Dalhousie University

International Ocean Institute

I.O.I. - Malta

SYNOPSIS

Research and Development is considered today the prime motor of technological innovation which, in turn is basic to economic growth. In the industrialised countries some fundamental changes have been taking place in the way R&D is financed and organised.

The cost of R&D in high technology is so high and the risk is so great that not even the mightiest company can afford to undertake it on its own. Over 50 percent fo all R&D in high technology in the developed world is paid for, in one form or another, by Governments. In most cases, however, not even the combined efforts of private and public sector are sufficient to make high technology projects competitive on world markets. Hence new forms of international, public/private cooperation are emerging, such as the EUREKA, EUROMAR, or ESPRIT projects in Western Europe.

What is remarkable about this development is that the Third World is completely excluded from it, and thus the R&D gap -- the worst of all development gaps -- between North and South is rapidly widening.

This paper attempts a brief analysis of the role of R&D and the way it is managed in the North, in the context of technological change and the challenges of the Service Economy. It becomes evident that the traditional concept of "technology transfer" is no longer useful in this new context. What is proposed, instead, is a more dynamic concept, that of "joint technolgy development" or "co-development of technology." The United Nations Convention on the Law of the Sea, 1982, is seen as offering the most advanced framework the realisation of this concept, and two case studies are presented: a proposal for a Mediterranean Centre for R&D in Marine Industrial Technology, already on the drawing boards of Mediterranean Governments and intergovernmental institutions (UNEP, UNIDO,

Pearson Institute, 1321 Edward Street, Halifax, Nova Scotia, Canada, B3H 3H5
Telephone: (902) 424-2034, Telex: 019 21 863 DALUNIVLIB, Fax: 902 424 2319

the U.N. Secretariat) , and a proposal for an "International Venture," proposed by the Delegation of Colombia, for the internationalisation of exploration, training and R&D in seabed mining technology in the context of the Preparatory Commission for the International Seabed Authority and for the International Tribunal for the Law of the Sea (the Jamaica Commission).

In conclusion it is pointed out that such developments are beneficial both to the industrialised countries -- through still wider cost and risk sharing and the expansion of markets -- and to the nonindustrialised countries -- by reducing the cost of access to technology, generating technologies that are more "appropriate," and offering the most cost-effective training opportunities through learning by doing. Potentially, they could contribute not only to industrial development, but, at the same time, to a sound environmental policy and to the strengthening of peace. Since technologies developed jointly, obviously are also owned jointly, technology co-development would provide a framework for the application of the principle of the Common Heritage of Mankind, not to existing technology, already patented and "owned," but to future technology, to be developed jointly, internationally, and for peaceful purposes.

It is a pleasure to be here.

Organisers are to be congratulated for this initiative and for presenting such a rich and comprehensive programme, dealing with all major ocean uses and their interaction.

The economic -- including the commercial -- opportunities offered by this new phase of ocean development is obviously enormous, consideringthat the oceans occupy three fourth of the earth surface, and the industrial penetration of ocean space has merely begun

But Ocean development has some very special characteristics: very different from industrial development on land.

On land we actually could develop irresonsibly: We could develop with the single, narrow and short-sighted goal of making financial profit. During the early phases of the industrial revolution we were blissfully unaware of the environmental debts we were accumulating; and those who had to pay them were only the working classes: only the poor. It is only now that the problem has taken on alarming proportions.

The development of a marine economy is fundamentally different -- for two reasons: First it comes later, at a time when the environmental crisis of the terrestrial

economy is fully mature; and, secondly, the medium, water,is different from land:In the oceans, everything flows; every activity directly affescts every other actiity; every geographic ocean area interacts with the world ocean as a whole. In the oceans, we simply cannot build an economy, if we, at the same time, kill the environment which includes the resource. We must, from the beginning integrate economy and ecology in a new way: Or otherwise there simply will be no ocean economy: Tourism will die; fisheries will die; aquaculture will not take off; the world climate will be affected negatively; human health will be impaired. The economic balance sheet will shout: "Bankruptcy" as loudly as the ecological balance sheet.

Thus the single-minded, narrow, and short-term goal of maximizing profits no longer works. It clearly needs to be integrated with longer-term and public-interest considerations. I think we all agree on that -- including even the most hard-nosed advocate of "privatization."

But if public and private goals need to be integrated, this will have some institutional implications, about which most people have as yet not thought that much, and to which we shall return at the end of these remakrs today.

Well, in this crisis we are all together: East and West, developed and developing countries, and thus it is in

our own best interest to do whatever we can to make sure that everbody else knows the rules of the new game.

For this we need information, and you have asked me today to talk about the information needs of developing countries.

Well, I have just returned from a region of developing countries, Ghana, in West Africa -- a beautiful country with a great tradition in fisheries; with an impressive University campus,where we had a conference in which a number of West African countries participated. And we were talking about marine resource management and how to benefit from the new ocean regime generated by the United Nations Convention on the Law of the Sea.

The telephons did not work. They had not qorked for years. (one thing I noted was the intensity of the automobile traffic; I was told that was because the telephones were down: you could not call: you had to go if you wanted to tell anybody anything); the Conference documents were typed on stencils on very very old manual typewriters and reproduced on manual rotary printers the way we did it half a century ago. Forget about fax.

Offshore, Europeans or others might be dumping highly toxic wastes, as they had just done in Nigeria -- and nobody

would even know about it because there was absolutely no way of gathering that information by monitoring and surveillance.

Foreign ships might be fishing out there too: Who could tell.

Foreign countries may have gathered intelligence about the mineral resources in their economic zones; and they would not even know it.

Obviously what these countries need is an upgrading of their technologies to cope with the problems of exploring and exploiting their resources, monitor activities in the area, and enforce their sovereign rights against foreigners. And marine industrial technology today, note well, is high technology. He who whould ignore the impact o new materials technology on practically everything we build and utilize in the oceans; of genetic engineering on aquaculture and even on metal processing and environmental protection; of lasers on deep-sea exploration, and, of course, of micro-electronics and information technology on absolutely everything, would be pretty well out of the race before even starting it.

"Technology Transfer" would have to take place, and I would like to spend a few minutes on this subject, because

it includes all we want to know about "information requirements." As you all know "information" today is a crucial factor in technology development. I think as much as 60 percent of investments in R&D go to "information technologies" including, of course, computers, hardware software, data bases, etc. Above all, however, it is the development of human resources, it is "training" that is of absolutely fundamental importance for the absorption of information. And, over-all, the proportion of money spent on R&D, including the development of human resources, in the total budget of an industrial enterprise, has grown quite remarkably. It is today the basis of technological innovation which is the basis of economic growth. And that, of course, goes for the developing countries as it goes for the industrialised countries, even though they are dismally far behind in this respect, and this, of course, is the main reason why the development gap, the technology gap, is growing.

Most developing countries have too little critical mass to cope with these problems individually. The only way they can face them with any hope of success is through regional cooperation.

And recently there have been a number of encouraging developments in this respect.

One of my organistions, ICOD, is going into this area now on a rather large scale. You may hve read in the papers just about a month ago that ICOD is assisting the South Pacific Islands with the establishment of a Regional Ocean Information System. The south Pacific Island states are in fact engaged in an ambitious project to create a regional system of ocean-related information. This new system, Pacific Islands Marine Resources Information System (PIMRIS) will create a network of information centres in Suva, Honiara and Noumea. As one of the experts of the region put it, rather joyfully, "Our researchers and decision-makers will soon gain instant access to vital marine information related to fisheries and offshore minerals. Managing this kind of information is a major step in managing the resources themselves."

My other institution, the International Ocean Institute, has initiated a programme for the establishment of Regional Centres for R&D in Marine Industrial Technology. We have started with a pilot project in the Mediterranean, which has taken off and is now dealt with at the intergovernmental level. There will be a series of meetings next year to get it done.

We have based our feasibility study on the most advanced concepts of industrial scientific cooperation, as exemplified by the European systems of R&D in high

technology (EUREKA, ESPRIT, etc.) where public sector and private sector cooperate at the international level and in the framework of international organisation.

And this takes me back to my earlier remarks: If indeed we need a new synthesis between more narrowly defined commercial interests and longer-term public-interest considerations, including the protection of the environment, this should reflect itself in new forms of public-private cooperation and organisation. And this is, I think, what we already are seeing happening everywhere: based on the fact that R&D in high technology is so costly and so risky that the private sector alone can no longer handle it, and that in all industrialized countries, R&D in high technology is largely borne by the State. Given the importance of R&D in the entire industrial enterprise, this ongoing transformation of the R&D sector will undoubtedly impact on the whole system.

R&D, in our Regional Centres, then should be financed half by industry, for whom this offers an obvious advantage, and half by Governments and international funding agencies, and these latter should pay for the participation of technicians and engineers from developing countries.

We now intend to make similar feasibility studies for such Centres in other oceanic regions: the Caribbean, the

Indian Ocean, the South Pacific, West Africa. The establishment of such Centres, incidentally, is mandated by the U.N .Convention on the Law of the Sea, and we hope that this will be one way of assisting developing countries to meet their information needs.

Business has a great stake in the expansion of our economic system into the oceans. But it can benefit from this unique opportunity only if it adapts to the uniqueness and novelty of the situation. "Privatisation", I am afraid, is not the answer. New forms of industrial/scientific cooperation between the public and the private sector, at the international level, is the answer.

Lecture: Malta, Dec. 11
FIS UNESCO Workshop.

THE FLOW OF ENVIRONMENTAL RESEARCH FINDINGS INTO ENVIRONMENTAL EDUCATION FOR THE FUTURE

The theme that has been assigned to me is an extremely difficult one. it is a real challenge: which is perhaps the reason why I accepted to deal with it, although with considerable hesitation and many misgivings. Actually I came hear to learn, not to teach. And when I realized that I was going to be the first speaker, without the benefit of listening first to my colleagues, my fears escalated into panic.

My theme is:

The flow of environmental research findings into environmental education for the future.

I can see three key elements, plus one, in this question: each one of them has generated an enormous literature. Each one of them is by itself immensely complex. These three key elements are:

. Training -- i.e., education;

. Research; and

. Environment.

The one I mentioned, somewhat mysteriously, as "plus one" is the Future.

Let me deal with each one of them separately, although they are inextricably interlinked. In conclusion I will try to come up with some practical suggestions.

1. Education has been in crisis for at least half a century: disrupted by World War II; debased by fascism; strained by the new phase of the industrial revolution and the changes this entailed in the labour market, in the family; overtaxed by the need of accommodating larger and larger number of students, of passing from elite education to mass education; distorted by the intrusion of the mass media; finally, challenged by the rapid pace of scientific research and discovery.

Education, certainly, is not today what it was when I went to school.

this, however, in as way is a timeless phenomenon. Education, when I went to school, was not what it was when even my older brothers and sisters -- a mere twelve years older than I -- went to school: so that they considered me rather as a complete barbarian. This is the generation gap which has been with our society since time immemorial.

But today the break is a bit more significant than that. The basic difference, perhaps, is that, in the past, the main purpose of the educational system was to socialise the student: to fit him or her into the existing social, cultural, and economic context. It was what the Club of Rome in its report **No limits to learning** calls "maintenance learning." With the shocks this social, cultural, and economic context has undergone in recent decades, such a system won't do any longer. What is needed now is what the Club of Rome calls "innovative learning." The main purpose of this new type of education is to teach how to learn. It is to adjust to change rather than to a stable system. Learning has become a life-long need, a life-long obligation.

The educational system now includes the work place. The industrial enterprise spends a considerable proportion of its

budget on training and retraining its personnel. What used to be called "sound commercial principles," gauged by "the bottom line," today includes considerations of the environment; of labour relations and participation; of changing consumer demands; of international relations. Employees are retrained almost on a yearly basis as specializations become ever more rapidly obsolete. If overly specialised training comes to dominate the outlook of an individual, The Club of Rome says, it tends to impede participation, to block individual fulfilment, and to contribute to personal alienation from society. Specialisations can be adjusted to rapidly changing needs only if there is a broad, interdisciplinary basis to which to return and from which to move in new directions.

The big issues of contemporary life -- food, energy, environment, disarmament, development, employment -- are increasingly interdisciplinary and cannot be straightjacketed into the traditional, sectoral educational system.

An "innovative" educational system, finally, the Club of Rome says, must be "participational." Participational in more than one sense: first of all, students must learn to participate actively in the whole process, from curriculum determination to teaching

methodology. Secondly, the right to participate must be extended to all layers or classes of the population, and their needs and their culture must be reflected in the programmes. Since it is impossible to ask the abjectly poor to actively participate in this sense, it follows that an innovative, participational educational system must aim at, and contribute to, the eradication of poverty. That is its social responsibility; that is part of its very nature.

And this applies not only to the intranational level; it applies to the international level as well. And it is here that we are experiencing the most profound difficulties. For the maldistribution of educational resources is even worse than the maldistribution of economic resources. The educational gap is simply horrendous, and it is at the very root of the economic gap.

The wealthiest quarter of the world (30 countries with 24 percent of the population) spends 75 times more per inhabitant on education than the least developed quarter (23 countries with 24 percent of the population) a ratio three times greater than their economic disparities, which are 25:1. Sixty percent of the world's population receives only six percent of world expenditures on

public schools. In terms of university expenditures, graduates, and professors, the USA, USSR, and Japan account for more higher education than the rest of the world put together.

And one last item of statistics: Thirty-seven countries representing 30 percent of world population possess 91 percent of the total number of scientists, engineers and technicians, while 115 countries with over two-thirds of world population possess about 9 percent of these qualified personnel.

Traditional methods cannot cope with a problem of this magnitude New, innovative teaching and learning methodologies, generating spin-off and multiplier effects, must be resorted to, including distance learning, televisions, interactive computer programmes, etc. These are available, and can be made available. What is needed -- here, as in so many other aspects of the great world problématique -- is the political will. National governments must be convinced of the absolute priority of education as a precondition for economic development in the contemporary world. Educational budgets must be increased in most countries by whatever means: cuts in arms purchases, taxes on luxury imports,

arrangements with multinationals operating in a developing country, etc.

At the same time, these efforts must be aided through regional, mostly South-South cooperation sharing facilities, personnel, and experiences, while both regional and national efforts must be assisted through global, North-South cooperation, through UNESCO, or through institutions such as the recently established Commonwealth Centre for Distance-Learning.

Let us now look at the second term **research.**

The role of scientific research in contemporary society has been transformed as fundamentally as the role of education.

In the past, scientific research could afford the lacklustre of the ivory tower. Today -- and even more so, tomorrow -- in our information and knowledge-based economy, science, as the philosopher Adam Schaff put it, "is explicitly assuming the role of a means of production." Basic research is the foundation of applied research which is the basis of research and development which is

the heart of technological innovation which, today, is the prime engine of economic growth, accounting, according to, e.g., Nobel Laureate Solow, for as much as 85 percent of economic development. Schaff goes as far as to assume that labour will disappear as a "class" in our social structure and that science will, more or less, occupy its place.

Adriano Olivetti predicted forty years ago that the worker of the future would be a scientist, and the Romanian political scientist Silviu Brucan suggested a number of years ago that the root of the then dawning Marxist malaise was the disappearance of the working proletariat.

Be that as it may, certainly we are witnessing momentous changes in the social structure, and the role of scientific research has assumed unprecedented social importance, breaking the divisions between disciplines and departments, transcending the walls of the ivory tower and penetrating government and industry. R&D departments consume a large proportion of the budget of every industrial enterprise. Almost half of the world's scientific research is pressed into service to the war-making machine which distorts the economy. The countries guilty of this distortion lose

their competitive edge on the world market of technology. The other half is grouping in R&D consortia, often international in character and financed jointly by the public and the private sector. This is a new phenomenon, peculiar to the 'seventies and, particularly, the 'eighties, in all industrialized countries.

Now it should be clear to all of us that training and research are intimately linked in the science-based industrial enterprise. One learns while doing research. training is part of research and research is part of training. We shall come back to that later.

Thus far I have been talking about training and research in a general sense; but what has been said applies equally to the specific case of training and research in environmental sciences.

So let me now come to the third and most complex component of my complex theme: the Environment.

Environmental studies, as a discipline, lie athwart the natural and the social sciences. Environmental research must draw on biology, chemistry, meteorology, hydrology, geology, medicine, radiology, anthropology, sociology, economics, law -- and I am sure I have not been exhaustive. It is therefore difficult to imagine that environmental studies can simply be added on to an otherwise unchanged curriculum, just as it is difficult to imagine that an

"environment department" can simply be added on to an existing governmental or intergovernmental structure while economic planning, industry, agriculture, urban planning, etc. remain the responsibility of other, separate departments. This was pointed out by the Brundtland report. Concepts, as important and comprehensive as that of "sustainable development," or "finding a synthesis between economics and ecology" do have their institutional implications. These have been hinted at in the literature -- especially the Brundtland Report -- but they have not been thought through, let alone implemented. There is a big task ahead of us.

The concept of "environmental studies," rather than being added on to the curriculum, thus should be infused into every department of a university, into every discipline of a secondary school. The teaching of economics, of law, thus must include environmental aspects; the teaching of biology or chemistry must stress the importance of these disciplines for environmental impact assessments and the regulatory and institutional measures to be taken to implement conclusions and recommendations. Interdisciplinary courses should be introduced, drawing on the faculties of all the involved disciplines. This may sound simple,

but it is difficult and frustrating: Because lawyers and economists and biologists live in different worlds, have different optical perceptions, and speak different languages. To focus these different perspectives on one single event or development would generate a new version of "Rashamon" (Rashamon, you may remember, was an outstanding Japanese film depicting one single event, a murder, as seen and reported by seven different witnesses, and thus this single event dissolved into seven different dramas)-- yet, the barriers between these disciplines have to be brought down if environmental studies are what they are supposed to be and if they are to be effectively integrated into the curricula of the future.

Students should be encouraged to design complex models for economic projections, internalising environmental parameters. Such models, thus far, have been designed in the field of fisheries economics -- I have in mind extremely interesting studies by Prigogine and Jaqueline McGlade on "optimum sustainable yield", integrating biological, ecological, meteorological, hydrological and chemical parameters with social, financial, and economic factors; but they have remained at the academic level; they have not been applied by industrial fisheries, let alone by fisheries in

developing countries. They have not been tested, and even though in fisheries science, more than anywhere, we have brought the concept of sustainable development down to earth, or to water, and concretized it, as it were, the results, thus far have been far from reliable. The International Institute for Applied Systems Analysis in Vienna has published a number of fascinating multidisciplinary studies, on water management, on energy, etc. But these, too have remained delinked from the educational system. Thus, here too, is a big agenda before us.

From my brief, all too sketchy analysis of the three components of the theme linking education, research, and environment, I have already passed to indicating at least one way in which research and teaching could be successfully integrated. But there are other ways. They need to be developed, in a general framework, including environmental research in all its diffused aspects.

Monitoring the health of the environment is the basis of environmental research. This is an activity that need not be restricted to scientific research institutions. On the contrary, the more people are involved in it, the more successful it will be. The Mediterranean Action Plan, and action plans in other parts of the

world. have amply demonstrated it. Environmental monitoring should be participational, involving, together with the scientists, NGOs, volunteers,fishermen, navigators, coastal residents, and students.

The Club of Rome suggests a general framework for integrating this kind of research into the learning process -- especially in developing countries. Learning, the Report says, "is a personal and social as well as an environmental activity. It encompasses intra-human, inter-human, and extra-human aspects.

> We believe therefore that a major effort should be made to restore balance between action and reflection by involving both public and private universities more directly in the evolution of society through research contracts and development projects.
>
> For example, who in the developing countries is better placed than the universities to implement literacy programs? Could not the students be given credits equivalent to two semester courses if they make ten persons literate by the end of the academic year? Could they not undertake field work connected with their studies for a number of weeks per year so as to extend the university out into the rural areas? The combination of just these two domestic innovations applied to the ten million university students of the Third World could, given adequate technical, financial and administrative back stopping, reduce conventional illiteracy by half within five years and eradicate it within about ten.
>
> Such programs need not of course be limited to literacy. They could apply to any of the areas of what might be called "domestic problematique" such as water resources, land conservation, health and sanitation, environmental protection, preservation of the cultural heritage, and so on. Government agencies and private

enterprises could contract with universities for work on any such environmental or developmental project.

Thus one might envisage industries, or Government departments contracting Universities -- or even secondary schools -- to undertake several weeks of environmental monitoring and to report their results for academic credit.

A third way of linking the three terms of our theme should be effected through the regional centres we have proposed for research and development in marine industrial technology. Marine industrial technology, or course, is merely an example, and we have focused on this, because there exists a legal mandate and institutional framework for action. In reality, however, marine industrial technology involves, in fact, all branches of so-called High Technology, from genetic engineering to laser, from new materials to micro-electronics, from fibre optics to acoustics and magnetology. If we make a breakthrough in integrating research and training in marine industrial technology, it should affect the educational system as a whole.

The purpose of these centres should be the joint development -- both South-South and North South of environmentally sound and socially relevant technology. This would include pollution monitoring and pollution control technologies along with

environmental impact assessment of any other marine industrial technology to be developed as well as integration of environmental parameters in economic forecasts, cost/benefit analyses and marketing projections relating to such technologies. Any project carried out under the auspices of the regional centre would have the participation of at least two countries, at least one of which would have to be a developing country. The cost for the project would be borne half by the private sector (the industrial enterprises who would have proposed the project) half by governments or intergovernmental organisations. The participation of the developing country would be paid for by the World Bank, UNDP, or other development cooperation agencies. The scientists and engineers of the developing countries would participate on an equal footing in the research and development activities, alongside their partners from the developed countries. Additionally trainees could be taken on to assist in the research. The results of the R&D are to be shared by all participating countries. The technologies developed in common are owned in common. The traditional -- and very unsuccessful -- concept of "technology transfer" has been replaced by the more dynamic, more modern concept of "joint development of technology."

Obviously, joint development of technology has a strong, built-in component of training and learning and represents a direct flow of environmental research findings into education. Here research is part of training and training is part of research.

The regional centres should also conduct, or be linked to, regular training programmes directly benefitting from the findings of the scientists and engineers engaged in the R&D.

The regional centres are conceived as focal points of very diffuse institutional networks. Although these networks will vary from region to region, we tried to design a general scheme, which was included in our feasibility study for the Mediterranean Centre for R&D in Marine Industrial Technology.

-- FLOW CHART --

We have dealt, thus far, with existing institutions, or institutions that could be established in the short term, and with short- or medium term possibilities of enhancing the flow of environmental research findings into education.

Now I want to come to the fourth term of my theme, designated as "plus one" in my opening remarks, that is, the future. In the longer term we certainly will have to rely on the new technologies

of education -- distance learning technologies, television, radio, interactive computer programmes, etc. for the building of an educational system that is innovative, widely participational, both intranationally and internationally, linking national, regional, and global levels, adjusting to change rather than to a stable system, and transcending the Rashamon syndrom through a genuinely interdisciplinary approach to the major issues of contemporary life. How can the flow of environmental research findings be enhanced in such a system?

I have tried to design a simple flow chart to describe a very complex process, and I shall now try to explain it.

This is a case study on how the whole system might work as applied to an aquaculture project.

My first assumtion is that environmental research and education does not take place in isolation but as an integral part of a development and production system. This is reflected in the R&D agenda of the R&D Centre in the central box.

My second assumtion is that the project is one that has been selected on the basis of the participation of several countries, including at least one developing country, and that it is carried out as a joint venture between industrial enterprises in both developed

and developing countries and a university, or universities, under the auspices of a Regional R&D Centre. The costs are borne half by the industrial enterprises, half by national governments. The cost for the participation in the R&D by the developing country or countries is borne by UNDP. This enables the scientists and engineers of the developing countries to participate in the R&D as equal partners.

Part of the agreement is that the University assigns students for field work for the assessment of the social and environmental impacts of the projects. They do this for academic credit.

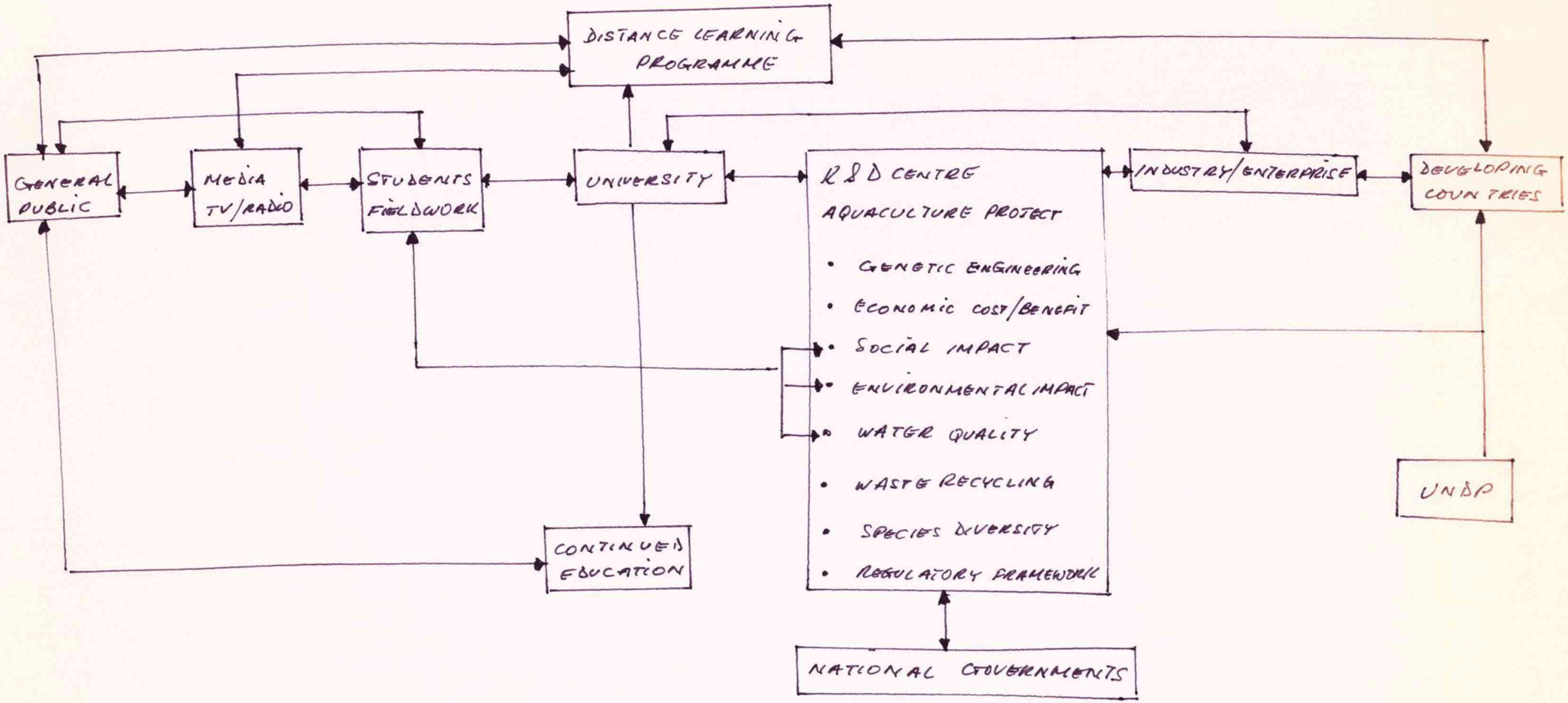
The work of the students is followed by the media, both television and radio. Interviews and images are projected to the general public. People thus are encouraged to join the students in monitoring social and environmental impacts.

The University incorporates the results of the research into its continued education programme which is available to the general public and thus enhances environmental education throughout the community.

The University also utilizes the research results for its distance-learning programmes which are made accessible both to developed and developing countries. Developing countries thus get

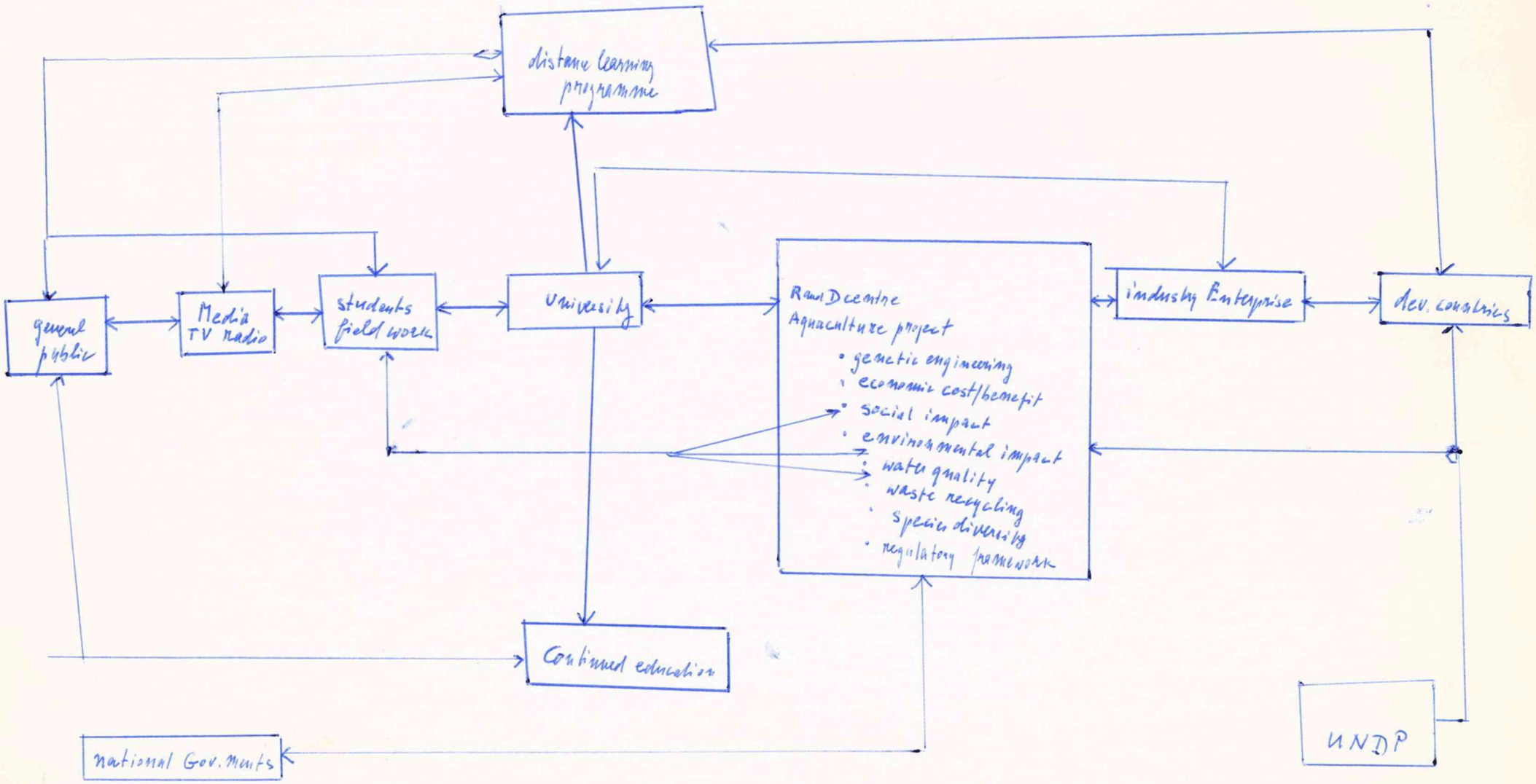
a twofold input of environmental education: through the direct participation of their scientists and engineers in the R&D, and through the distance learning programmes. The scheme links national, regional, and global levels of activities.

I think such a scheme probably maximises the flow of environmental research findings, integrated into a development project, into environmental education for the future.



LINKAGES BETWEEN ENVIRONMENTAL RESEARCH & EDUCATION

MULTIPLIER EFFECTS



Linkages between environmental research and education

Multiplier effects

Pacem in Maribus

International Ocean Institute
P.O. Box 524 Valletta - Malta Cables: Interocean

GUIDE LINES FOR A TRAINING PROGRAMME

INTRODUCTION

The following guidelines are based on four interrelated assumptions:

1. Plans for training for staff for the Enterprise must incorporate a substantial uncertainty factor. In contemporary economics, this is a general and pervasive phenomenon, but in the case of sea-bed mining it is of particular importance. No one is able to forecast when, and under what economic and technological circumstances, seabed mining is to start. it may be much sooner than some forecasters anticipate; or it may be during the first decade of the next century. Special Commission II has been unable to agree on a set of assumptions; and it is indeed impossible to do so.

2. Seabed mining will become economically attractive when either of two premises, or a combination of the two, are met. (a) The mineral market improves, with considerably higher and more stable market prices; (b) Technology advances, reducing the costs of production. We have no influence on (a); we do have a certain influence on (b). To reduce the uncertainty factor, it is therefore advisable to concentrate our efforts on (b).

3. In any plan of work, from the pre-investment phase onward, exploration, research and development, and the development of human resources are inseparably linked. They must be planned and carried out together.

4. The responsibility for the development of human resources which is essential for the participation of developing countries in the Enterprise, must be fairly allocated between the Pioneer investors and the international community at large.

I. NATURE OF REQUIRED TRAINING

A. The disciplines to be covered are numerous. They have been listed in a number of Secretariat documents as well as by some of the Pioneer Investors. What should be added here is the need for innovation: the study of the possible impact of various high technologies on R&D in mining technology. This will be elucidated under INNOVATION, below.

Sea Technology recently (June, 1987) published a special report on ocean engineering/resource development, with an article on "Educating the Ocean Engineer" by Stanley Dunn and Ray McAllister of the Ocean Engineering Department of Florida Atlantic University. The Authors conclude that, as a relatively new discipline,

> ocean engineering must take a systems approch to design problems, requiring a firm understanding of each of the technical areas involved.

The disciplines involved "include a significant emphasis on the social sciences and humanities as well as the development of communication skills." The wide range of technical disciplines is mapped on the following chart, reproduced from the article.

B. Considering the above mentioned uncertainty factor, training for the Enterprises should be divided into two parts: (a) building the initial staff of the Enterprise, in a narrow sense; (b) generating a pool of expertise in developing countries, from which the Enterprise, in future years, can recruit its staff.

Building the initial staff for the Enterprise. Since exploration, R&D, and the development of human resources are inextricably linked, this can only be done in connection with the exploration of the first mine site for the Enterprise. It will be on-the-job training, to be carried out on board the research ships, in the

laboratories analysing the data; the data storage centres, the processing laboratories, etc. Close cooperation with the Pioneer Investors will be essential. The Pioneer Investors should be urged to consider drafting a joint training programme, in conjunction with the joint exploration of the mine site which they are already considering as stated in the "Understanding" adopted at the end of the last Session of the Prep.Com.

The G77 should immediately prepare a list of applicants from each country for such advanced on-the-job training. the list should include a c.v. for each applicant showing the levels and disdiplines of pre-training. The list should be kept, and kept up-to-date, by the Secretariat and be at the disposal of the Pioneer Investors.

C. Candidates should probably have reached the level of dipl. ing. They should have been trained in at least five of the disciplines indicated in table 1 and completed a programme of roughly seven years, including undergraduate and graduate work.

Many of the developing countries already include some of the disciplines listed in Table 1 in the curricula of their technical institutions. Other countries should be urged to introduce training in these disciplines. UNESCO, and, especially its Intergovernmental Oceanographic Commission (IOC), as well as the United Nations University and its WIDER Institute (Helsinki) and UNIDO will assist developing countries in strengthening their basis for such training. Such a national basis is essential for the strengthening of self-reliance. Without such a national basis, international cooperation in marine sciences and technology remains ephemeral.

D. GENERATING A POOL OF EXPERTISE

While the roster of already trained engineers and scientists will form the basis for the formation of the initial staff of the Enterprise, as far as the developing

countries are concerned (the list could of course include candidates from the industrial countries as well), the continuous training of marine scientists and engineers at this level serves additional purposeS. (a) it serves to generate a pool of expertise from which the Enterprise, in future years, may recruit its staff; (b) it will assist developing coastal States in the management of their EEZ (offshore oil exploration and production; offshore structures; exploration and mining of nearshore mineral resources; design; communication, etc.)

E. Where the teaching of a required marine science discipline is not practical because of economy of scale, regional coopertion offers the best chance and will enhance collective self-reliance and South-South cooperation. An essential instrument would be the Regional Centres established by Articles 276 and 277 of the U.N. Convention on the Law of the Sea. Although these Centres, just like the International Sea-bed Authority and the International Tribunal for the Law of the Sea, are new institutions established by the Convention, the Preparatory Commission has no mandate to make practical arrangements for their establishment. The Secretriat for Ocean AFfairs and the Law of the Sea should be urged to take steps, in cooperation with the competent international organisations (especially UNEP, UNIDO, and IOC), to prepare for the early entry into effective operation of these Centres as soon as the Convention comes into force. They may play an important role inthe training of personnel for the Enterprise from developing counries.

F. As any other, private or public, industrial enterprise, the Enterprise must comprise a Department for Research and Development (R&D), including the development of human resources which is inextricably intertwined with the development of technology. Such departments occupy an ever more important space in the organisation and budget of any industrial enterprise. Development and competitiveness of the enterprise would be unthinkable

without such a department. The annual cost for this part of the Enterprise has been estimated as $50 million in the Austrian working papers on JEFERAD.

In his final Statement during the Fourth Session of the Preparatory Commission, the Chairman of the Second Special Commission indicated the need of dealing with the R&D Regime of the Enterprise. The Chairman should be requested to place this item on the agenda of future sessions as it provides an important element for the training of staff for the Enterprise.

G. Other measures for advanced training through cooperation with the international community could be developed by studying the experience in outer Space. The Committee on Peaceful Uses of Outer Space (COPUOS) has developed a remarkable network of training facilities on a global scale. The Report of the Scientific and Technical Sub-Committee on the Work of Its Twenty-Third Session (A/AC. 105/369, 28 February 1986), contains two recommendations:

   c. The United Nations should support the creation of adequate training centres at the regional level, linked, whenever possible, to institutions implementing space programmes; necessary funding for the development of such centres should be made available through financial institutions;

   d. The United Nations should organize a fellowship programme through which selected graduates or post-graduates from developing countries should get in-depth, long-term exposure to space technology or applications; it is also desirable to encourage the availability of opportunities for such exposures on other bilateral and multilateral bases outside the United Nations sytem.

The Report, then, gives an overview of training

activities during 1985-6 and 1987, which is impressive. Some excerpts of this report, with relevant information, is attached in Annex I.

G. Another interesting training scheme, which could be expanded to cover marine science and technology, is provided by the Third World Academy of Sciences. Information on this is attached in Annex II.

H. The Training Programme of the International Ocean Institute, Class A, would be a useful addition to any long-term technical programme and provide the inter-disciplinary and systemic component recommended by the article in Sea Technology. The programme could be redesigned in cooperation with the Secretariat to meet the specific requirements of the Prep.Com. A Report on one such course is attached in Annex III.

I. The Secretariat should be requested to prepare a roster of existing training facilities.

H. A scheme and time-table for training, both in the pre-investment and in the operational phase of the Enterprise is given in Table 2.

II. ON SELECTION CRITERIA

A. Qualification

As mentioned above, applicants for training for the Enterprise, whether in the pre-investment or in the operational phase, should have the qualifications of a Dipl. Ing. or Master in Science. They should be invited to a competitive examination administered by a Training Commission established by the Prep.Com

B. Equitable geographical basis

It would be desirable for Special Commission II to come

to an agreement as to the proportion of Enterprise staff to be employed from developing countries. It is assumed here that half of the staff should be so recruited.

Within this framework, however, it would not enhance the efficiency of the Enterprise to base recruitment on a quota system determined by the criterion of regional representation. Recruitment should be based on efficiency alone, as ascertained by a competitive examination. Ceteris paribus, however, preference should be given to under-represented regions; and should any region be seriously under-represented on the staff, special, additionl efforts should be made to improve training in such a region.

3. SHORT-TERM AND LONG-TERM REQUIREMENTS/PROJECTIONS, ETC.

Short-term training activities (building of the initial staff of the Enterprise: see I (B) above) and long-term training activities (generation of a pool of expertise in developing countries: See I (D) above); should be initiated at the same time. The development of human resources, intertwined with the development of technology is one continuous and dynamic process which is going on anyway, but, until now, to the exclusion of developing countries. It is our great opportunity, and our responsibility, to bring developing countries into this process.

During the short-term phase, a part of the burden will devolve on the Pioneer Investors, in accordance with the Convention, with Resolution II and the Understanding adopted by the Prep.Com. Even during these phase, however, the burden could and should be alleviated by the efforts within the developing countries themselves and by the concomitant beginning of the long-term phase where the burden falls on the international community as a whole.

4. INNOVATION

Returning, in conclusion, to premise 4 of the introduction to these pages, we wish to stress once more the importance of innovation in research and development in mining technology as the one factor most likely to make ocean mining economically interesting. More specifically, it will be the impact of the most advanced sectors of High Technology on mining technology that will bring about this change. A list of high technologies, and their possible impact on ocean mining was attached to the Statement made by the IOI during the Spring, 1987, Session of the Prep.Com. The list is being reproduced in the Colombian Working Paper, WP14, Add.2. It is attached here as Annex IV.

To give just a few obvious examples: Developments in research on blue-green lasers, which may penetrate the ocean waters from outer space, may alter our exploration technology. The perfection of subsea completion systems in the offshore oil industry in very deep waters or harsh climates, together with the building of submarine tankers, may revolutionize our mining concepts: the mining-ship may disappear in the wake of the drilling platform. Nodules might be collected and pre-processed by remote control in subsea completion systems and loaded on submarines which would take them directly to the processing plant. New inventions in materials technology my alter, and reduce the cost of, our instruments. Progress in magnetology or in genetic engineering may affect our processing technology: in future, perhaps 7 or 8 metals may be extracted rather than 3 or 4 as conceived today.

To enable developing countries to participate in this process, a special scholarship system should be established, possibly in cooperation with the Third World Academy of Science. Highly gifted marine scientists and engineers from developing countries should be selected

and awarded scholarships to work for a period of time in the most advanced scientific and industrial institutions in the developed countries to study the most advanced sectors of high technology for their possible application to seabed mining technology. This is not an extra-ordinarily costly scheme. in fact, it does not cost more than any other scholarship scheme. More than a financial question, it is a question of purpose, of organisation and of mutual trust and cooperation.

5. SUMMARY OF RECOMMENDATIONS

A. Exploration of the first mine site for the Enterprise, Research and Development of technology, and the development of human resources should be planned and conducted as a whole system.

B. Considering the uncertainty factor, training should be divided into two parts: building the initial staff of the Enterprise, in a narrow sense; and generating a pool of expertise in developing countries, from which the Enterprise, in future years, can recruit its staff.

C. The Pioneer Investors should be urged to consider drafting of a joint training programme, in conjunction with the plan for the joint exploration of the mine site which they have already announced, and the development of site-specific technology.

D. All members of the Prep.Com should prepare a list of applicants for advanced on-the-job training for the Enterprise. The list should include a c.v. for each applicant showing the levels and disciplines of pre-training. The list should be kept, and kept up-to-date, by the Secretariat and be at the disposal of the Pioneer Investors.

E. Candidates should have reached the level of Dipl. ing. or Master in Science.

F. Developing countries should utilize the assistance of UNESCO, IOC, UNU and UNIDO to upgrade basic training in marine science and engineering.

G. The Secretariat for Ocean Affairs and the Law of the Sea should be urged to take steps, in cooperation with the competent international organisations (UNEP, UNIDO, and IOC) to prepare for the early entry into effective operation of the Regional Centres established in Articles 276 and 277 of the Convention, as soon as the Convention comes into force.

H. The Chairman of the Second Special Commission should be requested to place an item on the R&D capacity of the Enterprise on the agenda of the Special Commission.

I. The arrangements for training made by the Committee on Peaceful Uses of Outer Space (COPUOS) should be studied as possibly useful precedents for training arrangements for ocean mining.

J. The Secretariat should be requested to prepare a list of other existing training programmes and explore possibilities of cooperation

K. The Prep.Com. should, in due time, appoint a Commission on Training to administer competitive exams for the selection of candidates for training with the Pioneer Investors and other programmes.

L. To encourage innovation, a Special Scholarship Scheme should be developed, in cooperation with the Third World Academy of Science, for highly gifted marine scientists and engineers from developing countries.