Kuala Lumpur and about 20 kilometers from Singapore. This relocation is underway and UTM still hope -s to maintain Kuala Lumpur site for other purposes.

UTM relocation to its new campus in Skudai, Johor Darul Taqzim, will speed up its expansion and development processes. Space is no longer an acute problem. This proposal for the establishment of hydrodynamic facilities, if supported by the authorities, will be a reality.

This is my sincere hope. With its existance, it will be the first and probably the only one in Malaysia. This facility is aimed to help in the education and training of UTM students in the Marine Technology course. However, with greater understanding and experience, it is hoped that research work could be undertaken for the local industries.

This collaboration with the industry is vital for the maximum utilization and survival of the proposed marine model basin (laboratory) facilities and this will justify its existance.

PART 2

PROPOSAL FOR THE ESTABLISHMENT OF HYDRODYNAMIC BASIN

CHAPTER THREE: MARINE HYDRODYNAMIC FACILITIES AT UTM

3.1 DEFINITION OF A HYDRODYNAMIC CENTRE

A hydrodynamic centre or laboratory is where a ship's model is tested to find its hull characteristics, in still water as well as in waves, and in various directions and magnitudes. The data and other information gathered from those experiments are analysed and noted, in order to determine the hull with the best performance. The model testing is part of the spiral in the design process. Some minor changes could still be made, if necessary, to further improve the designed ship to derive the most economical ship (13). It has been found that the contribution gained from a model testing could be as much as 2% of the total cost of the ship. This finding is based on cost analysis made by Professor Harry Benford. The cost benefit will be more significant if several prototype ships were built based on the same type of model.

In spite of recent progress in the theory of ship hydrodynamics, the final check still has to be the model test (36). The exact ship's model is either made of wood or glass fiber developed from the initial "lines plan" of the ship. Then it is tried out in the towing tank to find its resistance at different speeds, and the amount of horsepower needed to give those speeds. Later, the model could be tested for its manoeuvribility in waves of various magnitude and direction. This is perhaps the most vitally important stage of the whole undertaking. The finest calculations and scientific application are required, as the satisfactory performance of the finished vessel depends on it.

The careful and closer study of model and ship correlation requires good hydrodynamic facilities. Qualified and experienced staff members are also required to conduct the experiments and translate the results correctly and precisely. This helps to give a better picture of the characteristic of the new vessel that is to be built.

The hydrodynamic facilities could consists of just one basic facility, normally a towing tank or a combination of several other hydrodynamic facilities. In order to successfully cover the whole range of the hydodynamic experiments on that same ship's model, a combination of those facilities are necessary. This variation largely depends on the purpose of building such hydodynamic facilities itself, whether it is meant solely for teaching or purely research work for commercial basis. In most instances, both activities of teaching and research are done in the hydrodynamic facilities estabishment as they are inter-related.

Accordingly, from the hydrodynamic point of view, it may be said that the bigger a model basin tank is the better, while from every economic point of view the reverse is true. The large model basin tank entails appropriately big equipment with associated enormous increases in weights, stresses and high costs both initially and while in operation. In hydrodynamic sense, the larger the basin the more accurate and the reverse is true for small model basin. So, a dividing line should be drawn as to find just the right size to serve our purpose (24).

The hydrodynamic facilities built in universities or teaching institutions, in general, are normally small in size. Teaching is their prime objective. The staff members and some postgraduate students do some research work in a very limited area of hydrodynamics field. The main constraints are due to the facility limitations and the financial support is scarce. On the other hand, most hydro-dynamic research centres or institutes, are either fully funded by the government of the country or supported by public institutions and they generate their own resources through their expert services. They have quite a large and elaborate marine model basin facilities. These enormous facilities together with many highly qualified personnel will allow them to undertake any potentially sophisticated job assignment. One classical example is the David Taylor Research Center at Annapolis and Bethesda, Maryland, in the United States of America(14). The author is fortunate to have had the opportunity to visit those places during his field trip to U.S.A, in June 1989.

The David Taylor Research Center, which is a renowned hydrodynamic center has a large complex of model basins, towing carriages, water channels and cavitation tunnels to satisfy a wide variety of hydrodynamic experimental requirements.

The David Taylor Model Basin Building is 3200 feet (approximately 976 metres) long and houses the High Speed Basin, the Deep Water Basin, and the Shallow water Turning Basin. The 140 feet(approximately 43 metres) Basin and the Miniture Model Basin are located in other buildings and are used for small scale experiments.

The Harold E. Saunders Manoeuvering and Seakeeping Facility (MASK) houses five acres under one roof and contains the Rotating Arm Basin and the large Manouevering and Seakeeping Basin. The Seakeeping Basin has a wavemaking capability. In addition to the towing basins, the Center has three variable pressure water tunnels. These are used primarily to determine the performance and cavitation inception characteristics of propellers and ship appendages.

A Circulating Water Channel is used for stack gas flow studies over ship superstructures at various headings , towed body evaluations, and flow visualization experiments on ship hulls, rudders, fairings, struts, bilge keels, and other appendages The model is held stationary in the channel, while water flows around it at various speeds. Strips of yarn or dye show the flow patterns which may be observed and photographed through underwater windows.

Other supporting areas of the hydrodynamic facilities should include the model making facilities, computer data acquisition and software development and other logistics support. The size of the model basin tank, the model used and its data acquisation system will determine the degree of accuracy the model must represent in relation to the behaviour of the larger prototype. However, the wider and deeper influence of the model and the model basin tank lies in their uses, not merely for the solution of the individual design problem but as the instruments or tools of basic research.

Acting as tools for naval architects, this model testing together theoretical and full scale data provide all the essential checks on the prediction of model performances. Model testing, as mentioned earlier, is relatively cheap and its results can be obtained fairly rapidly for a variety of changes to enable the naval architects to achieve an optimum design of the ship (27).

3.2 BASIC PRINCIPLES OF HYDRODYNAMIC FACILITIES

As stated above, the hydrodynamic facilities could consist of several model basins, towing carriages and cavitation channels (tunnels). These hydrodynamic facilit-ies are used as tools by the researchers to discover the various capabilities of a ship's model. This is done by several experimental techniques.

William Froude was the man who postulated the idea of splitting the total resistance into the residuary resist-ance and the frictional resistance of the equivalent flat plate. He also argued that air resistance and the effects of rough water could be treated separately. By studying the wave patterns created by geometrically similar forms at different speeds, Froude found that the patterns appear-ed identical, geometrically, when the models were moving at speeds proportional to the square root of their lengths. This speed is termed the corresponding speed, and this is merely another way of expressing the constancy of Froude's number. He also noted that the curves of resist-ance against speed were generally similar if the resist-ance per unit displacement was plotted for corresponding speeds. Proceeding further, he found that by subtracting from the total resistance an allowance for the frictional resistance, determined from flat plates, a very good correlation could be made (28).

This led to Froude's law of comparison which may be stated as:

If two geometrically similar forms are run at corres-ponding speeds (i.e. speeds proportional to the square root of their linear dimensions), then their residuary resistences per unit of displacement are the same.

Thus the essentials are available for predicting the full scale ship from a model. The steps used by Froude are still used today, refinements being restricted to detail rather than the principle. For each particular value of the ship speed:

a) measure the resistance of a geometrically similar model at its corresponding speed,
b) estimate the skin friction resistance from the data derived from experiments on flat plates,
c) subtract the skin friction from the total resistance to obtain the residuary resistance,
d) mutiply the model residuary resistance by the ratio of the ship to model displacements to obtain the ship residuary resistance,
e) add the skin friction resistance estimated for the ship to obtain the total ship resistance.

It should be noted that any error in estimating frictional resistance applies both to the model and ship. Thus only the effect on the difference of the two is signnifcant.

It is now possible to see why earlier attempts to correlate the total resistance of ship and model failed. Two models with identical resistances could only represent ships with identical resistances if the ratio of their residuary and skin friction resistance were the same. Indeed, if model P had less total resistance than model Q it did not even follow that ship P would be less resistive than ship Q. Thus, even the qualitative comparisons made between models, used so frequently even today in many branches of naval architecture, may be invalid.

3.3 THE BENEFIT OF MODEL TESTING IN A MODEL BASIN

The cost benefit of having a hydrodynamic facility is clear but I will provide some mathematical calculations to justify the point.

Before a decision to make and test a model of a ship is made, the following matters should be agreed upon:-

1) Subdivision
2) Trim
3) Stability
4) Capacities
5) Freeboard and
6) Deadweight

Once the above-mentioned requirements are tentatively satisfied, it is then essential to refine the "lines" and conduct a model test for assured performance (16).

Justification for the model testing expenditures can be demonstrated by the following example. Tentatively, assuming the following criteria, and to find P:

(a) Fuel oil at 18.40 per barrel(bbl) (1),
(b) Interest rate of return after taxes at 10%.
(c) Steaming time at 50%,
(d) Fuel rate (RTA engine) 120 grams per SHP.hr (18),
(e) 40,000 SHP,
(f) Economic life of 20 years,
(g) Taxes at 35 %,
(h) 2% savings over the life of the ship as the result of improved hull form (3).
(i) 1 tonne = 7.3 US barrel (6)

$P = R/CRF$ where,

CRF is capital recovery factor before taxes,
CRF′ is capital recovery factor after taxes, and
R is annual amount of money or annual savings.

$$CRF = \frac{i * (1 + i)^n}{(1 + i)^n - 1} \quad \text{-- Benford (3)}$$

and

$$CRF' = \frac{CRF - \frac{t}{n}}{1 - t} = \frac{0.1175 - \frac{0.35}{20}}{1 - 0.35} = 0.154$$

where: n = economic life in years and t = tax rate, then:

$$R = \frac{\frac{days}{yr} * \frac{hr}{day} * \frac{q}{SHP.hr} * \frac{time\ at\ sea}{total\ time} * \frac{\$}{bbl} * SHP * \frac{SHP\ saved}{SHP}}{\frac{q}{bbl}}$$

R = (365 * 24 * 120 *0.50 * 18.40 * 40,000 * 0.02)/136,986
= 56,479 savings $/year.

P = R/CRF′ = 56,479/0.154
= $366,746 saved over the life of one ship.

If more than one ship is built to this one basic hull form, the present worth of the savings is a direct multiple of the number of ships involved. Accordingly, the economics are clear for any important ship and especially for multiple-ship programmes, so that it is wise to model test thoroughly the proposed lines in order to get an optimum hull form design.

Rational design of ship structures has forced the designer to determine quantitatively as many as possible of the factors affecting the safety and performance of the structure throughout its life, and to use this information to determine that particular design which optimizes perfor -mance and provides adequate safety. This process involves many calculations, but the use of computers can simplify the task, providing an automated optimum rational design.

Among the advantages in having the hydrodynamic facilities in an educational establishment is that the student can observe the experiments simultaneously and perhaps come to immediate conclusions as to the lessons to be learned from the tests. They will also have a better feeling about some of the naval architecture words (i.e. buoyancy, metacenter height, stability and others) when it is being discussed in the classroom.

Model testing is essential for newly built ships and should only commence when the designer is fully satisfied with the preliminary design. A sufficient number of cycle -s around the design spiral must have been made to assure, no surprises calling for lines changes will be required.

The technical information gathered from the model test will support improvement of the ship design in the country. It could be furnished to other government agencies especially in the Navy, Marine Police, Custom Department and Marine Department. Private companies and individuals could also benefit from the new findings by improving the ship design and upgrading the construction techniques. This support includes both experimental and analytical programmes related to every type of ship and craft, including platform, mooring and towed systems.

3.4 THE NEED FOR A HYDRODYNAMIC BASIN AT UTM

The Marine Hydrodynamic Facilities is required at UTM to provide training and teaching facilities to the undergraduate of Marine Technology degree and its diploma (semi-degree) programmes. Presently, the available facilities are more mechanical based. These facilities are used by all Mechanical Engineering students, irrespective of their majors. As a general arrangement, all Diploma and Degree students have to do some lab work that includes Machining, Fitting, Materials, Instrumentation, Thermodynamics and Fluid Mechanics. These facilities are more mechanical based and is related to the study of marine engineering.

At the moment, there are no facilities available with respect to a Naval Architecture Laboratory. So, most of the dissemination of Naval Architecture knowledge is done through textbooks and lecture notes. It will be more effe-ctive if we have the hydrodynamic facilities to conduct experimental studies on subjects like Stability, Resistance and Propulsion, Manoeuvering and Seakeeping and others.

A modest Hydrodynamic Laboratory facility is required to train our students in the field of ship design and naval architecture. Although the forefathers of some of the locals have knowledge on ship construction which was passed on to them and their younger generations by following their parents in their work, their method of dissemination of knowledge is by memorizing, fine tuning instincts and good judgement. Even then, this method of 'transfer of technology' is considered very inaccurate and quite unreliable. No formulae are used and there is neither any 'blue print' drawn, everything is estimated roughly to the nearest approximation by the rule of thumb.

This method could be applicable if we are making the same prototype ship over the years with the same kind of environment and loading condition. Nowadays, river mouths have been silting up and more and more machinery and equip-ment are placed on board. So, due consideration has to be given to these draft and stability problems, but with those traditional methods, modification on the original design will be difficult to make. Quoting from (9): the Captain Cook's expedition found that the Islanders' boats that they met while travelling near the Polynesian Islands near the Pacific Ocean were much faster and could easily manoeuver around their ship. This goes to show that they were quite advanced in their design of boats at that period of time.

Now, the situation has changed in the developed countries, especially the Western nations, as they have surpassed those Polynesian countries (a representation of the once civilised nations in the east) by leaps and bound-s. They have come up with more sophisticated propelled ship's due to the advent of propulsion plants and modern ship design technology which they mastered over the years. Now at this stage they are already well ahead into the futuristic ship projects which include; 'techno superliner', new cruise vessel, 'floating island', and superconduct-ive electro-magnetic propelled ship (31).

In order to keep abreast, with the marine technologi-cal development and achievement of the developed nations, Malaysia should come up with a reasonably satisfactory sized hydrodynamic facility. The projection of this facility should be such to accommodate our immediate need and also stand the test of time. Most established hydro-dynamic facilities in the advanced nations, have witnessed almost half a century of usefulness with perhaps many more years ahead.

By having a Hydrodynamic Facility at the University of Technology Malaysia, we could utilize it to conduct research work apart from the routine teaching activities. Research capabilities will be enhanced especially in the area of ship hydrodynamics and model making. Knowledge dissemination to undergraduate as well as to graduate students will be more practical orientated. In doing so, we will be able to create a pool of skilled experts. This will help to revitalise the maritime industry in the country which is heavily dependent on foreign expertise. This pool of local experts could also pool their resources together, to check any malpractises in the marine industry.

Proper management and operation of the hydrodynamic facilities over the years will also create a pool of knowledgable personnel in other non-marine disciplines. For example in underwater photography, electronics, remote sensing, data analysts and computer software development.

All this development will then ensure that ships built for coasting around Malaysian waters are not over-designed, taking into consideration the sea environment in the South-east Asia (SEA) region. Certainly the sea envir onment in the SEA region will not be too critical for a ship or even an oil platform which is designed to withstand a much higher sea spectrum, as in the case of the North Sea or the Atlantic and Pacific Oceans.

This hydrodynamic facility will also be able to accommodate other related marine research studies. For example hydrographic survey, fishing equipment and techniq

-ues, underwater civil structures, pollution safety control and defence. By proceeding along this route, we will ensure that the nation will be among the ranks of developing countries which are phasing up into higher technology advancement. This groundwork is a must before trying to leap further. There are lessons to be learned especially from the blunders that over-shadowed the HICOM during the initial development of the National Automobile Industry (PROTON) and a steel billet plant in Trengganu, when the supporting infrastructure and recruitment of personnel is not aligned with the development of that industry. In fact that was not the only reason for the short-comings, there were many others. Hopefully we realised those loop-holes and avoid from falling into it again, especially in the development of the proposed hydrodynamic facilities at UTM.

As pointed out earlier, this investment in building the hydrodynamic facilities is worthy as it will accelerate the progress of the nation in many sectors. The least significant contribution is that the training methodology in the hydrodynamic laboratory is applicable to other major industries, may it be marine, aeronautical, automobile or other heavy industries.

CHAPTER FOUR: THE HYDRODYNAMIC FACILITIES RECOMMENDED

4.1 GENERAL

Until the outbreak of the energy problem during the 1970's, shipyards all over the world were busy building ships to meet the demand of the times, with the result that ships of yesterday were being built to do the work of tomorrow. There was little, if any, serious research and development work being carried out, in order to utilize fully and exploit well-known naval architecture and marine engineering theories and practices. All efforts were conc-entrated to minimise first investment costs in order to obtain maximum return on investment. Perhaps such a mentality was acceptable in a growth economy and when not many people cared about efficiency. Today and in the future, improvements in efficiency in all aspects of the maritime industry is the aim (33).

Optimisation of all aspects of ship design based upon modern concepts and utilising modern technologies rather than developing existing designs will make the nation merchant fleet more efficient and competitive. Especially today, with the aid of highly developed electronic compute-rs, there is no excuse not to take advantage of modern methods of theoretical calculations based upon ship hydro-dynamics and new methods of experimentation based upon ad-vanced measuring techniques at the model basin. The build-ing of the hydrodynamic facilities will ensure that our future goal in developing the marine industry is achieved.

The choice of the hydrodynamic facilities is based on the study of facilities available elsewhere. Visits were made by other staff members to British Maritime Technolgy (BMT) England, Japan Ship Research Institute (JSRI) Tokyo, Ship Research Institute, East Germany, David Taylor Research Centre (DTRC) USA and various universities in England and Japan in order to have a better insight into the existting Marine Hydrodynamic Facilities (MHF). Discussions were also conducted with representatives from the Marine Research Institute (MARIN) Netherland, Ishikawajima Heavy Industries (IHI) Japan, Thyssen Rhienstall Federal Republic of Germany and Marine Institute Republic of China.

Information about MHF have been received from various countries namely:

1) Indian Institute of Technology, Kharagpur, India
2) Danish Maritime Institute, Lyngby, Denmark
3) The Hamburg Ship Model Basin, Hamburg, West Germany
4) Bulgarian Ship Hydrodynamics Centre, Varna, Bulgaria
5) Delft Shiphydromechanics Laboratory, Delft, Holland
6) Institute of Marine Dynamics, Kerwin Place, Canada

The development of the hydrodynamic facilities project can be approached as follows :

1) Preparation of specification for building and equipment
2) Construction of the building
3) Supply and installation of equipment for the Marine Technology Laboratory
4) Supervision of the installation and commissioning of equipment
5) Training of marine lecturers and technicians at suitable institution(s).

The proposed laboratory is recommended to be headed by a senior member of the academic staff, who will be responsible to the Dean of the Faculty of Mechanical Engineering. It is expected that the preparation of the detail specification of the equipment, and installation and commissioning of the major equipment will be the responsibility of the supplier(s). The supplier(s) work will be supervised by the academic staff with the co-operation of experts.

The services of the experts will be required for a period of approximately 3 years to assist in the supervision of the installation and commissioning of the equipment and the training of personnel.

Training of at least three marine lecturers and three technicians, for a period of about six months per person, will be required to ensure effective utilisation of the facilities. The training should be held at the supplier (s) established hydrodynamic facilities. The area of training are identified as follow:

1) Operation and maintenance of those hydrodynamic facilities.
2) Design and construction of models of marine vehicles and structures using several kind of materials.
3) Conducting and analysing towing, manoeuvring and cavitation tests, on marine vehicles and structures.

In order to come up with a suitable dimension of the hydrodynamic facilities, due consideration on the availability of suitable land space and capital have to be met. As discussed earlier, the objectives of utilizing it must be matched with the capital outlay.

The combination of hydrodynamic facilities that are requested for the UTM Marine Laboratory include the following :

1) **A Towing Tank**
2) **A Manoeuvring / Seakeeping Tank**
3) **A Cavitation Tunnel (Water Channel)**
4) **Data Acquisition and Analysing System**
5) **A Ship / Propeller Model Making Workshop**
6) **Naval Architecture Laboratory**

Further elaboration on the function and the main characteristics of the respective hydrodynamic facilities will be given in the following pages.

In choosing the required size of the hydrodynamic facility, due consideration is given on its capability within the desired range. In this respect, further consul-tation with the makers and experts will determine the suitable size. Apparently, this chosen size could be able to perform the listed functions as gathered from the makers advertisement. The important point to put across here is to make sure that the capability of each hydro-dynamic facility, satisfy our experimental need.

Accordingly, **Appendix B** shows the graphs for the number of marine hydrodynamic facilities being built versus their respective dimensions. The data on the hydro-dynamic facilities are gathered from many sources. While, the three main hydrodynamic facilities which are being considered and listed in **Appendix B** include the following: (i) **A Towing Tank (T.T)**, (ii) **A Manoeuvring-Seakeeping Tank (M/S.T)**, and (iii) **A Cavitation Tunnel**. The main dimensions for the T.T and M/S.T include the length, breadth and depth.

4.2 TOWING TANK

The towing tank is one of the main equipment in a model basin. It can come with various shapes and sizes. A towing carriage will be placed across the towing tank, to tow the model that is to be tested. The speed can be varied depending on the desired speed of the model in relation to the ship. The tank size, width and depth have to be taken into account to avoid undue counter forces in the water. The tank can also be equipped with a wave-maker at one end and a wave absorber at the other. Thus, wave effect on towing model could also be simulated. Again, depending on its uses, it can serve as an important tool to discover the ship's model frictional resistance and later to get the brake horsepower of the ship. Correlation evaluation is then made.(4)

Initially, a shallow towing tank could serve our purpose. Perhaps, in the future projecting plans, inclusion of a deep and broader towing tank will help to eliminate the side effect of shallowness for deep drafted ship and the wall effect in acquiring the readings.

The experiments that can be conducted in shallow water towing tank include the following:

1) Resistence and propulsion tests in calm water and wave of single ships and towed or pushed barge trains.
2) Open water tests of ducted propellers and propellers without nozzles.
3) Wake surveys, wave pattern measurement for wave analysis, flow visualization.
4) Pressure distribution on the hull and in the flow
5) Tests with large amplitude planar motion mechanism

6) Measuring of rudder force and moment

7) Zig-zag tests, emergency stopping

8) Tests of inland and river seagoing vessels in shallow water or in canals

9) Modelling of ship-bank interaction

Based on the finding of the statistical analysis on the suitable towing tanks dimensions in **Appendix B**. The size of the towing tank that is recommended at UTM is list-ed below, after taking all factors into consideration.

The main characteristics of the towing tank is as follows:

	Parameters	Dimensions
Bed of tank	Length	100 m
	Width	4 m
	Depth	3 m
Towing carriage	Power	50 kw
	Speed Range	0.2-3.0 m/s
	Weight	15 t
Wavemaker for regular and irregular waves	Single flap(Hyd./Elect.)	10 kw
	Wave height	0.25 m(app.)
	Wave length	0.2-0.25 s
Wave Absorber	Beach Type	

Rails - Suitable cross section and rigidity, supported at frequent intervals to permit adjustment for accurate alig-ment. Towing carriage run along rails which follow the curvature of the earth's surface.

Model size	Max. length	2 m
	Max. weight	0.2 t

A key element in the towing tank is the towing carriage. The carriage spans the full width of the tank and is 6 m long, and weighs about 15 tonnes. The carriage is powered by 2 electric motors with a total power of 80kw giving a maximum speed of 3.0 m/s. A computer controlled drive system enables the optimum duration of runs to be obtained for any test.

The second feature of this tank is the dual flap wavemaker. It is hydraulically/electrically driven and is of the dry back design. The dry back design feature enables maximum flexibility in the positions of the actuator-s and has a reduced power requirement compared with a wet back design. Phasing of the movement of one flap with respect to the other may be selected to minimise distortion in the waves. The flaps can be controlled to oscillate over a range ± 16 degrees, and to accurately follow the characteristics of any drive signal. The wavemaker can produce regular and irregular waves. The wavemaker can be driven directly by analog control or by computer generated command signals.

A beach is located at the opposite end of the tank. It is a conventional parabolic design and serves to prevent waves from being reflected back down and at the side of the tank and confusing the waves encountered by the model.

The reason for choosing this particular size, is that this is the familiar size found in most teaching institutions and the most commonly built towing tanks in the world . Reference is made to the Graphs 1, 2 and 3 in Appendix B. As regards to the length, the range of 100-149 m. is popular for teaching institutions / universities while the range 200-249 m. is popular for research institutions. The breadth which ranges from 3-5.9 m. is popular for teaching institutions while the next highest range, 6-8.9 m., is popular for research establishments. As for the depth it is obvious that the range from 1.5-4.49 m. is being sought.

The recommended towing tank initially will be able to train staff members and students to a certain level of competency. Upon realizing the capability and other potential, allowances are made for further expansion, depending on the availability of the capital and the interest it manages to generate. This process will probably take approximately 5 years. After that new resolutions have to be proposed to upgrade its facilities if things function according to plans.

The towing tank has certain capability and functions to test on the ship model. It has its limitation, when testing for ship manoeuvrbility in varying sea conditions. In that respect, another important hydrodynamic facility which should be considered is the manoeuvring / seakeeping tank.

4.3 MANOEUVRING / SEAKEEPING TANK

This is another major tool required to test on ship's model. The manoeuvribility can be tested as well as its seakeeping capability. The selection of the tank size is based on the most commonly built, as indicated in **Appendix** B. The main characteristics of the manoeuvring-seakeeping tank is as follows:-

	Parameters	Dimensions
Bed of tank	Length	40 m
	Width	20 m
	Depth	2.5 m
Wavemaker for regular and irregular waves	Wave length	1 - 12 m
	Wave height	0.02- 0.4 m
	Period	0.2 - 2.5 m/s
	Irregular spectrum	optional
(Wave generator; Multi flaps, Hydraulic/Electric operated, power approximately 50 kw.)		
Wave absorber & Power supply as in towing tank		
Computerised Planar Motion Carriage (CPMC); DC motor driven (Thyristor Leonard approx. 50 kw. or equivalent) AC input.		
Instrumentation and model size as in towing tank		

Basic standard tests conducted are as follow :

1) Manoeuvring tests - turning tests, spiral and reverse spiral tests for determination of hydro-

dynamic coefficients of the hull.

2) Seakeeping tests of towed, self propelled and free-running models.

The breadth of 18 m. or more of the tank is of special advantage for manoeuvring tests. This makes it possible to perform standard zig-zag manoeuvres even with large rudder angles. This results in a reduction of scale effects.

The main facility to conduct manoeuvring tests is the Computerised Planar Motion Carriage (CPMC). The CPMC is very valuable in giving improved predictions about the manoeuvring and coursekeeping qualities of ship's model.

The CPMC has two fundamentally different operating modes. In the towing mode it tows a captive model along a predetermined curvi-linear path at predetermined speed while the resulting hydrodynamic forces are measured as functions of time. In the tracking mode the CPMC automatic-ally tracks a model manoeuvring freely under the action of a temporally predetermined sequence of rudder and propeller manoeuveres. In both modes each run is complete-ly computer controlled from model stand-still to stand-still. The computer also effects data acquisition and processing.

Most of the seakeeping tests, however are carried out in one large tank. In this manoeuvring and seakeeping tank a double flap wavemaker is installed. Beside regular wave-s, irregular long crested according to any spectral shape can be simulated. The width of the tank allows testing of large free running models up to 30 degrees course angles with respect to following or head seas.

Tests in irregular seas with a spectrum corresponding to specific sea areas and weather conditions provide the required informations directly. Slamming behaviour, screw propeller emergence, and shipping of green water can also be determined from these tests.

The experiments in regular waves are useful to determine the response amplitude operators for motions, accelerations and added thrust or resistence. The statistical characteristics are then calculated using the response amplitude operators and the relevant spectra. As for comparison purposes the response amplitude operators can be calculated using strip theory.

In the case of wave generation capability, it will be complemented by devices to produce wind and current. For the former, an array of fans is planned, although other systems, such as fans mounted on the model may be used in some circumstances to reproduce the effects of wind. The tank is designed so that portable arrays of water jets can be employed to model current.

Besides the above equipment, there are gauges and service devices such as: pressure tranducers, dynamometers , steering gears, accelerometers, rate gyros, course gyros , DC power supply modules, tape recorders, pen recorders counters, digital voltmeters, and oscilloscopes.

In order to test for launching, installations and sea transport of offshore floating structures, we can make the centre part of the tank much deeper, two or three times the initial depth. Apart from the floating structures another important feature associated with the marine vehicles is the propulsive capability using propellers.

4.4 CAVITATION TUNNEL

The hull and propeller interaction is very important to the ship. The various sizes of the cavitation tunnels are listed in **Appendix B**. The modest size selected is listed below. The main characteristics of the cavitation tunnel is as follows:

	Parameters	Dimensions
Circuit size between channel centres	Height Length	4.5 m 7.2 m
Tests section	Cross section flow speed	0.4 * 0.4 m 10 m/s (max.)
Propeller dynamometer	fixed height and inclination type	
Drive system - 4 bladed axial flow impeller	Power Speed	40 - 60 kw 1200-1600rpm
Propeller model	Diameter	0.2 m (max.)
Data acquisition to be seperated from towing tank		

Other instrumentation include: pressure tranducers, measuring amplifiers and filters, electronic counters, digital voltmeters, digital frequency meters, precise digital manometer, stroboscope, etc.

The tunnel has a working section 400 mm. square and 2.5 length. In the working section, there are windows on all four sides to enable the model propeller to be illuminated with a stroboscopic light, and photographed. A dynamometer is installed to measure thrust and torque on the propeller. The extent of cavitation is determined photographically. It is possible to replace the propeller dynamometer with a three-component balance to measure forces on hydrofoils, rudders, shaft brackets, sonar domes and other submerged bodies. A five-hole pitot tube is used for measuring velocity distribution within the working section of the tunnel. Basic standard tests are performed.

Besides the conventional tests done on ducted propellers, fully or super cavitating propellers, bow thrusters, steering propellers, pumpjets and unconventional propulsion systems such as propeller and vane wheel, a special field of interest is hydroacoustics. Results of noise measurements for propeller models in cavitation tunnels and in the towing tank are important for the design of noise reduced propellers and serve to predict the acoustical behaviour of full scale propellers.

In ensuring that suitable and sufficient data and information is gathered, a good data acquisition and analysing system should be installed. Nowadays in this age of computerisation, a big data bank aligned to the main frame terminals is necessary to store and extract vast information.

4.5 DATA ACQUISITION AND ANALYSING SYSTEM

Listed below are the electrical source and the instru -mentation facilities attached to the main equipment.

Mains power supply - 3 phase and single phase 240 V, 50Hz. Good earth point & Housed in an enclosure

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Instrumentation facilities should include the following:

1) Dynamometer for measuring resistence, heave, pitch, roll, sway, yaw, self propulsion and open water propeller forces and moments.
2) Data Acquisition System ;- Computer, Analogue to Digital Converter, Data storage facilities, Monitor, Oscilloscope, Plotter and Printer, Software for analysis of results and the creation of spectral waves, Waves probes, motion measuring devices and signal conditioners.
3) Towing fittings;- Allows model to freely pitch, roll and heave. Allows fitting of transducers.

UTM is fortunate to have a very good network of main frame capability. So it has minimal difficulties in linking the mini computers in the marine laboratory to its central system before hooking up to the main terminals. The mini computers are dedicated to data acquisition and preliminary on-line analysis on the two towing carriages in the towing tank and manoeuvring/sea-keeping tank. The remaining computers are used for direct control of the model milling machine and the wavemakers. The computer central system performance will be elaborated further in 4.7 Naval Architecture Laboratory.

4.6 SHIP/PROPELLER MODEL MAKING WORKSHOP

The physical set up of this workshop will assist in the successful running of the hydrodynamic facilities and getting the desired and accurate results in the reading. Skilled technicians for model making and propeller making have to be trained.

An important part of any model test facility is the ability to manufacture, in a timely fashion, accurate models of the vehicles or devices to be tested. This is particularly true today because of the complexity and uniqueness of many of the objects to be studied. Precision machinery is needed for the manufacture of models and instrumentation using wood, metal or synthetic materials.

Accurate shaping of ship models is carried out by a numerically controlled milling machine. It is capable of handling very large models, although the size proposed is only two meters in length. The location of the cutter can be specified in five degrees of freedom and it also helps to reduce the amount of hand finishing. The five axis capability is also of value in the accurate cutting of any irregular shaped models or parts.

The milling machine forms one end of a chain of computer aided design and manufacturing programmes. These programmes provide for the digitizing and fairing of lines plans, and include a flexible graphics package, and programs for hydrostatic computation.

Propeller production is handled by essentially similar software on another five axis machine.

4.7 NAVAL ARCHITECTURE LABORATORY

Apart from the above facilities for the major exercises, it is necessary to have another supporting laboratory for the smaller experiments such as stability calculation for a barge or some inclining test. In that Naval Architecture Laboratory, the following facilities could also be housed together. That include the drawing and computer facilities.

1) Drawing Facilities

   40 drawing tables and chairs

   Size of table 1.5m * 0.8m * 1.0m

   Formica top and vinyl cover, one set of drawer and locker, drafting equipment of suitable size which include battens, weights, planimeters, integrators and ship curves.

2) Computing Facilities

   20 sets of microcomputers:

   640 kB Ram, colour graphic, high resolution

   Colour monitor, 2*360 kB disc storage, Networking.

   Hard discs: 20 MByte Networking

   Interface: Parallel Port (RS Serial 232)

   5 sets Printers:

   Near letter quality Dot Matrix

   Carrier width greater than 13 inch, CPM greater than 100, Support by well known word processor.

   One Set Plotter: 4 colours, A0 - A4 paper size.

   One Set Digitizer: A2 tablet size

   Software: CADD software, Ship Calculation: Conceptual Design Programme suitable for ship form design and Seakeeping system. All software must be IBM compatible.

The equipment for the Naval Architecture Laboratory should consist of the following, apart from the drawing and computer facilities.

1) Ship Stability Apparatus:
   Dynamometer plus models of general cargo vessels, trawler, semisubmersible and barge.
2) Ship Vibration Apparatus:
   To investigate characteristics of hull vibration Includes 1 meter long model
3) Ship Structures
   i) Ship hull strength - To investigate the stress created by a floating wodden block arranged in ship shape form.
   ii) Structural strength,
   iii)Fatique testing.

Within the Naval Architecture Laboratory, which house -s the computing facilities there is a direct link to the UTM main frame via the central system.

This central system performs a variety of tasks including final analysis of test data, numerically modeling, and CAD/CAM operations for model manufacturing. Extensive use is made of both high and medium resolution interactive graphics terminals.

The data acquisition systems function independently of the central system and only transfer data to it at the end of a model test. This has been done to provide increased reliability and to prevent excessive loading of the central computer.

Finally, a cost estimate will be a good closing.

4.8 COST ESTIMATE

The cost can be subdivided into 2 main components:

1) Cost of land, land development, infrastructure and building. These will be borne by UTM out of its allocation for development programme.
2) Cost of equipment, installation, commissioning, expert sevices and training of personnel. The estimated total cost about US$ 20 million.

The cost of salaries of the existing staff is not considered here because that cost is borne by the UTM even before the establishment of that proposed Laboratory.

The cost breakdown is as follows:		US$(million)
1) Equipment;		
The cost includes supply of all equipment, handbooks/manuals, warranty, project management		
a) Towing Tank	2.4	
b) Manoeuvring/Seakeeping Tank	6.0	
c) Cavitation Tunnel	1.3	
d) Data Acquisition System for all tanks	4.0	
e) Ship/Propeller Model making Workshop	0.7	
f) Naval Architecture Laboratory	0.6	
Sub-total		15.0
2) Installation and commissioning;		
The cost includes packaging, shipment, assembly, testing and commissioning of all equipment and facilities, traveling and accommodation expenses		3.0

3)	Training and experts services; This include salaries, traveling and subsistence for ; a) 6 staff for 6 months overseas training b) 3 man years of experts to train staff locally	2.0
	Total	20.0

This cost looks like a big figure but considering the benefits it will generate in future, certainly it will be justifiable.

CHAPTER FIVE: THE ESTABLISHMENT ORGANISATION AND MANAGEMENT

5.1 ORGANISATION RESTRUCTURING

The establishment of the Marine Technology Laboratory within the Faculty of Mechanical Engineering initially is a mere coincidence. In order to function effectively and efficiently it should be reorganised more in meeting and justifying it's existence. This restructuring process, presumably will improve and facilitate the running of the hydrodynamic facilities. If the need arises, more staff will be assigned.

I am proposing that the present manpower could be structured and reorganised under an establishment called The Institute of Marine Technology. This institute is within the university jurisdiction and will be headed by a director. The director, which is a senior post, could be appointed to any one of the existing members from the faculty or the university, whose engineering background is related to marine technology studies. His status is equivalent to the Dean of a Faculty. He should have the vision for the projection of the progress of the Institute of Marine Technology Laboratory. He will have more say when it comes to budget allocation for the Institute, from the university, which will persumably be quite a large figure by then.

The director of the Institute will be assisted by three well qualified personnel, namely;

(1) The Chief Scientist,

(2) Operating Manager and

(3) Chief Administrative-cum-Public Relation Officer.

The marine technology group of lecturers could be absorbed into this new system with a new setup and outlook . This setup will try to project the business-like image and keeness for progress and advancement. It will have more autonomy and could be easily geared in meeting national objectives.

Accordingly, the proposed structural scheme should be subdivided into three main areas namely:

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1) Research in the field of Ship Hydrodynamics and Development of Shipbuilding and Marine Industry;
   - a) Research Divisions
   - b) Laboratories
   - c) Towing Tank
   - d) Manoeuvring/Seakeeping Tank
   - e) Cavitation Tunnel

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2) Design and Manufacture of Ship Models, Propeller Models and Experimental Devices;
   - a) Departments for Development of Experimental Production.
   - b) Computer Technique
   - c) Model Workshops
   - d) Mechanical Workshops
   - e) Electrotechnical Workshops

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3) Administrative Service, International Co-operation, Training of Personnel and Public Relation Services;
   - a) Administrative and Auxiliary Departments
   - b) Scientific and Technical Information and Library
   - c) Miscellaneous services.

To ensure smooth operation of the Institute, periodical sessions with the National Scientific Council (NCRSD) which consists of representatives from various research agencies or government bodies should be conducted. This helps to ensure that the Institute is moving in the right direction in accordance with national requirements and objectives.

In addition to the above sessions / meetings, periodical annual scientific and methodological seminars should be held with participation from various agencies/bodies in the country as well as abroad. This will give good insight to the staff members of new experimental techniques and progress of research that has been done elsewhere.

As regards to the staff, it should consist of specialist as well as general staff, as listed below:

1) Hydrodynamicists
2) Naval Architects
3) Computer experts
4) Electricians
5) Model makers
6) Machinists
7) Draftsmen
8) Technicians
9) General workers
10) Secretaries/Clerical staffs

This staff will assist in the day to day running of the new Institute. This new set-up will give the Institute more autonomy, especially in meeting the expectation of the public. This will motivate the staff members to strive harder, as they will be considered to be the experts in their respective area. After all this is the only establishment of its kind ever to be built in the country.

5.2 EDUCATIONAL SPECIFICATION CONSIDERATION

The reorganisation means that the Marine Technology course which all this while has been under the Faculty of Mechanical Engineering is put under a new organisation and leadership. Greater emphasis on involvement in research activities as well as aligning the teaching workload to be more practically oriented.

Quite a number of courses have to be reorganised, especially in the third year diploma course and the fourth and fifth year of the degree course. Refer to **Appendix A**. The subjects that will be affected include the following:

1) **Diploma Level** (3 level programmes)
    - Basic Ship Drawing and Calculation (Level 1)
    - Construction, Repair & Conversion of Ships (Level 3)
    - Ship Drawing & Design (Level 3)
    - Strength & Vibration of Ships (Level 3)
    - Resistence, Propulsion & Motion of Ships (Level 3)
    - Ocean Engineering & Offshore Structure (Level 3)

2) **Degree Level** (5 level programmes)
    - Computer Programming (Level 1)
    - Basic Ship Drawing and Calculation (Level 2)
    - Production Technique (Level 3)
    - Technical Measurements (Level 4)
    - Naval Architecture (Level 4)
    - Applied Hydrodynamics (Level 4)
    - Shipbuilding, Repair & Conversion (Level 4)
    - Ship Resistence and Propulsion (Level 4)
    - Ship Structure and Vibration (Level 4)
    - Ship Design (Level 4)
    - Dynamics of Marine Vehicles (Level 5)

Ship Design and Drawing (Level 5)
Offshore Structures (Level 5)

The changes in these subjects are expected to improve the dissemination of knowledge to the students, and further enhance their understanding by allowing them to use the available tools. More detailed schedules have to be drawn out so that there will not be any conflict of time using the available facilities. Equal consideration should be given for teaching as well as for research.

Students as well as staff members from other faculties including those from Faculty of Mechanical Engineering will be given equal opportuinity for using the facilities. Perhaps joint research work could be done with counterparts from the Faculty of Civil Engineering and Petroleum Engineering.

These facilities ultimately, will be able to benefit the university as a whole. The important thing is that it helps to increase level of understanding and create competent graduates. They will be more confident in tackling their future work. This transition activities of equipping the students with certain skills and know-how has been passed more on to the university rather than the industry (26).

5.3 RESEARCH CONSIDERATION

The main objective of research and development is to improve the knowledge of the environment, behaviour of ships and offshore platforms at sea, structural safety, and development of expert services.

As far as ship's hulls are concerned, there was little that could be done on existing ships to improve performance except for three possibilities, namely:

1) Reduce the frictional resistence of the hull which became of greater importance because of slow steaming policy.
2) Improve the flow of water to the propeller, especially on ships where there was room to improve wake distribution because of poor after body lines.
3) Economise on fuel by using fuel saving propulsion plants.

Some of the areas which could be covered under the hydrodynamic investigations and testing with application of theoretical and experimental methods include the following:

1) Creation of new modern types of ships, floating structures and ship propellers
2) Improvement of technical and performance character -istics of ships in service
3) Design and improvement of fishing devices and perfection of fishing vessels in service
4) Modelling of ship motion in rivers and channels, choice of parameters for objects of marine and

river hydrotechnical construction

5) Improvement of cavitation characteristics of hydraulic machines (pumps, turbines, helms, etc.)

These are some of the areas that could be look into. It takes a dedicated staff member long man-hours, energy and patience to undertake a certain research project before he could finally come to a conclusion.

This sort of methodology will be applicable to the other disciplines of engineering. Therefore research and development (R & D) activities particularly in this area should be encouraged and supported. It will enable Malaysia to achieve a more competitive edge by producing well designed ship and increase indigenous technological capabilities of the people.

According to the Malaysian National Council for Scientific Research and Development (NCSRD) in 1983, the volume of research carried out in Malaysia over the last five years may be quantified as approximately 0.64 per cent of the GNP. While a World Bank study in 1982, reported that effectively it represents only about 0.5 per cent of the GNP. This was very low since 1 per cent of GNP is considered to be the level at which R & D can begin to effectively support socio-economic development in the country. While developed nations, for example like Japan spent 2.78 per cent of the GNP on R & D (11).

Later on in the preceeding chapter six and seven we will evaluate the impact of the MHF made upon the nation.

PART 3

IMPACT UPON THE NATION

CHAPTER SIX: JUSTIFICATION AND BENEFITS

6.1 FULFILLING THE EDUCATIONAL REQUIREMENT

As mentioned earlier in Chapter 2, one of the objectives of having a Marine Technology Laboratory (Hydrodynamic Facilities) in UTM is to produce well rounded land based marine technologist / engineers for the marine industries.

Marine Technology course like other professional engineering disciplines requires specific laboratory equipment in order to teach the subject efficiently and effectively. The would be marine technologist / engineers are required to have the ability to apply theories and principles to actual practical work. In this respect, a good and well equipped laboratory is highly essential and desired.

Since its inception in 1982, the Marine Technology course in UTM has proceeded without sufficient specialised laboratory facilities, although facilities in mechanical engineering have been adequate to provide understanding of the thermal and fluid subjects as regard to its dynamics and statics characteristics. The two main reasons for the delay in establishing the Marine Hydrodynamics Facilities:

1) The present campus cannot accommodate the Marine Technology Laboratory building and its equipment.
2) Priority is given to the planning of the laboratory facilities for the new campus in Skudai, Johor Darul Taqzim. Plans for the movement to Johor for the Faculty of Mechanical Engineering is scheduled on July 1989. The movement is in compliance to its original plans.

6.2 AIDING THE DEVELOPMENT OF MARINE INDUSTRY

In the Malaysian context, the marine industry is involved in the following activities, which include the construction of offshore oil platform and semi-submisible structure, the construction of coastal and deep sea fishing vessels and their landing sites, shipbuilding and ship-repairing of commercial vessels, improvement and upkeeping for several patrol vessels. The success of these activities requires not only proper utilisation, operation and maintenance of the vehicles in use but also the presence of good designers, naval architects and engineers to design and build these vessels and floating offshore structures. The Marine Technology course has mainly concentrated its effort towards this objective.

The importance of the marine technology course is here to stay. It will create an enormous impact to the industry as well as the nation. Its contribution to the marine industry and to the nation's economy can be expounded by the following notes;-

1) **Offshore Oil and Gas**
2) **Offshore Fishing**
3) **Shipbuilding and Ship-repairing**
4) **Commercial Shipping**
5) **Maritime Defence**
6) **Recreational Activities**

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(1) Offshore Oil and Gas

Until the early 1970's, oil exploration in Malaysia was carried out by foreign companies under the trade concession system. However in 1974 the national oil company (PETRONAS) was formed and since then, it has played an active role in oil/gas exploration and production (5). In 1986, there were 29 producing oil fields in Malaysia, while the average oil output now is 556,000 barrels per day. Malaysia is now a net exporter of petroleum and liquified natural gas which are the country's top revenue earner. As of January 1986, the estimated recoverable crude oil reserves were 3 billion barrels and natural gas reserves stand at 49 trillion cubic feet. Gas reserves, which could last over 100 years, are estimated to be equivalent to at least three times the oil discovered to date. The potential for future discoveries is estimated (Esso) at an additional 25 trillion cubic feet on a 50 per cent probability basis; this would bring total potential gas resources to over 70 trillion cubic feet (5).

Table VI-1: Gross Exports of Major Commodities (% share)

Item	1981	1982	1983	1984	1985	1986	1987
Crude oil	26	27	24	23	23	15	15
LNG	-	-	3	5	6	5	4
Manufactured goods	23	27	29	31	32	42	44
Natural rubber	14	10	11	9	8	9	9
Palm oil	10	9	9	12	10	8	8
Logs	9	12	9	7	7	8	8
Tin	8	5	5	3	4	2	2
Sawn Timber	4	4	4	3	3	4	N/A
Others	6	6	6	7	7	7	10
Total	100	100	100	100	100	100	100
Ringgits(million)	21.91	27.97	32.68	38.65	38.02	33.55	N/A

The revenue to be obtained from exporting petroleum and liquified natural gas is well assured in the future years. In fact crude oil and gas have been Malaysian major export commodities since the 1980's. Refer to **Table VI-1**.

Offshore oil exploration is an expensive business. The cost of hiring a drilling rig alone is about US$22,000 per day and this amounts to between M$1.7 million to M$3.4 million for a period of 30 to 60 days of drilling required per well. If the local oil companies such as Petronas are able to design, construct and operate their drilling rigs, this would reduce the sum paid out to foreign contractors for the hiring of these rigs. (US$1 = M$2.50 approximate).

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(2) Offshore Fishing

Offshore fishing is an important agricultural sector. Presently, Malaysia imports over US$134,800,000 worth of fish annually. The inshore fishing grounds which is within the three miles limit have been greatly overfished. New fishing grounds in the Exclusive Economic Zone have to be explored. The estimated fish potential in Malaysia waters is approximately 600,000 tonne valued at US$560 million. The reserves are distributed over an area of 400,000 square kilometers of sea. Fish harvest potential is about 59,500 tonne per year valued at US$55.2 million from 1986 onwards (31).

To exploit such a vast potential, Malaysia requires experts to design, test and construct suitable offshore fishing boats. The miniture model of the proposed fishing boats could be tested at the proposed Marine Hydrodynamic Facilities. According to the Malaysian Fisheries Department. a fishing boat complete with accessories would cost about US$120,000. The expected earnings from operating such a boat is about US$20,000 per year. According to the statistical study, about 120 new boats will be required annually and the preceeding five years to ensure maximum exploration of the available fish resources.

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(3) Shipbuilding and Ship-repairing

The shipbuilding industry will be another beneficiary of this Marine Hydrodynamic Basin. What is lacking in the local shipbuilding industry is a proper design and testing laboratory which can support all shipyards. As listed in **Table I-1** there are at least 12 major shipyards and more than 20 other smaller shipyards or slipways existed. Presently almost all designs and model testing of ships / boats and offshore structures that are built in Malaysia are done overseas. This is in fact a drain in technological know-how and foreign exchange.

Looking at the positive factor, as the proposed Institute of Hydrodynamic Center at UTM and Malaysian Shipyard and Engineering are located close to each other at southern Johor, close cooperation in this field is poss-ible. This will not only save the country foreign exchange but also improve university-industry collaboration.

Ship-repairing activities are actively done in most so called small shipyards as well as those which build ships. During the plunge in the demand in shipbuilding, ship-repairing activities help to supplement the balance of payments of the company, as it is a more lucrative proposition. The repair activities involved local fishing vessels and government patrol crafts.

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(4) Commercial Shipping

The sea transport is the main medium of our trade to overseas. Trade figure for 1986 shows that US$4.6 billion worth of Malaysian cargoes was exported by sea. However, Malaysian shipowners could only supply 20% of the freight services. This means that we are losing foreign exchange through freight charges paid to foreign ships for the carriage of Malaysian cargo. There is therefore a need for the expansion of our fleet. Given a proper incentive, more enterpreneurs would venture into shipping since it is a very profitable buisness. For example Malaysian International Shipping Corporation's before tax in 1986 stood at US$ 97.2 million (35).

The expansion of the Malaysian fleet implies that there will be an increase in demand for new ships. The growth is indicated in **Table VI-2**.

Table VI-2: Growth of the Malaysian Fleet.

Year	Number	Gross registered tons
1981	415	785,224
1982	514	1,003,191
1983	632	1,619,918
1984	737	1,825,748
1985	835	1,989,085
1986	917	2,096,476
1987	982	2,210,807

* Total includes all vessels over 150 tonnes, including those not actively trading.

Source: Malaysian Ministry of Transport.

Design and testing of these new ships hopefully could be carried out at the proposed Hydrodynamic Center at UTM, Skudai, Johor Darul Taqzim.

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(5) Maritime Defence

The Government sector, in particular the maritme defence, will benefit enormously in economic and strategic terms. The Royal Malaysian Navy, the Royal Malaysian Police and the Royal Customs and Excise Department and other enforcement agencies including the Marine Department and the Fisheries Department will need to acquire new vessels and replacements. Currently most of the vessels are acquired overseas at very high costs. Some are built at the local shipyards using overseas design. The cost could be greatly reduced by performing our own design and testing in the proposed Laboratory.

In terms of strategic value, Malaysia must be able to produce her own defence equipment to uphold and maintain her integrity in times of urgent need. In a joint Kuala Lumpur Declaration in 1976, the ASEAN head of states agree-d to declare South-east Asian regions as Zone of Peace, Freedom and Neutrality (ZOPFAN).

By having these hydrodynamic faclities, studies and programmes could be initiated to develop our own existing defence capabilities at a much reduced cost.

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(6) Recreational Activities

Water sports are becoming an increasingly popular leisure activity in Malaysia. Yachting, boating, wind surfing and scuba diving are some of the popular activities especially with the promotion of tourism year in 1990's. Yachting and boating clubs may require model testing to be carried out in the Hydrodynamic Laboratory. Such work will be similar to that done by Holland Marine Research Establishment (MARIN) on the famous racing yacht "Stars and Stripes" which won the prestigious America's Cup in 1987.

To ensure proper development and to improve the performance of the marine industry, research and development are essential. Towards achieving this end, the Marine Technology lecturers are at present actively involved in a number of projects in collaboration with various bodies. In a project funded by the NCSRD (Majlis Penyelid -ikan dan Kemaj Kemajuan Sains Negara -MPKSN), the lecturers involved are currently studying the traditional fishing boats with the aim of suggesting ways of enhancing their capability. It is hoped that the research will finally develop a design of a prototype offshore fishing vessel to operate in the Malaysian deep sea water.

These are some of the activities which indicate how the industry can in future benefit from a well-equipped laboratory run by qualified staff at UTM.

6.3 ECONOMIC JUSTIFICATION

Though the Laboratory is designated primarily for educational purposes it can also be operated commercially for the design and testing of various ship models.

In order to predict the number of design work and models required to be tested in the proposed Laboratory, a study was carried out on the yearly acquisition and forcast demand of new vessels between the year 1960 and 1995. The study was based on data obtained from the Malay-sian Register of Ships and Industrial Master Plan (21).

The types of vessels taken into account include; barges, tugs, foreign going and coastal cargo vessels, fishing vessels and yachts. Data on Naval, Customs and Marine Police crafts could not be obtained due to security reasons.

Based on the projected growth of the Malaysian fleet for the coastal trade, the Malaysian Industrial Master Plan Report forecasts the demand for new cargo vessels from 1985 to 1995. The report estimates that the required number of coastal vessels in the year when the laboratory is expected to be operational will increased considerably. the same report predicted the demand for new ships for foreign trade is found to be 32 for the year 1993.

The report has no figure for smaller vessels such as barges and harbour tugs. In order to obtain the expected number of these vessels, an analysis of the Malaysian Registry of Ships was carried out. The yearly acquisition of barges and their cummulative figures indicate an average acquisition rate of 8 barges per year.

Hence, it is assumed that if the present trend continues, a same number will be required in 1993 (21).

Thus, in summary it shows that from the year 1993 onwards a total number of 87 vessels will be required annually, of which 29 will be newly built ships, if the present trend continues. The estimated design cost of the new vessels are shown in **Table VI-3**. The total cost is expected to be approximately US$ 41 million.

Taking into account the size of the Laboratory and manpower available, the expected number of designs and models that the Laboratory could actually manage annually is 6 out of the 29 models that required testing. Therefore the expected annual saving in foreign exchange is then worth US$ 8.5 million. (Approximately US$1.41 saving/ship)

Table VI-3: Design and Testing Cost in US$ million

Type	Ship's Cost	% of Ship Cost	Cost/Ship	No. of Ship Required	Total
Foreign	24	10	2.4	11	26.4
Coastal	12	10	1.2	10	12
Tugs	6	20	1.2	2	2.4
Others	0.12	20	0.024	6	0.144
Total				29	40.944

In order to investigate the return on initial investment, the annual cashflow from the year the contract is signed until the year when the initial investment is fully recovered is considered.

The net present value criteria is used to determine the year when the initial investment is fully recovered. The detail calculation, as shown below;

1) Table VI-4: The initial investment of US$ 20 million will be spread over 6 years.

Year	Event	Payment %	Payment Amount (US$)
1	Signing of Contract and Detail Design	25	4.9 Million
2	Purchase and Installation of Equipment	51	9.8
3	Testing and Commissioning	15	2.9
4	Training	6	1.2
5	Training	1.5	0.6
6	Training	1.5	0.6
	Total	100.0	20.0 Million

2) The operating cost for a period of 10 years will include the costs of hiring manpower, maintenance, repair and overhead.

(a) Manpower Costs

In order to run the laboratory as a research and consultancy establishment, additional full time personnel are required. These research personnel will be employed on contract basis while the lecturers are under the university pay roll. The estimated cost of additional manpower (US$ 62,500).

(b) Maintenance and Repair

It is difficult at this stage to determine the maintenance and repair costs before a detail design is done. However, a rough estimate could be obtained by assuming that the annual maintenance and repair cost are mainly due to the replacement of electronic equipment which either has become damaged or obsolete. The rest are minor mainte-nance of mechanical and structural parts. It is estimate-ed that the maintenance and repair costs are 15 percent of equipment cost for a period of 5 years. The period is chosen based on the fact that most electronic equipment becomes obsolete after 5 years. For the first 4 years, the annual repair and maintenance is taken to be 1 percent of equipment cost. For the fifth year, a figure of 11 per cent is used giving a total of 15 percent.

(c) Overhead

An annual figure of US$40,000 is given for overhead. This figure includes the cost of electricity and water supply, computing time, hiring of typists, experts consult-ancy fees, office materials and travelling expenses.

Refer to **Appendix C, Table C-1** for further elaborat-ion of the operating cost of the proposed Hydrodynamic Center.

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3) Revenues

During the first 4 years of the project, an emphasis will be given on organising the laboratory and training of staff. Therefore, no revenue is expected. It is anticipated that the laboratory will be in operation at 50 per cent capacity in the fifth and sixth year beginning in an annual revenue of US$4.24 millions. (Refer to **Table C-2** and C-3 in **Appendix C** for further detail calculation of cashflow and return on investment)

In the seventh year, the laboratory is expected to be in full operation with an annual revenue of US $8.47 million. For the purpose of calculating return on investment, the annual revenue is assumed to remain constant for the subsequent years.

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4) Cashflow and return on investments calculations

The return on investment is defined with reference to the year in which the accumulated net present value is zero (34). Net Present Value is the accumulated present worth of annual cashflow. The present worth of the cashflow is based on 10 percent interest rate.

As indicated in **Appendix C** the return on investment will be positive on the tenth year of its establishment, this is common for an investment of a project of this magnitude.

CHAPTER SEVEN: RECOMMENDATIONS AND CONCLUSION

The building of hydrodynamic facilities, as suggested earlier is a worthwhile venture in a long term process. The fruitful results could be realised when the graduates from UTM get into the industry and perform well. Close rapport will develop between UTM and the industry, particularly the marine sector.

Since Malaysia has realised the importance of the sea , a new Law of the Sea Department, headed by a former graduate of WMU, has been established early this year 1989. This department which is directly under the Prime Minister Department is to oversee the present and hidden potential resources and to manage them effeciently and effectively. Perhaps this will culminate into the Ocean Management Plan strategy, which the country is yet to implement. In this case the Hydrodynamic Center will be able to play a major role in research and development in those potential areas and come up with more information and solutions.

Malaysia has yet to cultivate its indigenous technological capability. Foreign technology suppliers continue to play a dominant role in most Malaysian companies, including those that were established 15 to 20 years ago. To strengthen their indigenous technology development, developing countries like Malaysia must undergo a rapid technological transformation which is more than the mere importation of technology. It calls for the development of organisational capability in local industry and higher institutions to optimize the transfer process and ultimately lead to development of indigenous technological capability. Such capability would enable local enterprises or research institutes to search for, plan and implement product process knowledge. Also they could undertake main-tenance, trouble-shooting, product process modification, plant construction and possibly create new technological knowledge (11).

The policy maker should realise that these tasks of creating new technological knowledge could only be met, if we have the facilities to do our research work and after undergoing several years of evolution process.

This recommendation is also in line with the recommendation as outlined in the Malaysian government Industrial Master Plan that is to develop Malaysia as a industrialised nation. The principal objectives for manufacturing development are as follows:

(1) to accelerate the growth of the manufacturing sector so as to ensure a continued and rapid expansion of the economy and to provide a basis for attaining the social objectives consistent with the NEP;
(2) to promote opportunities for the maximum and efficient utilization of the nation's abundant natural resources;
(3) to build up the foundations for the country to leap-frog towards an advanced stage of industrialisation in the information age by increasing indigenous technological capacities and competitiveness.

In conclusion, I believe the recommendation for setting up the Hydrodynamic Center at UTM is justifiable based on the calculation of return on investment and also based on the benefit it generates to the national development and in meeting the national policies objectives.

APPENDIX A

CURRICULUM FOR DIPLOMA AND DEGREE PROGRAMMES AT UTM.

Course: Diploma in Mechanical Engineering (LEVEL 1)

All Courses (1DKJ/DTM/DKT)

Group 1

No.	Code	Subject	L	T
1.	DJJ 1504	Engineering Drawing	0	0
2.	FIZ 0102	Physics	2	1
3.	KIM 0052	Chemistry	2	1
4.	KIM 0511	Chemistry Practical	0	1
5.	MAT 0112	Geometry & Trigonometry	2	1
6.	MAT 0312	Algebra 1	2	1
7.	UIS 1111/ UPT 1111	Islamic Studies 1/ Ethics 1	1	1
8.	UPK 1111	Malaysian Studies	1	0.5
9.	UBI 1111	English Language	0	0
		Total	10.0	6.5

Group 2

No.	Code	Subject	L	T
1.	DJJ 1203	Statics	3	1
2.	DJJ 1922	Engineering Laboratories	0	0
3.	DJJ 1902	Plant Engineering	0	0
4.	DJJ 1991	Workshop Practice	0	0
5.	DJM 1502*	Basic Ship Drawing & Calculation	1	0
6.	MAT 0222	Calculus 1	2	1
7.	MAT 0001	Introductory Statistics	1	0.5
8.	UIS 1221/	Islamic Studies 2/ Ethics 2	1	1
9.	UPS 1121	Malaysian Studies	1	0.5
10.	UBI 1221	English Language	0	0
		Total	9.0	4.0

Note: * Only for 1DTM student

Course: Diploma in Mechanical Engineering (LEVEL 2)
All Courses (2DKJ/DTM/DKT)

Group 1

No.	Code	Subject	L	T
1.	DJJ 2203	Dynamics	3	1
2.	DJJ 2403	Thermodynamics	3	1
3.	DJJ 2703	Production Technology	3	1
4.	DJJ 2932	Engineering Laboratories	0	0
5.	DJJ 2991	Workshop Practice	1	0
6.	MAT 1332	Algebra 2	2	1
7.	UIS 2131/	Islamic Studies 3/	1	1
	UPT 2131	Ethics 3		
8.	UPP 2131	Malaysian Studies	1	0.5
9.	UBI 2131	English Language	0	0
		Total	14	5.5

Group 2

No.	Code	Subject	L	T
1.	DJJ 1203	Mechanics of Solids	3	1
2.	DJJ 2303	Mechanics of Fluids	3	1
3.	DJJ 2942	Engineering Laboratories	0	0
4.	DEL 1123	Electrical Technology	3	1
5.	MAT 1222	Calculus 2	2	1
6.	UIS 2241/	Islamic Studies 4/	1	1
	UPT 2241	Ethics 4		
7.	UPM 2141	Malaysian Studies	1	0.5
8.	UBI 2241	English Language	0	0
		Total	13	5.5

Course: (LEVEL 3)

Diploma in Mechanical Engineering (Marine Technology)

3 DTM Session 1986/87 onwards

Group 1

No.	Code	Subject	L	T
1.	DJM 3602	Marine Engineering Materials	2	1
2.	DJM 3422	Marine Power Plants	2	1
3.	DJM 3713	Construction, Repair and Conversion of Ships	3	1
4.	DJM 3513	Ship Drawing and Ship Design	2	1
5.	DJM 3952	Engineering Laboratories	0	0
6.	MAT 2232	Calculus 3	2	1
7.	UBI 3151	English Language	0	0
8.	UIS 3150/ UPT 3150	Islamic Studies 4/ Ethics 4	1	0
		Total	12	5.0

Group 2

No.	Code	Subject	L	T
1.	DJM 3213	Strength and Vibration of Ships	3	1
2.	DJM 3313	Resistance, Propulsion, and Motion of Ships	3	1
3.	DJM 3112	Outline of Ocean Engineering and Offshore Structure	2	1
4.	DJM 3523	Ship Drawing and Design	2	1
5.	DJM 3962	Engineering Laboratories	0	0
6.	UIS 3260/ UPT 3250	Islamic Studies 5/ Ethics 5	1	0
7.	UBI 3261	English Language	0	0
		Total	11	4

Course: Degree in Mechanical Engineering (LEVEL 1)

All Courses (1SKJ/STM/SKT)

Group 1

No.	Code	Subject	L	T
1.	SJJ 1203	Statics	3	1
2.	SJJ 1902	Plant Engineering	0	0
3.	SJJ 1912	Engineering Laboratory 1	0	0
4.	KSK 0012	Computer Programming	2	2
5.	MAT 0152	Mathematic	2	1
6.	UIS 1111/	Islamic Studies 1/	1	1
	UPT 1111	Ethics 1		
7.	UPS 1121	Malaysian Studies	1	0.5
8.	UBI 1111	English Language	0	0
		Total	10	6.5

Group 2

No.	Code	Subject	L	T
1.	SJJ 1512	Industrial Design	0	0
2.	SJJ 1504	Engineering Drawing	0	0
3.	SJJ 1922	Engineering Laboratory 2	0	0
4.	FIZ 0182	Physics	2	1
5.	KIM 0242	Chemistry	2	1
6.	KIM 0501	Chemistry Practical	1	1
7.	MAT 0242	Calculus 1	2	1
8.	UIS 1221/	Islamic Studies 2/	1	1
	UPT 1221	Ethics 2		
9.	UPK 1111	Malaysian Studies	1	0.5
10.	UBI 1221	English Language	0	0
		Total	9.0	5.5

Course: Degree in Mechanical Engineering (LEVEL 2)

All Courses (2SKJ/STM/SKT)

Group 1

No.	Code	Subject	L	T
1.	SJJ 2103	Mechanics of Solids	3	1
2.	SJJ 2303	Mechanics of Fluids	3	1
3.	SJJ 2932	Engineering Laboratory 3	0	0
4.	SEL 1123	Electrical Technology	3	1
5.	MAT 1001*	Intermediate Statistic		
6.	MAT 1352	Algebra	2	1
7.	UIS 2131/ UPT 2131	Islamic Studies 3/ Ethics 3	1	1
8.	UPM 2141	Malaysian Studies	1	0.5
9.	UBI 2131	English Language	0	0
		Total	13	5.5

Group 2

No.	Code	Subject	L	T
1.	SJJ 2203	Dynamics	3	1
2.	SJJ 2403	Thermodynamics	3	1
3.	SJJ 2512	Industrial Design	0	0
4.	SJJ 2942	Engineering Laboratory 4	0	0
5.	SJM 2502+	Basic Ship Drawing & Calculation	1	0
6.	MAT 1062	Statistic	2	1
7.	MAT 1242	Calculus 2	2	1
8.	UIS 2241/	Islamic Studies 4/ Ethics 4	1	1
9.	UPP 2131	Malaysian Studies	1	0.5
10.	UBI 2241	English Language	0	0
		Total	13	5.5

Note: *Prequisite, students must complete MAT 0001. If not register for MAT 1062; +Only for 2STM students.

Course: Degree in Mechanical Engineering (LEVEL 3)

All Courses (3SKJ/STM/SKT)

Group 1

No.	Code	Subject	L	T
1.	SJJ 3104	Mechanics of Solids	4	1
2.	SJJ 3304	Mechanics of Fluids	4	1
3.	SJJ 3603	Science of Material	3	1
4.	SJJ 3952	Engineering Laboratory 5	0	0
5.	MAT 2452	Numerical Methods 1	2	1
6.	UIS 3150/ UPT 3150	Islamic Studies 5/ Ethics 5	1	0
7.	UBI 3151	English Language	0	0
		Total	14	4

Group 2

No.	Code	Subject	L	T
1.	SJJ 3203	Applied Mechanics 1	3	1
2.	SJJ 3404	Thermodynamics	4	1
3.	SJJ 3703	Production Technique	3	1
4.	SJJ 3512	Industrial Design	0	0
5.	SJJ 3962	Engineering Laboratory 6	0	0
6.	MAT 2242	Calculus 3	2	1
7.	UBI 3261	English Language	0	0
8.	UIS 3260/ UPT 3250	Islamic Studies 6/ Ethics 6	1	0
		Total	13	4

Course: 4STM (LEVEL 4)

Degree in Mechanical Engineering (Marine Technology)

Group 1

No.	Code	Subject	L	T
1.	SJM 4901*	Technical Measurements	1	1
2.	SJM 4323	Naval Architecture	3	1
3.	SJM 4332	Applied Hydrodynamics	2	1
4.	SJM 4713	Shipbuilding, Repair & Conversion	3	1
5.	SJM 4972	Engineering Laboratory	0	0
6.	MAT 3452^	Numerical Methods 2	2	1
7.	MAT 3752	Mathematic		
8.	UIS 4170/	Islamic Studies 7/	1	0
	UPT 4160	Ethics 7		
		Total	12	5

Group 2

No.	Code	Subject	L	T
1.	SJM 4313	Ship Resistence & Propulsion	3	1
2.	SJM 4213	Ship Structure & Vibration	3	1
3.	SJM 4602	Marine Engineering Materials	2	1
4.	SJM 4523	Ship Design	3	1
5.	SJM 4982	Engineering Laboratory	0	0
6.	MAT 3561^	Tensor Analysis	2	1
7.	MAT 3762+	Mathematic		
8.	UIS 4280/	Islamic Studies 8/	1	0
	UPT 4260	Ethics 8		
		Total	13	4

Note: * Beginning in 1984/85 session

^ Beginning in 1985/86 session

\+ Till 1984/85 session only

Course: 5STM (LEVEL 5)

Degree in Mechanical Engineering (Marine Technology)

Group 1

No.	Code	Subject	L	T
1.	SJM 5222	Dynamics of Marine	2	1
2.	SJM 5513	Ship Drawing	0	1
3.	SJM 5423	Marine Power Plants	3	1
4.	SJM 5103	Offshore Structures	3	1
5.	SJM 5996	Thesis	0	0
6.	UIS 5190/ UPT 5170	Islamic Studies 9/ Ethics 9	1	0
		Total	9	4

Group 2

No.	Code	Subject	L	T
1.	SJM 5432	Marine Refrigeration & Air-Cond.	2	1
2.	SJM 5523	Ship Drawing	0	1
3.	SJM 5823	Sea Transportation	3	1
4.	SJM 5092	Marine Electrical Engineering	2	1
5.	SJM 5996	Thesis	0	0
6.	UIS 5200/ UPT 5170	Islamic Studies 10/ Ethics 10	1	0
		Total	8	4

APPENDIX B

THE NUMBER OF HYDRODYNAMIC FACILITIES BUILT VERSUS THEIR RESPECTIVE DIMENSIONS

The Hydrodynamic Laboratories which is covered in **Appendix B** consists of the (i) A Towing Tank (ii) A Manoeuvring-Seakeeping Tank and (iii) A Cavitation Tunnel. These are the three main facilities that is intended to be built at UTM Skudai, Johor Darul Taqzim.

In this respect, the data on the dimensions of the hydrodynamic facilities was collected through correspondance with all those associated operators around the world. As regards to the hydrodynamic faciliites in United States in America, the author had been fortunate enough to see those at David Taylor Research Center (DTRC) and at the University of Michigan, Ann Arbor. The information on the Japanese Ship Hydrodynamics Laboratories facilities was gathered from the book published in September 1986 by the Committee of Japan Towing Tank / The Society of Naval Architects of Japan.

In order to select a suitable size of the respective towing tank and manoeuvring-seakeeping tank, a statistical analysis of the length, breadth and depth versus the number being built is made. Since very few data was received as regards to the cavitation tunnel, the author has to make his own calculated judgement as regards to the suitable sizes required.

Herein, are the listing of all the towing tank, manoeuvring-seakeeping tank and cavitation tunnel datas. The following pages will show the graphs as in the case of them towing tank and manoeuvring-seakeeping tank, the number being built as compared to its various sizes of length, breadth and depth, which has been built around the world.

I) TOWING TANKS (T.T)	L(m)	B(m)	D(m)
1) Bulgarian Ship Hydrodynamics C.(BSHC)			
Deep-Water T.T	200.0	16.0	6.5
Shallow-Water T.T	200	16.0	1.5
2) Danish Offshore Laboratories (DOL)			
Deep Water T.T	250	12.0	5.5
Shallow Water T.T	90	30.0	0.9
3) Danish Maritime Institute (DMI)			
Final Testing Model Basin	240	12.0	5.5
Preliminary Studies Model Basin	18	2.0	1.0
4) Maritime Research Inst.Holland(MARIN)			
Depressurized T.T	240	18.0	8.0
Deep Water T.T	252	10.5	5.5
Shallow Water Basin	216	15.75	1.25
High Speed T.T	220	4.0	4.0
5) Ship Hydromechanics Lab.(TUDelft)			
No. 1 T.T	142	4.22	2.5
No. 2 T.T	85	2.75	1.25
6) Hamburg Ship Model Basin (HSVA)			
Large T.T	300	18.0	6.0
Small T.T	80	5.0	3.0
7) David Taylor Research Center (DTRC)			
Shallow Water Basin	363.5	15.5	3.0
Deep Water Basin	575	15.5	6.7
High Speed Basin	905	6.4	4.5
8) University of Michigan, Dept. NA&ME.			
Towing Tank	110	6.4	3.0
9) National Res. Council Canada (NRCC)			
Clearwater Tank (St.John)	200	12.0	7.0
Shallow Water T.T (Ottawa,Ontario)	100	7.5	1.5
10) Indian Institute of Technology (IIT)			
Ship Model Tank	151	4.0	2.5
11) Faculty of Fisheries, Hokkaido U.	50	3.5	1.5

12) Dept. NA, Faculty of Eng.,Tokyo U.	86.0	3.5	2.4
13) Dept.NA&OE, Fac.Eng.,Yokohama N.U.	100	8.0	3.5
14) Dept. NA, Fac.Eng.,Osaka U.	100	7.8	4.35
15) Dept. NA, College Eng.,U.Osaka P.	70	3.0	1.6
16) Kobe U. of Mercantile Marine	60	6.0	1.5
17) Dept.NA&OE, Fac.Eng., Hiroshima U.	100	10.0	3.5
18) Dept. NA, Fac.Eng., Kyushu U.	118	2.67	5.0
19) R.I.of Applied Mechanics, Kyushu U.	60	1.5	1.5
20) Nagasaki Institute of Applied Sci.	60	4.0	2.3
21) 3rd. Dept.,1st R.C, Defense Agency			
Large T.T	255	12.5	7.25
Small T.T	102.5	3.5	2.25
High Speed T.T	346.5	6.0	3.0
22) N.R.I Fisheries Eng.,Fishery Agency	68.4	4.0	2.0
23) S.R.D, Ship Res.Inst.,M. Transport			
No. 2 T.T	400	18.0	8.0
No. 3 T.T	140	7.5	3.5
24) The Shibuilding R.C of Japan			
No. 1 T.T	207	10.0	6.3
No. 2 T.T	207	8.0	4.15
25) Japan Marine Sci.& Tech. Center	40	4.0	2.0
26) Akishima Lab.,Mitsui E & S Co. Ltd.			
Large T.T	220	14.0	6.5
Small T.T	100	5.0	2.65
27) Research Institute, I.H.I Co. Ltd.			
Large T.T	210	10.0	5.0
Small T.T	46.5	2.5	1.5
28) Hiratsuka Research Lab.,S.H.I Ltd.	120	6.0	3.5
29) Tsu Lab.,E&S R.C.,Nippon Kokan.K.K.	240	18.0	8.0
30) Akashi Ship Model Basin Co. Ltd.	200	13.0	6.5
31) Nagasaki Exp.T.,Mitsubishi H.I Ltd.			
Large T.T	165	12.5	6.5
Small T.T	120	6.1	3.65

II) MANOEUVRING-SEAKEEPING TANKS(M.S.T)

	L(m)	B(m)	D(m)
1) BSHC M.S.T. Bulgaria	64.0	40.0	2.5
2) DOL M.S.T. Denmark	90	30.0	0.9
3) MARIN M.S.T. Netherlands	100	24.5	2.5
4) HSVA Large M.S.T .West Germany	78	10.0	5.0
Small M.S.T	37	6.0	1.2
5) DTRC. U.S of America	110	73.2	10.7
6) Institute for Marine Dynamics, NRCC. Canada	75	32.0	5.0
7) Dept.NA. Fac.Eng..U of Tokyo.Japan	45	5.0	3.5
8) S.M.Basin. Fac.Eng.,U of Tokyo	50	30.0	2.5
9) Tokyo U.of Mercantile Marine	54	10.0	2.5
10) Dept.NA. Fac.Eng.,Osaka U.	190	80.0	2.0
11) Dept.NA. Fac.Eng.,Kyushu U.	28	25.0	1.8
12) R.I Applied Mechanics. Kyushu U.	80	8.0	3.0
13) Dept.NA. Fac.Eng.,Nippon Bunri U.	40	2.5	2.0
14) The 3rd.Dept.,1st.Research Center The Tech.R&D Inst.,Defense Agency	190	130.0	3.5
15) Ship Dynamics Division. S.R.Inst.	80	80.0	4.5
16) Ocean Eng.Division. SRI,M.Transport	40	28.0	2.0
17) Inst. of Ocean Enviornmental Tech., Japan Foundation of S. Advancement	80	45.0	2.6
18) Research Institute. Ishikawajima-Harima Heavy Industries Co. Ltd.	70	30.0	3.0
19) Hiratsuka Research Lab., Sumitomo Heavy Industries Ltd.	56	30.0	2.5
20) Hiroshima R&D Center. Technical Hq. Mitsubishi Heavy Industries Ltd.	57.5	4.5	2.5
21) Nagasaki Exp.T.,Nagasaki R&D Center, Tech. Hq.,Mitsubishi H.I. Ltd.	160	30.0	3.5
22) Ship Design Dept.,Sasebo H.I.C.Ltd.	170	100.0	3.0

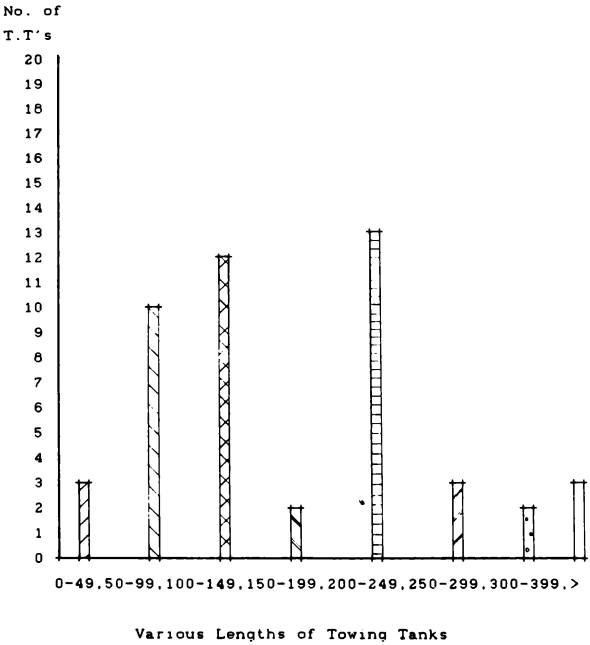
III) CAVITATION TUNNELS (C.T)

	Speed (m/s)	X-Sect. (m)	L (m)	D (m)
1) BSHC, Bulgaria				
No 1 C.T	14.0	0.6*0.6	2.6	
No.2 C.T	4.5	1.45*0.7	6.0	
2) MARIN, Netherlands				
Large C.T	11.0	0.9*0.9	10.5	7.0
C.T with Flow Regulator	7.0	0.4 dia.	5.7	5.3
High Speed C.T	65.0	0.04dia.		
	40.0	.05*.05		
	35.0	.04*.08		
3) HSVA, West Germany				
Large C.T	19.5	0.75dia.		
Medium C.T	10.0	.57*.57		
Small C.T	7.5	0.4*0.4		
4) DTRC, U.S of America				
Small C.T	6.2	0.03dia.		
Medium C.T	17.0	0.06dia.		
Large C.T	25.7	0.09dia.		
5) NRCC, Canada	12.0	0.5*0.5	2.5	
6) Delft U. of Technology	11.0			
7) Dept.NA,Fac.of Eng., U.Tokyo				
High Speed C.T 1,circular	80.0	0.03dia.	3.7	1.0
" " 2,rect.	35.0	.12*.025	3.7	1.0
3,square	20.0	.08*.08	3.7	1.0
4,rect.	50.0	0.1*.015	3.7	1.0
T.E Type C.T No1,square	15.0	.08*.08	6.8	2.0
" " " No2,rect.	15.0	.12*0.05	6.8	2.0
Marine Propeller C.T No1	11.2	.45*.45	9.0	2.7
" " " No2	19.5	.15*0.6	9.0	2.7
8) Shipbuilding R.C. of Japan				
C.T ,square	12.0	0.6*0.6	12.0	7.0

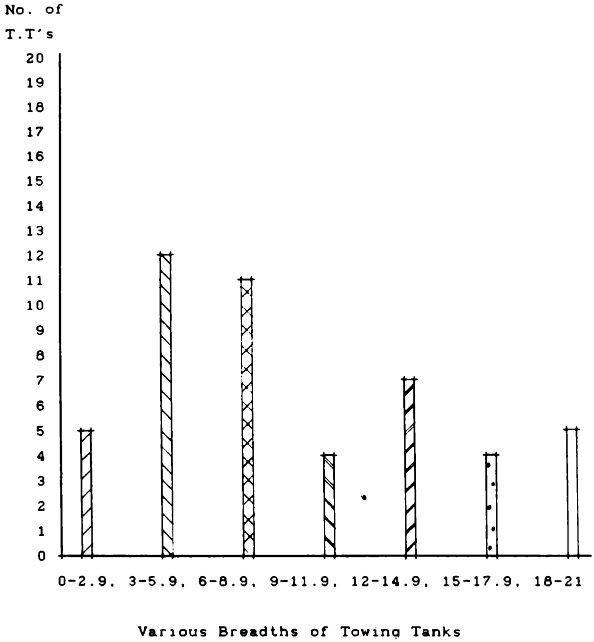
9) Akishima Lab.,Mitsui Eng.& Sh.				
No 1, square	15.0	0.6*0.6	13.5	7.0
No 2, rectangle	5.0	1.2*.85	13.5	6.0
10) Research Institute,IHI Co.Ltd				
No 1 C.T,rectangle	12.0	0.6*0.6	12.0	7.0
No 2 C.T,rectangle	6.0	.85*.85	12.0	7.0
11) Nagasaki Exp.T.,R&D C.,MHI Ltd.				
Sq. section,rounded corners	11.0	0.5*0.5	8.15	5.5

Graph 1:

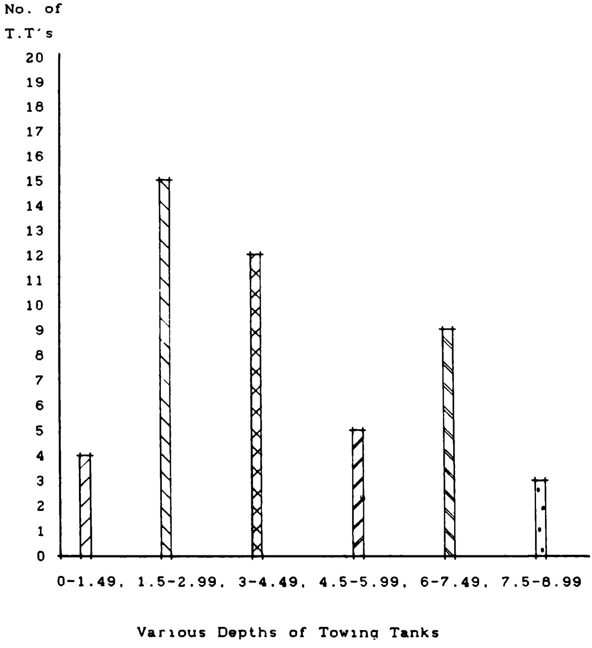
No. of Towing Tanks Built versus Lengths



Graph 2:
No. of Towing Tanks Built versus Breadths

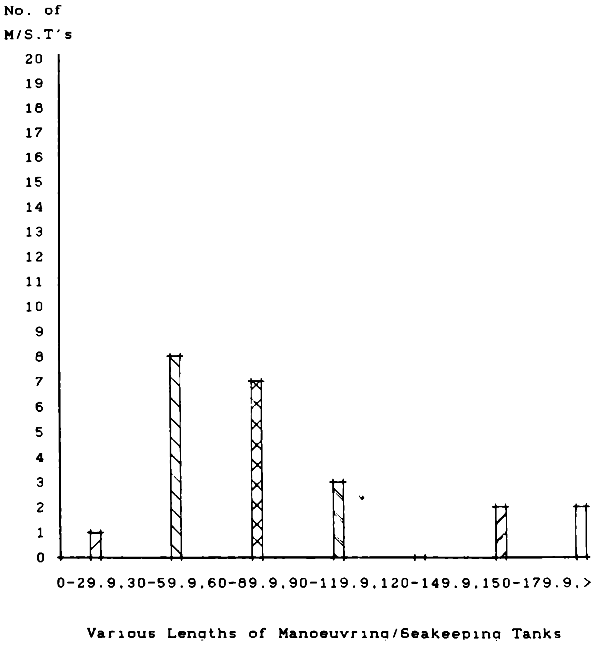


Graph 3:
No. of Towing Tanks Built versus Depths



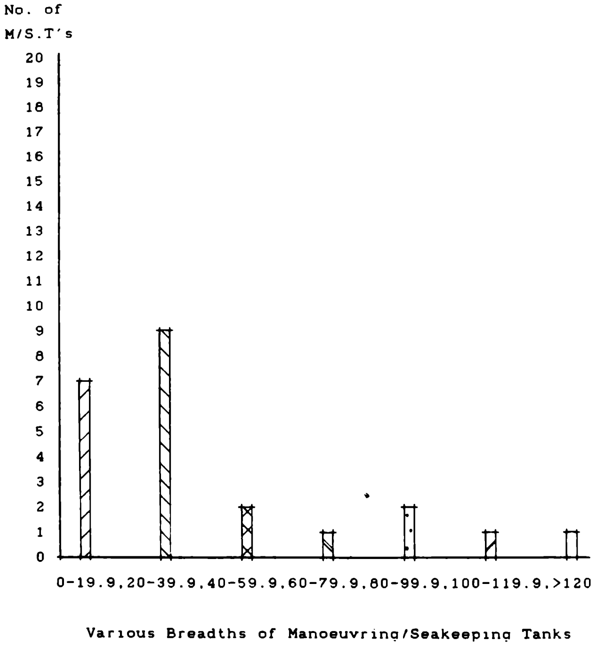
Graph 4:

No. of Manoeuvering/Seakeeping Tanks versus Lengths



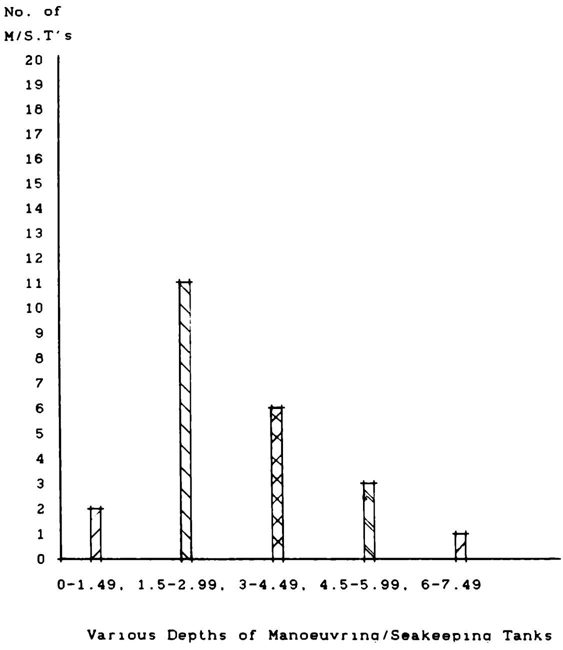
Graph 5:

No. of Manoeuvering/Seakeeping Tanks versus Breadths



Graph 6:

No. of Manoeuvering/Seakeeping Tanks versus Depths



APPENDIX C

DETAIL CALCULATION OF CASHFLOW

AND RETURN IN INVESTMENT

Net Present Value (NPV)

This technique involves setting up a projected cash-flow for each of the options under consideration. Revenues and costs are projected on an annual basis over the useful years of the invested enterprise. In the calcution just to identify the number of years when it will be profitable.

The net cashflow in each year is calculated, taking into account of capital payments, operating expenditure and revenues generated. These annual cashflows are then discounted back to the present and summed, giving the NPV of each of the options. In the following calculations, an acceptable interest rate of 10 per cent is used. The option giving the highest NPV is generally preferred (33).

The advantage in using this technique is that it takes account of both the cost and revenue flows and produces a single figure, which makes the comparison of options a simple matter.

The formulae taken from Benford (3) are as follows;

$P = (Pw-i-N)F$ & $F = (CA-i-N)P$

$(PW-i-N) = 1/CA = 1/(1+i)^N$ & $(CA-i-N) = (1+i)^N$

where;

- P = present amount, principal, present worth or value
- F = future amount
- PW = present worth factor
- CA = compound amount factor
- i = interest rate
- N = number of years

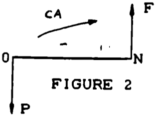


FIGURE 2

Table C-1: Annual Operating Cost for the First 10 years.

	Operating Cost in US$			
Year	Manpower	Maintenance	Overheads	Total
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	31,200	145,920	20,000	197,120
6	31,200	145,920	20,000	197,120
7	62,400	145,920	40,000	248,320
8	62,400	145,920	40,000	248,320
9	62,400	1,605,120	40,000	1,707,520
10	62,400	145,920	40,000	248,320

Table C-2: Detail Calculation of Cashflow

	Value in US$ (thousand)			
Year	Investment	Operating	Revenues	Cashflow*
1	4,900	0	0	-4,900
2	9,800	0	0	-9,800
3	2,900	0	0	-2,900
4	1,200	0	0	-1,200
5	600	197.1	4,235.6	3,438.5
6	600	197.1	4,235.6	3,438.5
7	0	248.3	8,471.2	8,222.9
8	0	248.3	8,471.2	8,222.9
9	0	1,707.5	8,471.2	6,763.7
10	0	248.3	8,471.2	8,222.9

* Cashflow = Revenues - (Investment + Operating)

Table C-3: Detail Calculation of Return on Investment

Value in US$ (thousand)

Year	Cashflow	PW*	Value**	NPV+
1	-4,900	0.9091	-4,454.6	- 4,454.6
2	-9,800	0.8264	-8,098.7	-12,553.3
3	-2,900	0.7513	-2,178.8	-14,732.1
4	-1,200	0.6830	- 819.6	-15,551.7
5	3,438.5	0.6209	2,135.0	-13,416.7
6	3,438.5	0.5645	1,941.0	-11,475.7
7	8,222.9	0.5132	4,220.0	- 7,255.7
8	8,222.9	0.4665	3,836.0	- 3,419.7
9	6,763.7	0.4241	2,868.5	- 551.2
10	8,222.9	0.3855	3,169.9	2,618.7

* PW = Present Worth Factor

** Value = Present Worth = PW * Cashflow

\+ NPV = Net Present Value (i.e NPV2 = NPV1 + Value2)

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