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EUROPE 1992 AND CANADA'S OCEAN INDUSTRY

External Affairs and
International Trade Canada

1992

CANADA
EUROPE

Canada

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September 1991

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FROM THE GOVERNMENT OF CANADA

External Affairs and International Trade Canada (EAITC) is pleased to offer the Canadian ocean industry, as part of the Going Global trade strategy, this comprehensive study on market opportunities in the European Community resulting from the Europe 1992 initiative and the possible means by which Canadian firms can capitalize on them.

Europe 1992 is happening now. The European Community's ambitious Single Market program has already dramatically changed the way Europeans are doing business. The process is irreversible; the pace is rapid and accelerating. If Canadian businesses are to profit from the opportunities that this enormous market will bring, they must be well-informed.

After the recent completion of a series of sectoral studies entitled *1992 Implications of a Single European Market*, EAITC conducted a consultative process which included government departments, the provinces and our European embassies to determine which subsectors should be the focus of further study. The result was the selection of the ocean industry, environmental industries, software, telecommunications products and services and value-added wood products. All of these studies will be published during the Fall of 1991 and into the Spring of 1992.

We also have tangible programs to introduce you to the European market. These are well-publicized through our CanadExport publications. Our trade officers in the European Community Division of EAITC and at the International Trade Centres in each province would be pleased to respond to your specific questions. Take advantage of these programs. They have been established to benefit you.

Publications that are currently available from the series *1992 Implications of a Single European Market* include: Agriculture and Food Products; Telecommunications and Computers; Automotive Industry; Minerals and Metals; Forest Products; Defence, Aerospace and Transportation; Specialty Chemical Products, New Materials, Pharmaceuticals and Biotechnology; Industrial Products and Services; Financial Services; Fisheries Products; and Professional and Consulting Services — Law and Accounting. Other reports include European Economic and Monetary Union; Company Law; Competition Policy; Standards; Freight Forwarding; 1992 and Related Issues; and Intellectual Property.

For more information on publications available, please contact the EAITC InfoExport hotline, 1-800-267-8376.

ACKNOWLEDGEMENTS

It has been an exciting challenge to work on this paper. The study has involved contact with many people in the freight forwarding and transportation industries in Canada and Europe. Without their cooperation, it would have been impossible to gain an understanding of the changing conditions affecting the freight forwarding industry in general and the particular implications of the Europe '92 program. I also needed assistance from members of the European Commission staff. Their help was indispensable in understanding quickly the scope and implications of the Europe '92 program.

I am, therefore, indebted to many people who gave their time, often showed me their company's facilities and arranged for meetings with others. I am pleased to acknowledge the persons interviewed in Appendix V.

However, I owe a special thanks to those who served on the CIFFA Steering Committee for the project. They are: Karl H. Legler, Starber International Inc., Chairman; Gilles Béchard, G. Béchard Ltd.; Patrick E. Cullen, Locher Evers International; C.J. Gillespie, Gillespie-Munro Inc.; H.J. Kuhn, Danzas; and H. Peter Merath, Panalpina. I would also like to acknowledge the special assistance provided by Allan Staruch of Industry Science and Technology Canada. Finally, I wish to thank Doug W. Pelkola of External Affairs and International Trade Canada, who not only guided the project but so often provided insights and helpful suggestions.

Of course, managing an international project and seeing it through to completion depends on having someone who can take care of the logistical details of an interview program and report preparation. My thanks to Teresa Cheung for her attention to detail and her patience throughout the project.

Notwithstanding the considerable assistance I have received, I take full responsibility for any errors and omissions in the report. I will be pleased to receive corrections and comments from readers.

Trevor D. Heaver

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ABBREVIATIONS

ADS	Atmospheric Diving Suits
ARE	Admiralty Research Establishment
ASW	Anti-Submarine Warfare
AUV	Autonomous Underwater Vehicle
BMFT	Federal Ministry for Research and Technology
BOD	Biochemical Oxygen Demand
C3	Command, Control & Communications
CANMAR	Canadian Marine Drilling Limited
CCMST	U.K. Coordinating Committee on Marine Science & Technology
C-CORE	Centre for Cold Ocean Resources Engineering
CCPRTM	Coordinating Committee for Marine Technology Research Programs
CMO	National Foundation for Coordination of Maritime Research in the Netherlands
DARPA	Defence Advanced Research Projects Agency
DEMOS	Environmental Management Options Scheme
DOE	Department of Environment
DOGGIE	Deep Ocean Geological/Geophysical Instrument Explorer
DOLPHIN	Deep Ocean Long Path Hydrographic Instrumentation
DTI	Department of Trade and Industry
DTP	Department of Transport
DUC	Dansk Untergrunds Consortium
EC	European Community
ECUs	European Currency Units
EEC	European Economic Community
EROS	European River Ocean System
ETIS	Environmental Technology Innovation Scheme
EUCLID	European Cooperation for the Long-term in Defence
FAR	Fisheries and Aquaculture Research
GATT	General Agreement on Tariffs and Trade
GEOMAR	Research Centre for Marine Geosciences
GSRT	General Secretariat for Research and Technology
HF	High Frequency
IEPG	Inter-European Program Group
IFREMER	Institut francais de recherche pour l'exploitation de la mer
IMR	Inspection, Maintenance and Repair
INMARSAT	International Maritime Satellite Organization
IRO	Netherlands Industrial Council for Oceanology
JOULE	Joint Opportunities for Unconventional or Long-term Supplies
MARIN	Netherlands Maritime Research Institute
MAST	Marine Science and Technology
MAT	Steel Bottom-founded Base
MOD	Ministry of Defence
MODU	Mobile Offshore Drilling Units
MOU	Memorandum of Understanding
MSAT	Mobile Satellite
MTD	Marine Technology Directorate
NAMSA	NATO Maintenance & Supply Agency
NATO	North Atlantic Treaty Organization
NERC	Natural Environment Research Council

NRA	National Rivers Authority
RFQs	Request for Quotations
ROV	Remotely Operated Vehicle
SMEs	Small- or Medium-sized Enterprises
SOAFD	Scottish Office Agriculture and Fisheries Department
SSDC	Single Steel Drilling Caisson
STEP/EPOCH	Science & Technology for Environmental Protection/European Program on Climatology and Natural Hazards
THERMIC	New Energy Technologies
TOC	Total Organic Carbon
UHF	Ultra High Frequency
UUV	Unmanned Underwater Vehicle
VDMA	German Machinery & Plant Manufacturers Association
WEU	Eastern European Union
WIR	Work Inspection Robot
WOCE	World Ocean Circulation Experiment
WRC	Water Research Centre

EXECUTIVE SUMMARY

This study was commissioned by External Affairs and International Trade Canada to develop information on the post-1992 European Community (E.C.) ocean industry market and to recommend marketing approaches for Canadian ocean industry firms.

R & D Lyons Consultants Limited of Halifax was the prime contractor and received input from Cabot Management Limited of Vancouver, and from General Technology Systems Limited and Cliff Funnell Associates — both of the United Kingdom (U.K.).

The study methodology relied almost exclusively on the current knowledge, experience and background, and in-house information available to the professional staff of the contractors. Some limited field work, to a major extent through telephone discussions, was undertaken to verify information. No extensive field information-gathering was conducted.

Markets

Offshore Oil and Gas

The main market in the E.C. is by far the U.K., followed by Denmark, Germany, Italy and the Netherlands. A relentless drive for cost savings is changing the requirements for technologies and allows new entrants into the marketplace if they meet more demanding requirements. The market for fixed platforms is likely to remain static and largely associated with shallower sites such as the Netherlands and the South Basin of the U.K. Submerged production systems taking advantage of previous investments in deep-water platforms and pipelines represent the favoured new technologies. Opportunities exist in the following areas: optimizing design criteria; installation methods; operations and maintenance management; maintenance technology; power and control systems; two-phase flow; and workover operations.

Ocean Sciences and Marine Environment

The ocean sciences market includes the provision of equipment and services for, predominantly, government-controlled marine science and technology laboratories engaged in national and international oceanographic and environmental programs. Most of the expenditures in the marine environment market are undertaken by government bodies through research and development (R&D) in support of policy, or to develop a better understanding of the environment. The major European program is the Marine Science and Technology (MAST) program. Many of the European institutes are involved in MAST as well as an umbrella project, EUROMAR. Both MAST and EUROMAR involve industry. Another important program is EUREKA, which supports industry-based R&D. The greatest areas of market potential in this sector relate to the protection and understanding of the marine environment. Opportunities exist in the following areas: autonomous vehicles for passive and active sensing and data gathering; improved deep-towed systems; medium-depth, medium-scale side scan sonar; instruments; autonomous seabed research stations; and equipment and services related to the monitoring, prevention and control of marine pollution.

Underseas Defence

The sale of underseas defence equipment into Europe has been strictly limited. So has intra-European supply, with procurement by the larger navies (France, Germany and the U.K.) and the second-ranking navies (Italy, Spain and the Netherlands) being predominantly from national industry. Overall, defence spending in Europe is expected to be cut eventually by 25 to 30 percent although underseas defence should fare reasonably well, as it is seen as a key element in securing sea lanes for rapid deployment purposes. Market growth areas include: mine warfare (sensors, on-board computing, long duration power supplies, etc.); surveillance (coastal radars, underwater detection, sensors, etc.); submarine equipment (sensors, weapons control, deployable antennae, etc.); and command, control and communication (C3) systems.

Coastal Interface

Coastal interface projects in Europe are primarily to maintain the commercial viability of ports by means of channel dredging and conservancy works. This is of particular concern to the U.K., the Netherlands, Denmark and northern Germany. Throughout Europe, coastal defence works are regarded as a public works activity with procurement subject to the open tender rules laid out in the E.C. Public Works Directive. The principal opportunity for new technology lies in instrumentation, communication and recording systems.

Conclusions

The key conclusion reached in this study is that, for the ocean industry, Europe 1992 will likely not produce a Single European Market for many years to come. Consequently, there will still be 12 single markets and any strategy will need to recognize that fact. In other words, Canadian companies selling into Europe will be dealing more or less with the same factors that exist today, including nationalistic protectionism.

Evidence of the lack of single market uniformity is the attitude of Member States to E.C. Directives. Although these are binding on Member States, each state is responsible for enacting domestic legislation to implement the directives. For example, the U.K. has been quick to enact the necessary legislation whereas Italy has been slow. This, to some extent, also reflects the attitudes of the countries toward imports. Some, such as the U.K., are relatively open while others, such as Italy, are more protectionist.

Although the European marketplace will not change appreciably, there are certain ongoing actions that will have an impact on Canadian market strategies. For example, the E.C. common external tariff ensures that goods imported from non-E.C. countries are subject to the same customs duties wherever they enter the E.C. Moreover, certain goods, appropriate to the Canadian ocean industry, can be imported duty-free or under a temporary suspension of duty. Another area is technical standards. An objective of the Single European Market is to harmonize standards so that any product that meets the standards in any Member State can be freely marketed in all other states.

A negative but important factor is represented by the E.C.'s public purchasing policies, which allow government purchasers to reject a tender where less than 50 percent of the value of the products is of E.C. origin.

Possible Market Strategies

The most important element of an overall Canadian marketing strategy is Canadian innovation in products and techniques. The strategy could be built around Canadian-developed innovations, treating them as initial door-openers to new European markets and as measures to solidify and expand existing markets.

An overall industry/government strategy could be developed, aimed at Europe 1992 to aggressively promote Canadian ocean industry leading-edge expertise in each of its sectors. The objectives would be, first, to gain recognition of Canadian technological and engineering innovation and, second, to develop an awareness in Europe that Canada has high-performance firms that deliver reliable products and services.

In general, the fundamental company strategies are as follows:

- Companies should have a presence in Europe through subsidiaries (or branch offices for the larger Canadian companies), strategic alliances or distributors/sales representatives.

- Companies involved in strategic alliances with European firms should have reciprocal arrangements to allow their European partners access to North American markets.

To illustrate the above, some possible company strategies are set out below:

- A company with a leading-edge technology in Canada works with a company with complementary technology in Europe. Specifically, the Canadian company would be a participant in a major multicompany applied research project and the European company would be working on a similar multicompany research project (say, one funded under the EUREKA program). The arrangement would have the Canadian technology utilized on the European project and the European technology on the Canadian project. The primary linkage would be between the two companies (likely small ones) and both would benefit from the reciprocal involvements. The arrangement would allow the Canadian company to establish a presence in Europe, relatively inexpensively, to establish working contacts with other applied targeted user communities in Europe.

- Utilizing the support of the Canadian ocean research institutional infrastructure, Canadian companies can present a larger capability in Europe to participate in European research programs such as MAST, EUREKA and EUROMAR. The rationale for the Canadian participation would be the contribution of innovative products, processes or techniques that would lead to connections for the Canadian company in the applied research community and also the target user community in Europe.

- A company manufacturing a product in Canada would negotiate a reciprocal deal with a company manufacturing complementary products in Europe. The arrangement would entail manufacturing (likely final assembly) of each other's products, and marketing and distribution in the other's territory. This would be a cost-effective way to enter the European market as a European company. The European partner would have a better handle on the ways and means of marketing and selling in Europe. This would help ensure earlier market penetration and a higher growth rate than if the Canadian company simply used a European distributor.

- A group of small Canadian ocean industry companies would join together in a consortium for the purposes of marketing into Europe and possibly project execution. The companies either would have similar products or services or would have complementary products or services. The former mix would be aimed at a general marketplace, the latter at specific projects that are bid on an internationally competitive basis or where the Canadian group could bid as subcontractor to a European prime contractor. In either case, the sum of the Canadian parts would be a more significant capability than that of the individual companies and would have more clout in the large European marketplace. As well, the combined marketing should result in lower costs for each company.

- The marine environment area may offer some of the best potential for Canadian companies. The market in Europe is dominated by E.C. Directives and government legislation, and every Member State will have to comply sooner or later. Countries such as Germany and the U.K. have both technology and money and are, therefore, difficult to access. Consequently, a key strategy would be to concentrate on those countries (such as Spain) that have heavy requirements but lack the technological expertise and the funds.

  Canada could conceivably negotiate bilateral science and technology agreements with countries that would have funds made available to clean up the marine environment. Canadian companies would provide the expertise and the host country would provide the infrastructure. In this way the Canadian companies would establish themselves in Europe and build up both relationships and markets, and the host country would develop its marine environmental industry.

Recommendations

Certain information is essential in order to develop realistic market strategies for Canadian ocean industry companies for the Europe 1992 marketplace. The basic requirements are: (1) knowledge of the Canadian ocean industry (i.e., type of products or services; size and location of companies; size, type and location of existing European markets; existing European strategic alliances, joint ventures and branch/subsidiary operations); and (2) knowledge of the European marketplace (i.e., size, type and location of markets; nature and location of competition; trends, political and cultural factors).

The present study has focussed on one half of the equation, the European part. In order to develop a final set of workable strategies, it is essential to determine the extent of existing Canadian ocean industry business with Europe. This can most effectively be done during dissemination to industry of the results of the present study, at which time the companies can have input to the development of strategies and also provide information on their European activities.

There are certain common approaches applicable to the overall Canadian ocean industry. However, it should be borne in mind that the sectors (i.e., ocean sciences) are different one from the other regarding nature of clientele, type of technologies, and size and location of markets. Consequently, sector-by-sector strategies are required to reflect the peculiarities of each.

Another important factor that should be taken into account in subsequent work is the geographical influence within Canada. One would assume that Eastern Canadian companies have an easier job of selling into Europe than those from Western Canada.

1. INTRODUCTION/RATIONALE

With a world ocean industry market in the order of $480[1] billion, there is a small but recognizable and critically important area of high technology that can be described as ocean technology equipment and services. It encompasses most of the high technology tools that are vital to the efficient exploration, understanding and use of the oceans. The producers of these technologies sell into a world market, and their consumers span all ocean sectors from underseas defence to offshore oil and gas, oceanographic research, commercial shipping, and the marine environment.

Canada is a recognized leader in the supply of ocean technology equipment and services and, to a large extent, depends on export markets for its survival and growth. With Western Europe representing approximately one-third of the ocean industry market worldwide, and the integration of the European Community in 1992, it is essential that Canadian industry examine its role in the European marketplace. As a result, External Affairs and International Trade Canada commissioned a study to develop information on the European market and, in particular, the portion that could be obtained by the Canadian industry.

1 All monetary references are in U.S. dollars unless otherwise specified.

2. OBJECTIVE

The object of the study was to provide External Affairs and International Trade Canada with a projection of the potential ocean industry market in the new European Community and to develop a marketing approach for Canadian ocean industry firms.

3. OFFSHORE OIL AND GAS INDUSTRIES

3.1 The Market in the Offshore Oil and Gas Industries

The development of the offshore oil and gas industries in Europe's North Sea has done to ocean technology what World War II did to the aerospace technologies. It has provided the spur to enable a range of innovation to be introduced much faster than was thought possible 25 years ago when only shallow-water (less than 50 m depth) sites were developed for production. At first sight, the technologies now appear to be maturing but a relentless drive for cost savings is changing the requirements for technologies and also allowing new entrants into the marketplace, if they can meet more demanding requirements.

In practice, the distribution of annual total expenditure on offshore oil and gas industries within the E.C. countries varies, with the U.K. dominating the totals:

Table 1

Distribution of Annual Total Expenditure on Offshore Oil and Gas Industries

	1990 $ M	%
Denmark	460	3.6
Germany	550	4.4
Italy	590	4.7
The Netherlands	610	4.8
U.K.	10,300	81.7
Others (mostly Ireland and Spain)	100	0.8
Total	**12,610**	**100.0**

The possible entry of Norway into the E.C. before the end of the century will change the balance somewhat, with the U.K. still accounting for more than half the European expenditures on offshore oil and gas.

In the U.K., construction expenditures were $5.9 billion, 30 percent higher than the previous year. As newer fields have come on stream, the unit cost of a barrel of oil landed in the U.K. has dropped from $15 in 1989 to $12, with incremental projects and Southern Basin activities costing $10 per barrel in 1990. Gross capital investment in the U.K. was almost $6 billion. This is 16 percent of total U.K. industrial investment and is the same in real terms as the peak investment year of 1985.

In 1990, U.K. companies were awarded 77 percent of the $10.5 billion worth in new projects in the U.K. sector. This compared with 81 percent of 1989 awards, but represents a 49-percent increase in volume, indicating that U.K. suppliers are approaching full capacity. Similarly, exploration activities have increased by 27 percent, reaching $2.5 billion. Unit drilling costs appear to be of similar value, with 224 wells drilled (159 exploration, 65 appraisal). This compared with the previous record of 190 wells in 1984. In 1990, proven and probable reserves of oil increased by 90 million tonnes (675 million barrels) which, after deducting production of 180 million tonnes, means reserves of oil have fallen slightly. Similarly, gas reserves increased from 65 billion m^3 to 1,960 billion m^3.

3.2 Technology for Offshore Oil and Gas Industries

Since the massive deep-water fixed platforms for the big oil fields in the late 1970s and early 1980s, the industry has sought to reduce costs by minimizing the requirements for fixed platforms and substituting either independent floating production platforms, often associated with offshore tanker loading buoys, or subsea production systems linked to older fixed platforms and pipelines. These developments in technology are most apparent in the methods proposed to produce oil from the deeper water fields where subsea systems are increasingly proposed:

Table 2
Subsea Production Proposed for Offshore Developments to be Commissioned in the E.C.

	1991	1992	1993	1994
Italy	—	1	—	—
Ireland	1	—	—	—
U.K. (North Basin)	2	4	4	10
(South Basin)	—	2		—
Total	3	5	6	10

Table 3
Floating Production Platforms for Offshore Developments to be Commissioned in the E.C.

	1991	1992	1993	1994
Ireland	—	—	1	—
U.K. (North Basin)	—	1	—	—
Total	—	1	1	—

Table 4
Fixed Production Platforms for Offshore Developments to be Commissioned in the E.C.

	1991	1992	1993	1994
Denmark	2	—	1	1
Germany	1	—	—	—
Netherlands	7	13	4	3
U.K. (North Basin)	2	2	10	6
(South Basin)	1	6	2	5
Total	13	21	17	15

In summary, the market for fixed platforms is likely to be static and largely associated with shallower sites such as the Netherlands and the South Basin of the U.K. The form of fixed platform is continually being developed by established suppliers to reduce their weight and manning levels.

Floating platforms appear less attractive than when pioneered. Submerged production systems taking advantage of previous investments in deep-water platforms and pipelines represent the favoured new technologies, with calls for R&D being required in:

- optimizing design criteria, including options available at conceptual stages
- installation methods: buoyancy, positioning and downhaul
- operations and maintenance management
- maintenance technology, including developments in atmospheric diving suits (ADSs), remotely operated vehicles (ROVs) and the use of one-person submersibles
- power and control systems, including power generation options (subsea or remote) and control options (hydraulic, electrical, hybrid)
- two-phase flow, i.e., transmitting mixtures of oil and gas along pipelines where, for example, there is a gathering system between remote subsea well-heads and the main processing facilities
- workover operations, for example, production logging, de-sanding, acidising, chemical and nitrogen injection, etc.

3.3 European Procurement for Offshore Oil and Gas Industries Worldwide

While the territorial imperative partly governs participation in capital investment for oil and gas, the continuing demands of international commerce ensure that organizations offering the right technology at the right price can participate in offshore exploration and appraisal activities worldwide. The following tables (Tables 5 and 6) of the types and location of mobile offshore drilling units (MODU) present a different picture of experience in offshore technology from the situation with production systems in E.C. waters.

The E.C. requirement for MODU is almost met by the number owned by E.C. principals. However, especially in U.K. sectors, the balance is made up of MODU with U.S. or Norwegian principals. Closer examination shows that France dominates the E.C. MODU fleet, with the U.K. and Denmark as equal seconds. Much of the French-managed fleet does not operate in the E.C. There is negligible offshore oil and gas activity in French waters.

The build-up of the French offshore capability reflects the French central government involvement. There has been an even more significant control of offshore oil and gas policies by the Italian government through the integrated state-owned oil company (ENI).

Although the Danes have a production monopoly in their North Sea fields, the Dansk Untergrunds Consortium (DUC), a more open market tradition exists there similar to the Dutch and U.K. approach to fostering domestic suppliers without over-protectionism.

It is also notable that two large French operating companies manage their worldwide operations and budgets from Paris, also including subsea and floating production systems. France and, to a lesser extent, Germany have onshore hydrocarbon production. Both have large service and supply industries. France, in particular, has large-scale exports in a number of positions in which it has technical leadership. Would-be entrants to the international offshore industry should consider appointing French-speaking Paris residents with an oil industry background to develop trading links with French operators and contractors.

Table 5
MODU (Mobile Offshore Drilling Units) in the World

	Ships	Semi-subs	Jack-ups	Submersibles
World Total	58	171	415	36
Owned by E.C. principals*	10	44	43	—
Belgium	—	1	—	—
Denmark	2	4	14	—
France	5	20	14	—
Italy	—	4	4	—
The Netherlands	1	2	4	—
Spain	—	—	1	—
U.K.	2	13	6	—

* Many are "flagged out", e.g., to Panama.

Table 6

MODU (Mobile Offshore Drilling Units) in the E.C.

	Ships	Semi-subs	Jack-ups	Submersibles
E.C. Waters Total	—	50	49	—
Owned by E.C. principals*	—	30	21	—
Belgium	—	1	—	—
Denmark	—	3	8	—
France	—	11	3	—
Italy	—	2	1	—
The Netherlands	—	1	4	—
U.K.	—	12	5	—

* Many are "flagged out", e.g., to Panama.

3.4 Import Strategies

In offshore oil and gas, any historic E.C. import strategy trends will be drastically changed by new legislation.

It appears that offshore E.C. oil and gas contracts are being treated as subject to the E.C. Utilities Directive, to be incorporated within the legislation of E.C. countries by the end of 1992.

The rules are intended to ensure that purchasing in these sectors is conducted on the basis of fair value for money, not national identity of individual countries. They apply not only to publicly-owned utilities and private bodies undertaking similar activities, but also to private companies in energy, water, transport and communications operating under special or exclusive rights. This appears to include offshore oil licenses, although some exemptions may be given by individual countries in offshore activities. At present, the Netherlands has applied to the Commission to be able to give exemptions, but the U.K. has not decided whether to apply or not. Apart from the Netherlands, no other European country has made such a decision.

Under the directive, supplies contracts will be covered if they exceed 400,000 ECU (European currency units, equivalent to approximately $430,000) and works contracts if they exceed 5,000,000 ECU (say, $5,350,000). Purchasers will be able to reject bids of non-E.C. origin, even if they are lowest. Also, they will be compelled to reject any such bid if an offer of E.C. origin comes within three percent of it.

The definition of E.C. origin is, however, only the place of last substantial transformation, i.e., it is not assessed by a complicated cost calculation. Finally, the directive may be modified as a result either of negotiations with an individual country or of a General Agreement on Tariffs and Trade (GATT) agreement.

3.5 Trends in Procurement for Offshore Oil and Gas Industries

In offshore projects, a pyramid of procurement hierarchies is normally formalized. At each stage in the project one organization vests procurement authority in another. For example, a syndicate of field licensees may nominate one oil company as operator. The operating oil company is then the client for a (number of) main contractor(s). The main contractor may, for example, head up design work himself but act as purchasing agent for goods and services including, for example, fabrication. Conversely, nominated items with long delivery periods may be purchased directly by the operating company and delivered directly to the fabricator. Further down the pyramid are many more sellers of goods and services who, in turn, purchase components from manufacturers or their agents. The offshore supplies industry is thus a vast heterogeneous business, with the only shared characteristic being some form of contractual arrangement with an oil company or its agent.

If other resources from the sea require projects with an economic impact comparable to one of the small- or medium-sized oil or gas fields in the U.K. North Sea, then its likely form of management, irrespective of ownership, will be modelled on present-day offshore projects. Oil companies are acknowledged as leaders in the development of professional purchasing.

As their industry has matured, oil companies usually have been able to obtain their specified requirements on time and at the keenest long-run price. In general, they will avoid becoming dependent on any one vendor. Thus, they will avoid or buy out exclusive intellectual property and seek to obtain specifiable goods or services from as many suppliers as will be sustained in a competitive marketplace. Oil companies are also leaders in the development of quality assurance systems. In the U.K., for example, 12 U.K.-based operating companies set up the Quality Appraisal Service Company (QUASCO) to conduct technical audits for prospective suppliers' production capacity, organizational resources, and compliance with safety and quality standards.

The above attributes are equally important outside the hydrocarbon industry and it is more than likely that any growth in other uses of subsea technology will obtain its commercial, as well as its operating, engineers from organizations used to oil and gas industry practice. Any catalogue of vendors for subsea technology will thus contain:

- project management organizations
- design contractors
- fabrication and assembly contractors
- goods and services contractors/ subcontractors
- manufacturers

Very few requirements for subsea projects are likely to be available off the shelf, and the volumes of goods are such that consumer-goods type assembly lines have limited potential. However, modern flexible manufacturing systems enable traditional jobbing shops to achieve the economies of scope that were once achievable only by large-scale operations.

3.6 Trends in Offshore Oil and Gas Precompetitive Research

The technology development discussed above is reinforced by generic research sponsored by individual governments and as part of the E.C. New Energy Technologies (THERMIC) program.

THERMIC has a 1991 budget of about $140 million to be spent on a variety of fields and sectors of energy research and demonstration projects in:

- rational use of energy
- renewable energy sources
- solid fuels
- hydrocarbons

The latter is relevant to ocean industry activities, as it includes projects for:

Exploration

(e.g., drilling methods and equipment, including automation and systems for data acquisition and handling)

Production

(e.g., offshore production plants):

- fixed structures (safety and reliability, and methods of removal)
- floating supports
- innovative techniques that can, by reducing investment costs, enable hitherto marginal fields to be brought into production
- submarine production systems, including the production of multiphase fluids
- production equipment, systems for automating offshore production plants, and processes concerned with the transport and treatment of flow
- submarine operating equipment and processes for carrying out work related to offshore hydrocarbon production

Transport

(e.g., techniques and processes for transport processed flow by pipeline and by ship including, in this case, loading installations)

Storage

(e.g., installations and processes for the storage of fluid products connected with production operations)

Projects are to be designed to prove the technical or economic viability of new technologies. They should have among their objectives the development of techniques, tools and processes designed to improve the efficiency of operations; and they should promote safety (e.g., through the use of robotics and telecommunications) and recognize the need to respect the environment.

Projects must appear technically and economically viable, but be difficult to finance because of perceived technical and/or economic risk.

Projects must be proposed and carried out by organizations in E.C. countries capable of promoting the supply and use of the technological developments for which support is requested. The Commission welcomes but, unless the project value is greater than $7 million, does not insist on proposals being made jointly by organizations in two or more Member States of the Community. Preference will be given to small- or medium-sized enterprises (SMEs).

Support will be in the form of a grant (with no requirement for repayment) of up to 40 percent (35 percent for dissemination projects) of the eligible costs of the project.

4. OCEAN SCIENCES AND MARINE ENVIRONMENTAL INDUSTRIES

4.1 The Ocean Sciences Market

This sector includes the provision of equipment and services for, predominantly, government-controlled marine science and technology laboratories engaged in national and international oceanographic and environmental programs. These include the World Ocean Circulation Experiment (WOCE) and the North Sea Project, as well as the activities of commercial organizations involved in ocean activities, excluding hydrocarbons and defence.

These technology areas include exploration, surveying and measurement technology (e.g., instrumentation, deployment systems, survey techniques, mapping, modelling, data management and analysis) and technology required for support of subsea operations (e.g., power, communications and navigation).

The market pull with regard to ocean science is the development of large international scientific programs and/or the development of enabling technologies. The main areas of increasing interest and likely development in the ocean sciences and environmental areas are:

- autonomous vehicles for passive and active sensing and data-gathering
- improved deep-towed systems
- medium-depth medium-scale side scan sonar
- improved expendable instruments
- improved swath, scanning and profiling instruments
- autonomous seabed research stations

[HMSO: CCMST Report — *Marine Sciences in The U.K., A Strategic Framework*, 1990]

A report, published by the Natural Environment Research Council (NERC) in March 1990, *Deep Sea Oceanography in NERC: A Report of the Expert Group Review Panel*, identified several areas of missing technology within the U.K. marine science area where future developments could stimulate new scientific work. These included:

- in-situ chemical sensor systems for tracer measurements
- interactive systems for controlling instruments on the ocean floor or within the water column
- low-light video systems for geological, geophysical or biological work on the ocean floor
- the general area of laser applications for controlled sampling of physical, chemical or biological properties
- remote manipulators for controlling and positioning equipment or sampling material on the ocean floor
- tethered vehicles for work on the continental slopes

The panel included experts from overseas and, therefore, it could be assumed that the requirements are not limited to the U.K. scientific establishment.

The development and application of autonomous underwater vehicles (AUVs) has received increased attention in science, the military and industry in recent years. The market is certainly not confined to Europe. The Deep Ocean Long Path Hydrographic Instrumentation (DOLPHIN) development will require a significant technological advance, especially in the area of power sources, before it can become a reality. In addition, the cost of R&D will be more than a single company, or even country, can invest on its own. Furthermore, as the main requirement identified in the relatively short term (excluding potential defence applications) is in support of such international scientific programs as WOCE, it could be important that R&D collaboration is also international.

With regard to markets, the WOCE project will require research ships making 24,000 precision hydrographic profiles along carefully designed trans-ocean lines. This is equivalent to one of the few first-class oceanographic ships surveying for 15 years [Dr. J. Woods, Director of Marine and Atmospheric Sciences Division, NERC, lecture on "New Technology for Ocean Sciences" — March 1991]. As it is expected that ocean circulation will be monitored routinely for climate prediction in the future, it is believed that the requirements for AUVs such as DOLPHIN, which is expected to undertake surveys at a tenth of the cost, will be enormous.

At an AUTOSUB meeting earlier this year, involving all scientific and industrial participants in the program, a figure of 300 such vehicles was predicted. Assuming a cost/price of $5 million, this suggests a $1,500 million market in the medium- to long-term for this area of oceanography alone. This does not include geophysical/geological surveying for scientific or commercial applications. This is obviously a large assumption, but the wider applications and their consequences on ocean exploration cannot begin to be estimated until the technological problems are solved.

4.2 The Marine Environmental Market

It is clear that the marine environment will be the strongest growth market well into the next century. The number of national and Pan-European R&D programs now under way is evidence of this. It is also becoming a fashionable subject for conferences and exhibition, with two major European conferences to be held this year: "Clean Seas '91," in Malta in November, and "Environmental North Sea Europe," in Norway in August.

Before looking at the available market information for this sector, it is useful to look at both the market applications and the types of equipment and services required. The main requirements relate to the monitoring, prevention and control of marine pollution. This can emanate from a number of sources, as follows:

Ships

- accidental leakage or discharge
- collision or explosion
- illegal dumping

Industrial Waste

- discharge into rivers and estuaries

Domestic Waste (Sewage)

- dumping at sea
- coastal outfalls

Mariculture

- accumulation of excess foods and excretion
- use of chemicals as a vaccine
- use of chemicals to dispose of sea-lice (dichlorvos)

Hydrocarbon Exploitation

- oil-based drilling muds
- drill cuttings
- pipeline leakage
- accidental discharge
- discharge of treatment water

Dredge Spoil

Mineral Extraction

Agricultural Run-off Into Streams and Rivers

- nutrients
- fertilizers
- animal slurry and silage
- atmospheric inputs from incinerators, power stations and general air-borne pollutants

The technology requirements include the following:

Services

- consultancy
- modelling (e.g., dispersal of pollutants)
- consultant engineering (e.g., outfalls)
- monitoring (e.g., surveys)
- pollution clean-up
- environmental impact assessment

Water Quality Monitoring Instrumentation

- towed platforms
- sensors
- data management

Instrumentation For Measurement and Control of Discharges of Possible Pollutants

- oil platforms
- ships
- industrial discharges
- coastal outfalls

Clean-Up

- booms
- skimmers
- filters/shakers for drill cuttings
- dispersants

Clean Technologies

- water-based muds

These markets, especially those related to monitoring of water quality or prevention of pollution, are in an early stage of development. The development of these markets is closely associated with the introduction of national/European legislation.

United Kingdom and General

The U.K. Coordinating Committee on Marine Science and Technology (CCMST) estimated a $600 million per year market in the marine environmental protection industry, including oil pollution clean-up. Total current U.K. expenditure on R&D is approximately $140 million per year, of which one-third is private sector expenditure, responding either to environmental protection requirements or exploiting near-market opportunities for goods and services. The majority is spent by the hydrocarbon and construction industries.

The balance, approximately $90 million per year, is spent by government departments, statutory authorities, research councils and the E.C. This includes monitoring and other mandatory activities to meet statutory responsibilities, which are not strictly R&D.

It is extremely difficult to obtain market statistics in the ocean industry area because official statistics, such as the SIC classification, do not usually distinguish between marine- and land-based equipment/instrumentation or services. However, the CCMST attempted to make some estimations, based on these statistics, and was able to calculate the following specific U.K. sales in the ocean sciences and marine environmental sectors:

Table 7

U.K. Sales in the Ocean Sciences and Marine Environmental Sectors

	Sales/$M
Environmental Protection	
• oil pollution control	38
• non-oil pollution control	578
• environmental data services	11
• disposal of waste, including coastal outfalls	875
Consulting engineering	114
Diving, including equipment	13
Metocean surveys	18

The CCMST report showed that the main areas of increasing interest and likely development, in the ocean sciences and environmental areas, were:

- engineered waste disposal on continental shelf and in deep ocean
- modelling of flows and dispersal of pollutants on shelf, coasts and in estuaries
- sediment transport-retention of nuclides and other contaminants in sediments
- chemical sampling and measurement at very low concentrations
- autonomous ROVs for chemical and environmental monitoring

In the area of discharge of sewage into the marine environment, the likely cost to the U.K. of achieving 100 percent compliance with the E.C. Directive on the Quality of Bathing Beaches was estimated in 1990 as $2,500 million. The estimated cost to implement the policy of higher treatment standards has been estimated to be a further $2,600 million [Metocean Consultancy Ltd: *Newsletter*, Spring 1991].

A recent study by TNO, in the Netherlands, for the World Bank and European Investment Bank, estimated that it would cost $16 billion to clean up the Mediterranean Sea as a result of pollution [TNO *Newsletter*, February/March 1991].

With regard to instrumentation for monitoring of water quality, in the U.K. two authorities have been set up with statutory duties and responsibilities relating to the environmental quality of controlled waters. In England and Wales, this body is the National Rivers Authority (NRA) and in Scotland, the equivalent bodies are the River Purification Boards. Controlled waters cover all shallow waters including rivers, reservoirs, underground waters, estuaries and the sea to a distance of three miles from the shore. This responsibility also includes the maintenance and improvement of fisheries.

Disposal of effluents from industrial firms and sewage treatment works in liquid form to water courses is permitted only if consent has been obtained from the NRA. Apart from the water and sewage treatment companies, industry is not presently required to carry out self-monitoring and, therefore, the NRA carries out its own monitoring programs. This is expected to change as a result of the *Environmental Protection Act*. However, the general view is that the reliability of automatic on-line monitoring instruments in the U.K., or elsewhere in the European Community (E.C.), is still below that necessary for continuous monitoring.

It is estimated that the market turnover for instrumentation, control and automation technology in the water industry is in the order of $28 million to $35 million, with an annual growth rate of four percent to seven percent [Report by City University for Chemical Sensors Club, Lab of the Government Chemist, U.K.] The European market is estimated to be $150 million.

Problems experienced with on-line monitors include:

- fouling of probes
- inaccurate and unreliable information
- existing probes perceived as incapable of accurate measurement of ammonia, undermining the practicality of the monitor
- scepticism regarding self-calibration

Clearly, NRA is moving toward standardization of monitoring equipment. Developments include:

- Hand-held multiparameter monitor — The monitor will be used for effluent control and pollution incident prevention and, for fresh water applications, measures six basic parameters — pH, ammonia, dissolved oxygen, conductivity, turbidity and temperature. For tidal waters, only four parameters will be measured — dissolved oxygen, conductivity, solids and temperature. The approximate price of such a system would be $4,000, and around 700 systems will be deployed by NRA alone.
- Transportable remote continuous monitor with logging capability — It is intended that such a monitor would be left unattended for one month. The price would be approximately $9,000.
- Fixed station remote continuous monitor using mains power — The price range would be $35,000 to $50,000.

In the longer term, it is proposed that a substitute for the laboratory-based biochemical oxygen demand (BOD) test for deployment in automated monitors be developed. It is believed that total organic carbon (TOC) monitoring might be such a substitute.

As a consequence of EEC Directives and implementation of the polluter-pays principle, every coastal outfall in the Member States could require on-line monitoring instrumentation. It is estimated that there are approximately 100,000 such outfalls (there are approximately 250 in the Forth Estuary in Scotland alone). Assuming that the price of instrumentation is reduced to $20,000, this suggests a potential market of $2,000 million for monitoring instrumentation alone.

Market projections for the year 2000 are available from the U.K. Department of Trade and Industry for monitoring equipment for the measurement, process control and analysis of water in an environmental protection context. The equipment is not limited to marine waters — it includes sewage treatment as well as domestic and inland waters — but it does give some indications of total figures. Furthermore, it demonstrates the wider applications/markets for this technology.

Table 8

U.K. Market Projections for Monitoring Equipment to the Year 2000

	$M
Belgium	42
Denmark	26
France	294
Portugal	25
Spain	150

Additional information on specific countries is as follows:

Germany

Federal government expenditure on environmental pollution in 1987 was $3,400 million of which expenditure on water/waste water pollution was $2,000 million (59 percent). Additional private-sector expenditure on the latter was $200 million. This expenditure is mainly related to construction of waste treatment plants and outfalls. There will be a consequent requirement for monitoring and control instrumentation and services.

Total expenditure on environment in western Germany was forecast at $24,000 million in 1990. Environmental restoration of eastern Germany will cost $120,000 million in total. It is forecast that environmental protection expenditure will increase by six to eight percent annually until the year 2000, including expenditure on water protection, waste disposal, measuring devices and regulation technology [U.K. DTI (Export Data Branch): *Environmental Export Opportunities*, April 1991].

Ireland

The government decided to eliminate untreated discharges of sewage from coastal towns by the year 2000, requiring investment of $700 million [U.K. DTI (Export Data Branch)].

Italy

The coastline of Italy is subject to pollution in many areas. The Adriatic Sea, in particular, is affected because of the River Po discharges into it. Pollution is very severe in the North Adriatic, with massive growth of algae and the lack of oxygen causing damage to fishing; the tourist industry is threatened. It was estimated that the phenomenon of algae caused a reduction in income of $2,600 million in 1990. Total expenditure on all urgent environmental problems, including air, waste and water is estimated at $60,000 million by 2000 [U.K. DTI (Export Data Branch)].

Portugal

From 1991 to 1994, Portugal will receive $140 million in E.C. aid to invest in the prevention and control of marine pollution. Of this, $18 million will be spent to provide ports with amenities and equipment to combat oil slicks and toxic waste spillages, to clean up beaches and coastal areas, and to build ballast water storage treatment units at ports. The total will also include a substantial sum for building and equiping laboratories to control environmental pollution [U.K. DTI (Export Data Branch)].

Spain

In 1988, the Spanish Chambers of Commerce Council estimated that the country's annual expenditure on all forms of pollution needed to grow from $1,400 to $4,600 million to bring Spain up to E.C. environmental standards. Marine pollution from rivers and estuaries requires significant investment in treatment plants and outfalls. An expenditure of $2,500 million is needed to solve the waste disposal problem.

4.3 Competitors

Major suppliers of equipment and services in the ocean sciences sectors are predominantly in the U.K., Germany and France. Major competitors outside the E.C. are in Norway and the U.S.

Competitors are predominantly small independents or subsidiaries of larger companies, e.g., GEC-Marconi and Dowty (U.K.), Thomson (France), Krupp (Germany). In the service area, there is also a competitive university sector supplying consultancy and survey operations.

In response to military expenditure cut-backs there is a growing trend for the major underwater defence contractors to consider the civil markets more seriously. In the U.K., GEC-Marconi is developing a very dominant position, similar to Thomson in France, as a result of its acquisitions of Plessey Marine and parts of Ferranti. Although it is doubtful that the larger contractors will be able to compete on low cost equipment, they have the financial, technical and, now, the manpower resources to compete for larger contracts, such as underwater vehicles and large sonar systems.

This trend is not limited to large companies. There are also a number of smaller, predominantly defence, contractors considering diversification. This is also true of the oil and gas suppliers, especially in the U.K., who are looking to apply technologies developed in the areas of vehicles, subsea electronics and other instrumentation to other marine markets.

The instrumentation markets are very well differentiated, with a large number of very competitive niche markets.

A key area identified in the ocean sciences sector is that of AUVs. This is an area in which Canadian companies also have potential. Within Europe, only two countries have an interest: the U.K. and France. In France this has been led by IFREMER, with ECA as a subcontractor for constructing the EPAULARD AUV. Within the U.K., considerable interest has been generated by the NERC AUTOSUB project by ARUS, and by a perceived military interest. A number of companies are active in this field, including: GEC-Marconi, Vickers Shipbuilding (VSEL) and a number of manufacturers of subsystems. There is a relatively large number of ROV manufacturers, especially in the U.K., e.g., Slingsby, OSEL and Perry Tritech, though it is not believed they will play a part, in view of the large development costs and the stage of market development.

In the area of surveying systems the market leaders are Krupp Atlas, GEC-Marconi, Thomson, Simrad and Dowty. These are all large defence contractors who have developed major systems on the back of the military. For example, Bathyscan, an interferometric sonar developed by Bathymetrics Ltd. in the U.K., is now tied in with GEC-Marconi under a marketing agreement. The smaller companies with niche products have entered into marketing agreements with established industry leaders.

The leading European companies in the area of manipulators are Slingsby Engineering in the U.K. and Cybernetix — a subsidiary of Comex SA — in France.

The market for marine environmental equipment is similar to that for ocean sciences in that there are a large number of small niche suppliers.

The following (in Table 9) are the leading companies:

Table 9

Marine Environmental Equipment Suppliers

U.K.	
Chelsea Instruments	• fluorometers, towed vehicles (Seasoar)
Kent Ind Measurements	• water quality
Marex Technology	• HF Radar (OSCR), surveys, consultancy
Phox	• water quality
Sonardyne	• acoustics, especially positioning
Valeport	• currents, data buoys, water quality
Wimpol	• surveys
France	
Nereides	• data buoys, water quality
Oceano instruments	• acoustics
Suber	• currents, data buoys
Syminex	• systems
Germany	
Dr. Langer	• water quality
M.E.	• CTD
SIS	• CTD
WTW	• water quality
The Netherlands	
Datawell	• wave buoys

Table 10

E.C. Coastal States

Member State	Coastline (km)	EEZ Area (000 km²)
Belgium	64	2.7
Denmark	3,379	68.6
France	3,427	341.2
Germany	2,389	50.4
Greece	13,676	505.1
Ireland	1,448	380.3
Italy	4,996	552.1
The Netherlands	451	84.7
Portugal	1,793	1774.2
Spain	4,964	1219.4
U.K.	12,429	2336.5
EEC	49,016	7315.2

Source: International Ocean Institute: *Ocean Yearbook 8*, 1990
U.K. DTI: *Ocean Technology—International Programs and Markets*

4.4 Trends and Opportunities in R&D Spending

Introduction

The total coastline of the E.C. Member States exceeds 49,000 km with a potential Exclusive Economic Zone (EEZ), excluding overseas territories, of 7,352,000 km^2 (Canada: 4,698,000.) Eleven of the 12 members are coastal states.

In the marine environmental and ocean sciences sectors, the areas of greatest market potential relate to the protection and understanding of the marine environment. These include monitoring and control instrumentation for industrial and offshore oil platform discharges and the monitoring of water quality in estuarine, coastal sea regions. The driving force for this relatively recent requirement has been the number of E.C. Directives, International Conventions such as the ones in Oslo and Paris, the International Ministerial Conference on the North Sea and the resulting formation of the North Sea Task Force and, most importantly, the enactment of legislation with regards to water and marine pollution and the implementation of the polluter-pays principle.

Unlike the above, which is legislation-driven, a longer-term market will be technology-driven. This relates to measurement of the physical/ chemical/ biological characteristics of the oceans by autonomous underwater vehicles. The U.K. NERCs AUTOSUB program demonstrates the interest in and need for such vehicles to support the WOCE.

There is difficulty in quantifying these markets as no market statistics presently exist for the equipment and services that will be required. This, therefore, has to be inferred or broadly estimated from other information in the public domain. At present, most of the expenditure in this area is undertaken by government bodies through R&D in support of policy, to develop a better understanding of the environment, or in order to comply with existing national legislation, E.C. Directives or International Conventions.

The following offers a broad summary of information available on R&D spending on ocean technology projects or programs in the Member States, with relevance to the ocean sciences and marine environmental sectors.

Europe

European Community R&D is supported through the E.C. Framework Program in discrete program areas. Prospective participants must respond to a call for proposal, which is time-limited, and may be awarded a research contract for all or part of the project. Research topics should be pre-competitive (not near-market) and preferably collaborative among organizations in the Member States. The funding is predominantly through grants of up to 50 percent for companies and 100 percent marginal costs for higher education institutions, and research and technology organizations.

The overall objectives of the E.C. activities related to marine R&D in the marine area have been summarized as follows [Philippe Bordeau, Directorate-General for Science, Research and Development, CEC: IOTRC, Hawaii, January 1989]:

- To contribute to a better knowledge of the marine environment in order to improve its management and protection, and to predict change.
- To encourage the development of new technologies for exploration, protection and exploitation of marine resources.
- To improve coordination and cooperation among national marine R&D programs in the Member States, and to help increase the effectiveness of these programs through better use of research facilities.
- To strengthen industrial competitiveness in the relevant sectors.
- To provide the technical basis for, and encourage the development of, competitive norms, standards and design guidelines in view of the completion of the internal European market in 1992.
- To assist European participation in worldwide ocean programs.
- To facilitate training and exchange of personnel.

The main E.C. program is MAST, which aims to:

- improve the knowledge of the marine environment
- promote new exploration technologies for the protection and exploitation of marine resources
- coordinate national R&D programs

Table 11

MAST Expenditures

	MAST I	MAST II
Marine Science	30-35%	30-38%
Coastal Engineering	15-20%	12-18%
Marine Technology	30-35%	24-32%
Supporting Initiatives	10-15%	10-20%
Integrated Projects	0	10-20%
Dissemination/Exploitation	0	1.04 MECU
Administration	8.25%	5.00%

MAST I (1989 to 1992) had a budget of approximately $60 million and 45 projects were selected for funding. These projects covered a wide range of topics including: physical oceanography, ecology/biology studies, biogeochemistry, coastal ecosystems/morphodynamics, underwater acoustics, robotics and development of new sensors.

A second phase, MAST II (1991 to 1994), has now been agreed to but calls for proposals have not yet been made as expected. The delay is caused by procedural problems between the European Commission and the European Parliament. The substances of this and the other programs affected are not the concerns. MAST II is expected to be launched later this year.

MAST II has an increased budget of approximately $125 million, with a similar technical content; however, the geographical coverage of the program will be extended to include the northern Atlantic and subpolar Arctic seas.

A breakdown of the expenditure of the two programs is as follows:

The focus of marine technology is to encourage the development of existing and new instruments and enabling technologies. It will be subdivided into one of four main topics:

Instruments For Science

- To include the development of new sensors and instrument packages for autonomous long-term in-situ monitoring for surface, water-column and seabed measurements as well as real-time data transmission and two-way communication/control links.

Underwater Acoustics

- To include self-navigating of autonomous vehicles, determination of sea floor properties, the bathymetry underneath ice, detection of ice and icebergs, acoustic communications, sub-bottom profiling, and innovative acoustic measurements.

Enabling Technologies

- To include underwater signal transmission, imaging, advanced robotics and testing advanced materials/components for use in marine instrumentation.

Studies on the Exploitation of Marine Resources (Excluding Hydrocarbons and Fish)

- To include studies on environmental impact and necessary technologies associated with the exploitation of these resources, particularly in the deep seas.

Integrated projects will be concerned with developing models to describe the general circulation in seas and oceans and its variability on time scales of decades, and with improvement of our understanding of physics and ecology. Two integrated projects are proposed, one on the Mediterranean Sea and the other on the northern Atlantic and subpolar Arctic seas.

Other relevant E.C. programs are as follows:

Fisheries and Aquaculture Research (FAR)

- This aims to promote interdisciplinary initiatives for rational and scientific research on resources; to develop aquaculture; and to develop new methods and procedures for exploiting little-researched resources.
- The program has a budget of $42 million for the period 1988 to 1992.

Science and Technology for Environmental Protection/European Program on Climatology and Natural Hazards (STEP/EPOCH)

- Marine environmental research in this program covers a wide range of studies, from research on individual hazard pollutants to long-term basic ecosystem studies. These are mainly directed at better understanding the structure and functioning of coastal ecosystems. Two examples of the type of large interdisciplinary and transnational research being carried out are the European River Ocean System (EROS) 2000 and the Phaeocystis project.

- The EROS project involves 25 institutions from 11 Member States in an investigation of the major source of nutrients, and organic and inorganic compounds in European coastal waters.

- The Phaeocystis project is a multidisciplinary cooperative study involving nine institutes from five countries.

- Phaeocystis aims to establish a predictive multicompartment ecosystem model of the changes in North European coastal areas due to cumulative nutrient discharges from land. It examines the biological, physical and chemical interactions leading to the development of phytoplankton blooms of the species *Phaeocystis pouchetii*.

- The total program has a budget of approximately $140 million for the period 1989 to 1993.

Joint Opportunities for Unconventional or Long-term Supplies (JOULE)

- JOULE aims to develop energy technologies that take into account new and renewable energy sources, to increase security of supply and reduce energy imports and to contribute to environmental protection.

- The program has a budget of $146 million allotted from 1989 to 1992, though only a small proportion of that would relate to marine renewable energy.

THERMIC

- This program supports pilot or demonstration projects in the same technology areas as JOULE.

- The program has a budget of $700 million for the period 1990 to 1994.

EUREKA

The EUREKA initiative was launched in 1987 to encourage industry-led R&D in leading-edge, innovative technologies. It supports industry-based R&D through individual R&D projects and also through umbrella projects whereby a package of related projects is assembled to make a coherent program.

Projects require the participation of at least two organizations from different EUREKA member nations (i.e., the E.C. countries plus the EFTA countries plus Turkey).

Funding for EUREKA projects is provided to participating companies through their own national schemes, usually to a maximum of 50 percent, and not through a central budget, as with E.C. Framework.

EUROMAR

The main umbrella project for ocean/marine environmental instrumentation is EUROMAR.

The aim of the EUROMAR project is the development, application and successful exploitation of Europe's advanced marine technology having worldwide market potential, with the following terms of reference:

- Foster technological progress for integrated ecological management of the marine environment.

- Promote cooperation between industry and science in developing marine instrumentation, methods and operational systems.

- Improve the productivity and competitiveness in European marine industry for worldwide application.

The estimated costs of the EUROMAR program is $204 million in the years 1989 to 1993. Approximately 50 percent will be provided by the industrial participants.

It is also possible, in some circumstances, for other nations to be represented and, in fact, a Canadian company is involved in the MERMAID project.

EUROENVIRON

EUROENVIRON is an umbrella project aimed at supporting R&D in sectors of environmental management, including the following areas of interest to the marine/aquatic industries:

- the handling and disposal of industrial and agricultural waste
- water quality
- environmental management
- clean production technologies

One of the individual EUREKA projects is concerned with underwater advanced robotics. This is an Anglo/Italian project that was originally looking to develop two vehicles: ARUS, an autonomous survey vehicle and Work Inspection Robot (WIR), a robot capable of IMR operations on fixed offshore platforms. The Program Definition Study for each vehicle cost approximately $2 million, but only the WIR vehicle is proceeding through to subsystem development. The total estimated cost of developing the prototype WIR is $20 million.

United Kingdom

The following are statistics obtained from the *Cabinet Office Annual Review of Government Funded R&D 1990.* It provides an idea of trends in some departments, with the most interesting being the Department of Environment. The figures relate to all environmental protection, not just marine, but indicate the importance of this area. The overall budgets and plans for each department, relating to the ocean sciences and marine environmental sectors, are shown in Table 12.

U.K. marine science and technology is the responsibility of a large number of government departments with the following activities and expenditure:

Department of Trade and Industry (DTI)

Wealth From The Oceans Program

- The program aims to encourage the development of U.K. collaborative precompetitive research into the enabling technologies for surveying, exploration, development and management of the oceans and their resources.
- The total budget is $35 million (55 percent industry, 45 percent DTI) for the period 1989 to 1993, with funding up to 50 percent.

Table 12

U.K. Budgets (in $000) for Ocean Sciences and Marine Environmental Sectors, 1989 to 1993

Department(s)	89/90	90/91	91/92	92/93
Environment (Env. Prot) (land, air and water)	20.7	32.1	34.2	34.2
Fisheries	24.0	25.5	26.5	27.5
NERC	29.6	30.9	32.5	30.8

Environmental Technology Innovation Scheme (ETIS)

- ETIS is a joint endeavour with the Department of the Environment (DOE) that aims to encourage innovation, improve environmental standards and help users or suppliers of environmental technology to become more competitive.

- The total budget is $7 million per year, with funding up to 25 percent for single companies and up to 50 percent for collaborative proposals.

Environmental Management Options Scheme (DEMOS)

- DEMOS aims to promote the widespread adoption of best practice technologies with broad potential for environmental benefits, especially amongst SMEs.

- The total budget is $8 million, with funding up to 50 percent for collaborative proposals.

Table 13

Expenditure in Marine Sciences

	$000
Department of the Environment (DOE)	
Disposal of radioactive substances	
• deep ocean disposal	88
• coastal discharges	875
Environmental Protection	
• toxic substances	341
• North Sea inputs	980
Geological studies	
• including offshore aggregates	360
Hydraulic engineering (e.g., waves, currents)	
• sediments on coasts, ports, harbour	1300
Water Directorate	
• sewage and sludge	485
• Environment Quality (EQ) objectives	140
• estuarine and marine pollution	485
• health, microbiology	217
Department of Transport (DTP)	
• oil pollution at sea	814
• oil pollution on shore	268
• chemical spillages at sea	592

Table 13 cont.
Expenditure in Marine Sciences

	$000
Department of Energy	
Petroleum Engineering Directorate	
• Offshore Safety	
oceanographic projects	585
• Environmental Protection	
surveillance of oil spills	315
Wave Power	
• small-scale low-cost wave power	291
• U.K. shoreline wave energy resource	96
Tidal Power	
• Mersey Barrage — feasibility	394
• Severn Barrage — development	193
• Conwy Barrage — feasibility	131
• Other (e.g., generic R&D, consultancy, environmental impact)	798
Ministry of Agriculture and Fisheries Department (MAFF)	
Aquatic Environmental Protection	
• radioactive waste disposal	6582
• non-radioactive waste disposal	6010
Marine Fisheries	
• demersal fish stock assessment	6365
• pelagic and industrial fish stock assessment	3120
• shellfish stock assessment	1446
• multispecies systems	908
Scottish Office Agriculture and Fisheries Department (SOAFD)	
Aquatic Environmental Protection	
• non-radioactive waste disposal	4170
Marine Fisheries	
• demersal fish stock assessment	2991
• pelagic and industrial fish stock assessment	3952
• shellfish stock assessment	1381
• multispecies systems	2480
• fish capture	1762
Ministry of Defence (MOD)	
• physical and chemical ocean environment	13808
• seabed studies	928
• under-seabed studies	298

Other U.K.-government budgeted expenditure in areas of marine science and technology appropriate to the ocean sciences and marine environmental sectors budget for the years 1989 to 1990 (unless stated) were as follows:

NERC

AUTOSUB Community Research Program

This is a project to develop autonomous, unmanned, long-endurance vehicles capable of collecting oceanographic data. The two systems being considered are Deep Ocean Geological/Geophysical Instrumented Explorer (DOGGIE) and DOLPHIN.

DOGGIE will carry side-scan sonar, sub-bottom profiler and magnetometer, and will be designed to operate with a range of 6,000 m at 200 m to 500 m above the seabed.

DOLPHIN will be a seven-metre long vehicle weighing five tonnes, with a range of 6,000 km and a depth capability of six km. It is proposed that the vehicle will ultimately undertake physical, chemical and biological measurements during trans-ocean hydrographic sections.

The aim is to develop a generic prototype in order to prove the concept of autonomy in a scientific mission in 1995. The cost of an operational DOLPHIN is estimated at $35 million (1991 prices).

North Sea Project

This is a $26 million, five-year program to survey and then model the physical properties of the North Sea on a seasonal basis.

Expenditure

The total expenditure by NERC in the area of marine science for the years 1988 to 1989 was $60 million.

Marine Technology Directorate Ltd. (MTD)/Science and Engineering Research Council

MTD is a company limited by guarantee. It was formed by the SERC with funding from DOE, DTI, MOD and industry, to support — among other things — university research in marine technology, using predominantly SERC but also industry funding.

In the areas relevant to the ocean sciences and environment sectors, expenditure in 1988 to 1989 was as follows:

Table 14

Ocean Science and Environment Expenditures

	$000
Underwater technology	961
Ocean resources	193

Germany

In western Germany each of the 11 Landers are responsible for running and funding its own research within universities or Lander Research Establishments.

More important to this study, however, is the federal research program coordinated by the Federal Ministry for Research and Technology (BMFT). Its remit covers the fields of basic research, applied research, and technological development and innovation. The largest centre for marine technology R&D under federal control is the GKSS Research Centre.

The GKSS Research Center, a limited liability company, has an annual budget of approximately $60 million and employs 800 people (1989), funded 90 percent by the Federal Republic (BMFT) and ten percent by the four coastal states of Bremen, Hamburg, Lower Saxony and Schleswig-Holstein. Its R&D is performed in the public interest and is related to the future requirements of the marine industry. Its main areas of activity are underwater technology, especially focussed on manned and unmanned diving techniques.

Other research establishments of interest are the Alfred Wegener Institute for Polar and Marine Research, founded in 1981, and the Institute for Marine Research in Bremerhaven. Their joint budget for 1987 was $53 million, also funded 90 percent and ten percent by BMFT and Lander State [BMFT: *Report of the Federal Government on Research 1988*].

In order to promote applied research in various fields of marine technology and to make results accessible to the practising engineer, Gesellschaft zur Forderung der Meerestechnik, g.V. — Society for the Promotion of Marine Technology (GMT) was constituted in 1984 in Hamburg as a technoscientific society. Members include industrial companies, consultants, associations and scientific institutions that encourage and sponsor R&D work in marine technology.

In September 1988, there were 67 members of GMT, including three industrial associations, of which 12 were involved in underwater technology and 11 in environmental engineering. At that time, it had seven technical committees operating:

- basic research
- design procedure
- chemical engineering
- ice technology
- underwater technology
- environmental engineering
- measurement and control

Between 1986 and 1988 GMT initiated 19 collaborative R&D projects costing $11 million (78 percent industry, 22 percent universities). [Europe and Sea Conference, Hamburg, 27-29 September 1988].

A further research establishment with industrial links is GEOMAR, a research centre for marine geosciences founded in 1987 and funded by the BMFT and the Schleswig-Holstein Lander. Geomar Technologie GmbH was founded in 1988 to provide marine geoscientific services as well as to operate the research centre. The shareholders of this company are the Geomar Enterprise Association — an association of SMEs active in marine technology — and larger German companies also active in this area, including AEG, Krupp-MAK and Preussag.

A similar organization is TERRAMAR, an interdisciplinary centre for shallow and coastal water research and protection.

In 1988 the federal budget for these and other marine R&D activities was as shown — the vast majority was through BMFT [BMFT 1988]:

Table 15

Marine and Polar Research

Marine Research	$53 million
Marine Technology	$55 million
Polar Research	$36 million

The above totals also include support for industry projects. In 1987, BMFT supported marine technology projects totalling $27 million, of which industry provided $14 million (52.4 percent) [BMFT 1988]. This included support of German involvement in EUROMAR.

A factor on future budgets will be the effect of German unification on public spending outside that relating to eastern Germany. However, this is still uncertain as pollution problems in the Baltic may dictate increased spending to bring the area within E.C. Directives.

France

Marine science and technology in France is coordinated within the Ministry of Research and Technology by the Coordinating Committee for Marine Technology Research Programs (CCPRTM). The budget for 1988 was approximately $220 million. The main organization through which the government promotes marine science and technology is the Institut français de recherche pour l'exploitation de la mer (IFREMER), a government agency that coordinates, funds and conducts marine research and is, in turn, funded by the French Ministries for Research and Technology and for the Sea.

In 1987, IFREMER's total budget was about $160 million, of which 80 percent came from public funds, with the remainder generated internally. IFREMER can also take equity positions in firms and sell equity in its own spin-off companies; as a result it derived FF160 million (160 million French francs) from equity participation payments.

Scientific research is split into three major program areas: living resources, which absorbs over 20 percent of the budget; engineering and technology (about 18 percent); and environmental research (about 18 percent).

With most of the French marine R&D being carried out in IFREMER, the Agence nationale de valorisation de la recherche (ANVAR) and IFREMER recently signed an agreement to enable SMEs to commercialize technology developed within that organization. Support comes via interest-free loans with repayment dependent on success of the project. If the project fails there is no repayment due.

Support for French involvement in EUROMAR is provided through the general Ministry of Research's Research and Technology Fund.

The Netherlands

Government funding of research in the Netherlands is administered by the Netherlands Industrial Council for Oceanology (IRO) and the National Foundation for the Coordination of Maritime Research in the Netherlands (CMO), responsible to the Ministry of Economic Affairs. In 1986, the CMO had a budget of $13 million ($11 million in 1985) [OECD: *Reviews of National Science and Technology Policy*, Paris, 1987].

IRO-funded research concentrates mainly on fixed-to-the seabed offshore technology, while CMO coordinates research more relevant to the ocean sciences. Areas of marine R&D identified as requiring attention over the next five years [Adrian Richards: IOTC, Hawaii, January 1989] include:

ROVs

- possibilities and application of heavy work ROVs
- application of land robotics to underwater systems
- tetherless vehicles

Seafloor Surveys

- hydrographic surveys (sonar and mapping)
- in-depth understanding of the mechanism of the sand transport and distribution system along the coast and around coastal constructions, as well as changes in the system
- development of simple, easy to handle boring machines for taking samples

Marine research is carried out by a great number of institutions, though the largest are the Netherlands Maritime Research Institute (MARIN), responsible for both Shipbuilding and Ocean Engineering, and Hydraulics Laboratory (WL), responsible for hydraulics research, systems analysis, environment and navigation. MARIN is responsible to the Ministry of Economic Affairs, and WL to the Ministry of Transportation and Public Works. The 1985 budgets for these institutes were $21 million and $34 million, respectively.

A Memorandum of Understanding (MOU) exists between the Netherlands and the Provincial Government of Newfoundland and Labrador. In addition there is an MOU between the IRO and the Newfoundland Ocean Industries Association for cooperation in ocean technology.

Italy

Italy does not have a national marine technology program. Funding of research in EUREKA projects was through IMI, the national bank. There is presently a budgetary problem forcing Italian companies to pull out of EUROMAR projects: no national funding exists. Much of the marine research in Italy is funded through state-controlled companies such as ENI and its subsidiaries.

In view of pollution problems in the Mediterranean, especially in the area of the Adriatic Coast, public spending on research for protection of the environment has increased, doubling between 1987 and 1988 [CEC: *CREST Comparison of Scientific and Technological Policies of Community Member States—Italy*, EUR 11985 EN].

Greece

Research from basic through to industrial technology is the responsibility of the General Secretariat for Research and Technology (GSRT), an autonomous body within the Ministry of Industry, Energy and Technology. In order to solve the problems of technology transfer in some selected industrial sectors and to link research with production the GSRT created a number of technical-sector companies. One of these was the Company for the Development of Marine Technology (MARTEDEC). [CEC: *CREST Comparison of Scientific and Technological Policies of Community Member States — Greece*, EUR 11983 EN].

GSRT's role is to:

- Supply current scientific, technological and marketing literature; systematically publish industry-orientated information and provide data bank support.
- Prepare feasibility studies, assessments and audits from technological and techno-economic viewpoints.
- Assess R&D in technological terms in order to ensure that the results are put to commercial use.
- Implement research programs and projects (sometimes on a transnational basis) aimed at solving problems regarding the application and use of scientific and technological knowledge by enterprises, particularly in the industrial sector.

In addition, two research vessels have been obtained in order to carry out oceanographic and biological studies in the Hellenic Seas and to participate in several international research programs.

National spending on marine research rose from $1.3 million to $3.5 million between 1981 and 1987 [CEC].

Portugal

The priority ocean industries area in Portugal relates to fisheries and mariculture.

Spain

Oceanographic and fisheries research is carried out mainly by the Spanish Institute of Oceanography, for which the Ministry of Agriculture, Fisheries and Food is responsible. It has an annual budget of approximately $19.2 million (1988) and a staff of 400 distributed among seven laboratories and a headquarters in Madrid. The breakdown of the 1988 budget for specific activities was as follows [CEC: *CREST Comparison of Scientific and Technological Policies of Community Member States — Spain*, EUR 11981 EN].

Table 16

Budget Breakdown for Aquaculture, Fishery and Marine Research

Aquaculture	$2.9 million
Fishery resources	$2.5 million
Other marine research, including physio-chemical oceanography and marine geology	$1.2 million

5. UNDERSEAS DEFENCE INDUSTRY

5.1 The Market

Although no specific functional European Community role has yet been established, defence in Europe is coordinated through a number of mechanisms. The North Atlantic Treaty Organization (NATO) is likely to remain pre-eminent in its role, but other concepts based on organizations such as the Western European Union (WEU) and the European Commission are emerging. Table 17 outlines the general pattern of alliances. The NATO-based Inter-European Program Group (IEPG) is important in the development of equipment.

There is no very large European market for defence equipment. Customarily, there are separate purchases by national governments, primarily from national sources. The defence industry is, therefore, more fragmented than might be expected and it often relies on exports to support economically-sized production runs.

Although joint and common procurements are limited, NATO does attempt to coordinate specifications and there is a certain amount of collaboration in R&D.

With the exception of France, current budgets are static or cut back. The increase in the French budget is largely due to large programs for a new nuclear carrier and an expanded nuclear submarine fleet.

Table 17

European Community Countries and Alliances

E.C. Members	Also Member of NATO	Also Member of IEPG	Also Member of WEU
Belgium	X	X	X
Denmark	X	X	
France		X	X
Germany	X	X	X
Greece	X	X	
Ireland			
Italy	X	X	X
Luxembourg	X	X	X
The Netherlands	X	X	X
Portugal	X	X	X
U.K.	X	X	X
Possible E.C. members before 2000			
Norway	X	X	
Sweden			
Switzerland			

Table 18 compares the navies of the E.C. countries and Table 19 overall defence budgets of the same countries according to NATO definitions. These indicate the pre-eminence of France, Germany and the U.K., with Italy in the second rank. A characteristic of the "Big Three" in the Community is the high percentage of the budget spent on equipment procurement, which is not true of all the smaller navies.

Naval equipment procurement accounts for about a quarter to one third of the overall defence equipment budgets of France, Germany, the U.K. and Italy. Currently this totals in excess of $10 billion per year, though a high proportion of this is for capital equipment such as vessels (Table 20).

Export Markets

After the Union of Soviet Socialist Republics and the U.S., France is the largest exporter of defence equipment of all sorts, followed by the U.K. Table 21 shows overall levels for 1989 for the main exporting countries of the Community. Equipment exports are about half national purchase levels. With the exception of Spain, none of these — nor any others of the Community countries — are major importers of defence equipment. In 1989, Spain imported about twice its level of defence exports. The export market for underseas defence equipment, mostly outside Europe, is in the order of $3 billion per year.

Table 18

European Community Navies

	Naval Personnel (Excluding Reserves)	Fleet (Vessels in Commission and Under Construction)		
		Large Vessels (Corvette and Larger)	Submarines	Mine Warfare Vessels
Belgium	4,500	4	—	20
Denmark	5,400	3	—	9
France	65,000	50	26	32
Germany	36,200	23	36	58
Greece	19,500	17	10	16
Ireland	931	—	—	2
Italy	48,000	35	10	10
The Netherlands	16,000	14	5	26
Portugal	13,000	14	3	—
Spain	40,000	18	8	12
U.K.	63,500	50	30	41

5.2 R&D

The expenditure on defence R&D in general is primarily by the national governments, though significant spending in France and Germany in particular is attributed to industry and to institutes. These, however, tend to be indirectly financed by government.

The major spenders, shown in Table 22, are France, Germany and the U.K. Generally, France and the U.K. have kept broadly equivalent levels of expenditure at about 12 percent of the total defence budget. However, in the 1990 to 1991 budget, France has increased this to 15 percent. For Italy, it is less than five percent. Present levels of overall R&D defence spending for France and the U.K. are over $4 billion in each case.

German levels have been substantially lower than these, but there is some additional investment in R&D overall in Germany. A portion of this is defence-related work.

In the case of the U.K. in the current year, about $600 million is assigned to R&D in underseas defence — ship construction and underwater warfare — or about 15 percent of the defence R&D budget. On a pro-rata basis, this indicates naval R&D by France, Germany and the U.K. to be budgeted at between $1 billion to $2 billion per year.

R&D Programs

There is extensive collaboration in government programs between NATO members of the E.C. Individual nations also collaborate outside NATO. Current major collaborative underseas defence projects include:

- Sea Gnat Decoy System: U.K., Denmark and the U.S.
- Barra Sonar buoys: U.K. with Australia
- sonar buoy and active dipping systems: U.K., France, Germany and Italy
- coastal mine sweeping: Belgium, Netherlands and Portugal

Equipment and design requirements for subsystems associated with major R&D programs include:

- airborne decoy systems
- attitude controls and servo-systems, transponders
- launch/deployment mechanisms

Mine Countermeasures

Equipment supply and design opportunities associated with mine sweeping include: sonar and magnetic detection systems; passive and active decoy systems; degaussing systems; ROVs; ship, aircraft and land-based control systems.

Passive and Active Sonar Buoys and Dipping Systems:

- fibre glass and alloy bodies
- deployment mechanisms
- sonar sensors
- transmitters
- on-board processors
- reception, interpretation and display systems

Table 19

Overall Defence Budgets 1990 to 1991
European Community Countries (Omitting Luxembourg)

	Total US$M	**% on Equipment Procurement**
Belgium	4,330	10.2
Denmark	2,380	13.1 (1989/90)
France	39,080	20.0?
Germany	35,890 (1989/90)	19.0 (1989/90)
Greece	3,140	21.8
Ireland	Small	5.0? Variable
Italy	22,710	15.0
The Netherlands	6,790	18.3
Portugal	1,600	7.6
Spain	8,931	12.3
U.K.	35,000	22.0

Source: NATO and other

Table 20

Naval Equipment Procurement Budgets 1990 to 1991 (Approximate)

	$B
France	4.0
Germany	2.2
Italy	0.9
U.K.	4.6
Total	**11.7**

Table 21

Defence Equipment: Major Community Exporters

	Overall Exports 1989 US$M
France	2732
U.K.	1620
Germany	780
Italy	149
The Netherlands	631
Spain	404
Total	**6316**

Table 22

Government R&D Expenditure Defence Largest Maritime Powers Europe, 1988

	$B
France	3.75
Germany	1.09
Italy	0.60
U.K.	3.17
Total	**8.61**

Source: U.K. Cabinet Office, *Annual Review of Government Funded Research and Development.*

European collaborative developments are likely to be significantly extended by the European Cooperation for the Long-term in Defence (EUCLID) initiative. This was proposed by IEPG to establish a common European defence research technology plan following on from earlier IEPG activities.

Apart from government collaboration, there is a great deal of intra-industry activity in systems and equipment development through collaboration or mergers across national boundaries. Examples are a new sonar firm set up by Ferranti (U.K.) and Thomson (France), and the new electronic warfare system being developed by GEC/MATRA and Dassault Électronique.

5.3 Competitors

The major suppliers of underseas defence equipment and systems (excluding shipbuilding) shown in Table 23 reflect the predominant position of the U.K., France and Germany. Of these, only five — Thomson, AEG, Siemens, Krupp-Atlas and HSI — are in the top 100 international armaments suppliers. Whereas the U.K. and France are both major suppliers to the world market, Germany up till now has had a relatively small global presence. However, this is not true of non-nuclear submarine building, where Germany is a major supplier, particularly to Third World navies, giving obvious advantages to German equipment suppliers. Nearly all procurement of diesel electric SSKs by Third World navies is from Europe.

A degree of consolidation is taking place in response to the general actual and expected reductions in defence spending in Europe and the opening of national markets in 1992. The proposed merger of the missile activities (including marine systems) of BAC and Thomson CSF has not progressed. This is possibly due to the shrinking of defence markets overall, leading to European companies wanting to secure and protect their domestic niche markets, contrary to the expected trends toward common European procurement.

The effect in the market is that competition will be met increasingly from divisions of larger groups; niche market companies and contract R&D organizations, such as the Admiralty Research Establishment (ARE) in the U.K., will aggressively seek to link up with major manufacturers for specific product development and marketing.

Table 23

Major Underseas Defence Equipment Suppliers
European Community
(Omitting Shipbuilding)

Anti-Submarine Equipment including Sonar Systems	
Dowty	U.K.
HSI	The Netherlands
Krupp-Atlas	Germany
Plessey	U.K.
Smiths Industries	U.K.
Thomson	France
Mine Countermeasure Systems	
AEG-Telefunken	Germany
Krupp-Atlas	Germany
MBB	Germany
Mines, Torpedos	
BAe	U.K.
Marconi	U.K.
MBB	Germany
C3 and Monitoring Systems	
Dowty	U.K.
GEC-Ferranti	U.K.
HSI*	Netherlands
Krupp-Atlas	Germany
Logica	U.K.
Marconi	U.K.
SD-Scicon	U.K.
Siemens AG	Germany
Thomson	France

*Recently acquired by Thomson CSF

5.4 Import Strategies

The import of underseas defence equipment into Europe has been strictly limited. So has intra-European supply, with procurement by the larger navies of France, Germany and the U.K. and the second ranking navies of Italy, Spain and the Netherlands being predominantly from national industry. Some material and services have been provided as direct donations via NATO to smaller navies like those of Portugal and Greece. As shown earlier, only Spain is a major net importer.

Coordination even of specification of equipment, through NATO and other bilateral and multilateral programs, has been fraught with difficulty over several decades. Attempts, for instance, to obtain joint specifications for vessels and some sea-borne weapon systems have, after protracted discussions, generally "run into the sand." Limited centralization and coordination of procurement and support has been achieved through the NATO maintenance and supply agency (NAMSA) in Luxembourg. The activities of this organization apply only to some programs and NATO members — for instance, in the marine sector for torpedos for France, Germany, Greece, Italy, the Netherlands, Portugal, Spain and Norway, and Turkey outside the E.C. The criteria for procurement of materials and services through NAMSA is that Member States achieve definite cost-savings. Procurement is through international tender on a best-price basis, but only among member countries of the programs.

Technology transfer from outside Europe has been predominantly from the U.S. and has applied in niche market sectors rather than for major systems, for instance in the predominant supply for a type of sonar buoys. Superior technology, for instance in thermistor chains, specialist information and C3 systems by companies like TRW, have found European markets.

Market penetration strategies from North America in the defence sector overall have involved the acquisition of European companies: Cossor by Raytheon and Short Brothers by Bombardier, for example. Higher activity in the European market by American companies can be expected as these expand their market strategies in response to the national government cutbacks.

Collaboration is seen by European industry as becoming increasingly costly and ways are being considered to streamline the process of finding partners and joint bidding. The problem of "juste retour" or fair sharing of contracts between the Member States participating is a general obstacle, but this would not arise with NATO or bilateral projects involving Canada.

5.5 Procurement and Budget Trends

- Overall, defence spending in Europe is eventually expected to be cut by 25 to 30 percent with the individual countries keeping broadly in their current balance. However, naval expenditure could be cut to a lesser degree as naval forces are, for the most part, not included in the CFE Treaty provisions for the reduction of conventional forces in Europe. The navy also has a special role. For instance, underwater warfare is seen as a key element in securing sea lanes in line with the NATO policy of reduction of forces compensated by rapid deployment.

- The general NATO target increase in defence spending by member nations of three percent per year has been dropped. In real terms, the U.K. is aiming at a five percent reduction in the defence budget in the near term while Germany is aiming at a four percent reduction. France is the exception, proposing a three percent increase. Italy and the Netherlands are putting through major reductions.

- Procurement will tend to become more centralized and standardized as a result of growing European cohesion exemplified, for instance, in IEPG and WEU activities and the emerging role of the European Commission. This will drive common specification and procurement, including the Single (1992) Market mechanisms.

- On the technical side, the growing cost of more sophisticated weaponry, the value of which has been amply demonstrated in the Gulf War, is tending to outstrip defence budgets everywhere.

- There are signs, however, that in the defence sector the expected open European Market will not emerge directly in 1992, with delays being justified by national security requirements. This will delay the economic savings of as much as 20 percent on total defence procurement in the E.C. that was predicted by the Commission report on completing the Internal Market.

- Two policies in defence equipment production and procurement are evident. In the case of the larger suppliers, particularly France and Germany, domestic production capacity is maintained by exports. For the smaller suppliers, the cost of R&D and production of new systems forces import rather than domestic development. With the increasing cost of high technology items, the U.K. is also tending to move in this direction.

5.6 Market Growth Sectors

Mine Warfare

Mine warfare fits in with the new NATO perception of a change toward low intensity conflict and special operations and as an international terrorism threat. There will be special needs to develop and deal with more capable, intelligent mines.

An example is the joint Advanced Sea Mine development program between the U.K. and the VSA involving British Aerospace Naval Weapons Division and Marconi Underwater Systems.

Equipments opportunities in the marine warfare area in general could include: sensors; on-board computing, including experts systems; long duration power supplies; mechanisms and subsystem propulsion.

Surveillance

This has several aspects:

- Treaty verification, which may involve some underwater monitoring.

- Policing, including illegal immigration, fishery protection and narcotics control. (Illegal immigration by boat is emerging as a major problem as internal barriers in the Community are relaxed. Fisheries protection and management will become an important community initiative area, particularly as the Community expands and greater efforts are put into protection of EEZs.)

Examples of areas for expansion are the proposed upgrading of coastal radar networks, surveillance aircraft capabilities and the general field of underwater detection.

Equipment opportunities could lie with sensors, independent power supplies, and the supporting electronic communications' data handling, processing and display systems.

Submarine Equipment

There is a considerable expansion in non-nuclear submarines in smaller navies inside and outside the Community as these are seen to be more fundamentally cost-effective than surface vessels. A large part of the supply is of European origin, particularly from Germany.

The largest new SSK programs are being undertaken by the German IKL, HDW, Ferrostaal, TNSW partnership.

Apart from opportunities in naval architecture subsystems such as electrical, electro-mechanical and electro-hydraulic subsystems and coatings, special equipment includes escape systems, sensors and weapons control systems, deployable antennae and arrays.

C3 Systems

There is a general rapid upgrading of capability in the marine sector as in other sectors.

A particular development is the expansion in the size and capability of ocean environment monitoring and prediction systems like Logica's ODESSA, providing a near real-time three-dimensional ocean model over a wide area.

Closer integration and expansion of electronic information capabilities is providing opportunities for system and subsystem design, and for components for navigation and communication systems and for action information systems.

6. COASTAL INTERFACE

6.1 Markets for Coastal Defence and Marine Works

The markets for coastal defence works are a function of length of coastline and the impact of failure of defences on any parts of the coastline with a vulnerable hinterland. Most coastal defence systems include methods of shallowing the depth of the ocean at the interface with the shore. Exceptions are where channels are formed and maintained for navigating deep-draughted vessels into ports.

The need to maintain the commercial viability of ports is a worldwide problem. In most European countries, channel dredging and conservancy works are funded by national authorities. The U.K. is exceptional in that dredging and estuarial navigation aids are funded by the individual harbour authorities, with only coastal navigation aids paid for centrally.

The inset on navigable depth illustrates the type of product that would appeal to the European market. European policies with regards to navigational safety are usually coincidental with the International Maritime Organization (IMO) views on such issues as safety of life at sea (SOLAS). Traditional seafaring skills that go into coastal engineering activities such as dredging are retained in Europe, but the substitution of crew by Third World personnel (already a very advanced process in trading vessels) may also be changing the characteristics of the European coastal defence works industries.
The requirement for coastal defence works in Europe can be gauged from Table 24. The assessment of

Navigable Depth

In many ports, the bottom of the access channel is covered with fluid mud suspensions of density between 1.05 and 1.3. This causes serious problems for hydrographic surveying, for maintenance dredging and for navigating deep-draughted vessels. To establish the lower navigability limit a port authority must determine where, within the transitional zone between water and stiff mud, the navigable fluid mud ends and the non-navigable seabed begins. Traditional survey techniques such as lead lines and echo sounders do not measure the navigability of the suspensions.

One technique which gives an indication of channel depth is double frequency echo sounding. Generally, 210 kHz is reflected by the top mud level and 33 kHz passes through the fluid mud layer and is reflected by the hard bottom consisting of sand or stiff, consolidated mud.

Frequently, as is the case in big European ports like Rotterdam, Zeebrugge, Dunkirk, Bordeaux and Nantes and in other river estuaries in Brazil, Venezuela and Indonesia, the difference between the 210 kHz and 33 kHz can be several metres. This approach gives errors, especially after storms. After a storm, the fluid mud is enlarged by the resuspension of already consolidated layers and an apparent loss of navigable depth is registered whereas the real depth has probably increased, due to the resuspension of the mud particles from the bottom.

It is thus the rheological properties of mud of differing densities that determine navigability. This in turn requires continuous monitoring of mud density to establish a reliable measure of navigability. To date, the only reliable measure of density has used the attenuation of high energy (greater than 600 kcV) radioactive radiation. Acoustic measuring has to date produced ambiguous results.

Preliminary studies by Belgian port authorities suggest that this approach could save them the cost of dredging 1/2 m of material from their navigational channels. The worldwide savings are likely to be many millions of dollars. The potential market for an effective mud density measuring device is thus likely to be substantial.

vulnerable hinterlands is an order-of-magnitude estimate reflecting the impact of changes in maximum sea levels. The changes in sea level may arise from a number of sources:

- perhaps, a general increase in water in the oceans
- increased strengths of storms as weather patterns change
- local subsidence of land (as in the southeast of England)
- reconfiguration of estuaries resulting in greater tidal surge effects

Throughout Europe, coastal defence works are regarded as a public works activity with procurement subject to the open tender rules laid out in the E.C. Public Works Directive.

6.2 Technology for Coastal Defence and Marine Works

The supporting R&D for coastal defences and marine works are scattered throughout a variety of agencies and institutions within the E.C. Historically, the Rijkswaterstaat, the Dutch public works department responsible for flood control and navigational dredging, and the Dutch academic community, especially at Delft, have developed expertise in planning "mega projects." Similarly, for example, British, Belgian and French laboratories provide full modelling and calibration services for both coastal defences and marine works.

The principal opportunity for new technology lies in instrumentation, communication and recording systems. The example of the effective mud density measuring device given above shows the type of product which requires extensive R&D and is sought in Europe today.

A novel offshore engineering problem is the removal of offshore oil and gas equipment at the end of their working lives. Over the past 25 years a variety of steel and concrete structures have been placed in increasingly deeper water off the coast of Europe. In their design, no consideration was given to their subsequent removal. Simple economics suggests they should be left in place to deteriorate or be partially demolished down to safe navigational depth (say, 50 m below water line). However, there are significant ecological and fishing industry pressure groups anxious to see complete removal from the seabed of all artifacts that once contained oil or gas. To date, only small platforms or those that have suffered accidental damage, such as Piper Alpha, have been removed from their sites.

Table 24

Coastlines

	Total (km)	% of E.C. Coast	Vulnerable Hinterland Estimated %	as km	% of Total
Belgium	66	0.1	100.0	66	0.4
Denmark	3,380	6.7	70.0	2,366	17.1
France	3,427	6.8	40.0	1,371	9.9
Germany	2,390	4.7	70.0	1,673	12.1
Greece	15,021	29.8	10.0	1,502	10.9
Ireland	1,448	2.9	10.0	145	1.0
Italy	4,996	9.9	30.0	1,499	10.8
The Netherlands	451	0.9	100.0	451	3.3
Portugal	1,793	3.6	30.0	538	3.9
Spain	4,964	9.9	10.0	496	3.6
U.K.	12,429	24.7	30.0	3,729	27.0

7. DISTRIBUTION CHANNELS

7.1 Introduction

Although the objectives of legislation are to create a Single European Market, known as 1992, it is unrealistic to believe that countries outside the E.C. will actually be dealing with a single market. There may be harmonization of customs duties, technical standards and an effort to create a free market in public procurement but in terms of distribution, customer preferences/bias and customary practices, there are 12 distinct markets. Distribution channels in the U.K., with privatization of public utilities and free market philosophies in most areas, are very different from France, with its nationalized industries, centralized industrial strategy and protectionist attitudes.

Therefore, it is difficult to identify a common European distribution channel, and each E.C. Member State needs to be assessed individually.

The following provides an overview for each market sector.

7.2 Ocean Sciences

The distribution channel under this heading will invariably be the same in all states as it is in most other non-E.C. countries — the purchasers will be the laboratories or research establishments who are participating in specific scientific programs.

There is no doubt that these laboratories are customers of off-the-shelf items, where these are relatively inexpensive. However, in the U.K. especially, there is sometimes a bias by the scientists/users to develop their own purpose-built technology on the basis that the cost of the development is cheaper than buying a system from a commercial manufacturer. This is usually based on false accounting in that only the marginal costs, e.g., materials, are used in the calculation, and not labour costs or overheads.

Despite the above, the laboratories do look to licence out technology to manufacturers, and purchase the commercial product or seek collaboration with manufacturers through R&D programs, such as EUROMAR and MAST.

7.3 Underseas Defence

Efforts are being made to develop a strategy toward an open European defence market in order to obtain maximum value from equipment budgets and for ensuring the continued development of the European industrial base. This is being attempted through the creation of IEPG and EUCLID.

To encourage this, national requirements for the development, supply and maintenance of military equipment will be published in contracts bulletins throughout the members' IEPG. For example, the U.K. Ministry of Defence publishes contracts, in excess of US$1 million, fortnightly.

Although there are initiatives for joint procurement of defence equipment through NAMSA, many military procurements are through national governments.

Military requirements will be purchased in one of three ways:

- through contracts branches
- through research establishments, e.g., U.K. Admiralty research establishments
- through subcontracts placed by prime or main contracts with the large contractors, e.g., GEC-Marconi, Thomson

Within the U.K., the initial point of contact for companies looking to break into the defence market is the New Suppliers Office. To be able to start selling to MOD, the company must be on the Defence Contractors List. For an application to be successful, the MOD must be satisfied that the company is offering a product or service that MOD contracts for directly, is commercially viable, has an acceptable quality management system, and has the necessary facilities and technical competence. There is no reason to believe that the above procedures are widely different in other states.

The defence market is undoubtedly an area that will be the last, in many Member States, to open the doors to non-nationals. At present, states are able to claim national security as a reason not to comply with Public Procurement policies.

7.4 Offshore Oil and Gas

By far, the main market in the E.C. is the U.K., followed by Denmark, Germany, Italy and the Netherlands.

Distribution channels for the U.K. market are through the oil companies and the offshore operators, represented by the U.K. Offshore Operators Association, as well as main contractors for equipment or underwater services.

The U.K. Offshore Supplies Office has made great efforts to establish a U.K. offshore supplies industry through use of R&D support and also by ensuring that U.K. companies are offered full and fair opportunity to compete for North Sea contracts. They, therefore, receive a copy of offshore contracts and will encourage the use of U.K. companies where those companies are able to provide equipment or services at a competitive price. This pressure is exerted through the exploration licensing rounds.

Subsidiaries of foreign companies can be treated as U.K. companies if they can demonstrate that they are not sales offices, but are contributing to the economy as if they were U.K. companies, e.g., using U.K. subcontractors, employing U.K. nationals.

It is not yet clear whether the Utilities Directive will apply to upstream oil and gas activities; however, it is not believed the U.K. policy will significantly change.

The major customer in Denmark is DUC, which is made up of a number of international companies and A P Moller. DUC was originally set up as the sole licensee in the Danish sector; however, other U.S. and European operators are now participating. Approaches should, therefore, be made directly to DUC or its main operators.

Germany has no national oil or gas company, but it has a very strong and competitive industry. As a result of the relatively poor early response of German industry to the offshore engineering markets, the Germany Shipbuilding and Ocean Industries Association (VSM) was formed in 1987.

In addition, a special division of the German Machinery and Plant Manufacturers Association (VDMA) is the German Marine and Offshore Equipment Industries. This group has 250 member-companies, with a total annual turnover exceeding DM4 billion (four billion Deutsche marks), of which 65 percent includes exports, and represents more than 90 percent of all German marine and offshore equipment manufacturers.

In Germany, emphasis is placed on quality and price and the ability to service the market.

Similar to Germany, the Netherlands has no national oil and gas company but has a strong supply sector through membership of associations such as IRO, mentioned previously. However, the Netherlands has a stronger open market tradition. Also, it should be remembered that a MOU exists between the Netherlands and the Provincial Government of Newfoundland and Labrador. In addition, there is a MOU between the IRO and the Newfoundland Ocean Industries Association for Cooperation in Ocean Technology.

The Italian oil and gas industry is dominated by the state-owned holding company, EN1. It provides overall policy and guidelines, as well as planning, coordination and financial assistance to the groups' companies operating worldwide in exploration, development and manufacture, and engineering construction. Subsidiaries include AGIP, Microperi and Technomare. There is definitely a tendency to award contracts to nationals.

7.5 Marine Environment

The distribution system in marine environment is similar to that of ocean science. In addition, water authorities, oil companies, the petrochemical industry, manufacturers of waste treatment facilities, engineering consultancies and national regulatory authorities form part of the distribution system.

Within the water sector this suggests that the difficulties for small companies are immense; in France alone there are 14,000 companies supplying water and 4,000 private companies in western Germany managing water and waste disposal. However, one advantage is that many of the large contracts will be affected by the Utilities Directive and, therefore, open to tender. This provides notice of potential projects.

There are also efforts to standardize instrumentation, especially for the water industry. One initiative is that of the Water Research Centre (WRC), the research body for the U.K. Water Authorities. WRC are presently developing the "Water Industry Specifications for Process Control and Monitoring Instruments," series 7-00-00. The stated aims of the specifications are:

- To specify the instruments that would be required to measure and control a particular part of the process.
- To enable instrument manufacturers to develop instruments for applications specific to the water industry by modifying their existing range or developing new instruments as required to meet the more exacting aspects of the specification.
- To enable the water industry to use the specifications to purchase to a common industry-wide standard.
- To enable instrument evaluations to be carried out against water industry approved specification.

With the harmonization of technical standards in Europe and the high profile of WRC as a world authority, it is worth taking note of these specifications.

7.6 Coastal Interface

This is also an area covered within the Public Purchasing Directives and, therefore, there will be notice of tenders in the *Official Journal of the European Communities*. The major distribution will be through the large civil engineering contractors, port and harbour authorities, local councils and water authorities.

8. REGULATORY AND TRADING CONSTRAINTS

8.1 Introduction

In many ways, the development of the Single European Market will be advantageous to Canadian companies. The purpose of the Single Market is to encourage trade and competition by removing internal obstacles to the free flow of goods and services. For example, Member States have no customs duty tariff between them and have a common customs duty tariff against goods from outside of the E.C. As a result, goods which are free from customs duty in one part of the E.C., either because they originate there or because any duty on them has already been paid, are free to circulate within the rest of the E.C. without any liability to pay further customs charges when they move from one Member State to another. The E.C. common external tariff ensures that goods imported from non-E.C. countries are subject to the same customs duties wherever they enter the E.C.

The E.C. also has a common commercial policy covering trade relations with non-E.C. countries. The E.C. has obligations under GATT not to discriminate against the trade of other members of GATT and not to increase trade barriers without giving matching concessions in return. Member States are also bound by the obligations of the OECD.

The key regulatory and trading issues relating to ocean industry markets in the E.C. are:

- technical barriers
- tariff barriers
- public procurement policy
- informal barriers

8.2 Technical Barriers

An area of potential advantage to Canadian companies will be that of technical standards. Previously, E.C. Member States have had their own technical standards and regulations that have acted as a serious barrier to trade when these were different between the states. An objective of the Single European Market is to progressively eliminate this barrier through harmonization of standards so that any product that can be sold in any Member State can be freely marketable in all other parts of the E.C.

In order to achieve this new approach, directives relating to technical harmonization and standards are being agreed. One such directive deals with electromagnetic compatibility and applies to almost all electrical/electronic appliances, equipment and apparatus. In addition, a European Organization For Testing and Certification was formally established in April 1990 to encourage agreement on the mutual recognition of test results and certificates.

Another directive aims to avoid new barriers by requiring Member States to notify the Commission in advance of draft proposals for new technical standards. Although harmonization of technical standards will not happen overnight, it will prevent new barriers as many states rely on this non-tariff barrier within the E.C.

8.3 Tariff Barriers

As previously discussed, there is harmonization of customs duties throughout the E.C.. With regard to import duties on marine equipment, as envisaged by this study, the level of customs duty or requirement for an import licence is dependent on the specific classification code of the product. On average, import duties fall between five and ten percent. However, there are certain goods, appropriate to the Canadian oceans industry, that are liable to a temporary suspension of duty or can even be imported duty-free.

As of January 1991, customs duties were suspended for goods which were intended to be incorporated in ships, boats or other vessels (as specified) for the purpose of their construction, repair, maintenance or conversion, and for goods intended for fitting to or equipping such ships, boats or other vessels. These include drilling/production platforms, tugs and pusher craft, fishing vessels, yachts and pleasure craft, cargo ships, cruise ships and similar vessels for transportation of persons and goods.

Furthermore, scientific instruments and apparatus imported for non-commercial purposes by approved establishments engaged in education or scientific research can be imported free of customs duties. This is particularly relevant to equipment sold to be incorporated in national and international oceanographic research programs.

8.4 Informal Barriers

Although the Single European Market can deal with barriers relating to financial and technical matters, it will find greater difficulties relating to other factors, such as national feeling, language, vertical integration and hidden subsidies.

For example, Italy and France are very protectionist, while the Netherlands and Denmark have free market policies similar to those of the U.K. (apart from oil and gas). Germany, though overtly free market, tends to prefer German suppliers based on a perception of superior quality.

8.5 Public Purchasing

It is estimated that purchasing by governments and other public bodies accounts for as much as 15 percent of the E.C.'s GDP. There are now two directives in force. These are:

- the Works Directive, covering public works contracts
- the Supplies Directive, covering public supplies contracts

The rules exist to ensure that public procurement of supplies and works is open throughout the E.C. and that contracts above certain thresholds are awarded to the supplier or contractor who offers the most economically advantageous tender. Contract notices must be published in the *Official Journal of the European Communities.*

A further directive to come into force on 1 January 1993 will apply new E.C. public purchasing rules to utilities in sectors previously excluded, i.e., water, energy and telecommunications. This rule applies to public bodies and to private undertakings that operate on the basis of special or exclusive rights. It is thought that this might include offshore oil and gas contracts. However, and this is important to Canadian companies, purchasers will be allowed to reject a tender where less than 50 percent of the value of the products is of E.C. origin. In addition, tenders where 50 percent or more of the value of products is of E.C. origin will have to be preferred if they are equivalent to tenders where less than 50 percent of the value of the products concerned is of E.C. origin. The Directive defines equivalent as being up to three percent more expensive.

All the directives apply to contracts above defined thresholds: 200,000 ECU for supply contracts, 134,000 ECU for supply contracts subject also to GATT rules and five MECU (five million ECU) for works contracts.

Military equipment is excluded from the Public Procurement Directives on the basis of security; however, it is the intention that there should be an open European defence market.

9. CANADIAN OCEAN INDUSTRY CAPABILITY

9.1 Introduction

Canada is a recognized leader in many areas of ocean industry, particularly in the supply of ocean technology services and equipment. In this section, brief sketches of Canadian capabilities are presented to provide a background against which new strategies to penetrate the European market can be formulated in light of the 1992 changes.

Canada's best ocean industry strengths relate primarily to cold ocean activities. Some of these strengths are as follows:

- experience and knowledge of the cold-ocean environment and its impact on engineering design and on operating procedures
- operations in and around sea ice in the Arctic and sea ice and icebergs on the East Coast involving remote sensing, marine communications and navigation aids
- ice-strengthened cargo vessel design and operations
- Arctic exploratory drilling from innovative fixed and mobile platforms (ice islands, gravel islands, etc.)
- East Coast exploratory drilling from mobile platforms (drillships and semi-submersible drillings)
- conceptual and preliminary design of petroleum production facilities and transportation systems for ice-infested areas
- underwater equipment and services (diving, ROVs, semi-autonomous underwater vehicles, etc.)
- environmental contingency plans, clean-up and protection in ice and cold water conditions
- facilities and technology for modelling the effects of ice on ships and facilities and testing the effects of low temperatures on equipment
- utilization of high technology in the development of cold-oceans instrumentation

Seven major capabilities are described below. They are:

- offshore oil and gas
- marine transportation
- ocean sciences/R&D
- undersea defence
- environmental
- communications and remote sensing and
- underwater services

The descriptions are not meant to be all inclusive but they do present many of the key players.

9.2 Oil and Gas

For more than 30 years, oil and gas exploration and development has been under way in Canadian cold oceans. Initially, it was a relatively modest effort, but the energy crises of 1973 and 1979 to 1980 led to a considerable optimism regarding the future potential of the Arctic and offshore Eastern Canada as a secure and reliable supply of energy for North America. Despite fluctuating political and economic uncertainty affecting developments, a world-leading cold-ocean oil and gas technology expertise has developed in Canada.

The Arctic, with temperatures ranging from 40°C to 79°C, together with the eastern seaboard, presents one of the most challenging offshore oil and gas exploration and development environments in the world. This industry in turn has provided a major stimulus and market for a wide range of other cold-ocean technologies. Dominated by the major oil companies including, among others, Amoco (which acquired Dome Petroleum), Petro-Canada, Esso, Mobil Oil and Gulf, the industry is poised for an upsurge due to the rising (although volatile) prices of oil and the recent signing of the Canada/U.S. Free Trade Agreement, which provides the U.S. with secure access to Canadian energy sources. Significant improvements by Canadian firms in the cost-effectiveness of resource development have also sparked renewed interest. The technologies are many and varied and range from year-round surface drilling systems to a conceptual subsea oil production facility under the ice.

Gulf Canada Resources Limited, of Calgary, has been a leader in oil and gas development in Canada for over 75 years. With such experience behind it, Gulf Canada has developed a state-of-the-art drilling system that sets the standard for the industry. To support this activity, Beaudril of Calgary, Gulf's contracting subsidiary, has a fleet of two specially designed drilling rigs and four Canadian Arctic Class 4 support vessels. One of the rigs is the first single-piece deep-caisson vessel designed for bottom founded year-round drilling operations in Arctic waters. The other is a floating rig designed for extended season drilling from the late thaws to early freeze-up.

Canadian Marine Drilling Limited (CANMAR) of Calgary, wholly owned by Dome Petroleum, has successfully met the challenges to offshore exploration drilling presented by Arctic waters since 1976. In over a decade as the leading operator in the U.S. and Canadian Beaufort Sea, CANMAR has gained considerable offshore Arctic experience including operation of a fleet of ice-strengthened drillships; designing, constructing and operating year-round drilling systems such as the single steel-drilling caisson (SSDC) and MAT (a steel bottom-founded base), together known as the SSDC/MAT; and managing integrated ice-breaking, marine support, transportation and maintenance repair facilities. CANMAR is the leading contractor in the Beaufort Sea, having drilled 27 of the 33 wells drilled from floating units in the U.S. and Canadian Beaufort Sea by the end of 1988. In total, CANMAR has drilled approximately 75 percent of all wells drilled from floating and bottom-founded units in the U.S. and Canadian Beaufort Sea.

Panarctic Oils Limited of Calgary has developed a pioneering concept of the first subsea oil producing facility under Arctic ice. The plan calls for a plant to be constructed on the ocean floor that would draw oil from the seabed and then transport it beneath ice in submarine tankers. The required technology exists at this time.

A significant Canadian capability exists in offshore exploration and drilling based on over 20 years of activity off the coast of Newfoundland and Nova Scotia where the conditions are similar to those of the North Sea. Many companies located on the East Coast but also in Ontario, Alberta and British Columbia have worked on various aspects of the industry including semi-submersible, drillship and jack-up marine operations, diving, material supply, geophysical and geological surveys, geotechnical analysis, weather forecasting, ice and iceberg management, oceanographic data collection, etc.

One major cold-ocean oil and gas success story is the 1990 approval of Mobil Oil's Hibernia Development Project located on the Grand Banks off Newfoundland. Together with joint venture participants Chevron Canada Resources, Gulf Canada Resources and Petro-Canada, Mobil is developing the Hibernia oil field that has proven and probable reserves estimated at between 525 million and 650 million barrels of oil. The project is an enormous opportunity for the cold-region ocean industry involving the equipment and services of many Canadian companies.

9.3 Marine Transportation

A considerable marine transportation expertise has developed in Canada because marine travel represents an essential and safe means of transporting goods to and from northern communities and remote sites. Apart from the more routine southern traffic, current estimates put the number of vessels operating in the Canadian Arctic each year at approximately 100. These vessels, involved with oil and gas exploration, are concentrated primarily in the Beaufort Sea and in the Eastern Arctic. Ship movements in the Eastern Arctic are most often involved with the transport of grain from Churchill, minerals from the Nanisivik and Polaris Mines and oil from Bent Horn, or are involved with community and industrial resupply.

On Canada's East Coast, the activities relate primarily to ice-breaking operations for cargo vessels and to offshore petroleum-drilling operations. In the latter case, supply vessels transit from supply bases on shore to the offshore drilling units. They are also used in iceberg and sea ice surveillance.

Ice continues to be the main factor affecting marine transportation schedules in Canada's cold oceans. Pushed by winds and currents, pack ice can trap large ships, exert tremendous pressures on their hulls and threaten their stability. Canadian companies have developed some very effective and innovative means for overcoming challenges presented by cold oceans. These range from the development of a variety of airborne and oceanographic instruments through to a demonstrated ability to construct ice-strengthened and ice-breaking vessels.

Determining the thickness of ice is a valuable tool for the selection of shipping routes, the study of ice movements and the testing of ice breakers. For example, Polar Tech Limited, of Sidney, British Columbia, has developed the Ice Load Drum used to examine the driving stresses and forces when ice sheets collide. Canpolar of Toronto and Aerodat of Mississauga have successfully teamed together to adapt electromagnetic induction from its use in mineral exploration to meet the specific requirements of ice profiling. As well, Oceanprobe Systems Manufacturing, a subsidiary of Arctic Sciences of Halifax, Nova Scotia and Sidney, British Columbia, has developed and manufactured oceanographic and ocean-related products with a major focus on the development of acoustic instruments for measuring physical oceanographic quantities.

At the other end of the spectrum, Canadian shipbuilding companies such as Versatile Pacific Shipyards of Vancouver and MIL Davie of Quebec have a demonstrated capability to construct ice-breaking and ice-capable ships as well as regular ships. Several marine transportation companies have banded together to form consortia such as the Canadian Marine Transport Group to promote the use and sale of Canadian ocean technologies and expertise on the export market.

9.4 Ocean Sciences/R&D

Several players combine to form the ocean sciences/R&D community for the ocean industry sector. They are government, industry and the universities. Government funded R&D is the largest activity although the apparent imbalance with private sector R&D is to some degree a problem of visibility. Industry internalizes its R&D delivery mechanisms while government delivery includes a visible and often time-consuming consultative program and delivery process. In addition, industry tends to maintain its R&D as commercially confidential when internally funded.

A number of federal departments are active in cold-ocean R&D, some with major roles, while others offer related support activities. The primary players are:

- Transport Canada
- Fisheries and Oceans Canada
- Energy, Mines and Resources Canada
- Environment Canada
- Indian and Northern Affairs Canada
- Department of National Defence
- Industry, Science and Technology Canada
- Department of External Affairs and International Trade
- Public Works Canada
- Ports Canada

These departments support many programs, initiatives and institutions, a selection of which will be presented to provide an overview of the ocean sciences/R&D capability.

A major program falling under Energy, Mines and Resources Canada is the Polar Continental Shelf Project. Its objective is to contribute to orderly scientific investigations of Canada's polar continental shelf and surrounding areas. Established over 30 years ago with a primary function to provide logistic support for scientists engaged in Arctic research, from 1988 to 1989 the program received $7.2 million and supported 240 projects covering archaeology to zoology, and also including marine ice dynamics, ice crushing and climatology.

Fisheries and Oceans Canada is responsible for four federal research institutes, including the Institute of Ocean Sciences in Sidney, British Columbia and the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. These institutes carry out research in a wide variety of areas such as ocean physics, frozen-sea research and remote sensing.

The National Research Council's Institute for Marine Dynamics in St. John's, Newfoundland, undertakes research in marine transportation, hydrodynamics and sea ice (in the Arctic Vessel Research Laboratory and in the Ice Science Laboratory). The staff of scientists, engineers and technicians has expertise in cold-ocean engineering, ice science, tank testing and full-scale trials.

Canarctic Shipping of Ottawa is a government/industry joint venture company established in 1975 to support and develop the technology for commercial vessels to operate on an extended basis in the cold oceans. The company is jointly owned by the federal government and Northwater Navigation Limited, and its primary activity involves the operation of the M.V. Arctic, an Arctic Class 4 bulk-ore and oil carrier. Serving both R&D and commercial purposes, the M.V. Arctic transports resources out of the Canadian Arctic and also serves as one of the most important R&D platforms operating in the Arctic. The ship is used extensively to collect data on ice characteristics and to develop new designs for ship structures operating in ice conditions.

The Centre for Cold Ocean Resources Engineering (C-CORE), located at Memorial University of Newfoundland in St. John's, has a mandate to carry out research related to offshore resource development, to contribute to the development of Newfoundland and Labrador expertise in cold-ocean engineering, and to disseminate knowledge into the public domain. C-CORE works within a five-year research plan in which research priorities are identified. The three major programs of the current five-year plan (1987 to 1991) are: ice engineering, remote sensing and related geotechnics. Current C-CORE projects involve examination of ice motion and dynamics, ice structure interaction and the advancement of remote-sensing techniques through the use of ground-wave radar.

In addition to federal departments and agencies, universities and university-based research institutions, a number of private companies are active in cold-ocean technology R&D. The primary function of these companies varies, but companies such as Canarctic Shipping, Fleet Technologies and Arctic Sciences do research of interest to marine transportation companies. Shipbuilding firms including Versatile Pacific, Wartsila and MIL Davie and hydrocarbon exploration and development firms such as Dome, Esso and Gulf conduct research in their areas of interest in cold technology.

9.5 Underseas Defence

The underseas defence segment of Canadian ocean industry can be categorized by the types of organizations that make up the industry. These include:

- niche market firms
- R&D, scientific and academic consulting firms
- product/system manufacturers
- major contractors

Niche Market Firms

The niche market firms provide a unique product or service and are generally tied to a leading-edge technology. Oceanographic/environmental instrumentation firms with a strong technical, scientific and engineering background fall into this category. These firms typically start out as one- or two-person garage shop operations and eventually develop into custom-design instrumentation businesses with sales volumes less than $10 million.

Canada has a concentration of firms in this category that generate a portion of their sales from the military market. Product areas include: fibre optic rotary joints, ROV services, acoustic data acquisition systems, subsea sensors, data storage/processing, communication and navigation support instruments, hydrophones and seafloor mapping systems.

Approximately 90 percent of defence R&D can be characterized as development. For the above firms to remain in a profitable niche, they strive to maintain a unique leading edge, because the technology niche they occupy today may be main stream technology tomorrow.

For example, the use of ROVs and the associated tracking and positioning technologies for commercial applications is becoming a major growth area in the 1990s for mine-hunting operations.

Canadian firms in this group also obtain substantial shares of their revenues from foreign sales (in the order of 50 percent).

R&D, Scientific and Academic Consulting Firms

Service companies are often known as contract R&D firms and maintain close ties with defence contractors. Instrument or data acquisition system design consultants, such as Seimac Limited, TTI Tactical Technologies Inc., Atlantis Scientific Systems Control Group, Ocean Routes Canada Inc., Raytheon Canada Limited and Dalhousie University are typical organizations in this category. For example, Dalhousie University receives an annual grant of $128,500 under the Military and Strategic Studies Program.

Product/System Manufacturers

This is the only supplier category that can be described as a volume manufacturer. These firms usually derive high-volume sales by supplying a standardized product to meet the market requirements of all or most segments of the ocean industry.

It has been identified that buoy systems, aircraft and earth-orbiting satellites represent a target area for new technology development efforts. Buoys are thought to offer a platform for collection of oceanographic and meteorological data in remote ocean areas; aircraft can be used effectively in the collection of meteorological, sea-surface temperature and sea-state data as well as launching expandable bathythermographs; and satellites are proving useful for regular synoptic coverage of surface ocean conditions and data communications links. Metocean Data Systems Limited manufactures data acquisition and telemetry devices and Internav Limited engineers and manufactures Loran-C receivers. Internav is also developing and will be manufacturing a line of GPS receivers.

These types of firms maintain a close, direct working relationship with their customers. A considerable effort is made to develop customer confidence in the product/system (dependability, reliability, serviceability) and the financial staying power of the manufacturer. Successful manufacturers typically have their product's specification written into Request for Quotes (RFQs).

Major Contractors

The major contractors are usually $100-million-plus organizations that produce large systems. Their success as a general contractor depends on a number of factors, including:

- Experience in large-scale project management and a knowledge of the particular application area in which the contractor wishes to provide equipment or services, e.g., AUVs, anti-submarine warfare (ASW) systems, integrated navigation/communication/battle management systems.
- A network of qualified and dependable subcontractors.
- A successful track record in implementing turnkey projects.
- Commitment and staying power to meet contractual obligations if a project encounters difficulties.

For a firm to meet all of the above requirements, it must by definition be large, have market presence and have financial stability.

For example, ASW electronic systems represent a growth market area in the 1990s. Major contractors that dominate the market include General Electric, IBM, Hughes & Sippican in the U.S.; Thomson, France; Ferranti, U.K.; and Krupp, Germany.

To a large extent, Canadian participation in this segment of the military market is best achieved by establishing relationships with major subcontractors. For example, the U.S. Defence Advanced Research Projects Agency (DARPA)/Navy Unmanned Underwater Vehicle (UUV) program represents a significant project where Canadian R&D, custom design and development, component assembly, systems integration and equipment manufacturing opportunities exist.

9.6 Environmental

It is two decades since a fully-laden oil tanker called the Arrow ran aground in the environmentally sensitive waters of Chedabucto Bay on Nova Scotia's northeast coast. Spurred by this disaster and by the prospect of offshore drilling and oil transportation in the Arctic, the federal government resolved to pioneer the science of oil spill clean-ups in cold climates. Resulting in Environment Canada's internationally respected Arctic and Marine Oilspill Program, the initiative plays a leading role in the development and testing of new and commercially available technology used to mitigate the effects of marine and Arctic oil spills. Environment Canada has, therefore, developed significant expertise in fields as diverse as remote sensing, clean-up technology, and the determination of the fate and effects of ocean oil spills.

As well, the Beaufort Oil Spill Co-op, managed by Canadian Marine Drilling Limited, was established by Gulf, Amoco and Esso to ensure that there was an industry-led body that could respond quickly and efficiently to oil spills in cold regions. Stored in Tuktoyaktuk, the Co-op has offshore recovery and treatment systems, containment barriers, skimmers, pumps and incinerators.

Several Canadian companies have developed techniques and products for use in cold-ocean monitoring and clean-up. Barringer Research Limited of Rexdale and Canadian Astronautics Limited have developed airborne oil-spill monitoring equipment. Aqua Guard, a division of Bennett Environmental Consultants of Vancouver, has developed a self-inflating oil containment boom for use in ice-infested waters. S.L. Ross Environmental Research Limited of Ottawa is a consulting firm specializing in oil/chemical spills and their control. The company has developed a particular expertise in cold-ocean spill control, contingency plans, techniques, equipment needs and training programs.

9.7 Communications, Navigation and Remote Sensing

There are a number of communications companies supplying voice, data, image and video services for cold-ocean communications. Canada's oceans, especially the Arctic, present some unique challenges for communications suppliers, the major challenge being ice conditions. As ice forms in cold regions, surface propagation becomes a problem to the extent that normal coverage can decrease from 200 km to 30 km (in some marine instances). Spray icing on antennae is another factor that hinders conditions, causing decreased coverage and blackouts. Electrical disturbances caused by the Aurora Borealis can have a severe impact on communications in the Arctic, causing static and blackouts.

A mix of communication technologies is being used to address these unique conditions and provide communications over cold oceans. HF, UHF and VHF radio are commonly used as means of communications. HF is most commonly used, not only for voice, but for large data collection on commercial ships and oil rigs. The Canadian Coast Guard provides HF, UHF and VHF based services for ships operating in coastal waters and the Arctic. As well, companies such as Daniel Electronics of Victoria and R.A.C.E. Technologies of Vancouver manufacture a range of radio communication equipment for use in cold oceans.

Several Canadian companies provide satellite communications equipment, systems and services that are of use in marine communications. Internav of Sidney, Nova Scotia, manufactures global positioning systems. Telesat Mobile Inc. (TMI) provides mobile satellite communications in Canada. The company intends to launch a satellite (MSAT) in 1993. Present communications are served by leasing satellite capacity from the International Maritime

Satellite Organization (INMARSAT). INMARSAT was established in 1979 to offer satellite communications services to civil shipping worldwide. Connection to INMARSAT facilities is provided for Canadian customers through Teleglobe Canada. Ultimateast Data Communications Limited of St. John's has been subcontracted the marine communications for TMI. The company also manufactures a communication modem and link controller, DataHail. When used with an HF single side-band radio link, DataHail can provide a data-link for marine communications.

In the area of navigation, Aanderaa Instruments Limited of Victoria distributes acoustic navigation and positioning systems that can be used in the world's oceans. Offshore Systems Limited, Vancouver, developed and markets integrated navigation and computer graphic systems used for marine communications.

Remote sensing techniques are receiving attention in Canada as more than 30 companies (1988) and several government agencies are involved in their use. As the techniques are used to monitor resources and environmental changes, several companies have developed considerable expertise in the application of the technology to the monitoring of ice movements off Canada's Arctic and eastern coasts.

One of the companies prominently involved in remote sensing is MacDonald Dettwiler Associates (MDA) of Richmond, which has manufactured an airborne synthetic aperture imaging radar system used to map and track ice floes in the Canadian Beaufort Sea. The radar, mounted on a small aircraft and operated by Intera Technologies of Calgary, generates photograph-like images of the sea ice in real time on board the aircraft and transmits them via a data-link to display systems on ships and drilling rigs operating in the region. As they are produced by radar, the images are unaffected by darkness or weather and reveal details on ice type and distribution, even when it is covered by a layer of snow. The imagery is used by ships' captains to plan the most economical route through ice-infested regions and to provide oil-drilling platform operators with advance warning of hazardous ice floes moving into the site of drilling operations.

Several other companies, including Itres Research Limited of Calgary and Canadian Astronautics Limited of Ottawa, use similar technologies as MDA's, while Arctic Sciences Limited is involved in the use of satellite-based remote sensing and imagery to study sea-ice and iceberg behaviour.

9.8 Underwater Services

Canadian companies have gained global recognition in the diving and subsea vehicle sector of the ocean sciences industry by developing and maintaining technological leadership in cold-ocean diving. Several Canadian companies have developed technologies designed to overcome the impediments to submarine exploration in cold oceans.

Can-Dive Services Limited of North Vancouver, formed in 1966, is an international diving company offering state-of-the-art diving technology and comprehensive support services for Arctic marine work. A pioneer in Arctic diving techniques, Can-Dive lists among its accomplishments the first deep helium dive in the Arctic, the salvage of aircraft and boats in Arctic waters, and welding and ship repairs on drillships in the Beaufort Sea. Can-Dive also provides year-round diving services to drillships using 300 m saturation-diving systems and diving bells.

In 1987, Can-Dive formed International Hardsuits Inc. of North Vancouver to manufacture and distribute the Newtsuit, a one-atmosphere diving suit designed to provide a means of working at depths of up to 300 m. This has advanced the ability to work in cold waters in a safe, practical and economical environment.

The Pisces series of submersibles has played an important role in the development of Canadian expertise in submarine exploration. Based at the Institute of Ocean Sciences in Sidney, British Columbia, Pisces IV has been used extensively in the Arctic for research purposes.

International Submarine Engineering Limited of North Vancouver has developed several submersibles, one of which is the autonomous remotely-operated vehicle designed to conduct hydrographic surveys under ice in a cost-effective manner.

10. CONCLUSIONS AND POSSIBLE MARKET STRATEGIES

10.1 Conclusions

The key conclusion reached in this study is that, for ocean industry, Europe 1992 will not likely produce a Single European Market for many years to come. Consequently, there will still be 12 single markets and any strategies will need to recognize that fact. In other words, Canadian companies selling into Europe will be dealing more or less with the same factors that exist today, including nationalistic protectionism.

Evidence of the lack of Single Market uniformity is the attitude of Member States to E.C. Directives. Although these are binding on Member States, each state is responsible for enacting domestic legislation to implement the directives. For example, the U.K. has been quick to enact the necessary legislation whereas Italy has been slow. This, to some extent, also reflects the attitudes of the countries toward imports. Some, such as the U.K., are relatively open while others, such as Italy, are more protectionist.

Although the European marketplace will not change appreciably, there are certain ongoing actions which will have an impact on Canadian market strategies. For example, the E.C. common external tariff ensures that goods imported from non-E.C. countries are subject to the same customs duties wherever they enter the E.C. Moreover, certain goods, appropriate to the Canadian ocean industry, can be imported duty-free or under a temporary suspension of duty. Another area is technical standards. An objective of the Single European Market is to harmonize standards so that any product that meets the standards in any Member State can be freely marketed in all other states.

A negative but important factor is the E.C.'s public purchasing policies that allow government purchasers to reject a tender where less than 50 percent of the value of the products is of E.C. origin.

The main observations of each of the industry market sectors are as follows:

Offshore Oil and Gas

- The U.K. is the leader with more than 50 percent of all European expenditures.
- The value of new projects in the U.K. North Sea sector rose by 49 percent from 1989 to 1990, to a value of $10.5 billion.
- The value of exploration rose by 27 percent, to a value of $2.5 billion.
- There is a trend toward subsea production systems, especially in deep water.
- The French and Italian offshore capability is strong and was developed with the aid of central government involvement.
- The E.C. THERMIC program has a 1991 budget of $140 million for energy research and demonstration projects including exploration and production (e.g., systems for automating offshore production plants) and subsea operating equipment.
- There is a trend toward robotics because of cost savings and improved safety.

Ocean Sciences

- The market pull is the development of large international scientific programs or development of enabling technologies. The main areas are AUVs, deep-towed systems, side scan sonars, expendable instruments and autonomous seabed research stations.
- AUTOSUB members in the U.K. estimate that the market in the medium- and long-term for AUV's for oceanography is 300 at $5 million each.

- The main E.C. program is the MAST Program, which has a budget of $125 million for the period 1991 to 1994.

- Many of the European institutes are involved in MAST as well as an umbrella project, EUROMAR, which has a budget of $204 million for the period 1989 to 1993. Both MAST and EUROMAR involve industry. European companies see their participation as an important vehicle for linkages with the research institutes that are their customer base. They also use the involvement as a catalyst to form joint ventures with other companies.

- Canadian companies can collaborate directly within EUROMAR. In addition, European subsidiaries of Canadian companies can, in theory, collaborate in E.C. Framework programs, such as MAST. There is still a protectionist attitude in some states and participation may be difficult to achieve in practice. However, the ocean industry is not seen as strategically important in Europe, and, consequently, the MAST program may not suffer the same level of protectionism as those of the higher profile industries.

- The EUREKA program supports industry-based R&D through funding from the E.C. countries themselves. Collaboration is encouraged by requiring the participation of at least two organizations from different EUREKA member nations. The EUREKA program is open to Canada.

- An example of one country's internal collaboration is Geomar Technologies GmbH in Germany, which was founded to provide services and operate a government funded Marine Geosciences research centre. The shareholders are Geomar Enterprise Association composed of SME's active in marine technology, together with larger German companies such as AEG, Krupp-MAK and Preussag.

Marine Environment

- The Marine Environment will be the strongest growth market in the 1990s. It will be driven by legislation.

- The main requirements relate to the monitoring, prevention and control of marine pollution. The technology requirements include consultancy services, water quality monitoring instrumentation, pollutant measuring instrumentation and clean-up equipment.

- The timing of the growth will, to a great extent, depend on the speed with which the Member States implement the directives emanating from the European Commission.

  The poorer states, which in many cases are those with the most problems, are slow to implement.

- It is important that Canadian industry be kept apprised of the E.C. Directives as they signal the start of the enactment of legislation.

- Eastern Germany and pollution in the Baltic are believed to be important areas for clean-up.

- A consequence of E.C. Directives and implementation of the polluter-pays principle could mean that every coastal outfall in the Member State will require on-line monitoring instruments. A rough estimate of the value of this market niche is $2 billion.

- No estimate is made of the overall market size. However, some examples of expenditures, real and estimated, to meet legislative requirements, are as follows:

Table 25

Expenditures to Meet Legislation Requirements

U.K.	$600M per year for marine environmental protection
Germany	$2B per year for water/waste water pollution
Italy	$60B to the year 2000 for all environment problems
Spain	$1.4B to $4.6B per year

Undersea Defence Industry

- Access to the defence industry market will likely not change much due to Europe 1992. No specific functional E.C. role has been established.
- France and the U.K. are the largest European exporters of defence equipment. With the exception of Spain, no E.C. countries are major importers of defence equipment.
- There is extensive collaboration in government R&D programs between NATO members of the E.C. focusing on, among other areas, mine countermeasures and sonar buoy and dipping systems.
- Areas of market growth are on-board export systems, long duration power supplies and surveillance systems.
- The E.C. countries with the largest naval equipment procurement budgets are the U.K., France, Germany and Italy in that order, with a total procurement in 1990 to 1991 of about $12 billion.
- The defence markets are shrinking and, therefore, companies increasingly secure and protect their domestic niche markets. Basically, the undersea defence equipment needs of the E.C. countries are being met by national industry and will continue that way.

Coastal Interface

- Coastal interface projects in Europe are primarily to maintain the commercial viability of ports by means of channel dredging and conservancy works.
- The market opportunities include the provision of instrumentation, such as an innovative mud density measurement device which would measure the navigability of channels. Other opportunities lie in communication and recording systems.
- Procurement for coastal defence contracts are subject to the open tender rules laid out in the E.C. Public Works Directive.

10.2 Elements of an Overall Canadian Strategy

The most important element of an overall Canadian marketing strategy is Canadian innovation in products and techniques. The strategy should be built around Canadian-developed innovations, treating them as initial door-openers to new European markets, and to solidify and expand existing markets. The hard core money-making business would follow on the heels of the reputation-makers.

Canadian ocean industry companies are involved in a considerable variety of products and services. The product-oriented companies play roles, more or less, in all the aspects of the innovation chain — R&D, pre-production engineering, manufacturing, market assessment and strategy, marketing, and distribution/sales and services. The service-oriented companies, including engineering companies, have their own innovation chain usually starting with R&D and culminating in new scientific and engineering methodologies and analyses. In the course of developing new ideas, the ocean industry companies, in addition to their own in-house research capability, draw considerably on their relations with Canada's research infrastructure, composed of government research agencies, universities and non-profit research institutions.

An overall industry/government strategy could be developed, aimed at Europe, to aggressively promote Canadian ocean industry leading-edge expertise in each of its sectors. The expertise could be shown as residing in the hands of the private sector but supported strongly by a national network of world-class institutions. The objective would be to first gain recognition for the Canadian way, which is one of technological and engineering innovation. Second, in the highly competitive world of Europe 1992, Canadian companies must be perceived as high performance companies that deliver reliable products and services.

10.3 Company Strategies

There are some generalizations that can be made concerning how companies can take Europe 1992 into account. For a particular company, these depend on a host of situations and factors, such as the nature and level of existing business in Europe and existing intercorporate relationships in Europe.

In general, the fundamental company strategies are as follows:

- Companies should have a presence in Europe. For those not presently established there, the ways are to set up subsidiaries or branch offices (for the larger Canadian companies), have strategic alliances (partnerships, joint ventures, cooperative research agreements, etc.) or have distributors/sales representatives.

- Companies involved in strategic alliances with European firms should have reciprocal arrangements to allow the European partners access to Canadian and U.S. markets.

Some preliminary company strategies are given below. As mentioned previously, more complete strategies can be developed only after the existing level of European business for Canadian ocean industry firms has been determined and after the firms themselves have an opportunity to provide input.

Some possible strategies are:

- A company with a leading-edge technology in Canada works with a company with complementary technology in Europe. Specifically, the Canadian company would be a participant in a major multicompany applied research project and the European company would be working on a similar multicompany research project (say, one funded under the EUREKA program). The arrangement would have the Canadian technology utilized on the European project and the European technology on the Canadian project. The primary linkage would be between the two companies (likely small ones) and both would benefit by the reciprocal involvements. The arrangement would allow the Canadian company to establish a presence in Europe relatively inexpensively, to make working contacts with other applied technology companies and to garner information on the targeted user community in Europe.

  For example, a consortium such as the British Columbia based SPIRIT project could establish mutually advantageous linkages with a similar European program, in this case, the British AUTOSUB project. Both projects are aimed at exploiting the key ocean science sector of AUVs that could have a wide variety of applications including defence, oceanographic research, offshore oil and gas, and others. Each program aims to develop a generic prototype in order to prove the concept of autonomy in a scientific mission by the mid 1990s. SPIRIT as a whole, or individual companies with specific enabling technologies, could establish relationships with AUTOSUB or component companies respectively.

- Utilizing the support of the Canadian ocean research institutional infrastructure, Canadian companies can present a larger capability in Europe to participate in European research projects. The rationale for the Canadian participation would be the contribution of innovative products, processes or techniques that would be useful to the projects. The participation would lead to connections for the Canadian company in the applied research community and also the target user community in Europe.

It is possible, for instance, for Canadian companies to be involved in the key European ocean industry R&D programs, E.C. MAST and EUREKA, and therefore become part of these important networks. European subsidiaries of Canadian companies can be participants if they are real operating companies as opposed to sales offices. Furthermore, the EUROMAR program accepts under certain circumstances direct participation with non-European companies with no European presence. In fact, a Canadian company is already involved in the MERMAID sub-project. Small- or medium-sized companies could be very attractive if they brought a larger Canadian institutional capability to the operation.

- A company manufacturing a product in Canada could negotiate a reciprocal deal with a company manufacturing complementary products in Europe. The arrangement would entail manufacturing (likely final assembly) of each other's products, and marketing and distribution in each other's territory. This would be a cost-effective way to enter the European market as a European company. The European partner would have a better handle on the ways and means of marketing and selling in Europe. This would help ensure earlier market penetration and a higher growth rate than if the Canadian company simply used a European distributor. As well, the reciprocal deal for North America would give the Canadian company a greater overall level of business.

This could be a very useful strategy to pursue for many of the small Canadian instrumentation engineering and manufacturing companies.

Companies such as Metocean Data Systems, a manufacturer of data-acquisition and telemetry devices, and Internav, a manufacturer of Loran-C receivers and — soon — GPS receivers, could manufacture complementary European products for North American use and, more importantly, have their products manufactured and distributed in Europe by, say, GEC-Marconi or Dority in the U.K.

- A group of small Canadian ocean industry companies might join together in a consortium for the purposes of marketing into Europe, and possibly project execution. The companies might have similar products or services or they could have complementary products or services. The former mix would be aimed at a general marketplace, the latter at specific projects that are bid on an internationally competitive basis or where the Canadian group could bid as subcontractor to a European prime contractor. In either case, the sum of the Canadian parts would be a more significant capability than that of the individual companies and would have more clout in the large, European marketplace. As well, the combined marketing should result in lower costs per company.

A consortium of Canadian firms known as the Canadian Environmental Group has just been awarded a multimillion dollar contract to clean up uranium mining waste in Eastern Germany. The five-company alliance has signed the agreement with Wizmut, the former East German enterprise, which has 40 mines and processing sites. It is a textbook example where Canadian firms have developed leading-edge technology in a specific sector and, in this case, will provide advice, technology and monitoring services while the bulk of the clean-up work will go to German firms.

A similar example is the Canadian Marine Transport Group Inc., a partnership of six Canadian companies that have been involved in Arctic development. The six partners have pooled their proven technology and have undertaken a coordinated joint-marketing initiative in the U.S.S.R. Since incorporation in July 1988, the CMTG has made over a dozen visits to the U.S.S.R., participated in exhibitions and workshops and hosted delegations of U.S.S.R. technical specialists. With the aim of fostering scientific and technical cooperation with U.S.S.R. organizations when long-term commercial opportunities are foreseen, several agreements, joint studies and commercial initiatives have already been concluded and several more are anticipated.

- The marine environment area may offer some of the best potential for Canadian companies. The market in Europe is dominated by E.C. Directives and government legislation and every Member State will have to comply sooner or later. Countries such as Germany and the U.K. have both technology and money and are therefore difficult to access. Consequently, a key strategy would be to concentrate on those countries such as Spain that have heavy requirements, but lack the technological expertise and the funds.

  Canada could conceivably negotiate bilateral science and technology agreements with these countries that would make funds available to clean up the marine environment. Canadian companies would provide the expertise and the host country would provide the infrastructure. In this way, the Canadian companies would establish themselves in Europe and build up both relationships and markets while the host country would develop its marine environmental industry.

10.4 Recommendations

Certain information is essential in order to develop realistic market strategies for Canadian ocean industry companies for the Europe 1992 marketplace. The basic requirements are: (1) knowledge of the Canadian ocean industry (i.e., type of products or services; size and location of companies; size, type and location of existing European markets; existing European strategic alliances, joint ventures, branch/subsidiary operations); and (2) knowledge of the European marketplace (i.e., size, type and location of markets; nature and location of competition; trends, political and cultural factors).

The present study has focussed on one half of the equation, the European part. In order to develop a final set of workable strategies, it is essential to determine the extent of existing Canadian ocean industry business with Europe. This can most effectively be done during dissemination to industry of the results of the present study, at which time the companies can have input to the development of strategies and provide information on their European activities.

There are certain common approaches applicable to the overall Canadian ocean industry. However, it should be borne in mind that the sectors (i.e., ocean sciences) are different one from the other regarding nature of clientele, type of technologies, and size and location of markets. Consequently, sector-by-sector strategies are required reflecting the peculiarities of each.

Another important factor that should be taken into account in subsequent work is the geographical influence within Canada. One would assume that Eastern Canadian companies have an easier job of selling into Europe than those from Western Canada.

As mentioned previously, the present study focussed on the size and nature of the European market. To develop workable strategies, it may be fruitful to examine some areas beyond the present study's scope. These are mentioned here without any in-depth discussion.

Canada is heading toward a reduced role in NATO. The impact of Canada's potential weakened influence could translate into lower regard for Canadian expertise in undersea defence and make it more difficult to access the European market. This could be examined after the existing Canadian undersea defence business with Europe has been determined and ways and means could be developed to counteract any negative fallout.

An examination could be made of the existing Canadian international science and technology agreements to ascertain their effectiveness. These may constitute logical building blocks, especially for new Canadian entrants to the European market.

The present study pointed out the importance of the E.C. Directives and the subsequent legislation implemented by the Member States. A thorough look at this area is in order, probably broken out on a sector-by-sector basis.

Lessons can be learned from successes in the past. Two may be particularly relevant. One is an examination of the ways in which European ocean industry companies have made inroads into North America (especially in the oil and gas sector) that is to some extent the reverse situation of Canadian companies selling into Europe. Another is an examination of the ways in which Canadian ocean industry companies successfully sold into the U.S. prior to the FTA. Similar opportunities/problems existed there as will exist with Europe 1992, especially with regard to the size of the marketplace and the level of trade protectionism. Special agreements such as the Defence Sharing Agreement might be highlighted to ascertain their effectiveness.

Appendix

Underseas Defence Equipment
Addresses of Major Suppliers

AEG Telefunken AG, Defence Technology Theodor-Stern-Kai 1-3 D-6000 Frankfurt 70 Germany	
British Aerospace Naval and Electronic Systems Division P.O. Box 5 Filton, Bristol U.K. BS12 7QW	Tel: 44 272 69 3831 Tlx: 449 452 Fax: 44 272 69 20 55
Dowty Defence and Air Systems Limited Kings Building Smith Square London, U.K. SW1P 3JG	Tel: 44 931 9855 Tlx: 916 174 Fax: 44 931 0946
GEC Ferranti Computer Systems Limited Naval Command and Control Systems Division Western Road, Bracknell Berkshire, U.K. RG12 1RA	Tel: 44 344 483 232 Tlx: 848 117
Krupp Atlas Elektronik Sebaldsbruecker Heerstr.235 D-2700 Bremen 44 Germany	Tel: 49 421 4570 Tlx: 245-7460 Fax: 49 421 457 2900
Logica 64 Newman Street London, U.K. W1A 4SE	Tel: 44 637 9111 Tlx: 27200 Fax: 44 637 8229
Marconi Command and Control Systems Limited Chobham Road Frimley, Camberley Surrey, U.K. GU16 5PE	Tel: 22 276 63311 Tlx: 858 289 Fax: 44 276 29784
Marconi Underwater Systems Limited Elettra Avenue Waterlooville Hants, U.K. PO7 7XS	Tel: 0705 264466 Tlx: 869233 Fax: 0705 260 246

MBB Messerschmitt-Bolkow-Blohm GmbH
Defence Systems Group
Marine and Special Products Division
P.O. Box 107845
D-2800 Bremen
Germany

Plessey Naval Systems Limited
Wilkinthroop House
Templecombe — Tel: 44 963 70551
Somerset, U.K. — Tlx: 46108
BA8 0DH — Fax: Extn. 2200

SD Scicon
1-3 Bartley Way
Bartley Wood, Hook
Hampshire, U.K. — Tel: 0256 742000
RG27 9XA — Fax: 0256 742700

Seimens AG Defence Electronics
Landshuter Strasse 26
Postfach 1661
D-8044 Unter Schleilsheim
Germany

Smiths Industries Underwater Systems Development
Smiths Industries Aerospace and Defence Systems Limited
Bishops Cleeve
Cheltenham — Tel: 44 242 67 3333
Glos., U.K. — Tlx: 43172
GL52 4SF — Fax: 44 24267

Thomson Sintra Activities Sous-Marines
1 Avenue Aristide Briand — Tel: 33 149 85 35
94117 Arcueil Cedex — Tlx: TCSF 204 780
France — Fax: 33 142 53 5262

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