ANNUAL REPORT 91

Institute FOR Prospective Technological Studies

JOINT RESEARCH CENTRE

COMMISSION OF THE EUROPEAN COMMUNITIES

EUR 14447 EN

A N N U A L · R E P O R T · 91

Institute FOR Prospective Technological Studies

JOINT RESEARCH CENTRE

COMMISSION OF THE EUROPEAN COMMUNITIES

EUR 14447 EN

Published by the
COMMISSION OF THE EUROPEAN COMMUNITIES
Directorate-General
Telecommunications, Information Industries and Innovation
L-2920 Luxembourg

LEGAL NOTICE

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 1992

Printed in Italy

ANNUAL REPORT 1991

TABLE OF CONTENTS

EXECUTIVE SUMMARY page 4

1. INTRODUCTION 5

2. SCIENTIFIC AND TECHNICAL OBSERVATORY (ESTO) 6
   - 2.1 "Innovations" Data Base - NOVA 6
   - 2.2 "R&D Projects Data Base - Qui Quod (Q^2) 7
   - 2.3 PROMPT Representatives in the USA and Japan 8

3. STUDIES FOR OTHER COMMISSION SERVICES 9
   - 3.1 Studies for the Forward Studies Unit 9
     - 3.1.1 Observatory of Climate Change Research and Policy 9
     - 3.1.2 Opportunities in Environmental Technology 12
     - 3.1.3 Japanese Industry and Global Environmental Problems 14
     - 3.1.4 Californian Industry and Global Environmental Problems 15
     - 3.1.5 Renewable Energies in a CO_2-Reduction Strategy 16
     - 3.1.6 Nuclear Energy Prospects 19
   - 3.2 Studies for Directorate General III 22
     - 3.2.1 High Speed Trains 22
     - 3.2.2 European Space Industries Competitiveness 23

4. STUDIES FOR THIRD PARTIES 26
   - 4.1 Uses of Cork 26

5. INTRAMURAL STUDIES 27
   - 5.1 Bibliometric Analysis Tools (MAP) 27
   - 5.2 Perspectives on the Process of Innovation for Advanced Materials 28
   - 5.3 The Role of New Materials in Europe's High Technology Industries 28
   - 5.4 Interregional Cooperation in Technological Innovation 29

6. WORKSHOPS 31
   - 6.1 Literature-Based Innovation Output Indicators 31
   - 6.2 European Network for Training in Strategic *Prospective* 32
   - 6.3 High Speed Trains 32

7. HUMAN RESOURCES 34

8. LIST OF REPORTS 35

EXECUTIVE SUMMARY

a) The primary tasks of the Institute for Prospective Technological Studies (otherwise known as PROMPT) are:

- Monitoring new developments in science and technology
- Strategic analyses of new areas of science and technology

b) The first of these tasks relates to an "observatory" function. Although our resources are not yet sufficient to execute this function fully, considerable progress was achieved in the development of ESTO (the European Science and Technology Observatory). ESTO has on-line access to some 500 data bases and the pilot version of its NOVA DB - aimed at identifying and evaluating technical innovations in key research areas - was brought to an advanced stage of development. The third major ESTO tool is the data base known as QUIQUOD or Q^2, which is an inventory of "who is doing what" in European science and technology; it was developed further and is now under evaluation. The Institute ran two successful trials during the year to collect scientific intelligence from Japan and the USA using personal representatives.

c) Studies conducted by the Institute are carried out strictly in accord with the "customer - contractor" principle. They are normally performed on the request of another Commission Service (including other parts of the JRC). The Commission Service which represented our main customer in 1991 was the Forward Studies Unit of the Presidency and six studies, all broadly related to the global warming theme, were undertaken for this client during the year. Two major studies were carried out for the Directorate General for Industry during the year. The first of these was on the future European high speed rail system and the second was on the competitiveness of the European space industry.

d) As the Institute constitutes an independent adviser to other Commission Services it is difficult for it to become heavily involved in work for outside bodies. However, one sizeable external contract was undertaken during the year (on the future uses of cork) and others are planned.

e) The Institute hosted a number of visiting scientific researchers during the year who carried out a range of intramural studies which have contributed to both the observatory and prospective aspects of our programme.

f) Three Institute workshops were held. One of these dealt with innovation indicators. The second concerned training in strategic prospective and was aimed at the establishment of a European network. Finally the Institute also held a workshop to revue the preliminary findings from the high speed train study.

g) Staff numbers remained constant during the year. The Institute has 11 scientific/technical personnel (9 of them A-grade), with 3 administrative / secretarial staff. A further 4 posts are under recruitment.

1. INTRODUCTION

The Institute for Prospective Technological Studies (also known as PROMPT) was created in 1989, following the new orientations and the new organization of the JRC which were put into effect at the end of 1988. The official document which describes these changes for the JRC, ("A new outlook for the Joint Research Centre" - COM (87)491), contains the following statements, relating to the new Institute for Prospective Technological Studies :

"prospecting, assessment, scientific watch and strategic analysis will assume a new significance in the context of scientific and technological developments.
This work will become an integral and essential part of the process of programming Community research. In particular, the scientific and technological watch function, which is virtually unknown in the Community, will be called upon to play a key role in the future alongside the prospective studies and technology assessment functions"
and
"the special feature of the JRC's role in this area is its ability to supply strategic analyses based on "inside knowledge" of the scientific and technical trends in the world of research".

Working from this base, and relying on the wide spectrum of scientific/technical knowledge available within the JRC, PROMPT supports a permanent system for information on and analysis of the state of science and technology in the European Community, and of its relative position world-wide. The activity includes the analysis of both the potential and the drawbacks of new technologies, the prospects for their application in various fields and the developments foreseen.

The focus of the Institute's activities is advanced, applied research, with priority going to the subjects covered by the Community Framework Programme and to those newly emerging technology areas which are potentially important for European society and industry.

The main functions of the Institute are to monitor, evaluate and alert, helping to bridge the gap between European science and European technology, with the intention of providing information on strategic options and opportunities with a European dimension, in a form suitable for users within the Commission, for science planners and for European industry.

The permanent staff of the Institute remains small in number. It is, however, being complemented by temporary staff seconded from Member States, by visiting scientists and by research fellows. In addition, PROMPT relies heavily on contributions from outside, through formal contracts or collaboration agreements with national institutes and industrial firms and through networks of individual correspondents in various fields and countries.

2. SCIENTIFIC AND TECHNICAL OBSERVATORY (ESTO)

The collection, reduction, storage, analysis and dissemination of a large amount of information in selected fields is an essential part of the activities of the Institute. Some of the tools for this activity were already available but others required further development for the effective execution of this function.
Thus far these tools have been mainly used to satisfy the requirements of PROMPT studies. However, there are plans to use them to provide a science and technology Observatory service for outside customers and to provide a regular Technology Watch function.

The first and most utilised tool is the direct on-line access to some 500 bibliographic and patent Data Bases. This is complemented by new techniques for structured searches and by a rapid system for document acquisition.

Direct access to information is also obtained through networks of correspondents and through Institute antennae which we intend to place in key countries/regions. In 1991 a PROMPT antenna operated on a trial basis in San Francisco, California for seven months.

Prompt makes extensive use of software tools for information treatment. In particular, two Data Bases have been created. The first (named NOVA), is for analysing the most recent information on scientific novelties and technological innovations and the second (named Qui Quod or "Q^2"), is for storing information on current R&D projects in the Community.

2.1 "Innovations" Data Base - NOVA

NOVA is a data base system which is under development in the Institute for the storage and retrieval of validated information collected in the course of contracted studies. The stored information should include the most recent achievements and breakthroughs in science and technology as well as information on trends and potential for innovation.

A pilot system for this information resource has been developed, including an input mask, a retrieval system and a basic "import/export" "from/to" text-file mechanism. In hardware terms this has been accomplished by linking a number of Macintosh PCs to the JRC Ispra ETHERNET network backbone and to the dedicated PROMPT server. In software terms a custom-made package, based on the "user-friendly" HyperCard Interface, was developed to facilitate access to the data records stored in the SYBASE SQL server. The software permits the input, retrieval and output of information stored according to requirements.

In the initial stages, the stored information will be primarily related to subjects that are currently studied by PROMPT, i.e. Global Change, Environmental Technologies, Renewable Energies, Nuclear Fission, High Speed Trains, Air Transport, Space Technology, Advanced Materials and Biotechnology. Consequently it is mainly our own staff who collect and enter the

information in the NOVA data base. This means that a critical filter is applied to the vast amounts of publicly available information. The number of outside contributions, through collaboration agreements and formal contracts with networks of experts in science and technology, will continue to rise depending on financial resources.

Information input may be performed either on-line through a MAC PC or in batch-mode from any other type of PC, through the use of a common word processor application. Information retrieval may be performed on-line through the HyperCard interface and custom-made software which performs a free text search based on keyword combinations using Boolean and/or proximity operators.

The prospective use of the information contained in the NOVA data base is to provide a system for the early detection of innovations and/or scientific breakthroughs with the aim to analysing their future evolution, impact and consequences.

2.2 "R&D Projects" Data Base - Qui Quod (Q^2)

The second large informatics tool which the Institute is developing is equally important. This is an information system, termed Qui Quod (or more simply "Q^2"), which should provide a continuously updated picture of projects and organisations active in European R&D in selected research fields.

The Q^2 information system has been designed and is in an advanced state of development. It provides access to existing national and international data bases and enables users to make integrated enquiries concerning information on European R&D projects. The objective is to provide a listing of all the active R&D projects in a specified research field with details on project definition and progress, institution, budget, staff, time-scales and fields of activity.

In order to achieve this objective, without unnecessary repetition of previous work, it has been decided that Q^2 should provide structured access to existing national and regional R&D data bases. However, this resource will be complemented by PROMPT's own data collection from alternative sources, whenever there are gaps in the existing information resource. (This approach is in agreement with the DGXII-A working group's recommendation on the harmonisation of national R&D data bases.)

We commenced building this data base with the field of Advanced Materials because there was an internal (JRC) customer for the information. Appropriate national, regional and sectorial R&D data bases were identified and the responsible people were contacted. Those data bases that allowed on-line access were interrogated and if this was not possible a batch consultation for selected advanced materials topics, either on hard copy or on magnetic media, was requested. All of the assembled data was downloaded to the Q^2 data base and organised to permit free text interrogation. Extensive tests have been performed and a record counting mechanism was used to identify related records for each project area, country and institution as well as other important factors characterising a R&D project.

The primary goal of assessing the relative importance, completeness and compatibility of these data bases in relation to PROMPT needs in the field of advanced materials has been achieved. Whether the quantity and quality of the data retrieved is sufficient for experts in any particular field (in this case advanced materials) is still to be fully determined.
This intercomparison showed up the need for greater organisation at the European level of existing R&D data bases, and identified the needs for a common multidisciplinary classification scheme and for methods for overcoming the language barrier.

A complementary study which would identify and access all available EC Member State structured sources of R&D data is proposed as the next step. The assembled data from this study would be compared and the results would help depict the overall status of European R&D project data bases and their respective levels of harmonisation .

2.3 PROMPT Representatives in the USA and Japan

It has been agreed that the Institute should, in due course, have detached representatives in Japan and the USA to support PROMPT's observatory function. Consequently, two trial operations were carried out in 1991 in support of the Institute's programme of work and to evaluate the *modus operandi* for these proposed PROMPT antennae.
The first of these trials involved a short, intensive study mission to Japan (reported in section 3.1.3) and the second involved a 7 month detachment of a staff member to the West Coast of the USA (reported in part in section 3.1.4).
The reports produced from these trials were of considerable value to our clients and our general conclusion from the trials is very positive and our long term aim is to have permanent antennae in these two countries.

3. STUDIES FOR OTHER COMMISSION SERVICES

Prospective Studies represent the main output of the Institute and since PROMPT is effectively an internal consultancy of the Commission the clients for these studies are usually other Commission Services. Nevertheless, the customer - contractor approach is applied strictly, both in regards to the budget and the time scale for a study. Furthermore, PROMPT delivers the study to the client on the usual consultancy basis that the results are for the client alone and are treated as confidential by the Institute. Consequently, only the broad lines of the studies are given below and the intention is to indicate the scope of our work and the Institute's capabilities rather than the detailed results.

3.1 Studies for the Forward Studies Unit

The Forward Studies Unit of the President of the Commission continued to represent our largest single client in 1991. A number of studies were completed all of which were to a greater or lesser extent related to the issues of global warming and global/regional environmental problems; other limited but frequent contributions concerned corporate strategies and the relations between technology, innovation and industrial policies.

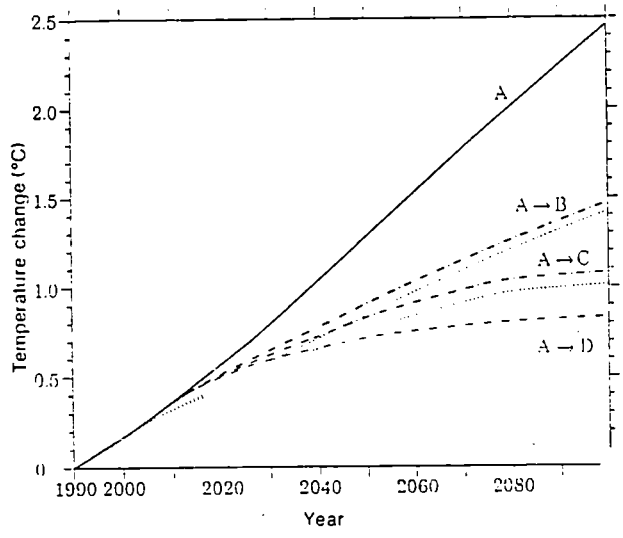
3.1.1 Observatory of Climate Change Research and Policy

This project, which has run since 1990, consists of a continuing survey of research progress and policy options in relation to the greenhouse effect and other related aspects of global climate change.

The objective of this project is to keep the customer up-to-date with regard to the most significant research results in relation to climate change issues. It provides a continuing re-assessment of their significance, of their potential impacts, and of the feasibility of response strategies as background information for policy makers.
In 1991, two reviews were issued which analysed about 120 items of scientific literature. Information obtained from scientific conferences and direct contacts with researchers in the field were also included in the reviews.
In order to illustrate the issues covered in the study, some selected excerpts from the reviews are presented below:

Even if the consensus expressed in the IPCC* report (Autumn 1990) remains a yardstick for a large majority of climate research workers, it continues to be contested, especially in the United States, where an active group of "sceptics" has proposed a research programme to the President which aims to demonstrate that the "popular vision" of apocalyptic climatic change is wrong.

A recent finding by an eminent climate modeller (who is certainly not in the group of "sceptics") is that the greenhouse gas induced warming expected by 2100 would be nearly unaffected by a further 10-year delay in commencing the reduction of greenhouse gas emissions (see figure). This has reinforced the opinion, which is commonly held in the USA, that energy strategies need not be adopted specifically in response to the greenhouse effect until research has uncontestedly proven the effect (via a massive "crash" programme).



Projected gh-gas induced temperature change to 2100 for a prescribed climate sensitivity equal to 1.5°C, for: IPCC scenario A(solid line); a linear transition from 1990 to 2010 from IPCC scenario A to either IPCC scenarios B, C or D (dotted lines); and a linear transition during 2000 to 2020 from IPCC scenario A to either IPCC scenarios B, C or D (dashed dotted lines). All calculations begin in 1765 and all temperature changes are relative to 1990. (from Schlesinger & Xingjian Jiang, *Nature*, 350, nr.6315, pp.93-94).

---

* Intergovernmental Panel on Climate Change, jointly sponsored by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO).

The (possibly cooling) effect of sulphate aerosols (an end product of natural or man-made sulphur emissions in the atmosphere) resulting from their direct or indirect capacity to decrease the solar radiation fraction absorbed by our planet, is becoming the subject of an impressive research effort. The stakes are very high because it could be that sulphate induced cooling has thus far masked the greenhouse gas induced warming, and could still mask it for a while. Furthermore, the effectiveness of fossil-fuel reductions could be strongly diminished or delayed by the associated diminution of the sulphate effect. Data are still insufficient to quantify this effect, but it is increasingly clear that the determination of *sulphate forcing* is becoming an important research issue, the results of which could have strong impacts on the energy strategies to be adopted in response to the greenhouse effect. The recent eruption of Pinatubo (Philippines) has also strongly contributed to evidence this issue.

Research on climatic feedbacks capable of amplifying or moderating the greenhouse gas induced warming is also very active. Research, which started recently in several places in response to a suggestion (by a "sceptic") that atmospheric water vapour could generate a negative feedback, has confirmed the previous consensus that water vapour feedback is largely positive. The cloud feedback studies are heavily limited by the inadequacy of cloud treatment in climate models. However, satellite observations have permitted the identification of a natural regulation process of the sea surface temperature by clouds, which supports the concept of a possibly negative cloud feedback.
Uncertainty still governs the results of studies of the other feedbacks (the list of which does not seem closed yet) but research seems to confirm that the majority have a positive sign (e.g., those due to snow, soil, rain-surface albedo, oceanic heat transport). Only the DMS (dimethylsulphide)-cloud albedo feedback, which involves the sulphate effect mentioned above, produces a negative feedback but with an uncertain magnitude.

Important research efforts are in train to interpret the global surface temperature record and to evaluate how far it demonstrates the reality of a greenhouse gas induced global warming. Statistical analysis of the record confirms without any ambiguity the presence of a warming trend (0.4K from 1910 to 1990). However, attempts at statistical correlations between surface temperature and climate forcings, in order to isolate the responsibility of greenhouse gases for the warming, seem doubtful. Thus far interpretations based on simplified deterministic climate models are more convincing. However, due to the "pollution" of the temperature record by many factors, internal or external to the climate system, the resulting uncertainty about the climate sensitivity (to greenhouse gases) is high and will remain high even with a temperature record longer by, say, one decade. For the same reason , the greenhouse warming hypothesis will remain difficult to disprove (even if the next decade should bring a global cooling of, say, -0.2K), because of the warming accumulated up to today.
All of these results are, however, hypothecated by the current uncertainty about sulphate forcing, which may have strongly diminished the (apparent) warming and the (apparent) climate sensitivity to greenhouse gases.

Fingerprinting methods, such as the recognition of the greenhouse effect in surface temperature patterns or in the atmospheric moisture field, look promising, although only from a qualitative aspect. The presence of a greenhouse signature in the surface temperature patterns at high latitudes has already been suggested. This hypothesis is supported by the 2% decrease of Arctic ice extent over the period 1978-1987, which has recently been ascertained.

Efforts to predict future warming based on statistical models seem very limited and rather unconvincing. In spite of their complexity, General Circulations Models (GCM) appear to be unavoidable tools, both for a reliable quantitative prediction of warming and the investigation of the other aspects of greenhouse gas induced climate change. Considerable efforts towards their development and improvement are in progress world-wide. Important advances are reported, especially as regards the coupling of Atmosphere-GCM and Ocean-GCM, and the first transient

simulation with such a model on a 100-year time scale. The latter shows that the IPCC reference greenhouse warming projections, based on a simplified coupled atmosphere-ocean model, are pessimistic in the short term but reasonable in the long term.
Good prospects are reported for the coupling of a surface wave model and a carbon cycle model to such a GCM model. This should considerably improve the reliability of climate projections in the near future.

The overall impression obtained from the survey of recent greenhouse effect related scientific literature is that the scales are turning a little bit more towards the confirmation of the greenhouse effect hypothesis, but, that the uncertainties remain enormous and that research is currently more urgent than the definition of response strategies.

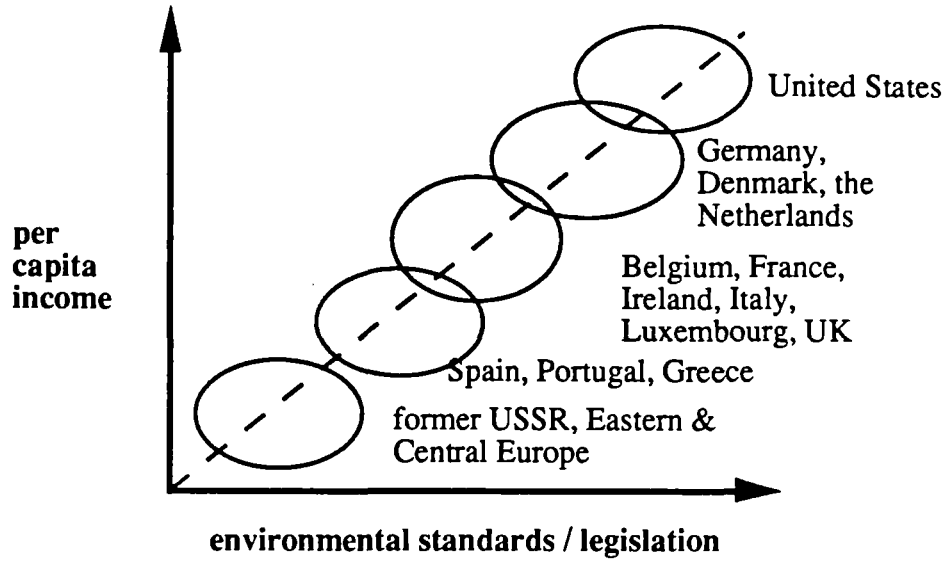
3.1.2 Opportunities in Environmental Technology

The industrialised world is waking up to the fact that there are opportunities as well as costs in the environmental business. A Nature headline in 1990 read "Japan sees gold in warming" and several conferences in 1991 addressed the impact of environmental pressures on corporate strategy. This awakening has been hastened by the realisation of the magnitude of the environmental clean-up task in the former Communist Block countries.

Most estimates put the annual global market for environmental goods and services at about $200 billion dollars. In fact, in the United States some analysts suggest that pollution abatement and control expenditures may outstrip spending on national defence by the turn of the century. Not surprisingly, environmental technologies are fast becoming one of the highest strategic priorities of industry and governments. Within this context, the Forward Studies Unit requested a study on the main opportunities for the European Community in environmental technologies.

Environmental technology is taken to encompass a range of equipment, techniques and processes that may be used in pollution abatement, and any 'clean' technology that helps in pollution prevention. As a starting point, an analysis of the basic environmental issues facing the European Community was carried out since it is these environmental issues that drive technology needs. However, not all issues were addressed, and topics such as noise pollution, indoor air pollution, oil and chemical spills on water, asbestos and hazardous wastes were not covered.

Environmental technology markets within the European Community are highly segmented as a result of individual country attempts to control pollution through their own regulations. In general, there is a positive correlation between high environmental standards and high per capita income (see figure). Hence, richer countries tend to have more stringent environmental legislation and more developed environmental technology markets. The completion of the Internal Market may be expected to produce some changes, but environmental technology markets are likely to remain segmented. This is because a set of minimum standards will apply rather than total harmonisation of standards, with individual countries allowed to go beyond the EC directives.



One of our main findings was that environmental technology business opportunities over the next 5 to 10 years are likely to remain mainly in the area of add-on pollution clean-up technologies, driven by 'compliance' to ever stricter regulations and enforcement.

Major opportunities are in the following areas:

- electricity generation: flue-gas desulphurization systems, NOx reduction technologies, 'clean-coal' technologies
- transport: emission control catalysts, trap-oxidisers for diesels, commercialisation of super fuel-efficient vehicles, reformulated fuels
- water treatment: treatment plants, drinking water purification technologies, industrial waste water treatment
- soil-remediation: physical soil-remediation technologies, decontamination by microbes
- solid wastes: treatment, separation and recycling technologies

As regards achieving the ambitious 'sustainable development' environmental objectives of pollution prevention, waste minimisation and re-use of materials, first defined in the Single European Act adopted in 1986, much remains to be done.

In general, the technology to meet the objectives of the Single Act is available, but significant barriers hinder their adoption. Firstly, existing legislation often fails to take a multi-media approach, focusing on single pollutants; this can have the effect of promoting the use of add-on pollution clean-up equipment. Secondly, prices of products and processes rarely reflect the hidden costs of environmental degradation and other social costs.
There appears to be a clear need for new initiatives and instruments to promote pollution prevention and our future work will seek to address some of these issues.

3.1.3 Japanese Industry and Global Environmental Problems

With the increasing importance of the environment in the industrial field it is important for Europe to gain an insight into current Japanese industrial strategies in this field. Consequently, a short, but intensive mission, to Japan was undertaken in order to make a preliminary study of Japanese industrial approaches to global environmental problems.

Japan has suffered from appalling pollution problems. However, in all fields the situation has improved remarkably in recent years. Taking air pollution as an example, the adoption of stringent air quality standards and massive investment by industry has resulted in national success in controlling air pollution. This success has not only benefited the Japanese people but also Japanese industry. In fact, if European utilities need to purchase SO_x scrubbers today they are as likely as not to buy Japanese. (A further example is afforded by Japanese cars which have been able to penetrate the North American market so well because of their advanced emission control technology.)
In order to obtain a first impression of the technological response of Japanese industry to current global environmental problems a study mission to Japan was carried out in 1991. During the mission, in-depth discussions were held with government offices, national laboratories, industrial associations, utilities, private companies and academics. One clear conclusion is that there is a strong concern for environmental problems at the highest level in all the organisations visited and this concern is reflected in well funded programmes.

Two headlines sum up, in a rather "black and white" fashion, the possible difference in attitude between European and Japanese approaches to this problem.

Europe: "The Cost of Keeping Cool" Economist 26/01/91
Japan: "Japan Sees Gold in Warming" Nature 25/10/90

However, the current Japanese concern does not seem to be primarily motivated by the prospects of industrial opportunity in the environmental business as epitomised by the Nature headline. On the contrary, the concern seems to reflect a new Japanese corporate desire to rectify the environmental damage caused by earlier industrial activities. This does not mean that they will not market technology which is developed to deal with environmental problems whenever this makes commercial sense - and there are a number of such examples.

Another motivation - particularly with respect to "Greenhouse Gases" - is the need to "insure against the problems of tomorrow". If new environmental regulations are imposed, corporate Japan intends to be in a position to be able to cope with them. CFC's, for example, are being phased out by companies more rapidly than required under the Montreal protocol.
A very wide range of technical options is being explored. $C0_2$ technology is being developed for possible application in ten years time. Nevertheless, the situation concerning the development of $C0_2$ technology in not the same as that concerning SO_x technology development in the 60's and 70's. To combat SO_x emissions Japanese industry invested massively in R & D. This is not yet the situation for $C0_2$.
Although the longer-term $C0_2$ separation, recovery and fixation R & D projects are in their infancy and funding is still relatively small, such programmes are found in a large number of private sector organisations and the programmes are significant, individually and collectively.

(e.g. In 1991 a utility company started a pilot scale experiment on CO_2 separation and recovery technology by a chemical absorption method.)
Consequently, if CO_2 technology becomes necessary, Japan should be in a good position to exploit it in the market place.
Japanese companies are taking the long-view and developing technology now to deal with global environmental problems which may only become real in the next century.

There is a proviso. The global environment is a political issue. If it ceases to be a political issue, much of the pressure to develop the necessary technology will disappear, even if companies continue to produce products with a green label, which is equivalent to a marketing bonus.

3.1.4 Californian Industry and Global Environmental Problems

Following the study of Japanese industry and the environment (section 3.1.3) it was decided to conduct a similar study in North America. The study concentrated on California because this State has often set the pace and the agenda for the environmental movement and, consequently, has more experience than most regions of both the costs and the opportunities associated with environmental pressures on industry.

This study was based on a series of visits to California research centres, academia, utilities, industry and industrial associations, consultants and State bodies. The United States in general, and the State of California in particular (which has tended to lead the way on the environment), uses regulations as a primary tool in combating environmental pollution. Hence, there are a plethora of regulations on all aspects of the environment which are administered by a considerable bureaucracy.

There is no doubt that environmental regulations have added to industrial costs in California and may be a contributory factor in the current reduction in manufacturing employment in the State. Certainly on the manufacturing side there seems to be more concern with environmental "costs" than with "opportunities".
However, there has been an enormous expansion in environmental services right across the spectrum, but particularly in the waste management business. There are considerable risks in the business of waste disposal but also enormous profits to be made. Waste Management Inc., for example, has consistently outperformed high tech companies such as Apple or Microsoft.

For "Greenhouse Gases" (GG) the approach is summed up by the catch phrase "no regrets policy". This means that the energy industry will do those things that make economic and environmental sense but which will also result in reductions in GG emissions. With this policy, the utility, Southern California Edison, have announced that they will reduce their CO_2 emissions by 20% (from 1988 levels) by 2010 (in spite of increased demand for electricity). The development of CO_2 scrubbers is considered an unnecessary and expensive option.
The main contribution to *air pollution* in California is of course exhaust emissions from the transport sector. The new regulations that will come into effect in Southern California will

require major innovations in car engines and the electric vehicle option is once again promoted as a solution to the problem.

Under the Federal Resource Conservation and Recovery Act (RCRA) there has been considerable progress in cleaning up *waste water* discharges but the question remains - how clean is clean? Point source discharges of waste water have been the easiest to target and industry has developed the technology to purify and recycle waste water rather than to discharge it. The technology is well established (chemical treatment, filtration, biological treatment, ion exchange) and the results can be impressive. Dow Chemicals for example have virtually ceased aqueous discharge into the Sacramento River Delta. The financial savings are also significant - particularly the avoidance of regulatory fees.

Solid waste disposal is a huge and growing business and is perhaps one of the key environmental political issues. On the municipal waste side, the US disposes of more than 750 kg of waste per head of population per year - while the California figure is almost double this! Disposal technology is becoming increasingly sophisticated but remains essentially "low-tech". The bulk of solid waste is entombed in landfills with clay liners and clay caps. Methane extraction systems are becoming the norm with useful energy gains. The "not-in-my-backyard" (NIMBY) syndrome has lead to the development of super-landfills in remote desert areas. No new garbage dumps have been opened in California in recent years.

In conclusion one can say that Japanese industry tends towards a longer-term and more comprehensive approach while American industry tends towards a shorter-term and more targeted approach. This difference is <u>not</u> universal and is <u>not</u> large but, on average, it is significant. Nevertheless, there is a definite recognition by the better American companies that "end-of-the-pipe" solutions are more expensive in the long run than process modifications.

3.1.5 Renewable Energies in a CO_2-Reduction Strategy

As part of the Institute's spectrum of work on global environmental problems we undertook an in-depth study of the potential role of renewable energies in mitigating the CO_2-problem. The study brought together information from many sources concerning the role renewables could and should play in a new energy structure. A general conclusion is that it would be difficult for renewables to play a major role in the future energy mix if one did not consider the whole economic system when assessing energy costs. In this field neither a pure technology approach, nor a pure economic approach is sufficient, since market pricing mechanisms do not work adequately.

Clearly, energy is the single most important factor influencing global warming and the environment. At present there is no scarcity of energy supply if we use fossil fuels. However, even if fossil fuels are essential for current energy demands, they should not remain the major basis for a sustainable world of tomorrow because of the CO_2-effect. This is a *global problem*, and it must be examined from a global point of view. There is also the obvious danger of interruption due to political events. For this reason alone diversity of supply must be a basic

objective of any energy policy. In addition, the expected population increase in developing nations and their expectation of increased welfare benefits will lead to a continued increase in the demand for energy.

The present (commercial) world energy system is characterised by three numbers:

Fossil	89%
Hydro	6%
Nuclear	5%

The high contribution of fossil fuels has lead to annual emissions of CO_2 of the order of 6 GtC/a, of which 75% are produced by the industrialised world.

Amongst the options for change, two are widely canvassed, namely, *nuclear energy* and a more extensive use of *renewable sources*. However, the widespread use of nuclear energy is not without serious political and social difficulties at the moment. Furthermore, the dimension of the CO_2 problem limits the prospect of nuclear energy making a significant impact on the global warming problem.
With respect to the dimension of the CO_2-problem, one should recall that nuclear energy contributes only 5% (on a thermal heat basis) to the total world commercial energy consumption. Consequently, to change from a fossil fuel base to a nuclear base would be an enormous undertaking, even disregarding the problems referred in section 3.1.6 of this report such as radioactive waste storage, proliferation risks, lack of qualified personnel, the possibility of nuclear blackmail and the need for fast breeders.

Hence, the magnitude of the problem requires one to make a careful examination of the remaining option, namely, a *combination of various renewable sources*: biomass, wind, photovoltaics, and maybe geothermal energy.

On a world-wide scale renewables (including non-commercial energy from biomass) contribute about 18% to primary energy consumption. The essential question is, "Is it possible to increase this share substantially and at an affordable cost?".
The major contributions are:

hydropower	6%
biomass	11.5%
geothermal	0.2%
wind	0.1%
solar	0.2%

Obviously, hydro and biomass are by far the predominant sources. Both can be increased, hydro from 500 to about 900-1200 Mtoe/a (interestingly, the major potential for expansion is in developing countries, which might benefit from this in a future economic growth phase). Biomass could increase its share from 900 to about 2000-2500 Mtoe/a. However, apart from short rotation, intensive culture woody biomass, there is the problem that energy crops would consume acreage probably better used to grow food crops in many parts of the world.
The *geothermal energy* resource is theoretically immense and there is a good engineering experience base, but the practical resource is geographically restricted.
Wind energy is also restricted to certain areas, even if these regions are quite large. Since several GWs are already operational, the necessary steps (technical and financial) to augment its use are fairly predictable. However, due to the high visibility of these plants a conflict with environmentalists may arise in the future. (Off-shore sites may avoid this problem with a possible gain in available wind energy, however mitigated by higher operation costs).

Finally there are the *ocean technologies*. However, these are unlikely to make sizeable contributions before the second half of the next century.
Most of these energies are based on *energy flows* and not on *energy stored* by nature during millions of years. A typical example of an energy flow is solar radiation. Leaving aside the use of solar-conscious architecture, which without doubt could and should be used in an intelligent and aesthetically satisfactory way, there remains solar thermal and photovoltaic energy. The thermal line has had some success under favourable economic conditions, but it needs direct sunlight and mechanical systems which add to complexity and increase capital and maintenance costs.
Photovoltaics, on the other hand, is conceptionally and practically simpler. It has a potential on any scale, from mW to GW, but due to its high cost it continues to have a "niche" image, even if these niches are very helpful in developing an economically sound system. Furthermore, in combination with hydrogen or superconducting dc lines, it has a (very) long term, large scale potential.

At present the use of renewable energies reduces the quantity of CO_2, which would otherwise be produced, by the order of 1-2 GtC/a, i.e. by about 15-30%. A further reduction of another 2 GtC/a is technically feasible, and this use of renewables would provide the energy needed for sustainable growth for another 1-2 billion people. This additional reduction in CO_2 would initially come from additional use of hydropower (+0.5 TW), then biomass (+1 TW), then from wind (+0.5 TW), and finally from solar (+1 to ?). (All of these techniques have a considerable employment potential.)
The parallel development of energy saving measures and a moderate increase in the use of nuclear power could buy the necessary time to allow a gradual transition to an energy-flow based society over the next few decades. Energy saving will be the first (and only immediately available) step, but it will not be sufficient as an ultimate solution.

Our study clearly indicates that the sustainable world it not a mirage, it is a target which could be realised by adopting a long term *constructive strategy*.

Now is the time to look at renewables in a dispassionate way, to ensure that the existing potential for large scale use is taken up. If this option were followed it would solve a large part of the problems created by the increasing carbon dioxide content of the atmosphere, *and* the steadily increasing anthropogenic heat input into our ecosystem.

There will be a huge financial investment in the energy systems of the next century. Renewables should get a major share of that market. Thus, besides helping to cope with a tremendous environmental problem, there is also a considerable business opportunity for European industry. A late start would run the usual risk of losing this market to competitors.

Moreover, since the industrialised world has a serious responsibility for the present environmental situation, it has the moral obligation to offer help to those who are not in such a favourable position.

The report sets out to show that there are energy systems which are more in line with nature than most presently used techniques, which are based on the consumption of millions of years' value of stored energy in, geologically speaking, a moment of time. This crude "deforestation" policy for coal and oil must be stopped. Future energy systems should be based on a new investment pattern, namely tapping natural energy flows. This would not only constitute a *challenge* for Europe but could also be a *chance*. The problem is to start "just on time", that is neither too early, nor too late.

3.1.6 Nuclear Energy Prospects

As a further contribution to the background studies associated with global warming the Institute set out to assess the potential role of nuclear energy in this regard. Inevitably, the study also encompassed the wider issues associated with nuclear energy such as reprocessing and waste treatment.

Depending on the rate of penetration of nuclear energy in the energy system, (typically in the form of electrical energy), nuclear energy can contribute to the abatement of *greenhouse gas emissions*. However, the greenhouse effect is not the main argument in favour of nuclear energy.
Amongst the most fashionable arguments in favour of nuclear energy, concern for *chemical pollution* is prominent. Clearly, nucleo-electric energy and nuclear-derived carriers, such as hydrogen, make no contributions to this most important type of pollution.
Even so, environmental problems are not perhaps a sufficient justification for the introduction of nuclear energy. A further vital reason should be the desire to *reduce Europe's dependence* on foreign energy supply. To this end, reprocessing and recycling are necessary. Reprocessing may also become a simpler and safer way of disposing of reactor generated radioactive waste, than that of long-term storage of spent fuel.

The main constraints on the introduction of nuclear energy are the development of acceptable fuel reprocessing and recycling systems and the improvement of radioactive waste disposal techniques.
Reprocessing and recycling should be carried out to an increasing extent in order to gain experience. An "interim" period of spent fuel storage is technically possible and economically sensible. The essential question is, whether the spent fuel confinement is conceived for say a 50 year interim period or whether it is conceived and designed as a "final" disposal. However, direct fuel disposal cannot be an ultimate solution for the management of nuclear energy if there is to be any nuclear energy in the long term.

The contribution of nuclear energy to diversification requires that the fuel cycle be "closed", in the sense that the spent fuel be reprocessed in order to recycle the recovered fissile material.

Recycling plutonium and uranium in thermal reactors, which is a fairly well established technique (MOX fuel), should become routine, reducing the consumption of uranium ore by some 40%. However, a complete independence of uranium supply, or at least a better use of resources by a factor 60, would only be achieved if plutonium were recycled in fast reactors. (In thermal reactors two recycles is now a practical maximum.)
Recycling in thermal reactors would not only lead to a considerable saving in fissile materials (and avoid the depreciation of Pu with storage time), but would also lead to the development of reprocessing and fabrication techniques which could pave the way towards the more rational utilisation of nuclear fuel in fast reactors. There will also be large stocks of plutonium released as a result of nuclear weapon reduction programmes.

Current evaluations indicate that it pays to allow the fuel element to "cool down" for 30 to 50 years before *reprocessing*. After this time the alternatives are to either store the fuel, contained in special casks which appear to last for, say, another 100 - 200 years, or to reprocess it and store the radioactive waste. The volume of highly radioactive waste is, after conditioning, one order of magnitude smaller than the volume of the corresponding spent fuel. However, for storage in

deep repositories the volume ratio between the two approaches is not as large as this, due to power density constraints within the repositories. Some evaluations suggest that the two approaches would result in about the same overall volume. The ultimate choice may well be based on economics but the costs of both are quite uncertain. At present direct disposal appears to be cheaper. The outcome would be more favourable to reprocessing if the assumption, that deep underground repositories will be the final location (a consequence of IAEA Principle 2), were abandoned in favour of storage in engineered repositories at ground level or at moderate depths underground. In the present underground disposal philosophy the long term containment, up to one million years, is provided by the geological formation. However, nobody seems to be asking the basic question, "How many suitable salt mines or absolutely compact granite structures can be found?".
If, on the contrary, confinement in engineered repositories were acceptable, it would make sense to search even for very expensive encapsulation technologies. The long term behaviour of these containers could be analysed with reliable thermodynamic models against etching and corrosion. Whereas no satisfactory proof can be put forward for the deep repositories which must last a million years.

Any development of reprocessing techniques is basically aimed at a simplification in waste storage:

- reducing waste volumes
- improving accuracy in isotope separation
- partitioning the waste into groups
- improving encapsulation and confinement techniques

The current PUREX process which is based on fuel dissolution, separation of the dangerous isotopes by solvent extraction and their subsequent conditioning, poses a number of problems related to costs, volumes, and leakages. Development efforts are towards size and costs reductions and increased robustness and process simplification. Current research aims at improving separation and reducing volumes through new extraction solvents; substituting wet technologies with dry technologies, mostly based on high temperature processes, such as electrochemistry of molten salts; laser induced separation; and sublimation and volatilisation processes. It should be noted that nothing about the fundamental PUREX chemistry is seriously deficient. Many of the current troubles are in the associated processes, some of which would be required even if a totally different separation technique were used. Most of the problems are linked to the way in which the plant is engineered or the way in which the objectives for the engineering have been set.

Considerable experience has been gained in fabricating mixed (Pu and U) oxide fuel (MOX) for recycling in Light Water Reactors. This technique was developed in Belgium, Germany and, more recently but extensively, in France, where EDF has chosen to recycle Pu as a national policy. (When stored, plutonium depletes with time, its value decreases and its handling becomes more dangerous.) However, spent MOX fuel (and its reprocessing wastes) is more radiotoxic (by a factor 10 over standard oxide fuel) after one recycle. On the other hand, the presence of larger quantities of Pu^{232}, which is a strong neutron absorber, makes neutron economy worse and thus it becomes economically inadvisable to have more than two recycles.
These problems do not exist if plutonium is recycled in FBRs. By recycling plutonium these reactors could provide independence from foreign supply by, say, the year 2040, if the breeding ratio and the cooling time before fuel reprocessing are improved over present values. It is estimated that an improvement of the breeding ratio up to 1.3 and a reduction of the cooling time from 3 to 2 years would be necessary.
If the radiotoxicity of the wastes could be reduced, it would only be necessary to confine the nuclear waste for a shorter time - perhaps only a few centuries. Over this "short" period one could rely on the resistance of the waste matrix and on artificial barriers, and institutional

surveillance would make deep geological disposal unnecessary. This philosophy is behind the option of *partitioning and transmutation* (P-T).
The first step consists of separating long-lived radionuclides, chiefly plutonium, neptunium and americium and some fission products such as Tc^{99} or I^{129}, from the high level waste streams produced during reprocessing. It is very important to extract neptunium, and above all americium, from the waste stream, because this reduces the time required to reduce the toxicity of the high level stream to safe values from a few thousands to a few hundreds of years. The second step consists of reducing the activity of the extracted isotopes by transmutation. This can be achieved either by exposure to a neutron flux in a nuclear reactor or by bombardment with charged particles in a high energy accelerator.
Various laboratories have investigated the P-T concept and two important meetings were held on this subject at Ispra in 1977 and 1978 and a synthesis was published by IAEA in 1982. Most assessments concluded that the radiological advantage was too small and the complications too large to justify expensive and lengthy research on this subject. Consequently the studies stopped everywhere.
However, the "Commission Castaing" (France) has recently supported the P-T concept as the most acceptable long-term solution for back-end nuclear wastes. The Commission Castaing has also pointed out the necessity to simultaneously reduce the volume and the alpha-emission of the wastes not involved in the above process, i.e. the Low- and Medium-active wastes.
The main difficulty in the partitioning phase lies in separation of americium and curium. These two elements (Am^{241} and Am^{243}, Cm^{242} and Cm^{244}) have chemical properties similar to those of the Lanthanides (elements of atomic number between 57 and 71). Thus, after extraction of U and Pu from the waste stream, Am-Cm-Lanthanides are extracted together. The difficulties come at the next step, with the separation of Am-Cm from the Lanthanides which are intense beta-gamma emitters. Apart from safety problems only one solvent has been found which can resist the high level of radiation occurring in this phase and selectively fix Am and Cm. This compound is named DTPA (di-ethylen-tri-amin-penta-acetic acid). Though improvements to the basic scheme have been conceived, severe problems remain to be solved before these processes can be operated on an industrial scale.

In a reactor the separated actinides are transmuted into short-lived or less radiotoxic nuclei by fission or to a lesser extent by neutron capture. This can occur in thermal or fast reactors, with qualitatively better results in the latter case (due to higher fission/capture ratio) but with longer irradiation times.
Since more actinide atoms are produced during reactor irradiation they must be endlessly recycled. Consequently, radiotoxicity requirements pose very stringent demands in terms of loss of actinides to the waste generated at each recycle (at least one order of magnitude lower than presently achievable). A further difficulty with this process is that curium increases during recycling making partitioning and fuel fabrication difficult due to neutron emission by curium.

Bombarding actinides and fission products (such as Cs^{137} and Sr^{90}) with high energy charged particles is in principle more attractive than the use of reactors. This idea has been studied since 1974, but it poses severe technical and energy balance problems. Indeed, to be effective, it would require proton beams with 1-2 GeV energy and an intensity of about 300mA. Such an accelerator does not exist, though it has been studied in Berkeley (Material Testing Accelerator) and in Canada (DEMO accelerator). Transmutation can also occur by fission caused directly by a high energy proton beam (spallation reaction). However, with conceivable proton energies (1GeV) and beam intensities (300mA), the annual transmutation of neptunium and americium would correspond to less than half the production of a 1000 MWe PWR. However, if, using proper geometries, it were possible to make use of the secondary particles, produced by internal cascade in a bulk target (protons, neutrons and pions), the transmutation efficiency of the accelerator could reach the production of 10 such PWRs, according to Brookhaven studies. However, huge technological problems would have to be solved. The present intensity available

with a 1GeV linear accelerator is only 1 mA (Los Alamos). The target and blanket associated to such an accelerator would look like a fission reactor core, in the sense of having problems of heat release, radioactivity and neutron flux shielding.

In conclusion, the P-T technique must rely heavily on high standard quality industrial practices but the goal of reducing the source term in High Level Wastes makes sense if the losses of long-lived alpha emitters to the L- and M-active waste streams during continuous recycling are kept very low. Otherwise the employees and the public would be submitted to such a high irradiation level as not to counterbalance the expected benefits for future generations.

Clearly, there are considerable problems in this field and rapid progress is not expected.

3.2 Studies for Directorate General III

In 1991 PROMPT started a programme of work for DG III, the General Directorate for The Internal Market and Industrial Affairs. Two large studies were executed as base mark surveys and it is expected that work in these fields will continue in 1992. The first study concerned the high speed rail network in Europe and the second the industrial aspects of space.

3.2.1 High Speed Trains.

This project, which started in 1991, is mainly concerned with the power supply for high speed trains. The study includes an intercomparison of the three main supply systems used for high speed trains, a market prospective and a technological prospective.

After a long period of steady decline, several national railways realised that their competitors (airways, lorries and private cars) were facing a situation of growing congestion and "green" opposition, so that the times were ripe for the networks to offer a new service, the High Speed Train (HST), and to recover a substantial market share. The Ministers of Transports recommended in 1988 that an integrated European High Speed Network be realised and the European Commonwealth of Railways (CCFE) proposed a master plan, to develop 50 000 km of high speed lines within 20 years.

Unfortunately, earlier attempts to set up a large European consortium to produce the HST had failed (1984) and several countries had developed their own trains in isolation, which further enhanced the national character of networks and makes "interoperability " still more difficult. A "universal train" would be obliged to embark half a dozen different power modules to accomodate the different electrification systems and an even larger number of control-command

and safety packages. Such a monster would not only be too costly, but also too heavy to be allowed to circulate on many high speed lines. Special multistandard trains have thus to be developed in cooperation between neighbour networks, to serve regional purposes such as the Transmanche and the PBKAL.

While Directorate General VII is responsible for transport policy at large, DG III sees that the networks together with the International Union of Railways and the European standards organisation, CEN/CENELEC, promptly harmonise their technical norms in such a way that HSTs can really circulate all over Europe, without limitations in their destinations or performance.

To speed up the process, DG III has set up several working parties with the networks and railway industry, and asked Prompt to make an independent study on the power supply for HSTs. This study was initiated in March 1991, and a preliminary report was presented to DG III in June; an interim report was produced in September and reviewed in November, by a restricted Panel consisting of representatives of CCFE and of the main manufacturers. This Panel suggested many modifications but approved the general approach followed by Prompt and recommended that the study be continued.

This approach bears on three groups of studies:

- a factual comparison of the technico-economic merits of three main electrification systems still in competition for high speed traffic; this is done by intercomparison of several simulations performed by three networks, which volunteered for this exercise
- a market prospective, based on a joint UIC/DG VII study on the future development of high speed traffic in several regional corridors in Europe. In fact Prompt plans to translate these traffic forecasts into rolling stock requirements for each electrification region, which will give an idea of the number of polycurrent locomotives to be built for each combination of standards.
- a technological prospective, to understand how the past evolution of line voltage and semiconductor technology is likely to continue in the future and if it would help in adopting one single type of electrification or, conversely, changing the terms of competition and collaboration between manufacturers.

3.2.2 European Space Industries Competitiveness.

An independent assessment of the competitiveness of the European Space Industry, analysing the sectors of launchers and launch services, of telecommunications, of observation satellites both for meteorological purposes and for remote sensing of earth resources. Microgravity applications are also considered.

In 1988, the European Commission sent a Communication to the Council, on a "Coherent European Space Policy". This document was deemed necessary because space activities were

clearly entering an era of commercial applications and the mandate of the European Space Agency (ESA) falls short of this domain. Furthermore, the "juste retour" principle that guides ESA's industrial policy is clearly incompatible with the rules of competition policy of the European Community. Last but not least, many contractual agreements with the USA around the Space Station raise international legal and commercial problems which cannot be ignored by the Commission. ESA was also eager to obtain from the Community, a more substantial support for basic and industrial research, in many areas: telecommunications, microelectronics, materials, health, etc.....

While several studies were entrusted by ESA and EC to contractors, DG III asked Prompt to execute an independent assessment of the competitiveness of the European Space Industry. Prompt's conclusions were developed in an interim report delivered to DG III in September. These conclusions were substantially less optimistic than the commonly accepted views. However, this analysis was confirmed some weeks later by the positions expressed by representatives of aerospace industries, convened at Brussels by DG III.

On the one hand, space markets appear less important than usually claimed, on the other hand, European space industries are not in a position of competitive advantage. While ESA's programmes have undeniably contributed in developing a strong technology base in Europe, industrial structures are still too much fragmented and production costs remain 20 to 40 % too large to commercially compete. Industry cannot make long term plans and is not compelled to face the necessary restructurisations, because European governments themselves have no long term space policy, and, primarily, no common defence policy. Technology push alone falls short of creating appropriate commercial muscle.

The only domain where Europe is leading is the development of launchers and launch services. In this particular case, a strong European consortium, Arianespace, was established which was able to grasp more than half of the whole world market. However a big strategic mistake of the USA, which chose the recoverable STS (Shuttle) as a unique launch system, offered unexpected opportunities to Europe. This favourable circumstance no longer holds and the US are back in the disposable launcher business, also challenged by China and Japan. The ex-Soviet space programme, if properly and commercially managed would also be a dreadful competitor. So the future, for Arianespace, will be difficult.

In the telecommunication satellite area (including mobile communication and positioning), European industry has proven competence, but has never been able to win a single commercial competition, without some political support (developing countries, institutional clients). One US manufacturer alone, produces more telecom satellites than all European industries together, offering better prices, faster delivery and higher reliability.
Observation satellites belong to two categories: meteorological satellites that are bought by intergovernmental organisations, thus a stable but limited market; and earth resources satellites (remote sensing), which was a monopoly of the USA until recently. Europe has made an important step in optical remote sensing with SPOT, but is lagging much behind in microwave observation, with the first ERS satellite just being launched. Earth observation appears to be a very limited market, which can only develop if governments agree to set up international agencies (for climate change, for environmental monitoring, and major risks, for arms control) and to provide them with long term budgets to acquire a fleet of satellites. Such decisions are considered but consistently delayed.

In every domain, Europe appears to have concentrated its efforts on the space segment, while ground services and integrated services happen to be the more profitable and more strategic ones. In telecommunications, for instance, a global war has developed between Japan and the USA, for programme production and final distribution as well as selling the related hardware (antennas, receivers, terminals, etc..).: Europe is largely absent from this competition. In the

meteorology arena, the value of the space segment is much lower than the one of the ground networks and massive data processing Europe, again, is largely dependent on foreign technology for that purpose.

Microgravity applications aroused much interest ten years ago. Now industry has learnt that operational costs are much higher than expected and that the availability of (and access to) appropriate space facilities are a remote expectation. Europe is fully dependent on US and CIS' space stations and large capacity launchers and projects as Hermès and the free flyers will only partly offset this situation of dependence. While some European industrialists have joined their efforts to promote microgravity applications, earlier entrants are now looking for cheaper and more readily accessible ground-based or suborbital facilities.

In all domains, Europe has developed technology but has not been able to address properly the commercial reality. Governments have subsidised technology, but have not stimulated transnational ventures and the emergence of large players. They did not yet succeed in providing business with clear commitments concerning their long term support to earth observation and their progress towards a common defence procurement policy is very slow.

By the end of 1991, DG III received this warning from Prompt, a convergent message from the industrialists, and a clear evidence from the last ESA's Council of Ministers (November 1991) that the Space Agency's budget and plans are at a turning point. Many initiatives are required before the next meeting of this Council to review the whole situation.

In this context, DG III has asked Prompt to initiate a second phase of its study, with a more long term, prospective approach of the market.

4. STUDIES FOR THIRD PARTIES

Since the reorganisation of the JRC into a number of sectorial institutes (of which PROMPT is one) in 1988, there has been a requirement for a proportion of the institutes' programme of work to be for third parties under contractural arrangements. This has the merit of bringer a closer contact with the "real world" and provides an extra validation of our competences. Furthermore, it provides a small addition to the JRC income. However, it should be noted that for PROMPT this work only represents a change of client (between internal and external) as all of our work was of a contractural nature.
One study was completed in 1991, in the field of materials.

4.1 Uses of Cork

A study on current research activities and technical prospects of a natural material - cork - has been executed.

Natural cork is a fascinating material, with some exceptional properties. It has been used for a variety of purposes, ranging from footwear to fishing floats, for some 3000 years.

Today cork is best known for its use as a beverage stopper. Yet it has a variety of other uses, including such high-tech applications as in the heat-shields for space shuttles. Until now, however, information on such non-beverage uses of cork has been anecdotal rather than exhaustive.

The Institute was contracted by the Stazione Sperimentale del Sughero (Cork Experimental Station) in Tempio Pausania, Sardinia, to conduct a survey entitled "Research on and technical prospects for cork: a bibliographical analysis".
Using the Institute's extensive on-line data bases it was possible to identify a wide range of applications for cork. Then, with the help of advanced software tools which had been implemented at the Institute (see section 5.1), a map of related applications was constructed and an analysis of the different paths cork-related research was following in different countries was carried out.

Our interim findings were presented as the centre-piece of the International Conference "Cork: New Technologies and Future Potential", held in Tempo Pausania on 26th October, 1991.

5. INTRAMURAL STUDIES

The Institute hosts a number of visiting researchers under several schemes of fellowships (post graduate, post doctoral and fellowships for senior scientists). These visiting researchers contribute to the development of longer-term and more basic projects and at the same time gain experience from working in a Community Institution. Four of the projects which were carried out by such visitors are described below.

5.1 Bibliometric Analysis Tools (MAP) (Robert Braam, University of Leiden)

A graphical mapping tool, based on co-word techniques, has been developed within the Institute to provide a rapid preliminary analysis of large amounts of bibliographic information.

Large quantities of information need to be processed in connection with science and technology monitoring. Consequently, a tool that systematically combs through a set of collected documents and analyses the most common relations found amongst them is very useful. Therefore, a facility for bibliometric analysis based on published methods was developed and tested on a variety of publicly available documentation, so as to assess its potential value as an aid in performing studies.

The result of this development effort is a set of custom made programs called MAP (created using the SAS application software). MAP is menu-driven and user-friendly. It includes a data preparation module, a data similarity and data limitation module, a word frequency analysis module and finally a word co-occurrence analysis module. The result is a set of tables that may be best exploited when their graphical representation is produced through a manual procedure using standard software drawing tools.

The type of analysis carried out by MAP may be used to provide an overview of all of the main points of interest of a data set. These "points of interest" may be identified by the relatively higher frequency of occurrence of certain "key-words" included in the documents of the data set, or of their interrelations, identified by the number of co-occurrences and their relative strength of association.

The analysis can be used either in the case of a relatively unknown sector where the main converging research efforts can be identified, or a relatively well known sector can be analysed for emerging new research efforts.

5.2 Perspectives on the Process of Innovation for Advanced Materials (Maria Martin, University College, Dublin)

The importance of technological innovation for economic growth is well recognised and advanced materials have been identified as one of the key technologies worthy of funding and promotion. However, if innovation in this area is to be successfully stimulated an understanding of both the diffusion process of new materials into the various market sectors and the whole innovation cycle is desirable.

There have been many studies of the innovation process but very few attempts to model the whole process from R&D, through product development, to market penetration. Currently there are considerable expenditures on advanced materials R&D both at the Member State level and at the Community level. Consequently, we decided to carry out a pilot study of the whole innovation cycle for a few well characterised advanced materials.

The need for "well characterised" materials, i.e. materials for which there were good R&D and economic statistics, meant that materials which are fairly mature in terms of the innovation cycle had to be selected. Therefore the materials which were chosen (polycarbonates, polyethylene terephthalate, acrylonitrile-butadiene-styrene, and glass fibre reinforced plastics) are not currently the object of advanced materials attention.

An S-shaped curve has been widely and successfully used as a model for the diffusion of technology. This study found that the same logistic growth curve could be used for both the research activity (as measured by the number of research papers related to the topic) and for the level of product/process innovation (as measured by the number of patents). A program to fit the statistical data to a 3-parameter logistic growth curve by non-linear least squares regression was developed as part of the study.

5.3 The Role of New Materials in Europe's High Technology Industries (Fabiana Scapolo, Universita' degli Studi di Milano)

*This thesis, **Ruolo dei Materiali Innovativi nello Sviluppo delle Industrie ad Alta Tecnologia in Europa** (The rôle of new materials in the development of high-technology industries in Europe) was undertaken in fulfilment of a degree in International Economic Organisation for the Faculty of Political Science.*

New materials have played an unexpectedly crucial role in recent industrial development. To a major extent they have achieved a hidden revolution at least as important as the innovation flowing from much more highly-promoted technologies such as informatics and biotechnology.

Moreover, and equally importantly, they have been responsible for changing the rules of the innovation game. Economic theories on the role of materials in industrial development have been turned on their head. Materials can now be customised to meet product requirements rather than acting as a constraint on new design. Traditional suppliers of materials have been displaced by firms from entirely different industries such as chemicals. The concept of "strategic materials" has become largely redundant.

The thesis traces in detail the development of the various types of advanced material now in common use, distinguishing between those with structural and those with functional properties. It examines the process by which the availability of these new materials has changed the innovation process, necessitating such approaches (mistakenly regarded as "fashions" by some analysts) as "client-mediated innovation" and integration of research and design. It is demonstrated how the new development avenues opened up as a result of this novel situation transcend the old concepts of technology-push versus demand-pull.

Reviewing the various national and EC strategies towards exploitation of new materials the thesis notes the current dominance of the US and Japan but paints a hopeful picture for Europe if only a centralised research, development and innovation policy is adopted, to take full advantage of the Single Market and to avoid past mistakes of allowing European breakthroughs to be exploited mainly by others.

5.4 Interregional Cooperation in Technological Innovation (Thomas Heinemeier, University of London)

This study is concerned with the factors which contribute to the development of cooperative agreements between private and public actors from different regions.

The prospect of technological innovations contributing to economic growth or restructuration plays an increasing role in shaping economic and science and technology policies at th national and subnational l vel. These policies often c `tain features which have the objective of assisting enterprises to cooperate in research and technological innovation. In recognition of the role local or regional innovative activities play in territorial development, many recent policy initiatives are intended to foster arrangements between territorial units in which certain innovative activities are concentrated. The understanding of the drives underpinning this trend should allow one to devise more effective policies and cooperation projects.

The preliminary stage of the study has involved familiarization with public and private policies in the EC member states and elsewhere towards innovation, particularly with respect to cooperative strategies, and the underlying theories. This movement towards cooperative strategies had to be related to the general characteristics of the innovation process.

The term *technological cooperation* is commonly used to describe a variety of agreements. This study is confined to undertakings that involve joint research and product development and the consequent innovative activities.

From a review of the literature on cooperative arrangements between multinational enterprises and geographical agglomerations of innovating companies and research institutions a number of conflicts inherent in innovation cooperation were identified. The great variety of economic, institutional, socio-economic and socio-cultural factors that impinge on the innovation process is often subsumed under the notion of innovation systems, that vary across nations and regions. It has been found that, under the theories of innovation and technology driven growth in the context of global technological competition, regional innovation systems face a fundamental paradox which should prohibit the kind of cooperation considered, both inside a nation as well as trans-border.

The objective of the study is to identify those factors that enable this problem to be overcome. The study will be submitted as a doctoral thesis in cooperation with the University of London's School of Economics and Political Science.

6. WORKSHOPS

As part of its programme of work the Institute hosts a number of meetings each year at which invited experts from European and other countries contribute to studies on various subjects. Three of the 1991 meetings are described below.

6.1 Literature-Based Innovation Output Indicators

On 28 - 29 November 1991 an international workshop was held at Ispra which resulted in the creation of an informal network for the exchange of information and experience on the the development of innovation indicators based on surveys of trade journals.

As part of its "technological watch" function the Institute is constantly exploring ways to improve the monitoring not only of scientific breakthroughs but also of the the whole process of technological innovation. This aspect of the Institute's work gave rise to a workshop in 1991 which was held at Ispra on 28-29 November. This meeting brought together researchers who had either already performed literature-based innovation surveys or who were intending to do so. Participants came from Austria, the UK, France, Ireland, Italy, Norway, Sweden and Switzerland, in addition to members of PROMPT and representatives of DG XII.

This workshop followed a 1990 Institute meeting on "The use of survey techniques in technology foresight studies", which had recommended that PROMPT should support the work of Dr Alfred Kleinknecht, of SEO (University of Amsterdam), in order to explore the possibilities of extending to other European countries a technique of innovation monitoring which he had developed for the Netherlands Government. Essentially this technique consists of the systematic scanning of technical journals and analysing the information gained within a consistent and well-defined framework.

Initial results from the Netherlands survey encouraged us to promote use of this technique as a comprehensive, objective and powerful tool for surveying the innovation process sectorally, regionally and over time. While it does not entirely replace more traditional survey techniques, such as postal questionnaires, it can provide a major extension to and validation of these other inquiries.

The workshop revealed considerable interest in extending and adapting the Netherlands survey to cover the rest of Europe. It was agreed that participants should constitute themselves into an informal network to this end.

Proceedings of the workshop, together with some additional papers, will eventually be published as a book.

6.2 European Network for Training in Strategic *Prospective*

As part of its foreward planning for participation in the Human Capital and Mobility (HCM) programme the Institute held a meeting of experts to prepare for the establishment of a European network for training in strategic prospective.

The EC's Third Framework Programme includes an activity entitled "Human Capital and Mobility" (HCM) with the objective of encouraging networking and exchanges of young researchers throughout Europe. A small part of this activity has been earmarked for the JRC, to enable it to expand its existing policy of hosting young researchers and to encourage networks and exchanges with other research centres.

As part of the preparation for participation in HCM the Institute held a meeting of experts, drawn from universities, research institutes, business schools and government agencies, to discuss the prospects for establishing a European network for training in strategic *prospective.* This meeting, which was held on 13th November,1991, was chaired by Michel Godet and François Bourse of the Centre National des Arts et Metiers in Paris.

Aside from establishing the willingness of the various participant organisations to receive and supply research fellows under HCM auspices, the following principles were agreed:

There is, worldwide, a growing demand for *prospective* and strategic analysis.

Although its competence is fragmented, Europe enjoys a leading role in this type of analysis.

The opportunity exists to assert the superiority of the European approach over the hitherto dominant US school of strategic analysis.

Formal constitution of the network, which is seen as not only a means of training new *prospectivistes* but also as a meeting ground for the various bodies involved in this area, is foreseen following the launch of the HCM chapter of the Framework Programme.

6.3 High Speed Trains

During the year the Institute hosted two workshops connected with its studies of the future European high speed rail network. The first concerned the conclusions of the phase I study and the second was a preliminary workshop for the power supply intercomparison study.

PROMPT completed its phase I study of the future European high speed rail network in September 1991. The results of this study (see section 3.2.2) were submitted to a group of high

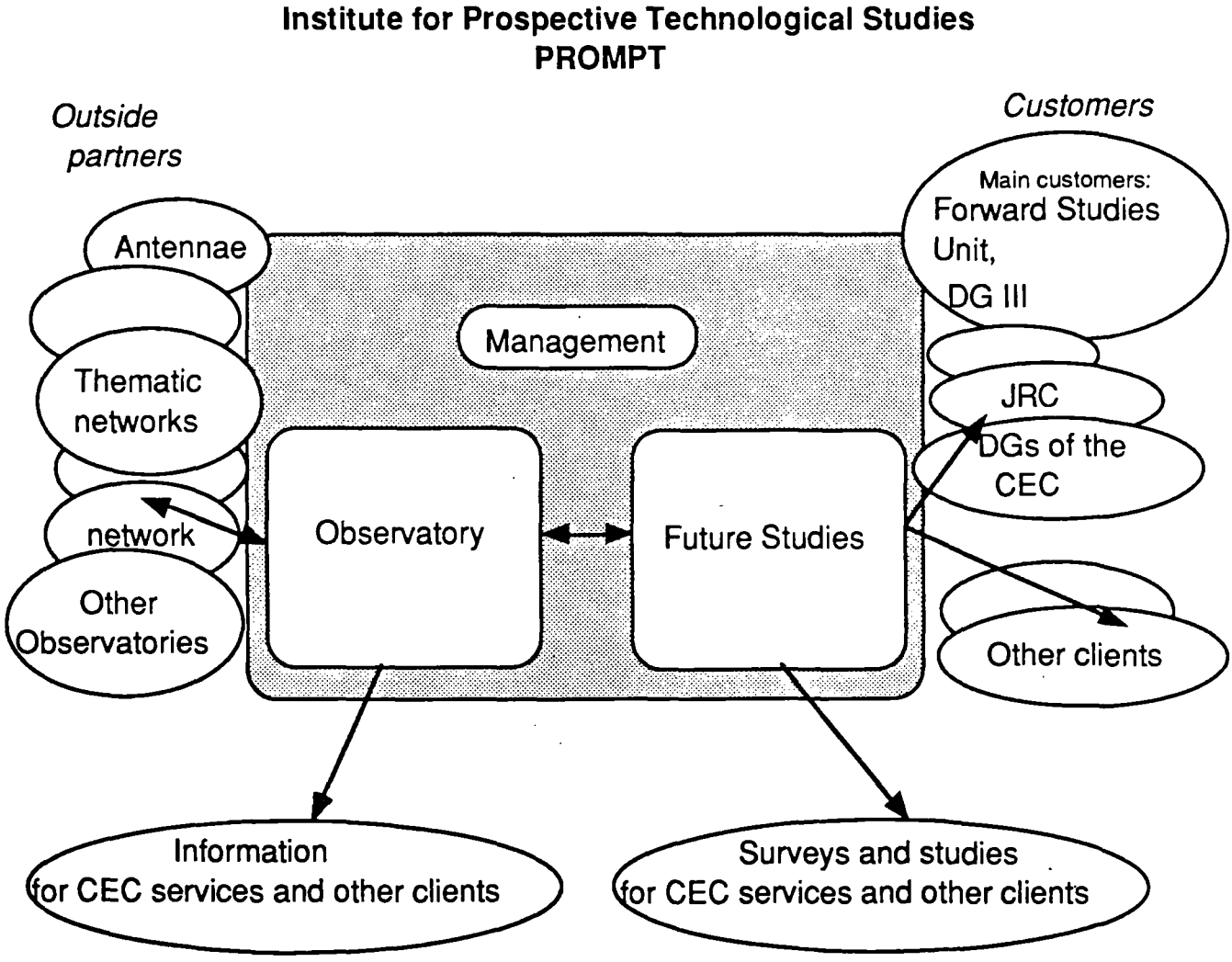
level experts representing the industry and the CCFE (*Communauté des Chemins de fer européens*) at a workshop in November. The workshop concluded that PROMPT should continue with this work which was both stimulating and useful.

The second workshop was held in December and concerned the comparative simulation of power supply systems for high speed trains. It was based on preliminary work carried out for PROMPT by Dr Ventura of Ansaldo and Professor Sciutto of the University of Genoa. The workshop agreed the basis for the intercomparison study and selected three representative lines for this purpose. The actual simulation studies will be completed in 1992 by DB (Germany), FS (Italy) and SNCF (France).

7. HUMAN RESOURCES

As of 31st December 1991, the Institute's staff numbered 14, of whom 11 where scientific personnel. The Institute also hosted 2 post-doctoral and 1 graduate fellows and an undergraduate trainee.

Organization Chart:



8. LIST OF REPORTS

PROMPT Reports (as of 20.1.1992)

Client	Title	Date
Commission : Forward Studies Unit	Science and the Greenhouse Effect	June 1990
	Technological Response Options to the CO2 Issue * Overview * CO_2 and Energy Consumption Setting Targets for Europe *Annex* : The role of electricity generation * The role of Renewable Energies *Annex* : Energy from biomass	September 1990
	Climate Change Research and Policy: Updates (A periodic survey: N°1)	May 1991
	The Japanese Technological Response to Global Environmental Problems	May 1991
	Nuclear Energy-Reprocessing and Recycling are Key Issues	July 1991
	The Technological Response to Global Environmental Problems - California	September 1991
	Opportunities in Environmental Technology	October 1991
	Climate Change Research and Policy: Updates (A periodic survey: N.2)	November 1991
	A prospective Assessment on the Role of Renewable Energies in response to the CO_2 problem	January 1992
Commission : DG III, DG VII, DG XII	Pre-Lotos Study : Air Transport and Aeronautic Industries	September 1990
Commission : DG III	Compétitivité des industries spatiales européennes (Interim report) *Annexes* : * Rapport V.Panin (Consultant) * Microgravity: Future for the Space Industry ? (Status and Trends)	September 1991
	L'alimentation en énergie des réseaux européens de Trains à Haute Vitesse (THV) (Interim report) *Annexes* : * Technologie de la traction électrique roue/rail et aspects énergétiques * Evolution prévisible de la technologie ("Science et Technologie") * Alimentation en énergie électrique (Electricité de France) * Industries et marchés de la grande vitesse ferroviaire (JANE'S Inf. Group) * Introducing HST trains in Europe (IIASA)	September 1991

PROMPT Reports (as of 20.1.1992) cont

Client	Title	Date
Commission : DG XI	Some Technology Options for dealing with Environmental Pollution	January 1992
Commission : DG XII	Concept des noeuds technologiques et de leur rôle dans la compétitivité	July 1990
Commission : JRC	Contribution to the Strategic Planning for the JRC : State of technology in ten years time * This World Around Us * Science and Technology Issues * S/T Assessments	March 1990
	Forecasting Technological Innovation (published by Kluwer Academic Publishers)	1991
	Prospectives on the Process of Innovation for Advanced Materials	September 1991
	Foci of interest and attention in global environmental change research; a literature-based assessment	December 1991
	Ruolo dei Materiali Innovativi nello Sviluppo delle Industrie ad Alta Tecnologia in Europa	December 1991
BMFT - Germany	A Critical Literature Survey on the Prospects for Thermonuclear Fusion Energy	August 1990
Cork Experimental Station, Sardinia	Research and Technical Prospects for Cork. Phase I Study	January 1992

European Communities — Commission

EUR 14447 — Institute for Prospective Technological Studies Annual Report 1991

C. Rinaldini, M.D. Rogers (Editors)

Luxembourg: Office for Official Publications of the European Communities

1992 — 38 pp. — 21.0 x 29.7 cm

The primary tasks of the Institute for Prospective Technological Studies (otherwise known as PROMPT) are:

- Monitoring new developments in science and technology
- Strategic analyses of new areas of science and technology

The first of these tasks relates to an "observatory" function. ESTO (the European Science and Technology Observatory) has on-line access to some 500 data bases and the pilot version of its NOVA DB was brought to an advanced stage of development.

The third major ESTO tool is the data base known as QUIQUOD or Q^2, which is an inventory of "who is doing what" in European science and technology.

Studies are normally performed on the request of another Commission Service. The Commission Service which represented the main customer in 1991 was the Forward Studies Unit of the Presidency and six studies, all broadly related to the global warming theme, were undertaken for this client during the year. Two major studies were carried out for the Directorate General for Industry. The first of these was on the future European high speed rail system and the second was on the competitiveness of the European space industry.

One sizeable external contract was undertaken during the year (on the future uses of cork).