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MEMORANDUM

TOWARDS A EUROPEAN TECHNOLOGY COMMUNITY

CONTENTS

TOWARDS A EUROPEAN TECHNOLOGY COMMUNITY

I. THE CHALLENGE FACING EUROPE

Technological progress plays a central role in our societies because of its impact on economic growth and job creation, social and cultural progress, environment and security. It is increasingly becoming a strategic factor - one which (as the Commission stressed in its communication to the Brussels meeting of the European Council in March 1985) the Community must turn to account in order to regain its competitiveness and lay the foundations for more vigorous and more stable growth and to ensure greater economic convergence by increasing the innovative capacity of all the Member States.

The Community has an internal market on a scale similar to those of Japan and the United States, but it has to face the competition of those countries with a market segmented by many barriers and with no common technological strategy: with a few notable exceptions, R&D policies and resources are applied by the Member States without any coordination.

The consequences are beginning to show. Since 1972 the annual growth rate in real terms of the production of high technology goods in Europe has not exceeded 5% while the rate in the United States is 7,6% and in Japan 14%.[1]

Europe's mediocre industrial performance has eroded its trade surplus in high-technology products. Over a 20-year period the export cover of high technology imports into the Community fell from 190% to 110% (1983).

Europe launched the first two industrial revolutions: is it now missing out on the third? Can Europe be satisfied with its continuing domination in medium-technology products when the newly industrializing countries of Asia and Latin America are ready to take over? Must Europe meekly accept the brain drain to the United States and let Japan take over its market shares?

Can Europe maintain its standard of living, reverse the unemployment trend and ensure that it can stand on its own feet without responding to the technological challenges of the outside world?

For a response to these challenges, Europe has a potentially powerful armoury:

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[1] From 1973 to 1983 the Community's specialization index for trade in high technology products fell from 1,01 (OECD = 1) to 0,82 while that of the United States remained constant at 1,26 and that of Japan went up from 0,7 to 1,26.

- For Europe's industry, a continent-wide market rid of the barriers now dividing it into unviable segments;

- National R&D efforts which have maintained the high level of European science but whose dispersal deprives the Community of the synergetic effects and the economies of scale that would stem from a collective effort targeted on certain jointly defined strategic priorities;

- The cooperation among European firms which has positive results when it can flourish under the stimulus given by such research programmes as ESPRIT, industrial programmes like Airbus and strategic programmes like the Space Agency.

The Community must therefore as a matter of urgency summon up its considerable resources to reverse a trend whose present consequences are lost market shares, less job creation, increased technological dependence and the emigration of its finest research workers.

The Commission considers that Europe will be able to harness the new technologies for a common purpose only if a genuine European Technology Community is established which:

- exploits the Community dimension to the utmost extent possible;

- promotes the greatest possible synergetic effects from the interactions of national and Community efforts.

Exploiting the Community dimension

The Community dimension offers the following advantages:

- It will guarantee that the demand for products and services supplied by European projects can expand dynamically as the result of the opening up of public contracts and the adoption of international standards preventing the walling-off of markets and restriction of competition.

  There is therefore a close link between the Commission's proposals for (a) completing the continent-wide market and (b) creating a European Technology Community.

- The Community will ensure that the technology effort is closely tied in with common policies and in particular with trade and competition policies;

- Through cooperation and exchanges, it will increase the potential of purely national programmes and reduce wastage arising from unnecessary duplication.

- It will give more scope to the universities, individual research workers and specialised SMEs (which are sometimes overlooked in strictly intergovernmental schemes of cooperation owing to the complexity of industrial groupings and institutional structures).
- Lastly, the Community's R&D instruments are immediately available and can be adapted to the needs of different projects in view of the urgency of the action required. Some current programmes (ESPRIT, BRITE and the definition phase of RACE) can provide a framework for projects that fall naturally within their general field such as information technologies, broadband networks and new materials.

Synergetic effects of Community/Member States interactions

The aim is to combine on the basis of clearly defined objectives:

- the use of Community programmes proper;
- the development of strictly national programmes;
- the pooling of national programmes by some States, including non-Community countries, possibly with an additional Community contribution;
- identifying the scope for the synergetic cross-fertilizing of national and Community programmes.

Just as it is neither possible nor necessary to bring everything under the Community umbrella, so it would be just as inappropriate to confine the Community's efforts to the portion of public R&D expenditure which it finances from its own resources, even though that portion is to be substantially expanded. Bridges must be built between programmes at different levels - national, intergovernmental and Community - that contribute to common scientific and technological objectives in order to integrate them into a truly Community scientific and technological strategy.

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Some will argue, against the advantages of the Community dimension, that the Community's decision making and management procedures are complicated and cumbersome. But in fact the aim must be to exploit all the possibilities offered by the Treaties and where necessary adapt their provisions in order to guarantee that account is taken both of the interests of all parties and of the need for prompt decisions, flexible and decentralised management and appropriate financing arrangements.

That is the Commission's aim in this proposal, in the conviction that the Community's institutional system - which needs to be made more effective and more democratic - remains, in the last resort, the only guarantee for the European identity and common interests against the weight of national sovereignties, legitimately concerned to put national interests first.

II. THE EUROPEAN TECHNOLOGY COMMUNITY

1. Legal and political bases

The European Economic Community can offer the necessary basis for launching a true European Technology Community, so designed as to allow Member States to reserve or restrict their participation to certain programmes only.

That having been said, the European Technology Community could be brought into being through a variety of institutional arrangements, which are set out in a separate paper; they are all founded on a political commitment, of contractual force, by Member States to give the new Community the powers and resources to take action in its field.

2. Objectives

The fundamental objective is to strengthen the technological bases of European industry and to develop its international competitiveness.

To serve this objective, the Technology Community must have the remit and the resources to carry out certain actions in the interests of the Community: to conduct technology research and development programmes with the participation, which may vary from one programme to another, of the Member States, firms and research centres, and to carry out horizontal or back up measures in support of the TRD programmes.

It is not proposed at this stage to put forward a definitive plan, but the main types of measure, whether or not they are to be conducted at the Community's initiative, can be set out as follows.

3. Types of technological research and development (TRD) projects and programmes

3.1 Research on generic technologies

The main object of this type of project is to induce industrial firms to join forces and cooperate with university research centres and public authorities for mastery up to the development stage of technologies whose specific applications will spread throughout the industrial fabric, modernizing processes or giving rise to new products. These include the technologies of composite materials, micro-electronics and optronics and those in the huge field of biotechnologies (see Annex).

By reason of their very purpose, these projects are generally restricted to the pre-competitive stage, but, over and above the results expected from scientific and technical research, they will increasingly draw together European firms, research centres and public authorities into the networks that will be the foundation for industrial cooperation proper in production and marketing structures.

3.2 Development and exploitation of joint facilities for basic research purposes

Europe, both Community and non-Community, has already started on the path of joint exploitation of large-scale equipment and specialized laboratories which it would be absurd to duplicate. It was the motive for establishing CERN in Geneva and the JET project at Culham. Other projects of this type are planned in the same spirit, such as the Synchrotron, and the Oceanography Centre. The human and material capital which the Member States have already pooled in the Joint Research Centre (JRC) can be harnessed in a public service mission which could take the form of a programme on the safety of the environment in the broad sense and the definition of reference standards.

3.3 Strategic programmes

These are technology-intensive programmes or major talent- and resource-mobilizing projects whose specific purpose could be a field in the general interest (space exploration, for example) or the supply of advanced public services (telecommunications). In this type of programme the R&D phase is only preparatory to the public investment and exploitation phases.

Beyond their specific purpose, the strategic programmes would seek to open up a "critical mass" of public contracts in strategic sectors in order to combine demand-pull with the technological-push generated by research programmes.

The programme of the European Space Agency is the model here. Its successes have restored Europe's confidence in its technological and industrial capacities and shows what can be done when the States of Europe aim at a strategic target and agree to pool the bulk of the national resources they are devoting to it.

Another model could be, in telecommunications, the RACE programme proposed by the Commission.

The IRIS programme proposed by the Italian Presidency for the development of the European market in the "social products" of informatics could also fall into this category.

4. Horizontal back-up tasks

4.1 International cooperation

The European Technology Community should open negotiations with non-Community countries and international institutions on:

- the ways and means whereby it could take part in their research programmes and they could be associated with its own TRD programme;
- international standards for exchanges of technology (intellectual property, competition rules, access to information, restrictions on technology transfers and so on).

4.2 Coordination of national and Community TRD policies

Besides its own programmes, the European Technology Community would also be required to promote the coordination of national and Community policies, to propose the means of strengthening their complementary aspects; it would seek to instigate concerted actions which it would encourage by bearing coordination costs and possibly by meeting a minority share of project costs.

4.3 Dissemination of knowledge and exploitation of the results of Community programmes

Community action must not be limited to developing research; it must also help to exploit results which lend themselves to commercial applications. In some cases it may be useful for the Community to have the means to bear certain pre-development costs, at least in part, in particular in the case of innovative SMEs.

4.4 Stimulation of the Community's science and technology potential

This type of horizontal task must be a permanent function of a European Technology Community. The aims and methods can be defined on the basis of the lessons taught by the current experimental programme under the four-year programme.

In this context it might be possible to act upon the suggestions of the Economic and Social Committee[2] for setting up in the Community a network of centres of excellence recognized and supported by the Community. These centres would agree to cooperate in programmes for information exchange and research worker mobility defined by the Community and in framing the training policies required to meet any Community shortages of science specialists.

5. Methods of cooperation and financing arrangements

The aim of the following proposals is to reconcile unity of vision and strategic coherence at Community level with the greatest possible flexibility in the management and financing of programmes and in the level of participation by Member States and their nationals.

5.1 A coordination framework

. The Community TRD strategy is at present defined in a multiannual framework programme. This could become a coordination framework for Member States' and Community policies pursued in response to needs jointly identified in certain fields. The adoption of such a framework programme and its periodic review would give all the Member States the opportunity to establish in every field whether Europe has an adequate S-T base and whether the resources deployed will enable its industry to meet outside competition.

. In the institutional system of the Communities,[3] it is up to the Commission to fulfil its role as the driving force by issuing proposals on its own initiative for the adoption and review of the framework programme and following up its implementation.

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[2] ESC, Normann report, Information report on EEC shared-cost research programmes, Brussels, 1985.

[3] Which would also be that of the Technology Community under the basic assumption of this paper.

. It is up to the Council,acting on the Commission's proposals and after consulting Parliament, to adopt the framework programme and to establish in agreement with Parliament the multiannual cash limit for budget resources to cover the Community's participation in the financing of TRD programmes.[4]

The Council decisions adopting the major specific programmes could conceivably be taken unanimously, but the ways and means of implementation should then be decided by a qualified majority and with considerable delegation of executive powers to the Commission.

5.2 Flexible cooperation methods

To carry out ambitious programmes, forms of cooperation must be found which:

- draw together for each project those partners - governments, firms and research centres - wishing to participate on the basis of a clear perception of the costs and benefits of their cooperation;

- lead to the establishment of industrial consortia and the organization of intergovernmental cooperation in such a way as to harness the best available skills;

- rely on a European network of research establishment and universities in regular touch with each other and able to act as centres for generating research and technology and disseminating the results;

- allow participation by partners from non-Community countries.

Without going into the detail of management approaches and financing techniques, the wide variety of the methods worked out under the Community's research activities should be noted.

In precompetitive research, the most widely used and most satisfactory management method at present[5] is the shared-cost project whereby the Community awards research contracts (50% of the cost financed from the Community budget) to multinational groups made up of university research centres, public laboratories and private firms. This method of management has demonstrated its

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[4] Community financing is the catalyst for eliciting contributions from governments and business. These latter sources of financing do not fall within the the Community's budget procedures.

[5] According to the ESC survey of co-contractors (ESC, Normann Report, op. cit.).

effectiveness in the ESPRIT programme, which is primarily designed to encourage trans-European cooperation.

Another method is the concerted action involving several project promoters who share the financing; the Community defrays only the administrative costs of concerting and coordination under agreements signed by the Member States concerned and certain non-Community countries.

Finally, additional programmes are financed solely by the Member States wishing to take part; these will no longer be limited solely to the nuclear field as soon as the new own resources decision has entered into force.

Such management methods can be further adapted to take account of particular requirements and to allow for the greatest possible degree of flexibility in participation by Member States and their nationals in the various parts of the research programmes.

The concerted actions could be broadened to cover a wider range of sectors and strengthen their coordination capacity with a modest financial contribution from the Community.

The Community could also make a minority contribution to national or multilateral measures, public or private, which are of Community interest; this would be an expanded application of a method of action already used under programmes to stimulate the Community's scientific and technical potential.

Where it is a matter of providing assistance for the exploitation of results with the aim of extending the support given to precompetitive research (predevelopment, prototype) and promoting the application, especially by innovative SMEs, of the results, the Community must be allowed to deploy non-budget resources, such as innovation loans and risk capital holdings.

The management tool used for the JET programme - the joint undertaking provided for in the Euratom Treaty - can serve as the model for other projects for the joint development and exploitation of major scientific facilities. It presents several advantages:

. variable configuration of national contributions
. opening to participation by non-Community countries
. legal and financial autonomy
. variable level of Community budget contributions.

Finally, for the implementation of major strategic programmes for technological development, plans must be laid for establishing, separately for each programme, European agencies with legal and financial autonomy. This method has been adopted successfully by the European Space Agency for pooling national resources allocated to a programme of common interest.

The Community nature of the agencies would be given practical expression by the link with the framework programme and the minority contribution which the Community could make in the form of a grant (financed out of own resources) to the agency's budget, on the understanding:

- that the agencies would be principally financed by contributions from the participating Member States; these contributions would not pass through the Community budget;
- that a minority contribution from the Community budget to the agencies' operating expenses and a Community budget guarantee for loans issued by the agencies should be possible and should be decided on a case-by-case basis by the Council acting by a qualified majority.

5.3 Mobilization of financial resources

The scale of the funds needed to promote technological progress and face the competition from other major countries means, as the European Council has recognized at successive meetings since June 1983, that the resources allocated to Community R&D must be substantially increased.

Nevertheless, even with such an increase and counting in the Community's other financing instruments (borrowing/lending, additional programmes,[6] and so on) the share of Community resources allocated to R&D will still be only a small proportion of the total amount of such expenditure in Member States' budgets.

It is therefore essential that national efforts, which will mobilize the greater part of resources available for TRD, should be targeted on common objectives and a clear identification of the priorities adopted by each partner. For Community measures proper, the management methods and financing techniques (summarized below) open up wide possibilities for adapting to specific situations, the variable participation of Member States and their nationals and the association of non-Community countries or international institutions.

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[6] Provided for in the new Decision on own resources.

The proposed plan of approach therefore assumes:

- that the Member States are prepared to define, in a Community context, the strategy lines for action at both national and Community level;
- that the European Council will confirm its determination to increase the share of the Community budget devoted to the financing of R&D programmes.

MANAGEMENT METHODS AND FINANCING TECHNIQUES

Community framework programme

- Multiannual budget endowment to cover all expenditure from the Community budget provided for in the framework programme

1. Research programmes

- Shared-cost projects (e.g. 50% Community budget, 50% public and private co-contractors)
- Concerted actions (for the coordination of current research activities in Member States). Expenditure from the Community budget limited to covering the general costs of concerting and coordination (about 2% of total cost); it could be increased in some cases for the following purposes:
  - to increase the incentive to cooperation, in particular where research activities are widely dispersed (medical research, for example);
  - to go beyond mere concerting of existing programmes and encourage the development of new research.

2. Development and exploitation of joint facilities

- Joint undertakings with or without participation of the Community, all Member States, non-Community countries;
- Direct action by the JRC under the Community budget, with the possible addition of
- Additional programmes under national budgets.

3. Strategic programmes

either: Specialized Community agencies

or: Bi-, tri- or multilateral associations of public or private European undertakings (on the lines of Airbus).

Sources of finance:

- Minority contribution from the Community budget to agencies' operating expenditure
- Contributions (under an ad hoc breakdown) of the Member States (or of their undertakings)
- Trading receipts of agencies and invoicing of services to Member States.
- Community budget guarantee for agency loan issues.

4. Measures to stimulate the Community's S-T potential

- Contributions from the Community's research budget, with possible addition of assistance from the structural Funds.

5. Aids to exploitation of results (defraying of predevelopment costs)

- Loans to SMEs (application of new technologies and innovation) (NCI IV)
- Risk capital contribution (pilot experiment now under way)
- Community budget Chapter 75
- Invoicing of services rendered.

6. Criteria and methods for selecting priority TRD programmes

Scarce financial resources and even scarcer human resources (and Japan's example) suggest that only a small number of carefully selected programmes should be launched at the same time. In the selection of programmes a decisive voice must be given to those who will be committing their assets and whose spirit of enterprise will be the key to industrial success at the end of the road. The aim is not to explore every possible scientific avenue but to strengthen the technological bases of European industry.

The broad criteria for the selection of the first list of programmes to mobilize talent and resources and serving precise objectives could be as follows:

- they must make a substantial contribution to strengthening Europe's scientific and technological potential, especially in fields where the international competitiveness of its industry is under threat;
- be of major economic and social value in harmony with the concerns and characteristics proper to our society;
- constitute measures for which the European dimension is a major advantage or even a necessity;
- they must be sufficiently attractive in aspiration and content to draw the best brains;
- they must attract public support.

For the selection and detailed planning of priority programmes and projects and the definition, for each of them, of participation, financing and management methods, the following procedure could be followed:

- A high-level group of senior officials under the Commission's authority would be instructed to identify strategic options and priority themes and projects, to lay down the terms of reference for the detailed definition of each programme and to draw the conclusions. This executive group could be assisted by leading figures from research (in particular members of CODEST) and industry.

- For each theme, groups of experts from industry and research convened by the Commission would define precise programmes with their targets, costs, time scales and conditions of participation. Each group would be chaired by one of its members.

- On the basis of this work, the Commission would draw up proposals either for projects to be implemented at the Commission's initiative or for the means of associating the Community with initiatives by Member States which would serve common objectives.

- After consultation of the high-level group, the proposals would be sent to the Council, which would decide on the legal and financial details for each programme adopted.

The Commission has already made an initial study of themes which could be adopted. The Commission has drawn up detailed data sheets (attached) for each of these themes, which are to be regarded as examples rather than proposals:

1. Information technologies and their main applications e.g. computer-aided manufacturing, artificial intelligence and the supercomputer
2. Biotechnologies, in particular genetic and biomolecular engineering and their applications to health and agro-industry
3. New (e.g. superconducting and ceramic) materials
4. Lasers and optics
5. Big science facilities such as particle/radiation sources and advanced windtunnels
6. Broadband telecommunications
7. New-generation means of transport
8. Use of space
9. Conquest of the marine environment
10. Education and training technologies

A necessary first step is to instruct the Commission to launch forthwith the procedure for defining these priority projects so that some projects can be approved by the end of the year.

SYNERGETIC AND COMPOUND EFFECTS

The following project areas are interconnected in many ways and mutually reinforcing. Table 1 shows the level of interactions between projects.

To complete the description and give a synoptic view of the whole field, Table 2 shows, for the measures proposed, their potential applications and their impact on competitiveness and employment, and Europe's relative position in each area.

TABLE 1

PROJECT INTERDEPENDENCIES

xxx very important
xx important
x slight
. very slight

										Information Technologies			New Materials				Large accelerators		
		Telecommunications	Supercomputers	New generation of transport systems	Health-care technologies	Education and Training	Space	Agricultural industrial project	Deep-sea exploitation	micro and opto-electronics	Art. Intelligence and Advanced Info Proc.	Computer Integrated Manufacturing	Advanced Materials	Superconduction	Aerospace prop.	Lasers and optics	High-energy physics	synchroton	Windtunnels
Telecommunications		▨	xx	x	xx	xx	xxx	.	x	xxx	xxx	xx	x	.	.	xxx	x	.	.
Supercomputers			▨	x	x	x	xxx	.	xx	xxx	xxx	xx	xx	x	.	xx	xxx	.	xxx
New generation of transport systems				▨	.	.	xx	.	x	xx	xx	xx	xxx	xx	xxx	x	.	.	xxx
Health-care technologies					▨	x	x	x	x	xx	xx	.	xxx	.	.	xx	.	xx	.
Education and Training						▨	.	.	.	xx	xxx	x	.	.	.	.	x	x	x
Space							▨	xx	x	xxx	xx	xx	xxx	x	xxx	xxx	x	x	xxx
Agricultural industrial project								▨	x	x	xx	xx	x	.	.	.	.	x	.
Deep-sea exploitation									▨	xx	xx	xx	xxx	x	.	x	.	.	.
Information Technologies	micro and opto-electronics									▨	▨	xxx	xx	x	.	xxx	x	xxx	xx
	Artificial Intelligence and Advanced Information Processing									▨	▨	xxx	x	x	.	xx	xx	x	xxx
Computer Integrated Manufacturing												▨	x	.	.	xx	.	.	x
New Materials	Advanced materials												▨	▨	▨	xx	x	xxx	xx
	Superconduction												▨	▨	▨	x	xxx	x	xx
	Aerospace prop.												▨	▨	▨	.	.	.	xxx
Lasers and optics																▨	.	xx	x
Large accelerators	High-energy physics																▨	▨	.
	synchroton																▨	▨	.
Windtunnels																			▨

TABLE 2

		OBJECTIVE	IMPACT			POSITION OF EUROPE	POLYVALENCE	EEC ACTIONS CURRENTLY IN TRAIN OR PREPARATION
			TECHNICAL ADVANCE	COMPETITIVITY	EMPLOYMENT			
1. Telecommunications		stimulate economic activity	high / diversified	high	high / positive	good	very high	RACE, TBB, video conferencing
2. Supercomputers		high performance computation	high / diversified	high in small sectors	none	slight	very high	ESPRIT
3. New generation Transport syst.		confort and security of transp.	marked	high	high / positive	good	limited	
4. Health-care Technologies		improvement in health and long.	high / diversified	consid. for farmaceuticals and equipment	marked / positive	satisfactory	very limited	
5. Education and Training		optimisation of human resources	high/ diversified	important due to need for trained manpower	high/positive both directly & indirectly	good	high	Technical Education Initiative
6. Space		High value added services	high/ diversified	in specialised sectors	slight/ positive	good	potentially considerable	CCR DGXII-DGVIII
7. Agricultural industrial project		Use of biosphere for renewable goods	high/ diversified	high	high/ positive	good	none	biotechnologies
8. Deep-sea exploitation		Raw materials and agriculture	moderate/ specialized	within traditional industries	weak/ positive	good	weak	
9. Information Technologies	micro & opto-electronics	Improvement of existing functions & creation of new ones	high/ general	very high	medium/ positive	weak	full	ESPRIT
	Artificial Intelligence and Advanced Information Processing	Development of expert systems	very high	high/ very specialized	weak	medium	full	ESPRIT
11. Computer Integrated Manufacturing		Automation of manufacturing methods	high/ diversified	very high	slight	medium	high	ESPRIT
New Materials	12. Advanced materials	scientific and technical progr.	high in the long term	high in the long term	slight in the short term	satisfactory	very high	BRITE
	13. Superconduction	scientific and technic.progress	high long term	in the high in the long term	slight in the short term	satisfactory	important	BRITE
	14. Aerospace prop.	hypersonic propulsion	high in narrow sector	high	slight	good	high	
15. Lasers and optics		Scientific and tech.progress	marked/ diversified	indirect	slight	good	high	
Large accelerators	16. High energy physics	Research into element.particules	high narrow sector	very indirect	slight	excellent	slight	
	Synchroton 17.	Photon-matter interaction	high/ diversified	indirect	slight	good	slight	
18. Windtunnels		Development of aeronautics on transport	high/ diversified	essential	slight	good	very high	

ANNEX

POSSIBLE MOBILIZING PROJECTS

The projects listed below have been selected because of their potential industrial and socio-economic impact. At this stage they should be regarded as examples rather than as final proposals, which will have to be examined in much greater detail and discussed in depth and be the subject of consultations between the various parties concerned in the political, economic and scientific arenas of the Member States.

1. Information technologies and their main applications, such as computer-aided manufacturing, artificial intelligence and supercomputer

2. Biotechnologies, in particular genetic and biomolecular engineering and their applications in the health field and in agro-industry

3. New materials, such as superconductors and ceramics

4. Lasers and optics

5. Large scientific instruments such as particle/radiation sources and advanced windtunnels

6. Broadband telecommunications

7. New-generation means of transport

8. Use of space

9. Mastering the marine environment and exploring the earth's crust

10. Education and training technologies

1. INFORMATION TECHNOLOGIES AND THEIR MAIN APPLICATIONS

These technologies include microelectronics and optoelectronics, the software industry and all the other disciplines associated with data processing such as artificial intelligence, in other words all the techniques that play an important role in the acquisition, processing, transmission and storage of information.

Large-scale precompetitive R&D activities are being conducted in this field at both Community and national levels. At Community level, the ESPRIT programme (European Strategic Programme for Research and Development in Information Technologies) represents a public and private-sector investment to a total of 1.5 million ECU for the period 1984-88.

The main applications of information technologies include telecommunications (a special Community programme intended to meet requirements in this field has been placed before the Council), defence, computer integrated manufacture and automated office systems (the last two sectors, also covered by ESPRIT, are of major strategic importance with regard to the provision of products and services), and consumer electronics with its substantial growth rate. All are heavily dependent on both advances in information technologies and further development of them.

In all these sectors, additional emphasis should be placed on two specific fields of the work conducted at various levels within the Community : firstly microelectronic and optoelectronics, then artificial intelligence and advanced information processing.

MICROELECTRONICS AND OPTOELECTRONICS

Microelectronics is at the heart of thousands of products ranging from highly sophisticated systems such as telecommunications and observation satellites or professional and personal computers to watches and toys. Today, the world turnover in this industrial sector is about US $ 30 thousand million, but the estimated turnover in other sectors in future years which make use of microelectronics amounts to more than US $ 660 thousand million.

Optoelectronics utilizes the visible part of the electromagnetic spectrum in order to fulfill the same functions as conventional electronics (e.g. data transmission, processing and storage). Its advantages are a transmission capacity which is thousands of times as great and a speed which is theoretically 1000 times as great.

European industry's share of the world market in this rapidly expanding strategic sector is very small : about 5 % of the world market in the case of the most advanced products and 10 % as regards all products taken together.

The small volume of production combined with the later arrival of microelectronic products on the market (mainly integrated circuits) deprives European industry of a source of revenue comparable to those of its principal rivals to finance the investments that are necessary to remain in the race or even to enter it as a credible runner.

European investments over the last two years were between US $ 300 million and US $ 400 million while the US and Japanese firms invested four to five times as much during the same period.

As in case at present in the USA and Japan, a cooperative approach to research and development is becoming an imperative necessity in Europe. ESPRIT is showing the way for coordinated research within the Community : it is hoped that proper financing will be accompanied by a number of major mobilizing and coalescing projects in both the equipment field and materials. European production depends for basic materials and its most critical equipment on imports mostly from the US or more recently Japan. With a few exceptions this dependence results in Europe technology suffering from delivery delays of at least one year. However, as Japan recently demonstrated, it is possible, to re-establish (or establish) a certain foothold (even by aggressive means as in the case of Japan) in a carefully chosen sector of the market and, by so doing, bring about further advances and growth in the sector.

The supply or manufacture of integrated circuits under licence appears to be both economically sensible and devoid of risk. There is a greater level of integration aimed at obtaining both better performance and lower production costs. Increasing amounts of system manufacturers' know-how is incorporated into the silicon chips which are sub-assemblies with considerable added value, not just "simple" components.

Two examples can serve as illustrations :
- semiconductor memories
- microprocessors

Both these could suitably be covered by a European programme since they are the driving forces behind the development of the integrated circuits industry and data processing for which Europe now depends on the United States and Japan. Losing control over these sub-assemblies would seriously inhibit innovation capacities as regards the design of complex systems, an area in which Europe has traditionally been very strong, and would result in a brain drain and loss of jobs.

- Random access memories. The aim could be create a 64 megabit memory by 1995, i.e. a chip with a capacity 100 times that of the present advanced circuits. The only way to do this is to reduce the lateral dimensions of the structures (to less than 0,5 um), something which cannot be done by means of the equipment available today, and to evolve a new memory cell concept, probably based on three dimensions. The project would call for around 2000 man-years.

- Advanced microprocessor. The object would be to design and construct, within five year, a European-inspired microprocessor circuit, incorporating the latest results in terms of breakdown-tolerance, architecture and addressing. With the aid of an appropriate strategy, a joint development, using, for example, certain of the micronic manufacturing technologies and design systems currently being studied in the context of the ESPRIT programme, could result in a standard. An estimated 1000 man-years would be needed for this project.

Alongside these widely used integrated circuits, systems manufacturers want to reduce the gestation time for an electronic assembly in order to make it more competitive. One solution seems to be to set-up prototype workshops (foundries) for the production of integrated circuits. Because there is only a very limited European market at present, this could cover construction of the following :

- silicon signal-processing circuits
- very high speed GaAs circuits

- The "Silicon Foundry" project would involve the rapid creation (approximately 2 years) of a joint European workshop, first using proven CMOS-technology, then a mixed CMOS-bipolar process, properly adapted to this type of application like those developed under the ESPRIT programme. The most important point remains, however, the development of CAD tools and the establishment of a standard cell library, in order to achieve fast and effective integrated circuit design. It is estimated that such a project would involve 1000 man-years and investment in a suitable production line (150 million ECU).

- Although there is at present only a very small market for GaAs foundry products, there seems to be a great many applications :
  - . cache memories and ultra-high-speed arithmetic units for super-computers ;
  - . processing of high-speed signals and random logic for broadband telecommunications or cellular radiotelephony for example.

  The considerable investment, in terms of both equipment and brainpower, required for R&D in respect of manufacturing and design technologies for ultra-high-speed circuits makes the idea of having a European industrial consortium attractive as regards developing the technology and establishing a pilot unit. An initial estimate suggests that 1000 man-years would be required over five years.

The object of the four projects described above is to maintain or improve Europe's position in the field of professional electronics. In order not to be left behind on the high-definition television markets of tomorrov and, therefore, in an important part of the consumer sector, European industry must provide for the development of a range of specific integrated circuits for digital coding and decoding of signals along similar lines to those currently recommended for satellite television (DC2-MAC-packet), as soon as possible after standards have been defined. With the development of the equipment for production and programme-recording, the project is likely to involve around 1500 man-years over a period of 7 years.

ARTIFICIAL INTELLIGENCE AND ADVANCED INFORMATION PROCESSING

Artificial intelligence is a fairly recent discipline that is developing very rapidly. New, more sophisticated and more powerful expert systems are announced at frequent intervals.

Expert systems provide a considerable improved service in many areas of application : medicine, biology, chemistry, geology, design aids and fault detection in industry, to name but a few. They have repercussions in all branches of the economy and expect a direct impact on industrial competitiveness.

Although European technology is well placed here (partly thanks to ESPRIT and a few national projects), Japan has proved in the past that efforts which combine basic technology with a careful choice of markets can place it in a strong position in new high-technology sectors (for example memories). Government programmes under way in Japan and the United Stated and the concerted R&D efforts of American companies are focusing on artificial intelligence and software technology; this fact alone should convince Europe of the need to contemplate intensifying its efforts in order to avoid a subsequent decline in its industrial competitiveness in these key sectors.

The entire field of artificial intelligence and advanced information processing is currently covered by the Community's ESPRIT programme. The efforts undertaken should nevertheless be intensified with a view to :

- enhancing the integration of simple artificial intelligence systems into the more complex systems which more closely resemble human thought processes and are more capable of meeting the potential needs of users;
- improving the conditions of economic production in order to reduce the final cost of such systems.

The diversity of the fields of application, the lack of industrial experience in the use of such systems and the relative "simplicity" of all present day systems taken individually show that a great deal of investment still has to be made in order to integrate artificial intelligence into systems that can be used by professionals who are not computer specialists.

Such investment should cover :

1. The industrialization of the initial results already obtained, focusing on :

   - software technology, since - as with any software - expert systems will have to satisfy industrial production criteria;

   - the architecture of complex systems, in order to enable expert systems to cooperate with each other and give access to large amounts of data. Such architectures will also have to satisfy external contraints relating to confidentiality, response time, man/machine interface, etc.;

   - the integration of these components into specialized systems by means of design aids.

2. The intensification of research on basic techniques, with special emphasis on modelling: knowledge models, learning models, dialogue models and reasoning models. These developments benefit in particular from progress made in education technologies.

3. Industrial awareness schemes for the uses of these new technologies. Such action can be facilitated particularly by placing specialized centres at the disposal of those concerned (see the section on large computers).

Two examples of projects may help to illustrate better what is desired.

- Expert system for weather forecasting and the environment
- Knowledge-based multi-sensor system

Each of these projects illustrates one of the first two points mentioned above.

The aim of the first project is to use existing basic techniques and apply them to a specific case of sufficient complexity in order to improve industrial competence with regard to integration and the archtitecture of complex systems. This project needs the results of current studies on the acquisition, representation and hardling of knowledge and of systems interconnection networks. The developments will include the programming of a complex system, the construction of a knowledge data-base, and the design and production of architectures suited to cooperation between expert systems. The project is expected to take some 1000 man-years over a 5 to 6 year period.

The aim of the second project is to intensify studies of basic techniques ; by linking two fields, sensors and knowledge, this project should provide the stimulus to intensify the work on knowledge models to make knowledge accessible to acquisition systems via a machine/machine or man/machine interface. The work involved is expected to require 250 man-years over a period of at least three years.

COMPUTER INTEGRATED MANUFACTURING

Encompassing a range of technologies that make it possible to achieve integrated factory automation within a broader framework of operations and company management, CIM is at the heart of a continually expanding market and is now affecting industrial sectors where it was unknown (for example, the clothing and food industries). Statistics show that the European market in the computer-aided design and manufacturing (CAD/CAM) sector alone was worth US $ 320 million in 1982 and forecast that this market will represent US $ 1.050 million in 1985 and grow by nearly 50% to US $ 1.550 million in 1986.

Precisely because it covers several pre-existing sectors, it is as yet extremely difficult to quantify CIM as a whole accurately.

Europe's wealth, which was in the past based on its ability to produce goods with a high added value at competitive prices, is today threatened by competition in this area from other countries that benefit from:

- lower labour costs (Asia or South America);
- more stringent quality control (Japan);
- huge internal markets (United States);
- direct government financing (United States and Japan).

Progress in manufacturing technology, which has been made possible by the application of information technology (IT), will soon have a major impact on factors affecting production (such as the effect of the direct labour cost on the overall cost of production, or the importance of large scale production, which is partly called into question by flexible manufacturing systems or FMS).

The general improvements in the efficiency, reliability and adaptability of manufacturing systems brought about by IT offer Europe a unique opportunity of regaining its predominant position in the manufacturing industry, provided it makes the necessary efforts.

In Japan and the United States, major R&D activities have been financed by the state in recent years, with remarkable results: public funds amounting to US $ 444 million were thus spent in Japan between 1972 and 1982 on stimulating the machine-tool industry. During the same period, Japanese exports in this sector increased from about half to three times those of the United States.

The Japanese are particularly effective in ensuring that ideas and energies are pooled, that cross-fertilization takes place between different disciplines and that there is continuity between projects.

In the United States, the combined effect on CIM of expenditure by the Department of Defense (DOD) and civil financing is considerable. The US Air Force has for a long time been actively supporting developments in CIM, which has made it possible to provide decisive financial support for a large number of projects in the field. Interest in advanced production technologies in the United States has considerably increased since the seventies. In general, activities have been coordinated by the DOD within the MANTECH programme. The ICAM (Integrated Computer-Aided Manufacturing) programme, which was launched in 1977-78 by the US Air Force, has been allocated rapidly increasing funds.

Production technologies are passing through a transitional phase. Europe cannot let slip the opportunity it is being given of capitalizing on existing R&D investments. It must make optimum use of the assets and resources that exist in the Community. The world market in industrial automation will probably be worth something between US $ 65 million and 75 million in 1989, whereas it represented only US $ 15 million in 1983. A great economic effort needs to be made to support such growth: the European CIM market should double over the next four years.

Nevertheless, without an energetic standardization and coordination effort, the results obtained in the different countries would not be able to mesh together, and the risk of duplication of research work would be great.

The economic and social importance of CIM is decisive, as can be seen from the example of FIAT. A motor manufacturer of the size of FIAT owes its survival through the recession (which was threatening to cause the collapse of the firm in the seventies) to a great extent to the large-scale introduction of CIM in its production processes. This clearly brought about major social upheavals, since the introduction of CIM systems involves a transitional phase during which the improvement it enables large firms to make in their competitive position is not immediately counterbalanced by the creation of new job opportunities. This is an extremely delicate problem which will have to be taken into account when considering plans for European involvement in CIM.

Furthermore, technological dependence on the United States and Japan would prevent Europe embarking on a positive reaction process which would enable it to reap the greatest benefits from its own technological advances. It is already possible to envisage production systems largely based on European technology in which the direct labour cost represents less than 10% of the total cost of the product.

It can be deduced from these considerations that an international European effort in this area is even more essential than it is desirable, particularly since there are examples which demonstrate the validity of such an approach: one of the most obvious examples is the ESPRIT programme, in which the Community has proven that it is able to act as a major catalyst in promoting R&D on the technologies necessary for the development of CIM. These technologies cannot, however, create wealth in themselves, as long as they are not applied effectively.

Two projects, which are described below are therefore being proposed as part of the actions planned for the area of CIM. One is aimed at developing integration centres for the elements which go to make up computer-integrated manufacture, which are the result of research work carried out by European manufacturers as a whole, and which should make a contribution to consolidating their position on the European and international markets. The other project is more specific, namely to develop a virtually independant robot to operate in a hostile environment. This second project is a concrete example, with a particular topic, of the potential of the new technologies.

HIGH-PERFORMANCE COMPUTERS

The new computer architectures have been designed either to increase computational power for numerical-data processing (supercomputers) or to make possible the processing of symbolic (non-numerical) data, in such applications as artificial intelligence.

The supercomputer market, which had a value of US $ 15.000 million in 1984, is expected to show an annual rate of increase of 20%. This market is a US monopoly (IBM and three other companies), although a number of Japanese firms have been attempting to fill certain gaps since the end of 1983. The European industry, which is not represented in this market, has concentrated its effort on medium and low-power computers. European users are totally dependent on the US and may soon be similarly dependent on Japan. These users, however, are found in such different industrial sectors as oil prospecting, the chemicals industry, aerospace - particularly as regards wind-tunnel applications (see advanced wind-tunnel project) - and meteorology to quote just a few examples. Moreover, only a limited number of supercomputers have been installed in Europe owing to the scale of investment required, with consequent disadvantages for the whole fabric of industry (designers, users) and the universities (teaching, research).

Although the symbolic data-processing market is only at the initial stage of development, it is expected to show considerable growth as the application of artificial intelligence becomes more widespread. Studies reveal a potential for expansion at least as rapid as that of the supercomputer market. Plans for the development of appropriate machines were first announced by the Japanese under their fifth-generation project and a similar announcement quickly followed from the US, where a large number of microelectronics and data-processing firms agreed to pool their efforts.

Although ESPRIT covers the design and development of such machines in Europe, it makes no provision for them to be made available to industrial or university users. Such experimentation in industrial contexts provides indispensable assistance for the improvement of design.

A mobilizing project relating to new computer architectures could be devised as follows:

1. Design and development of new architectures

   The human and financial resources, as well as the level of competence, required for the development of a supercomputer, call for association and cooperation at the European level.

   Architectures for symbolic data-processing are covered by ESPRIT and some of the relevant projects are already in progress. A parallel study of the integration of these two types of architecture as a back-up to the creation of information-handling systems could make use of expert-systems architecture and contribute to their development.

2. Creation of service centres

   Specialist service centres could be created in order to accelerate the execution of certain studies and the exploitation of the results obtained from ESPRIT and the above-mentioned projects.

   These centres would be interconnected so as to benefit from the complementarity of services, speed up the exchange of information and promote the use of advanced new computer equipment.

   They would make it possible to provide:

   - bases enabling the designers of new architecture to evaluate their work in progress,

- research facilities and a framework for teaching and training experiments for university staff,
- the software and basic equipment required by industry for the improvement of its software technology,
- the user services required.

Such centres could be distributed throughout Europe, possibly in a specialized form such as:

- a supercomputer service, operating as a service office[1],
- an applications-support centre designed to familiarize potential operators with these new computer facilities, provide them with training in their use and enable them to assess their impact on existing working methods,
- project-support centres, involving the participation of industrialists and the Commission, designed to promote the spread of European products and the convergence of the participants' interests (definition of standards).

The scale of the investment required to launch such a project means that it is difficult, not to say impossible, for industry alone to take an initiative. These difficulties could be overcome by the establishment of European-scale cooperation on this subject.

Two projects may help to illustrate how a supercomputer can be used in these fields.

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[1] Service office : provision, within a network, of a specialized service shared by a large number of users.

- Supercalculator for numerical data-processing
- High-performance calculators encompassing both symbolic and numerical data-processing.

The aim of the first project is to increase computational power for numerical data-processing (100 GFLOPS). This can only be achieved by relying on a number of complementary sectors : microelectronics (As Ga rapid components, see p. 1-4), software technology (programming tools), design aids, plus a number of sectors where it can be applied (oil prospecting, chimical industry, aeronotics, meteorology, etc.). Given the multi-disciplinary nature of the teams, this project calls for a high level of coordination ; it is expected to take 2500 man-years over 5 to 6 years.

The second project, which integrates symbolic and numerical data-processing involves the study of an architecture or rather a family of architectures, the components of which will be existing computers (supercomputer, non-von Neumann machines) ; it will be adaptable to ranges of applications. This project will benefit from the study of architecture of multi-expert systems and provide a back-up for applications requiring high performances either in terms of the volume of information handled or of the necessary response times. It is expected to take some 2000 man-years over a 6 year period.

2. BIOTECHNOLOGIES

The first steps taken by the Community to master and exploit modern biotechnologies date back to the launching of a research and training programme in the field of biomolecular engineering (1982), which was followed in 1985 by the approval of a more substantial biotechnology programme. These programmes are characterized by a choice of topics and implementing procedures that should make it possible to remove a set of barriers which seriously jeopardize the chances of exploiting in Europe the recent advances in biomolecular engineering : the inadequacy of research support infrastructures, the failure of fundamental knowledge to keep up with new methods of investigation, the fragmentation (or even divergence) of efforts between one country and another and between publicly-funded research and industry, and the difficulty of at last reaching a critical mass. This initial Community action represents a capital of invested effort which, if it is to be fully exploited, should be able to give birth to major action projects that pursue commonly-recognized objectives and whose repercussions whould be perceptible. The Commission is today in a position to implement such projects, which can be developed on the basis of technological knowledge that has been built up through programmes in hand, to stimulate intense activity embracing - without any discrimination between disciplines - the many scientific and technical achievements of our time, and lastly to combine existing resources to carry out pre-competitive work of interest to the Community.

These projects can be classified under three main headings which illustrate effectively the qualities of living matter and the nature of its relationships with the environment :

1. Genetic and biomolecular technologies as applied to the exploration of the properties of living matter;

2. Agro-industrial technologies for the benefit of better cooperation between agriculture and industry;

3. Health technologies for the benefit of the development of preventive medicine.

I. Genetic and Biomolecular Technologies

Introduction

Genomes constitute the basis for differentiation between species and for their "competitive" properties. One intrinsic quality of genomes is their capacity to reproduce themselves. However, through the generations and in the continuity of phylogenetic lines, their reproduction is subject to continual, infinitesimal variations which accumulate in time giving rise to the well-known phenomenon of evolution-selection. Evolution is registered by the genome and is inherent to life. Selection, on the other hand, is artifactual, resulting from the "dialogue" between genes and an unstable, changing environment. The process of evolution and selection not only leads to an enriching of the biosphere by diversifying the capacities of living beings, but also results accidentally in chance errors (evolutionary cul-de-sacs of the scale of geological eras; individual, genetic defects and handicaped persons on the scale of human generations). It has always been characteristic of human activity to exert a strong influence over the selective pole of the evolution-selection binomial, e.g. by selecting animal and plant species for agriculture and by collecting microbial stock for food fermentations.

Towards the end of the 20th century, the technological society is faced with the effects of a vastly increased capacity to understand and master the evolutionary mechanisms of biomolecules and species, which have until now been a mystery to us. It is possible for the first time to control both poles of the evolution-selection binomial simultaneously. The technological leap forward which is at the origin of this unprecedented situation comes from the development, in only ten years, of a number of molecular tools which are prodigiously successful in elucidating the mechanisms underlying the properties of living organisms, in parallel with the development of increasingly effective back-up instrumentation for retrieving and processing biological data.

In the present state of basic technological knowledge, two big projects would immediately make use of the most advanced genetic technologies for the benefit of the scientific and industrial Community :

- the description of the genomes of a number of higher organisms and the genetic and molecular exploration of some of their functional properties with important implications for the medical sector or agro-industry;

- directed evolution making it possible to plan development at the level of molecules and organisms.

A. Description of the structure of the genomes of certain higher organisms and of the mechanisms determining important functional properties

This is a task very much of the moment both because of the size of the stake involved and both of the present synergy between traditionally isolated disciplines such as formal genetics, cell biology and molecular biology. In the forfront of this mutual enriching is molecular biology which is providing formidable investigatory tools such as restriction enzymes for gene cutting and grafting (splicing), molecular hybridization techniques to identify genes with DNA probes, two- or three-dimensional electrophoresis techniques to describe the polymorphism of DNA, RNA or protein types and the kinetics by which they appear, specific marking by monoclonal antibodies and, of course, the ever-increasing number of molecular cloning vectors permitting in vitro purification, amplification and mobility betwen the different hosts of a theoretical, unlimited number of genetic properties.

The study of genomes has become central to genetic technology because :

- the most immediate use of the abovementioned molecular tools consists in using them to explore the genome and the way in which it functions;

- in a more distant future, their exploitation in medicine, industry and agriculture will depend on how well the structures and means of regulation of the genomes (the only sources of new genetic properties) of useful organisms are understood.

The genome contains all the silent or expressed genetic data that each organism transmits to the genetic "pool" of its succeeding generations.

The project should be approached in two ways : on the basis of the total genome and on that of the important property.

- As regards the whole genome, the task is so complex and important that well-reasoned choices must be made. One or two animal and plant species should be selected and a full set of data compiled on their genomes (genomic libraries), with physical maps being produced gradually. Since the structure of genomes is not fixed, it will be important to gain a better understanding of their stable states and changes. At his level, the silent sections of the genome are particularly important and the project will have to include the study of genetic data sequences common to different genomes, the study of repeated DNA sequences (an as yet unexplained minority factor in animals and a majority one in plants), and the study of the kinetics of transposable elements. Unless account is taken of the internal organization of hereditary material, no long-term protocol is conceivable either for the transfer of genes between species that are useful to human beings or for the correction of certain genetic defects affecting human health.

- On the basis of the important property, it is essential to be able to reconstitute the metabolic intermediaries involved in the expression of a useful character, and to trace back the molecular path which make the function subject to the control of a given number of genes. It is the expressed part of the genome which is then explored, and this task - which complements the preceding one - can be satisfactorily completed only if it is perfectly targeted on a limited number of properties that are "useful" (in terms of their exploitation by man) or, at all events, "important" (in terms of health and resistance to illness). This project could then provide a knowledge base and a technological platform enabling preventive medicine or the improvement of animal and plant species to be further developed. The latter aspect concerns, in particular, genetic engineering applications in agriculture, which are still held back by our lack of basic knowledge of the biochemistry, physiology and genetics of the characters that determine the economic importance of the higher plants : senescence, reproduction, hybrid vigour, symbiosis, the build-up of proteins, carbohydrates and oils, etc. These characters must be precisely defined in terms of essential functions and underlying mechanisms if the effectiveness of genetic engineering is to be increased and the scope of its applications broadened.

The number of these essential functions and of the corresponding gaps in the knowledge we could possibly have of them is today so great that no rational and effective effort could be made without extensively pooling the skills and resources that have scattered among a few European laboratories. The pooling of all these skills is not merely necessary in order to attain a critical mass in terms of scientific investments and optimum distribution of research work; it is also a requisite condition for the parallel development of advanced research on a few plants that are cultivated on a large scale and constitute some of the challenges facing the common agricultural policy : barley, in terms of its capacity to produce a high-calorie animal feedingstuff whose nutritional value is perfectible (amino acids), the field bean as a source of protein, and oilseed plants, not to mention the many other species that make it possible to exploit natural fibres and secondary metabolites or merely constitute useful sources of genes for protocols involving transfer through natural reproductive barriers (resistance genes, etc.).

B. Methods for controlling molecular evolution

A project aimed at making it possible to plan molecular evolution can be tackled, as in the preceding case, via an approach based on function (a peptide or an enzyme function) or an approach based on the encoding molecule (which on this scale, is not a genome, but a simplified molecular matrix, an RNA).

The function-based approach is tackled in the context of protein engineering, which is the subject of a Commission project that forms part of its current biotechnology programme. Although this project - which is still inadequate when compared with the number of active molecules whose structural and functional analysis is becoming desirable - is sure to develop far beyond the limits of the current programme, it will not be included in this sheet as a new project designed to strenghten the technological base already operational in the Community.

The encoding molecule approach is concretized in the development of a highly futuristic technology designed to provoke the acceleration of molecular evolution in order theoretically to reproduce, over a compressed timescale, some of the evolutionary processes which may have given rise to life on earth. The approach springs from a theory ("the hypercycle") based on the belief that molecules organize themselves spontaneously in conditions in which Darwinian selection takes place.

Some of the principles on which this theory is built have found perfect experimental illustration in the in vitro replication properties of a molecular matrix (RNA). This system is capable of reproducing the type of events that were probably involved in the origin of life, by producing random sequences of genetic information through RNA reproduction. Since such reproduction allows a limited degree of inaccuracy, this self-replicating process gives rise to variations in the phenotypes. The method is aimed at establishing what types of sequences can appear in each replication cycle and studying the possibility of producing a spectrum of all the possible types of sequences that is sufficiently dense to make it possible to select those which offer a phenotypical advantage and identify the structures responsible for the acquisition of a property under investigation.

The technology developed to build this "machine for accelerating molecular evolution" should be exploitable for the screening of very large numbers of genetic information sequences similar to those encoded for known proteins, in order to select for optimized biotechnological properties. It will make it possible to produce, in accelerated time, macromolecules bearing genetic information of a novel nature, i.e. the combination of which would perhaps not have had the chance of occurring in nature.

Biotechnological applications are still subject to the development of appropriate technological processes for automated series dilution, the synchronized incubation of molecular populations and growth measurements, all of which will require sophisticated instrumentation based on laser and computer technology. They no longer have to depend, however, on any hypothetical progress in science, since it has been demonstrated that they are founded on the logic of biological evolution and selection.

II. Agro-Industrial Technologies

Rapid developments in knowledge and techniques, notably in biotechnologies and automation, are rapidly altering the socio-economic environment in which agriulture operates as a producer of a great variety of renewable materials, some of which are produced in excessive quantities, while others are insufficient for our needs.

Furthermore, the nature, volume and marketing of these products give rise to problems which research must help to solve, in particular by providing openings for greater diversification and an improvement in the quality of the raw materials produced, and in their use by the consumer and the industrial networks. Such developments would obviously reduce the cost of the common agricultural policy, which currently accounts for the lion's share of the Community budget. Indeed, closer integration of agricultural and industrial activities, which has become desirable and possible mainly through developments in the new biotechnologies, could lead to favourable developments and new openings for the CAP. Among other things, it is now possible to transform agricultural products into chemicals, so introducing a new flexibility into the use of our resources.

If agricultural production is to be better matched to the needs of consumers and industry, projects based on agricultural land management and use of agricultural products must be implemented.

A. Projects for improved land use better adapted to the market

- Development of remote-sensing and computerized soil-management techniques in order to achieve the optimum balance, at regional level, between various types of crops, grassland, woodland and leisure areas.

- Improvement of the agronomic properties of crops, so as to reduce the required amount of fertilizer (fixation of atmospheric nitrogen) and pesticides in order to cut input costs and damage to the environment; improved adaptability of plants to difficult eco-climatic conditions.

- Development of crops better matched to the needs of the consumer (such as improving the nutritional and organoleptic properties) and industry (polysaccharides, oils and fats with special properties, molecules with high added value, fibres, etc..).

B. Projects for better use of products

- Use of starch and sugar as raw materials, under certain market conditions, for a wide range of industrial products (organic acids and antibiotics).

- Separation, treatment and new uses of milk derivatives.

- Development of biosensors to verify the quality of food products throughout the agri-foodstuffs production chain, in order to respond more fully to consumer concern about food quality.

- Agricultural and agri-foodstuffs engineering to improve tools, especially through use of advanced monitoring and analytical techniques.

C. Demonstration projects

- Growing and exploiting industrial products, at farm level, based on improved or radically new species, for technical and economic evaluation.

- New harvesting and on-farm processing methods, in the spirit of the agricultural refineries described by Rexen and Munck(1).

III. Health Technologies

The extremely spectacular progress which is now taking place in the fields of genetic engineering, cell pathology and scientific instrumentation should make it possible to achieve a considerable improvement in diagnostic methods (particularly early diagnosis) and, as a result, in the rapid treatment of developing diseases or the protection of individuals who are especially susceptible to certain forms of attack from the environment.

The contribution of the new technologies to preventive medicine can take a wide variety of forms, encompassing basic applications of genetic engineering and new developments in the fields of scientific instrumentation and medical equipment.

A. Applications of genetic engineering

Manufacture of effective totally non-virulent vaccines

It is now possible, by means of gene cloning in bacteria or by the total synthesis of polypeptides, to produce antigens (principally viral) which possess effective vaccinal properties, and do not necessitate the maintenance of expensive cell cultures or entail any risk of the spread of living micro-organisms. Foot-and-mouth disease, rabies and intestinal corona viruses are examples of serious and highly contagious diseases in response to which this manufacturing strategy could be made rapidly operational within the Community.

The production of monoclonal antibodies

Monoclonal antibodies have the ability to eliminate the chemical substances which stimulated their synthesis. They are formed by hybridomas (i.e. by laboratory-produced hybrid cells which combine the ability of a tumour to reproduce indefinitely with the capacity of a normal tissue to synthesize a given antibody). Monoclonal antibodies are already used in general serology for the purification of macromolecules, cell- and blood-typing and the diagnosis of infectious diseases. A community R&D effort could result in their being used in the near future for such purposes as immunization against viral or bacterial diseases, the manipulation of immune responses, the localization and identification of tumour cells and the treatment of auto-immune diseases, and cancers.

Synthesis of nucleic acid probes

DNA (or RNA) probes, which reproduce a definite sequence of genetic information capable of recognizing the same information and linking up with it, offer the medical industries a vast range of applications. An enzyme, reverse transcriptase, which enables genetic information to be reproduced from its product, has made it possible to isolate and clone such information and, as a result, to obtain polypeptides (insulin-growth hormone, etc..) which are of enormous interest to the pharmaceutical sector.

As regards preventive medicine, the probe method provides a more effective means than antigen variance for the identification of certain types of (viral or bacterial) attack to which the organism is subject and, as a result, for the classification of the virulence of the strains and their particular affinity for a given animal species or category of individual. Community research will make it possible to exploit the probe method more effectively and to apply it, in particular, to the typology of numerous viruses or bacteria which epidemiologists require for confirming their diagnoses.

B. Scientific instruments and medical equipment

The development of scientific instruments (particularly medical electronics) and heavy medical equipment, which is already extremely advanced in the United States, can also make an important contribution to preventive medicine. This development requires an extensive electronics and data-processing infrastructure, which is lacking in Europe. Nuclear magnetic resonance (a technique for the selective visualization of organs or the external measurement of their metabolism based on their chemical properties rather than their opacity to X-rays) provides a good example of a revolutionary diagnostic tool mainly developed in Europe (UK) which has been exploited on a large scale in the US and Japan. In this field as in many others (help for hemiplegics, treatment of deafness and eye trouble, patient monitoring, interpretation of radiographs, etc..) there is a need to combine the considerable breakthroughs made in electronics and data processing with the advances achieved in the technology applied to the living being. In this instance also the scale of the task to be accomplished makes a Community response the only viable option.

In the case of both genetic engineering applications and medical instrumentation it appears that Europe's backwardness cannot be attributed to a lack of ingenuity on the part of its research workers but that it is mainly due to the fragmentation and isolation of their activities and the compartmentalization which too frequently separates university research from industrial application. The critical scale required for breakthroughs in preventive medicine can only be achieved through a pooling of resources and infrastructures in the Member States and Community efforts to ensure that they are used in a systematic and rational manner.

3. NEW MATERIALS

Materials take pride of place in all technological achievements, since they generally constitute a sticking point in technological progress. Any nation or group of nations which were to lose mastery of this field would find itself in a state of dependence on other countries, not only for supplies of the materials themselves, but also in terms of the technological achievements made possible by such materials.

The future of such sectors as the motor or aviation industries, the success of space programmes, the development of highly sophisticated kinematic robots, biotechnologies (using membrane technology, for example), and the development of bio-compatible prostheses are all dependent on progress in the materials field.

The failure of materials through fatigue or their deterioration through corrosion costs Europe more than 200.000 million ECU each year. The development of new types of polymers and of automated large-series production techniques, for example, would enable these economic losses to be reduced considerably.

The actual production of advanced or new materials is an important economic activity. The world market in ceramics, which is currently worth more than US $ 400.000 million (of which a 60% share is held by Japan) should increase to US $ 20.000 million over the next ten years. It is also estimated that, by the year 2000, there will be a market of several tens of thousand million dollars in composite materials and of between US $ 10.000 million and 20.000 million in technical polymers.

There is a long-standing tradition of materials development in Europe, which still has excellent materials laboratories and is in no way inferior to its overseas competitors in terms of the calibre of its research workers. The annual budgets for materials R&D of all the Member States put together are similar to those of the United States (with a Federal budget of US $ 1.000 million) or Japan (where the MITI's programme on new materials has a budget of US $ 5.400 million over ten years). And yet, European materials research is constantly losing ground:

- European laboratories have been greatly overtaken in the new materials openings that have emerged over the last 20 years;
- the major avant-garde inventions in the advanced materials field, such as amorphous metals, memory alloys, electricity-conducting polymers, carbon fibres, etc. have been made in the United States and Japan.

Nevertheless, European researchers publish extensively, but seem to take no interest in technological transfer:

- three out of four patents concerning new materials are filed by American or Japanese researchers;
- hundreds of millions of dollars are spent each year either on straight imports of new materials or semi-finished products into the EEC or on manufacturing licences obtained from American and Japanese companies;
- thousands of jobs are thus lost each year to the European economy.

This genuine technology gap in the materials field can be attributed only to the structural weakness of European research (the lack of coordination, the dispersion of efforts, duplication and the lack of communication between administrations and industry in the Member States).

Europe's innovation deficiency in the advanced materials field is naturally echoed by the lack of industrial investment in an area involving a degree of risk.

In order to remedy this situation and create major innovations or facilitate emergence of new materials, it is necessary simultaneously to pursue two lines of development, namely research aimed at constantly improving existing or "advanced" materials and systematic broadbased fundamental research. The study of materials has made considerable advances in recent years as a result of the completion or the progress to project stage of large-scale scientific and technical instruments such as particle and radiation sources (see §5 "Large-scale scientific instruments"). Widespread use of these instruments on a European level should enable major advances to be made in the field of materials. Research work must focus not only on improving the properties of materials, but also on production processes, utilization techniques (bonding, shaping, etc..) and testing methods. The categories of materials to be considered are sophisticated ceramics, advanced composite materials (metal, fibre, etc..) polymers (of the electricity-conducting type, for example), new alloys, and organic molecules or proteins intended for the new "biochips".

In this area, a more specific application could be considered, namely chemical or biochemical sensors working on a model of human perceptive organs, which would be likely to have applications both in medicine (diabetes, for example) and in industrial process control (see §2 "Biotechnologies").

In connection with the field of materials a specific action on superconductivity could be commenced. This technology is capable of numerous applications: in addition to those at the research level such as high-energy physics or fusion, more industrial applications can be envisaged, in particular in transport (magnetic suspension trains) and in the production and transmission of electrical energy (alternators, cables). European industry has recognized skill in metallurgy, metal fabrication and low temperature sciences and the development of cryogenic systems at a competitive cost and of the technology and a European production capacity for superconductor magnets, on demand, could provide important outlets for such skills.
A coordinated programme dealing in particular with the development of new superconductor materials (for example "A15" alloys and niobium/tin) the cryogenic system itself (helium II) and the techniques for the production of superconductor magnets capable of bringing about significant progress in this field.

Another specific action in connection with the materials field could be the study of an advanced aerospace propulsion system, such as a ram-jet engine for hypersonic speeds. The development of such a system with hydrogen as the fuel would represent a specific scientific and technological challenge for the European scientific and industrial community. The combination of work on materials, on combustion phenomena, on structures and on aerodynamics should ensure an independent technological base for Europe, in particular in very high speed commercial aviation. Once more the field could become the centre of interest if the necessary attention were given both to the problems of the market and to the constraints connected with the protection of the environment. It is clear that the European aerospace industry is not itself capable of financing such a high risk, long term project.

4. LASERS AND OPTICS

For centuries Europe had the monopoly of the development in optics - both its theoretical development and the development of instruments and components. However, over the most recent decades Europe has lost this monopoly: many important developments and new applications have been realized, mainly in the USA and to a certain extent in Japan. But in certain sectors European industry is still exporting more than it imports. The generally high level of training in optics and connected fields coupled with the growing laser industry and the many potential applications represent a valuable starting point for large-scale Community action aimed at facing up to foreign competition and winning back some of the lost ground.

R&D aimed at the development of optics and, in particular, lasers could improve the competitiveness of a large number of economic activities by improving conventional technology and introducing new techniques. Some of these possibilities and certain R&D topics are described below.

Industrial lasers (basically CO_2 and Nd. Yag) for metalworking (drilling, cutting, welding, deburring, surface treatment) currently cost 50 to 200 dollars per Watt. Complete systems represent an investment of anything from 100 000 to 1 million dollars. Although the number of industrial lasers is increasing - in particular because laser working offers a degree of accuracy and a flexibility unequalled by conventional systems, at least for non-metallic materials - the cost of these systems must be reduced further and higher yields must be obtained as well as better reliability and more accuracy. Special solutions must be found for low-absorption metals such as gold, silver, copper, brass and aluminium.

In chemistry, the development of selective laser photochemistry would improve the competitiveness of small quantity manufacture. Isotopic separation, the treatment of radioactive waste and chemical waste, the synthesis of high-value chemical products and pharmaceutical products of extremely high purity are other potential applications, many of which are a function of the development of lasers in the ultra-violet range.

In medicine, the use of lasers is increasing at almost an exponential rate and, in certain cases, laser therapy has already shown its superiority over conventional techniques. Developments could result in fibre optical systems for illumination, imaging and surgery in areas of the human body which are difficult to reach. In particular, the development of a free-electron laser would seem to be particularly suitable for medical applications by reason of its comprehensive range of frequencies, its high power density and its capacity for dimensional control of the beam and its impulse length.

New developments in lasers could considerably extend their role in fields where they are already well-used, such as telecommunications, in the precise and remote measurement of dimension, shapes, speed and acceleration, and in non-destructive testing.

Finally, in the field of energy, and outside the use made in thermonuclear research for inertia confinement the development of extremely powerful lasers could result in studies in parallel with the development of extremely large mirrors for future long distance cable-less electrical energy transmission systems in the underdeveloped nations of Africa and South America.

Many of these applications depend on the <u>development of materials, components and techniques</u> such as materials with a refraction index gradient; optical materials with high infra-red quality (at wavelength of the CO_2 laser); techniques for cathodic pulverization (sputtering) for better surface coating adherence; optical manufacturing processes for semiconductors materials ; holographic components with special functions, including the creation of computer-generated holograms; non-linear optical effect materials for the manufacture of optical processors; optical quality plastics; production techniques for aspherical elements, etc.

No doubt the economic impact will be considerable. The added value in the optical industry (in particular lasers and optical instruments) amounted to approximately 2 700 million dollars in the United States in 1981. All the market indicators predict considerable growth. The market envisaged in the United States for civil lasers should grow from US$ 210 million in 1982 to US$ 1 600 million in 1995. It is estimated that in Japan the market for lasers, fibres, detectors and complete systems will grow from US$ 460 million in 1980 to US$ 65 000 million in the year 2000.

Such growth will obviously have effects on employment: in the United States, for example, employment in the optical industry grew by about 20% in the 1978 to 1982 period.

Although the examples quoted above are not fully up-to-date and refer only to the situation in the United States, it is clear that the optical field is one of extremely high technological growth, which is capable of improving the quality of life, industrial competitiveness and employment.

Two major projects could be envisaged :

- the development of a continuous CO_2 laser of around 50 kW within five years could be undertaken at Community level, the emphasis being on problems (cost, reliability, beam transport system, energy efficiency and power control, ways of machining reflecting metals such as aluminium, gold, copper) in the industrial use of this laser for machining and surface treatment of metal and other materials. In the future it could also be used for other purposes such as energy transmission between the earth and satellites or even defence in space.

- A second line of development could be lasers emitting at short wavelengths (far UV or even X-ray). The most promising solution is the excimer laser which because of the great variety of the laser medium can generate a wide range of wavelengths suitable for selective photochemistry : isotope separation, synthesis of extremely pure pharmaceutical and chemical products, manufacture of integrated circuits (lithography, deposition of dielectric films). One objective could be to produce a laser emitting 1 kW at a wavelength below 200 nm within five years.

Alongside these specific efforts, research into materials, for example for optical elements, windows and the coatings suitable for laser wavelengths, production techniques, for example, aspherical elements or coatings, and the development of components should be actively pursued.

Clearly, the work proposed in both the optical field and, in certain cases, the laser field would have spin-off in the field of earth-observation systems mentioned in point 2.6 above.

5. LARGE-SCALE SCIENTIFIC INSTRUMENTS

PARTICLE AND RADIATION SOURCES

Over the last 30 years our knowledge of the ultimate components of matter and the forces which link them to each other has made considerable progress. This has been made possibile by the implementation of more and more powerful accelerators and collision rings. However, the results of research on the unified theory of forces, kept as simple as possible and based on a reduced number of particles and forces, can only be confirmed by experiments in enormous rings several kilometres in diameter. These require funds on a scale only achievable at a European level and developed and cross fertilized by techniques in all the advanced technological fields (materials, superconductor magnets, vacuum technology, etc).

Also included in this same category of equipment are the large synchrotrons intended for the production of intense light beams generated by particle acceleration (electrons) under the effect of external magnetic fields. The light produced is suitable for many applications both in research and industry (the study of surfaces, spectrometry, catalysis, difraction, x-ray lithography, etc).

Large-scale accelerators, like all the other major apparatus managed under the auspices of a number of countries, makes a considerable contribution to bringing together the scientific community of all the participating countries. In addition, the sheer size of these projects, as well as the importance and novelty of the discoveries they allow helps to regenerate confidence in the destiny of Europe and in its capacity to take its proper place in the world by means of an increasing joint use of its human and material resources.

On a more immediate and concrete level, the construction and implementation of a major synchrotron light generator would have important socio-economic spin-off, in particular with relation to industrial applications of this radiation and the multidisciplinary nature of such applications, which would make this installation a place for the convergence and mutual fertilization of almost all the industrial research fields in chemistry (reaction kinetics, applications of photochemistry, product analysis, etc), in the field of materials (study and monitoring of their structure, the various phases in their preparation, their surface properties, etc) and in the field of biotechnology (structure of complex molecules, biochemistry, monitoring and analysis of products, etc).

ADVANCED WIND TUNNELS

The development of aeronautics requires the use of advanced wind tunnels which simulate flight conditions in the subsonic, trans-sonic and hypersonic regimes. These installations are indispensable for the development of new aircraft and engine units. Having an advanced aerodynamics wind tunnel at the European level is a necessary condition for Europe's competitive position in the aeronautics field to be conserved. In addition, studies should be carried out on "numerical wind tunnels" which are in fact three-dimensional simulators which require computing power of a level which should be achieved at the beginning of the 1990's. These numerical wind tunnels will enable mathematical models to be constructed of the aerodynamic flow round complex-geometry obstacles, and this is crucial for the development of future highly-integrated propulsion unit and structural configurations. Such simulations would enable a considerable reduction to be made in the increasing number of hours in the wind tunnel which could otherwise rapidly become prohibitive.

6. BROADBAND TELECOMMUNICATIONS

1. The convergence of telecommunications, data processing and audiovisual systems will modify the nature of telecommunications, upgrade the use of data-processing equipment (computerized data-processing) and considerably expand the range of services available both to enterprises and individuals.

   Total investment in telecommunications within the Community over the next 15 years is estimated at between one half and one million Mecu (500.000 - 1.000.000 million ECU). This investment should primarily cover the replacement of existing switching equipment and transmission lines by new products offering greater technical and economic advantages.

   These investments and associated services will have a direct impact on employment. The establishment of "data motorways" will make concrete the development and investment potential of the terminals and new services sector and help to stimulate employment based on the provision of equipment for the electronics industries and the creation of new industrial services. By resolutely progressing as regards the "costs and performance" of advanced telecommunications services, the Community will become more attractive from the standpoint of the introduction of new economic activities or the revival of activities.

   Emphasis should therfore be given to the improvement of the quality-price ratio of telecommunications equipment and services, and to the provision of advanced services at acceptable costs to the user. This will have a favourable effect on traffic, thereby guaranteeing operators satisfactory conditions for the recoupment of their investments.

   The development of these sectors will be conditioned by progress made in the fields of microelectronics, optoelectronics, and communications software. Achievement of such progress will necessitate considerable efforts aimed both at the establishment of advanced information-transmission infrastructures and also at the development of terminal equipment, services and new applications.

2. From the technological standpoint, the evolution of telecommunications systems can be said to be dominated, on the one hand, by the generalized use of digital rather than analog signals and, on the other hand, by the introduction of optical media to replace the purely electronic means of transmitting and controlling these signals.

   The transitions from electronics to optics offers considerable advantages for the different key telecommunications operations : i.e. transmission, switching, processing and storage of signals. The technology of optical signals transmission is already comparatively advanced (at least in the fibre optics sector), although the other functions are still at the preliminary stage of laboratory development.

   In theory, optical switching, signals processing and storage should be fare more efficient than the corresponding electronics-based operations. This is because of the considerable advantage offered by light as regards speed, mobility and wavelength compared with electrons. A one-centimetre square optical switching system is capable of processing 10 million independent light beams and switching each in less than 30 picoseconds. In principle, an optical processor of the same size could handle three hundred thousand gigabits/second, a figure corresponding to the traffic which would be generated by a videophone conversation between the two halves of humanity.

   In the medium and long-term, optical techniques offer the prospect of achieving performance/cost ratios which will make it possible to provide advanced (broadband) telecommunications services at rates equivalent to presen-day telephone charges and therefore acceptable to the majority of the population.

3. Execution of the following development projects could be considered :

a. Optical telecommunications processor

This processor is the central element around which the entire optical communications system will be built. Its principal functions are :

- input/output (multiplexing, demultiplexing, signals recognition and conversion, signals transmission and reception, etc.) ;
- switching ;
- control (signal processing, traffic management, systems maintenance and monitoring) ;
- interaction with operators and the environment.

These operations will be executed/monitored using high-performance software backed up by advanced, widely distributed systems architectures.

Estimated resources required : 1500 man/years over 10 years.

b. Miniaturized radiotelephony

Mobility and accesibility are two of the kew factors in the evolution of communications. Ultra-light personal terminals will constitute the essential elements of such progress in the context of public cellular radio. These developments will call for major efforts orientated towards the introduction of :

- low-power miniature radio transmitter/receivers ;
- high-density cellular radio systems ;
- a flexible frequency and traffic management method.

Estimated resources required : 400 man/years over 5 years.

4. The initiation of technological development projects with a view to the introduction of broadband integrated communications systems meets all the distinguishing criteria of a major European project offering widespread economic and social advantages. It will stimulate technological progress in various key areas (particularly microelectronics and optoelectronics). It will also give rise to a number of applications, enjoy considerable support from industry and enable links to be established with existing programmes (e.g. ESPRIT, national programmes such as ALVEY, the French electronics network

programme and the Federal German microelectronics and information and communications technology programmes). Lastly, it will contribute to the attainment of the Community's regional development objectives and to the creation of jobs and the growth of exports.

7. NEW GENERATION TRANSPORT MODES

The main requirements place on future transport models will be safety, environmental protection, speed and energy saving.

The new information and CIM technologies, together with the development of new materials and base technologies, should be able to help reconcile these principal needs.

Speed (linked with safety and environmental protection) should related first and foremost to both supersonic air transport (see the section on new materials) and high-speed rail transport.

The safety, environmental protection and energy-saving aspects would be of prime concern to road transport in order drastically to reduce the number of collisions, atmospheric pollution and energy consumption in the ten years ahead. Significant progress, based on new technologies, could also be made in urban transport.

In the field of road-transport safety and comfort, for example, a priming project should be devoted to the development of a satellite assisted navigation system having the advantage, from an industrial standpoint, of complexity. This aspect would have a knock-on effect on a large number of upstream sectors, since it involves the development of digital road maps (high-definition, compact VDU screen technologies, the provision of digital radio links with fixed receivers, and improvements to signal accuracy (the civilian navigation systems currently available are accurate to 100 metres, which is inadequate for drivers of road vehicles, even on spacious motorways). Moreover, a project of this type would have multiple repercussions on other areas of application (management of a fleet of transport vehicles, automation of agricultural machinery etc.). A project of this type would require 12 months of specification definition, two years of parallel feasibility studies covering two or three possible options, and three to four years of pre-industrial development of the options selected at the end of phase 2. The definition phase would require 30 man/years. The volume of work in the subsequent phases would depend upon the specifications arising from Phase 1.

A second priming project in the field of road safety could examine the feasibility of an automated motorway transport system. Its aim, which would be wider than its predecessor as regards the financial commitments needed and its possible impact, would be the development of a full-scale prototype automated motorway. The work involved would thus be :

- system design
- the development of devices providing overall control of automated vehicle flows
- the development of access and regulation systems (in the event of accidents or unforeseen breakdowns)
- the development of on-board control units
- solution of the problems involved in adapting conventional vehicles to automated movement conditions.

Projects of this type are naturally ambitious and costly but, apart from the fact that it is possible to derive benefit from the research and practical work on the automation of rail and urban transport (in which Europe is very advanced), account must be taken of its considerable impact on improving safety and the overall efficiency of road transport.

This second project would need to be spread over a longer period of 8 to 10 years. It would comprise :

- an 18-month definition phase
- a three-year feasibility phase, in which groups of companies and public and private institutions (transport research institutes, road-safety agencies, vehicle manufacturers, equipment manufacturers etc.) would compete with each other
- a four to five year experiment under real-life conditions, (development and installation of equipment, trials, tests and conclusions).

The definition phase would require roughly 200 man/years. Any work done in this sector would be greatly attractive both socially and politically and would spur technological development. It would thus have a positive effect on, in particular, the vehicle and vehicle-related industries and would help to boost the electronics industry, which would also need to become involved.

8. USE OF SPACE

Brought on by the American military programmes, the accelerated development of new detection systems (IR, visible, microwave) associated with on-board systems for real-time processing and analysis of received signals will be accompanied by increasing restrictions on the transfer of technology in what is a highly sensitive area.

Unless Europe accelerates its own development of on-board sensors and of processing and analysis systems, it will fall further and further behind as far as earth observation is concerned.

Earth observation techniques provide extremely important data for numerous sectors: protection of the environment, climatology, meteorology, oceanography, hydrology, agriculture (forecasting of harvesting patterns), raw materials (through geology), transport, fishing and development aid.

Not only will such data permit more effective implementation of Community policies in all these sectors, but in a sensitive area such as agriculture, Europe cannot afford to be without the data that would be available to its competitors.

Space is the ideal setting for transnational research with spin-offs in areas of common interest (joint policies) calling for public funding, having a mobilizing effect and providing opportunities for cooperation with non-member states.

The decisions taken by the European Space Agency in January are intended to increase Europe's autonomy as regards space exploitation (earth observation, telecommunications, microgravity, space-related science and technology) and to maintain independence as regards launching systems (Ariane programme).

In order to develop these techniques at European level, one might consider an integrated system of observation and telecommunications satellites, making use of those generations of satellite already in existence such as SPOT (France) or ERS-1 (ESA), and new developments such as a large man-tended polar earth-observation platform. The latter is currently under discussion in the context of Europe's participation in the American space station programme.

Furthermore, apart from their key role in the development of an intra-Community wideband communications network, telecommunications satellites will be needed to channel data from earth-observation satellites to the analysis centres.

Radioastronomy using long baseline interferometry has been developed considerably on earth (e.g. Nançay, Cambridge) and has furthered exploration of the universe. If an interferometer of this type could be put into orbit around the earth, it would be possible to overcome certain constraints such as radio noise or the limitations associated with basic physical dimensions. It would call for advanced techniques for assembling structures in space and highly accurate pointing of antennae in orbit.

By analogy, it is also possible to envisage the sending into orbit of an optical interferometer, which would in addition require the development of new optical techniques (mirrors and detectors in conjunction - see §4 - Lasers and optics). Interferometer techniques would certainly involve an element of international cooperation with the United States and the Soviet Union in respect of observations.

Pending an opportunity to take part in the development of a space station that should be put into orbit in 1992, Europe has already been able, thanks to Spacelab, to carry out experiments on materials manufacture in space. From 1988 onwards, it will be able to participate in long-term (six-month) space missions using the European Retrievable Carrier. Action is proposed in order to provide coordination back-up for the industries that might be interested in production in space (pharmaceuticals, crystals, biological processes, etc.), thus enabling them to acquire greater knowledge of the available opportunities.

Likewise, the aims of a European technological programme are also covered by the European space programme. The development of the Hermes manned space vehicle, with its different technological challenges, should therefore be actively encouraged, together with any work to further the major political objective that has been set of maing Europe fully independent in the manned exploitation of space.

The main aims of action relating to production in space should be :

- to increase industry's knowledge of the utilisation of techniques for the manufacture and improvement of products in microgravity and hard-vacuum conditions ;
- to promote the earliest possible use of production in space through pilot experiments that pave the way for industrial-scale operations.

These objectives could be attained through :
- the overall coordination of a prospective user community ;
- the identification of the candidate industries which have hitherto not been associated with the European space programme, but could be involved in the new activities that are becoming possible ;
- the classification and, in association with the competent European space authorities, development and implantation of typical pilot experiments.

A first step would be :

- to convene, in association with the ESA and the space industry, a meeting of the prospective user industries, and then draw up an indicative work programme that would lead to flight-experience opportunities for those industries.

This could be supplemented by :
- the publication of a notice aimed at the industries that might be interested in experimental opportunities ; the selection of an initial list of pilot experiments that could be financed in full ; and the establishment of a second list of experiments that could be financed on a cost-sharing basis.

A schedule of costs can be drawn up, ranging between the comparatively minor expenses involved in the identification and coordination of the industries that might be interested in such projects and specific allocations for the typical experiments. In the latter case, a cost of nearly 50 million ECU can be envisaged. At all event, the programme would proceed in phases, the first of which would involve approaches to industry, followed by th identification and development of the pilot experiments and finally the execution of the experiments in orbit.

9. CONQUEST OF THE MARIN ENVIRONMENT AND EXPLORATION OF THE EARTH'S CRUST

MARINE ENVIRONMENT

Europe, with some 10.000 kilometres of coastline and almost two million square kilometres of continental shelf, can play a leading role in the conquest of the marine environment and exploit its resources provided that it takes a broad view of its action and formulates a plan capable of mobilizing its research and development capacity to the full.

The implementation of such a plan requires that considerable technical difficulties be overcome. It is from the work involved in surmounting these difficulties that technological spin-off can be expected. The conquest of the sea implies a challenge, in sectors which are already expanding rapidly (electronics, telecommunications and robotics), and other areas such as chemistry, biology and materials science, metallurgy and very high pressure technology.

The plan could be an opportunity to increase our basic knowledge, establishing a range of new targets, and develop a host of technologies which could come up trumps for Europe in the long term.

The present position of oceanographic science and technology in Europe is favourably comparable to that in other nations, in contrast to the situation prevailing in other areas of advanced technology where our competitors' lead makes for an unequal struggle. Europe can assume leadership in this promising field, develop the support technologies extensively and benefit from the resulting industrial spin-off within a few years, by choosing the exploitation of the marine environment as one of Europe's elements of technological ambition: and all this without excluding any other strategic applications.

A major objective would be to develop the capability for sustained physical presence of man in the seas and on the ocean floor.

A key element of the enterprise can be found in the design and construction of modular self-propelled vessels for use as shelters, for deep-water exploration and for work with the intention of developing accommodation capacities and diving depth in stages.

Two fields of application from which European industry could benefit extensively are deep drilling and robot machine development : deep drilling for geological exploration and the exploitation of gas and oil resources; development of robot machines for various tasks such as exploration for and exploitation of resources on the sea-bed or just below it or the inspection and maintenance of drilling equipment, pipelines and cables.

This stage of the analysis will be confined to technologies possessing the greatest potential for applications and growth, those most suitable for reinforcing existing skills or for plugging technological gaps, which, although in themselves representing a substantial turnover, constitute an essential condition for the existence of much greater turnovers downstream and are hence of a special strategic nature.

STUDY OF THE EARTH'S CONTINENTAL CRUST

For some years earth science specialists have been aware of the paradox that while great advances have been made since 1968 in knowledge of the oceanic crust as a result of the Deep Sea Drilling Project, relatively little is known as yet about the earth's continental crust.

What results can be expected from programmes to survey the continental crust ? Essentially, a better knowledge of structures, materials and fluids and a number of longer-term practical benefits. More specifically :

1. From a scientific point of view they will provide more information on :
   - the structure and composition of basement rock, deep sedimentary basins and fold systems;

- the nature and geometry of major intracrustal discontinuities (large-scale thrust faults);
- the nature and depth of the Mohorovicic discontinuity between the crust and the mantle within the lithosphere;
- the physical properties of rocks; distribution and effects of stresses at depth;
- the study of fluid phases, their origin and circulation and their role in petrogenic and dynamic processes.

2. The practical benefits will be in the fields of :
   - metallogenics and mineral deposits; development of magma systems (granitic domes), hydrothermalism at depth, monitoring the structure of mineral concentrations;
   - geothermal energy, hydrocarbon prospecting (deep basins), ..;
   - earthquake mechanisms and earthquake prevention;
   - storage of nuclear waste;
   - design and manufacture of drilling equipment suited to the extreme conditions encountered in deep drilling.

Existing Programmes

1. Major national reflection shooting programmes : DEKORP in the Federal Republic of Germany, ECORS in France, BIRPS in the United Kingdom, COCORP in the U.S.A., and so on. The aim of these programmes is to identify structures up to depths of around 50 km. Some bilateral cooperation exists.

   The international European Geotraverse programme, implemented under the auspices of the European Science Foundation, pursues similar objectives.

2. Deep borehole programmes :
   - "ultra-deep" boreholes (10 to 15 km) : Kola in the USSR, a drilling project in the Appalachians (U.S.A.) and the KTB project in the Federal Republic;
   - medium-depth boreholes (1 to 5 km) : deep geology programme in France, which actually started up during last Winter, and boreholes of a similar depth in the West of the U.S.A..

These boreholes can provide samples for direct analysis as well as an opportunity for all kinds of in situ geological and geochemical measurements in the boreholes. They are proving essential as a means of verifying and clarifying the information obtained from large-scale seismic profiling (an example being the Kola drilling project, where the initial assumptions were proved wrong).

International Cooperation : Aims and Prospects

Although promoters of the various programmes listed above have contacts with each other, genuine international cooperation - which is advocated by most specialists - has yet to materialize. Potential subjects for such cooperation would include :

- joint studies of deep structures involving two or more countries;
- development of methods and instruments for geophysical, geochemical and hydrological measurements and for drilling boreholes;
- making samples from deep boreholes available to European laboratories;
- setting up of proper permanent laboratories for the study of the earth's crust ("crust labs" on the lines of the "space labs").

The potential benefits of cooperation in these fields are considerable. In addition to the anticipated scientific, technical and economic spin-offs, it can also provide an opportunity for in-depth dialogue between specialists (such as geologists and geophysicists), who up to now have had few such opportunities.

10. EDUCATION AND TRAINING TECHNOLOGY

If it is to remain in control of its economic and political future, the Community must re-think and step up its efforts in the field of education and training. In order to compensate for the limited natural resources (energy, minerals) in Europe, one must develop human and technological resources. Although in their various forms the latter account for almost 7% of the Member States' GNP, the demand is increasing and is being met only in part at present. Not only is the range of knowledge and specialists increasing constantly, but in numerous sectors the demand for specialists is growing all the time.

Consequently, there is now demand for:

- a greater variety of courses in order to meet specialized and interdisciplinary requirements,

- better access to education and training, making them available, for example, when and where they are required and not only at certain stages in an individual's life and in specific places,

- better adaptation to pupils' specific needs.

It is important to meet these needs in order to improve educational and training performance in the traditional sense, but it is also essential to do so in order to meet the growing demand for continuing education and training among the active population. The mismatch between requirements and available capacity is one of the causes of the structural unemployment that is emerging during this period of technological development.

The traditional approaches to education and training have made it difficult to remedy the mismatch. However, progress in the fields of information and telecommunications technology offers the opportunity of adopting a fresh approach, characterized by greater flexibility and more accessible and improved economic conditions.

This area is generally known as education technology. It will not be sufficient, however, to combine data-processing, telecommunications and television to broadcast the type of programmes covered at present, for example, by the Open University of U.K. The development of education will make it possible to realize completely the potential offered by the new technologies and will call for very great efforts to be made over a long period.

The proposed type of education should enable all levels of personnel to be suited to the changing needs within their organisations and environments in such a way that relevant education would become an integral and coherent part of professional activities.

The technological input required to develop the necessary educational instruments and equipment would be free of any specific cultural associations and could be largely independent of language and discipline.

Education-related projects would meet important social and economic needs, stimulate research and technological development in large sectors and help to increase the number of skilled workers available on the labour market. The resulting products and services:

- would offer opportunities for exporting equipment and software,
- would stimulate job creation in industry and the service sector,
- would offer fresh opportunities in relation to the educational requirements of the developing countries.

In this field, one mobilizing project should be devoted to the development of European learning capacities for the benefit of advanced technologies. This project should involve in particular :
- the development of information tools and computer languages specifically for educational purposes ;
- the development of microknowledge models ;
- the development of artificial intelligence techniques for education and training ;
- the development of sub-function integrated circuits.

The introduction of such a project would require between five and seven years and a research and development investment the equivalent of 500 man/years over the time-span of the project.