COMMISSION OF THE EUROPEAN COMMUNITIES

COM(82) 486 final /2

THIS DOCUMENT CANCELS AND REPLACES
DOC. COM(82) 486 final OF 28/7/82

APPLIES TO THE ENGLISH VERSION ONLY

Brussels, 13 august 1982

COMMUNICATION FROM THE COMMISSION TO THE COUNCIL

on laying the foundations for a European strategic programme of research and development in information technology : the pilot phase

COM(82) 486 final/2

Communication to the Council on
Laying the Foundations for a Strategic programme of
Research and Development in Information Technology
"ESPRIT": The Pilot Phase

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A. <u>ESPRIT and its European Community context</u>

1. ESPRIT is an essential part of two recent approaches presented by the Commission to the Council. On the one hand there is the overall R&D strategy of the Community (1), for which the setting up of a framework programme of Community scientific and technical activities is an essential part. The 1984-87 framework programme (2) is structured around seven major goals of Community policies.

These are:

- improving agricultural competitiveness
- improving industrial competitiveness
- improving the management of raw materials
- improving the management of energy resources
- strengthening aid to developing countries
- improving living and working conditions
- making better use of the scientific and technical resources of the Community.

A number of scientific and technical objectives correspond to these goals which will act as guidelines for all relevant R&D activities within the Community framework.

2. On the other hand ESPRIT is an essential element in the industrial strategy of the Community, outlined in COM(81)639 (3) and in COM(82)365 (4), in which investment in R&D, particularly in information technology is seen as a precondition to restoring industrial and innovation competitiveness (5).

(1) COM(81)574 - Scientific and Technical Research in the European Community, proposals for the 1980s

(2) SEC(82)896 - Framework Programme for Community Scientific and Technical Activities 1984 - 1987 : first outline

(3) COM(81)639 - A Community Strategy to develop European Industry

(4) COM(82)365 - Communication to the Council on the problems of investment

(5) COM(81)620 - A policy for industrial innovation

3. The European Council, meeting in Brussels on 28th-29th June 1982 singled out IT as an urgent subject for increased action. Moreover, at the Summit meeting in Versailles in June 1982 the leaders of industrialised nations agreed on the need for collaboration in the new technologies such as information technology. The programme outlined below fits within the scope of these recommendations.

4. The Commission has already identified the weakness of the European situation in a Communication submitted to the Council on 25th May 1982 (1) on the need for a European Strategic Programme for Research and Development in Information Technologies (ESPRIT). It was stated therein that the purpose of that Communication was to enable preparatory discussions to begin so that decisions could be taken more rapidly later on. It was also stated that the main ESPRIT programme would be prepared and presented in time for discussion to begin before December 1982. The case was made for an initial phase involving pilot projects whose purpose would be to enable a progressive start up and to work out methods of collaboration and it was stated that details of pilot projects would be submitted before Autumn 1982 since there was an urgent need to begin these in January 1983.

5. The Council itself acted speedily to consider COM(82)287 to the extent to which the Ministers of Research of the European Community meeting in Luxembourg on 30 June 1982 gave a generally favourable response to the Commission's analysis of the need for a Community research programme for medium to long-range R&D in the information technology field and the approach of a first phase involving pilot projects. The Conclusions of the Presidency of that meeting are attached as an annex.

(1) COM(82)287 "Towards a European Strategic Programme for Research and Development in Information Technologies".

6. The purpose of this present Communication is threefold.

- To respond to the favourable reception given to the analysis presented by the Commission in its Communication COM(82)287.

- To provide an outline of the overall ESPRIT programme.

- To provide details of pilot projects in order to enable rapid conclusions to be reached on setting up a first phase.

B. Outline of ESPRIT

7. Programme objectives

There is increasing evidence that a considerable proportion of European R&D resources is directed towards research which is aimed at catching up with that which has already taken place elsewhere. Long-term industrial research, which could in effect provide product leadership, is to a large extent neglected because of resource limitations, and ESPRIT will aim at correcting this situation.

8. The overall objective of ESPRIT is :

- to provide the basic technologies which European industry needs to be competitive with that of Japan and the USA.

To achieve this objective ESPRIT needs to be :

- aimed at pre-competitive technology
- concerted with national activities in the Community

9. Given that there is a shortage of qualified manpower and other resources, which means that companies or governments individually cannot address all topics on a sufficient scale, the concentration of ESPRIT on pre-competitive research will enable the necessary critical mass to be reached in key areas.

10. Carrying out this work on a European scale will result in the technological foundations needed for the development of standards of European origin.

Programme Preparation

11. As outlined in paras 27-31 of COM(82)287 a number of major companies have made available approximately 100 people who have worked together in a Steering Committee and in five technical panels. They have advised the Commission on an outline for an integrated pre-competitive programme, and on a number of projects within that programme, which could be started immediately and serve as the basis for a first phase.

12. Having played a leading role so far in assisting the Commission in the preparation of the programme, these companies have indicated their desire to participate in its execution, providing part of the finance and making facilities and qualified manpower available.

13. It is intended to further widen this preparation process by involving more organisations who are interested and have a contribution to make. This will be achieved through requesting the participation of companies, universities and research establishments in:

- review panels of users and the scientific community
- technical workshops
- seminars
- direct contact on the initiative of industry

This process has already begun.

Preliminary Outline of ESPRIT

14. At this stage, the preparation of ESPRIT has not been completed as explained above, and therefore indications on its technical content are only of a preliminary nature.

15. The overall trend of the information technology sector, which can be expected to continue over the decades to come, is towards providing the end user or group of users with services that are more integrated into his or her natural working and living environment. This means improvements of orders of magnitude in the ease of use and the reliability of IT systems.

16. Thus IT systems of the future must move closer to the needs of their users, support them in an intelligent fashion, provide them with the appropriate information in a timely fashion. They must not only supply the appropriate answer to a user query, but also be capable of explaining how this answer was derived and, if necessary, enter into a clarification dialogue with the user if the query is ambiguous or illogical. This implies a qualitative jump in the interfacing capabilities of IT systems, as well as in their processing abilities and communication with relevant knowledge bases.

At the same time, and since users will be more and more dependent on IT systems in their everyday work and life, these systems will have to become orders of magnitude more reliable than they now are.

17. These simultaneous quantum jumps in ease of use, multi-media interfacing and reliability will require considerable increases in processing power as well as innovative architectures.

18. The corresponding technology is referred to as "Advanced Information Processing". In turn, the feasibility of such systems heavily depends on still greater improvements in the microelectronics area as well as in the development of adequate software.

19. Two of the largest markets estimated for I.T. systems in 1990 are in the Office Automation area and in the Computer Integrated Manufacturing area.

20. Correspondingly, the ESPRIT programme will be organized around these five interrelated themes. They are briefly discussed in the remainder of this section.

Microelectronics

The growing importance of VLSI (1) silicon-chips for any electronic equipment makes it essential to possess production, design and test capabilities, particularly as there is a trend to function-specific chips. System costs and performance depend on this VLSI technology, which is vital for the whole IT sector.

Going from the present state of the art 3-5 micron processes to processes based on 1 micron dimensions will reduce power consumption tenfold, and increase packing density eightfold. The latter will reduce costs by the same order ; a tenfold increase in speed and reduced power consumption will improve system performance.

Both Japan and the United States have a significant lead in VLSI technology.

Submicron work is required to stay in competition with them.

As the circuit geometry decreases to less than 1 micron, the number of cells on the chip increases, to ranges above 100,000 perhaps up to a million on a single chip. Thus CAD (2) needs to take a different approach, such as a structured, hierarchical approach, in order to be able to decompose massive information handling problems into smaller, more easily solved ones. Data bases need to be designed to handle such structural information, and standards need to be developed for them. A qualitative improvement in CAD techniques is needed in order to take full advantage of the VLSI technology potential.

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(1) Very Large Scale Integration
(2) Computer Aided Design

Software Technology

Software is of growing importance. The application market is growing at 49% a year and system software at 32% a year. Computer Aided Manufacturing including graphics, standard mainframe software, specific turnkey systems, business applications, microcomputer software and microsoftware publishing are all areas of rapid growth.

Software production is very expensive, both in funds and in scarce skilled labour, and almost unmanageable. Yet software must become available, at the right time to support other high technology developments in the IT field, for example and office automation. Software quality will have a decisive influence on the cost and competitiveness of European IT-products and applications. Cooperation and mutual information between hardware manufacturers, software houses, industry, users, academics and practitioners must be promoted. Such cooperation requires establishment of Standard Software interfaces if it is to be effective.

The research and development programme will contain work on the scientific foundations of software technology and lead to practical applications of formal methods to produce provably correct programmes and systems. Tools and development techniques, related to formal methods, both those for industrial development with large teams of specialized software engineers and those for individual applications developers, will put software development on an engineering basis. For automated software engineering environments, the problem of integration accross life cycle phases is a main long term research goal. For this, a unifying theoretical foundation is a prerequisite. Computer aided software life cycle management, integrating technical development and business decision making, will be developed ; for this, models of the product life cycle, roles of developers and users need to be studied and influence factors classified and investigated. Results will be applied on prototype management systems, to be extended later to management expert systems.

The research results will be of benefit to large and small companies and users alike.

A comprehensive set of engineering and formal standards, unified framework of concepts and descriptive notations will ultimately be necessary.

As a first step, emphasis is being placed on common tools, formal methods and transformations, and information management. These require a state- of-the-art data exchange network for communication between participating partners, with remote logon and file transfer protocols.

Advanced Information Processing

At the end of the decade, in a rapidly growing market, applications of information technology, among them business, engineering and office automation applications, will be largely based on knowledge processing, together with the processing of information directly perceived by a wide range of sensors. The goal of this research programme is the industrial exploitation of advanced information processing in Europe. Thus, work on information and knowledge engineering, storage and usage, signal processing and external interfaces and novel computer architectures is required.

Work on information and knowledge engineering will determine suitable forms of knowledge representation, methods of deriving facts from data, and inference and deduction techniques. New efficient hardware and software architectures will support knowledge based systems. A technology for the design and exploitation of expert systems will be developed. For the area of external interfaces and signal processing, the work will concern algorithms and architectures for signal analysis, pattern matching techniques, scene and movement analysis, feature extraction and image understanding. Natural systems will be studied concerning their feature extraction and understanding logic. For information and knowledge storage and usage, the work will establish interfaces, languages and software technology for constructing, distributing and partitioning knowledge bases.

Research concerning novel architectures will focus on data base machines, highly parallel ultra computers, dataflow machines, inference machines and highly parallel non-programmable units.

Office Automation

Office Automation is expected to become the largest single Information Technology market. In the USA both IBM and Xerox each spend more on this subject than European industry and academia combined, and the Japanese fifth generation computer concept is also aimed at these applications.

Definition of office automation objectives and their exploitation is highly dependent on local cultural considerations. In this context architectural and software considerations require great attention, and work must be done on the man machine interface. This includes document creation and distribution, workstations, integrated text-voice-image communication with value added functions, storage, access to and retrieval of knowledge rather than information stored in the system and all aspects of intelligent man-machine interactions.

Communication is the central element of office systems. Not only does it create additional processing requirements, but also it has the effect of bringing disparate systems into contact, thus making standardization essential.

Computer Integrated Manufacturing

Computer Integrated Manufacturing Systems involve the overall and systematic computerization of the manufacturing process. Such systems will integrate Computer Aided Design, Computer Aided Manufacturing, and Computer Aided Engineering, Testing and Repair and Assembly by means of a common data-base.
European manufacturing industry, whether small, medium-sized or large companies, will all benefit from such systems.
Integrated system architecture and general software development represent the largest elements of research and development work required. Machine control is another central feature involving automated assembly and assembly operating systems, robot operating systems, imaging, and computer numerically controlled machine tools. Sensors and micro-electronic sub-systems must also be resolved to permit the development of the necessary advanced components. A number of pilot advanced development centres as test benches for the demonstration of advanced computer integrated manufacturing systems are anticipated as means for keeping the recommended R&D programme properly goal-oriented.
The new generation of CIM technology will allow users to introduce it in a progressive manner according to their own specific needs and situation.

ESPRIT and the Community Dimension

21. Among the reasons for a Community dimension two are especially important :

- the relationship between R&D, standards and markets
- the scale advantage in combining R&D resources.

22. In the field of technology, standards are adopted either because companies are sufficiently successful for their systems to be adopted as de facto standards, or because authorities create them by regulation. European industry in general suffers on the one hand by not being large enough to impose de facto standards and on the other by having different national authorities adopting in some cases differing national standards.

23. Because ESPRIT is pre-competitive and long-term and because it covers, in an integrated manner, most of the area of IT, it will of necessity thrust the participants into devising new forward looking standards and so pave the way towards the implementation of widely applicable standards evolved within the Community rather than imposed from outside.
The importance of standards for the creation of a more homogeneous European home market in the IT sector is capital.

24. If the European industry is to be a valid competitor it must be master of its own technology - that is to say, that the long-range basis for new product development must be available here, in good time, to those who will need it. The task has two main requirements:

1. To reverse the present trend where an excessive proportion of the available R&D resources are devoted either to catching up with what is done or known elsewhere or to short-term development. The result is a lack of punch in any major attempt to develop new technologies, which no one company or country can tackle alone.

2. To reverse the present situation where both national company and university programmes address short-term fragmented aims, often linked to fragmented markets, leading overall to very inefficient duplication and gaps and a lack of mutual support and contact, for example in developing overall systems.

25. ESPRIT will thus not be in competition with national programmes; it will, on the contrary, reinforce them and make them more effective.

To date national programmes have some or all of the following features:

a) The highest technology areas in industry supported by government finance or in the government's own laboratories are often defence-related and are covered by tight security rules and slow to move into civil applications.

b) Research related to telecommunications is conducted by or for PTT authorities who maintain very close relationships with the national suppliers.

c) Research carried out by industry with or without government support is primarily related to products or processes which are likely to produce a return on the money invested in an excessively short period of time.

d) University work, often of the highest standard, is inadequately articulated with the needs of industry. Results are published quickly and applications are developed by those quickest off the mark - often Japanese or USA companies.

e) Between companies who are not multinationals very little intra-European collaboration takes place, so that similar work goes on simultaneously at different places without co-ordination or without opportunity for benefitting mutually from exchange of experience.

26. ESPRIT will reverse the current emphasis and focus it on longer-term technological research, establishing co-operation between industries across the European frontiers as well as co-operation between universities, research institutions and industry. Nothing in the programme will prevent companies continuing to compete in the market with products and systems derived from the work. The pilot projects will, in that respect, be typical of the main programme.

27. Existing Community activities in the IT field belong to a number of categories, among them long term R&D, technology transfer, and the support of the Community infrastructure. In the first category is

the current microelectronics programme which has been taken into account in the considerations given to the new proposals, and ESPRIT will itself fall into this category.

Apart from this work there are those activities which are aimed at transferring technology which has been acquired during an R&D phase to the stage of practical and marketable applications - for example the second part of the multiannual informatics programme. Finally, and in order to enable the results ofexisting national and Community programmes to be fully exploited, a series of measures must be taken to improve the environment and infrastructure ; these have been emphasized in the first part of the multiannual informatics programme (particularly standards) and in the proposal to the Council on telecommunications. Projects such as INSIS and CADDIA are also primarily aimed at developing harmonised information exchange systems.

28. A further element in the Community dimension is the need for the Community :

- to make full use of IT in education
- to ensure that sufficient people trained in IT are available.

In this respect the Commission has already made proposals to the Council (1).

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(1) COM(82)296 - 3.6.1982 - The New Information Technologies and vocational training - new Community initiatives for the period 1983/87.

Implementing ESPRIT

29. A programme of the nature of that outlined above will be highly complex to prepare and execute. The Commission therefore proposes a phased approach with a highly important one-year first phase. This first phase will involve no commitment to any further phases, but will provide useful experience in resolving complex issues.

30. The vehicle for this first phase will be a number of pilot projects which are described in detail below. Whilst this is in progress discussions on the overall programme will proceed in parallel.

31. Programme management will have to be:

- very flexible to take account of the fact that the IT sector is subject to a rapid rate of change
- very efficient to ensure the participation of many small companies active in the field, which must not be discouraged by bureaucratic procedures leading to high overheads.

32. Many companies have complex relationships with companies in non-Community countries, which might in some circumstances benefit ESPRIT. Any proposal involving third parties and third party technology and know-how will be assessed on its merits and judged by its overall benefits to ESPRIT.

33. Facilities, background know-how and background patents, plus personnel, will be the biggest contribution of industry. For this, companies must be convinced that a reasonable return can be expected for their participation. The financial contribution of industry will be assessed taking into account the above contribution.

34. Information, know-how and intellectual property resulting from the work will be firstly accessible to those participating and next, under appropriate conditions to the public authorities financing it. A differentiated approach is therefore proposed, where the participants will have access on a basis dependent on the level of their contribution.

35. In order to ensure concertation with national programmes, national authorities will be fully consulted in the preparation phase, in working out the methodology for the programme, in identifying potential participants and the evaluation of proposals. Participation in the programme will be open to those Community companies, universities and research establishments prepared to collaborate, who have a competence and who fulfil the selection criteria.

C. Pilot Projects

Purpose of Pilot Projects

36. Given the novelty to Europe of large scale co-operation in research of this kind, the Commission regards as essential the adoption of a phased approach. The purpose of this will be :

a) to have a progressive start-up

b) to innovate methods of handling this type of programme.

37. In putting forward a first phase, it is the intention that pilot projects will be a useful means of putting cooperative arrangements into practice, and of gaining experience on these complex and difficult issues. This experience can then provide the basis for a better management scheme for the overall programme due to start in 1984, provided the pilot projects are started in January 1983.

38. In advising the Commisssion on an outline programme, companies were able to propose for a first phase a number of projects with the following characteristics :

a) they can be started immediately

b) they are useful in their own right especially because of their impact on standards

c) although they will take several years they are capable of a milestone approach, so that a review of progress could be carried out at the end of the first phase.

After having identified a number of candidate projects, the Steering Committee, following the proposals of the panels eventually proposed fifteen of them on which they had been able to reach unanimous agreement. A sixteenth project, an information exchange system, was also included to provide the participants with an appropriate communication system.

39. Although the projects are important technically in their own right, they are not a full programme in themselves in that they alone can in no way meet the overall ESPRIT objectives. They do however form part of the overall programme, and if they proceed as expected they will produce results which can be integrated into those of the overall programme.

Broad Description of Pilot Projects

40. The 15 projects selected are further described in Annex II. As an indication of their diverse but appropriate nature with respect to the overall programme, two examples are given below :

41. The first, "Advanced Interconnect for VLSI" is concerned with a very specialised basic technology without which the design and manufacture of advanced VLSI devices will not be possible.
The second, "Functional Analysis of Office Requirements" is, by contrast, directed to promoting scientific, standards-supported, applications of new advanced information technologies to Office Automation.

42. Examples :

42.1. Advanced Interconnect for VLSI

A Silicon integrated circuit is made from a wafer of pure silicon onto which has been fabricated by a series of deposition, diffusion and lithographic processes a very large number of microscopic electronic components. These are grouped together by metal interconnections to form circuits or cells performing specific electrical functions. Within the next five years, it will be possible to pack one hundred thousand cells or more on a fifty square millimetre VLSI chip (about the size of a small finger nail), in mass production.

In order to achieve this density of integration the size of any feature of the microcomponents must not be greater than 1 micron (millionth of a metre) as compared to 3-5 micron in commercial use today. There is at present no mass production technique that is compatible with one micron feature technology, either for connecting together the components that constitute a cell or for interconnecting the densely packed cells. The millions of connections required must be isolated from each other and yet be as short as possible in order to avoid reducing the speed at which the circuits can operate. In order to solve this problem it is proposed to develop a technology whereby four very thin insulated layers of metal interconnection patterns with a minimum feature size of 1 micron can be included in the fabrication process.

An additional and vital benefit of this interconnect technology is that it will allow the design of interconnections patterns and hence the layout design of the whole circuit chip to be automated by a computer aided design system. Development of such a CAD system is the object of another Pilot Project entitled "High Level CAD for Interactive Layout and Design".

42.2. Functional Analysis of Office Requirements

This Pilot Project is in the field of Office Automation. It is concerned with overcoming problems that face industry because there is no existing scientific framework classifying office functions which can be used to determine how office automation needs can be met. Future products and standards must reflect the users' needs, rather than what technology can offer.

The object of this project is to move towards the successful and economic realisation of this goal by a formal approach from which a series of common user functions can be identified across a wide range of different organizational activities.

Functions exercised in an office environment are divided between those which are deterministic and those which are judgemental. The surveys and studies that will be carried out as a part of this project will concentrate largely on the judgemental functions in order to provide office automation systems that will meet the great majority of future needs for computer aided management and professional facilities.

The first year plan of this project will enable criteria for this classification to be established and for a statistically valid, world-wide survey related to a methodology for describing the operation of an office, to be defined. Subsequently, the result of the survey will be used to prepare a classification of office types by high level functions. It will then be possible to define common functions that will be the subject of standards suitable for office automation, as well as technology advances required from the ESPRIT programme in order that these functions may be included in future systems.

The experience of European Office Systems Manufacturers has convinced them that analysis of office functions is essential for a high penetration of office automation systems. By leading to a structured user market based on specifications and standards this project will make it possible for them to take and maintain a leading position in this new, fast-growing market place.

Implementation of first phase of pilot projects

43. Call for participation in pilot projects will be made on an open basis. Given the short time available national authorities will be asked to support and cooperate in an exercise to identify potential participants and in getting the first phase under way.

44. Before the end of the first phase, a review will be carried out. This will establish the basis for future progress and will provide the opportunity to finalize the size and procedures for the overall programme.

45. The principles applied to the handling of information, know-how and intellectual property rights will be as described in para. 34 above although it should be noted that one of the goals of this first phase is to work out the details of satisfactory arrangements for ESPRIT in this respect.

46. For the first phase a figure of 11.5 MECU is included in the 1983 budget to cover 50% of the cost of the first phase of these projects. The other 50% will come from industry.

D. Conclusions

47. The Commission proposes that active discussion with industry and national authorities should continue to define the overall programme so that it can be ready by the end of 1982.

48. The pilot phase should be agreed and implemented with the support of national authorities.

49. The necessary budgetary measures should be adopted to enable the one-year pilot phase to begin in January 1983.

50. The Commission invites the Council to adopt a Resolution to that effect.

Working paper only: not to be regarded as in any way committing the Commission of the European Communities or any of its servi̊es.

TECHNICAL OBJECTIVES OF PILOT PROJECTS

NOTE: This document is a preliminary draft and is only intended to serve as a basis for further technical discussions. The objectives and the background of ESPRIT is described in two Communications by the Commission of the European Communities to the Council, COM(82)287 and COM(82)486, and this document is an Annex to the latter. It should only be read in the context of the statements made therein.

ANNEX I

22.07.82

ESPRIT

Technical Objectives of Pilot Projects

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ADVANCED MICROELECTRONICS

1. The two topics proposed link specific objectives for which actions are proposed in the framework of Council Regulation 3744 and the more comprehensive capabilities to be achieved by the main ESPRIT programme.

1.1 Project: Advanced Interconnect for VLSI

High density multilayer interconnections are essential for VLSI. Although experimental minimum feature-size components of less than 1 micron have been demonstrated, the corresponding interconnection densities have not yet been achieved.

The object of this project is to develop a four layer, metal interconnection technology that will enable these densities to be achieved and implemented via high level CAD procedures as a normal production process.

First Year Review Milestones:

1. Initial evaluation of technology options.

2. Initial process selection experiments completed.

Subsequent Review Milestones:

3. Demonstration of selected process at 2 micron feature size.

4. Completion of 1 micron feature process.

5. Reliability assessment.

The project aims at completion in four years

1.2 High Level Computer Aided Design for Interactive Layout & Design

The increasing complexity of VLSI will pose more and more difficulties of layout and connectivity to the I.C. system designer. The solution to these problems will be increasingly time consuming and error prone unless a powerful computer aided approach is available. The goal of this project is to provide the I.C. system designer with powerful, .fast, high level computer aided layout tools. It should also result in the development of standards and modular packages essential in order to ensure broad applicability and use.

The cost effective industrial implementation of these tools will place requirements on Advanced Information Processing Technology.

Specific Objectives

The specific objectives are to provide:

1. Establishment of standards for structured data bases, taking into account the functional electrical, symbolic, logic and graphical descriptions.

2. Establishment of modular software packages for automatic routing and placement, graphics, layout to logic verification, topological checking, simulation, mask tooling and cell compaction.

3. Establishment of accessible design rules and modelling libraries.

4. Establishment of user friendly man-machine interfacing e.g. direct handwritten document input etc.

First Year Review Milestones:

(a) For Objective 1 (Standards)

a1 Standards definition for structured data bases.

(b) For Objective 2 (Modular Software Packages)

b1 Module definition
b2 Survey of currently available modules and implementation

b3 Establishment of software packages at the 1000 gate for cell based and 5000 gate level for ULA and Full Custom circuits.

(c) For Objective 3

c1 Definition of standard formats for design rule and modelling libraries .

(d) For Objective 4

d1 Hardware interface:

Subsequent Review Milestones:

End of second year:

a2 Standards acceptance by project participants

c2 First demonstration of accessibility

End of third year (see Note 1):

b4 5000 and 50,000 gate level for cell based circuits, 10,000 and 50,000 to 100,000 for Full Custom circuits.

d2 Software development completed

Notes:

1 The high level CAD layout tool should substantially reduce the current design time needed to proceed from a functional specification of the logic to a pattern generator tape. A typical reduction that should be demonstrable by the end of the third year is a 10.000 gate level full custom layout that now requires around 2 man years to complete, should be reduced to around 5 man days, made up of 2 days computing time and 3 days human intervention. The use of increased computer power should enable similar results to be achieved for 50.000 gate level full custom layouts.

2 This project is a necessary complement to EEC Regulation 3744/81 as it is aditional and complementary to it.

3 Requires a data communications network and computer system through which users can access and contributors submit CAD tools (see section 6, page 34).

4 Development of 3-4 level multilevel metal interconnect is essential for routing automation.

5 Development and acquisition of improved and networked computing capability will determine the rate of implementation of the more advanced part of the project.

The project aims at completion in three years.

SOFTWARE TECHNOLOGY

2. To start the cooperative research and development work, three initial projects are proposed:

- Portable Common Tool Environment
- Formal Specification and Systematic Program Development
- Software Production and Maintenance Management System (SPMMS)

All three projects aim at an automated well understood environment but stress different aspects. Experience gained from these projects should form a good basis for the other work in the programme.

The first project, Portable Common Tool Environment is concerned with the problem of providing a common base for software development toolsets, to define interfaces and standards. In the long term it may form the basis from which to establish common European development methods and tools to the extent that this is necessary. The immediate actions proposed will provide industries and research institutions with an adequate basis to undertake the development of the full environment in a cooperative manner.

The second project, Formal Specification and Systematic Program Development is concerned with developing, for industrial application, a new methodology and supporting technologies.

The third project, Software Production and Maintenance Management System (SPMMS) is designed to meet the need for complete, consistent and efficient information management of all information to be produced in the life cycle of a software product. SPMMS will be an automated environment organising and coordinating operations on a common data base for all specialised teams participating in an industrial software production process. This project focusses on the information management aspect of software development management and tool support.

2.1 Project: Portable Common Tool Environment

The aim is to design and develop an environment consisting of:

1. Hardware and communication support, in the form of sophisticated individual workstations capable of being connected via a local network, and of interchange with other such installations through a wide area network at the European level.

2. System architecture; software support in the form of basic mechanisms to support file management, program execution and tool cooperation.

3. Standard interfaces for tools.

4. An initial set of tools.

First Year Review Milestones:

a) For Objective 1

Definitions:

a1 Requirements for Workstation
a2 Requirements for Local Area Network
a3 Plan for Establishment of Local Area Network

b) For Objective 2

b1 Choice of underlying system
b2 Definition of an architecture and of basic mechanisms (DBMs)

c) For Objective 3

c1 Definition of Tool Interfaces

d) For Objective 4

d1 Definition of initial tool set

d2 Specification for some new tools

d3 Architecture of the Portable Common Tool Environment

Subsequent Review Milestones:

a4 Completion of workstation and Local Area Network - 18 months
b3 Implementation of basic mechanisms (DBMS)
d4 Conversion of existing tools
d5 Complete specification, design and implementation of new tools required.

The project aims at completion in four years

2.2 Project: Formal Specification and Systematic Program Development

Specific Project Objectives

The overall objective is to identify a systematic approach to software development. This systematic approach must include formal specification techniques, validation techniques, accurate prediction of project parameters, management monitoring facilities, and a convenient environment for the subsequent enhancement of software. The approach must be supported by a coherent set of tools.

This tool set must reflect the essential characteristics of each phase of the Software Life Cycle, and must make the best use of today's technologies.

First Year Review Milestones:

(a) Initial definition of Systematic Program Development model.

Subsequent Review Milestones:

(b) Selection and enhancement of suitable specification language or languages to enable unambiguous analysis of models. Prototype development of an experimental tool subset.

(c) Select and trial candidate methodologies. Assess their performance. Candidates include HDM, COMPASS-DSL, SDL, etc.

(d) Specification of analysis, validation and implementation tools to support the systematic program development method.

Potential longer term research includes:

(e) Specification of automatic program generator, and a prototype implementation of a suitable tool.

(f) Specification of management system tools interworking with the design method via the project database, and prototype development of suitable tools.

(g) Establishment of coherent documentation system with interfaces to all tools, including technical and management tools.

Note:

1. Several teams should undertake the research in a number of Community countries. The teams should have free access to all participating firms, universities, institutes etc.

2. The teams will need access via a data communication system to a large mainframe and a large mini, with some graphics workstations.

3. For budgetary reasons this project will run for the second half of the year only. Leading up to this time there will be a coordinating activity with the Portable Common Tool Environment project.

The plan aims to complete milestones a to d in 3 years and milestones a to g in 5 years.

2.3 Project: Software Production & Maintenance Management System (SPMMS)

Specific Project Objectives

The main project objectives fall into three categories, corresponding to the aspects of functionality, implementation, and possibility of evolution.

(1) The project is to define and implement a system which manages and executes the activities of recording, relating, retrieving and archiving all the information to be produced and used in the life cycle of a software product. This information exists in the form of all kinds of informal or formal documents: for instance, design documents, test plans, sources, objects, binaries, change requests, resource deviation reports, and data dictionaries. Much of this information is the result of a specific life-cycle production step and serves as an input to a subsequent step. However, much information has as well to be stored and appropriately made available in the operation and maintenance phases of a software product, especially if this product is installed in different versions and undergoes frequent enhancement.

The SPMMS System is hence to cover the needs of a complete, consistent and efficient information management for all the people involved in the whole range of the different subtasks of software engineering: designing, programming, integration, validation, installation, maintenance, project and product management.

(2) The project is to use the approach of distributed system architecture in order to make the system tailorable to a wide range of software production and maintenance environments.

(3) The project is to design an open-ended SPMMS in the sense that it is usable with a wide range of methodologies and tools for different production, maintenance and management activities.

<u>First Year Review Milestones:</u>

Preliminary Results from:

a) Observation and evaluation of the functionality of existing systems covering parts of the desired functionality.

b) In parallel: Investigation of information and data to be handled by the system. Derivation of general structures and development of a generic data model which fits into the system.

c) In parallel: Investigation of user needs and behaviour in order to create assertions for user-friendly interfaces and protocols. Development of a dummy interface to make more precise the requirements for a workable user model, like a rapid prototype to help formulate the requirements.

<u>Subsequent Review Milestones:</u>

d) Design of a first prototype, including basic functions like recording, retrieval, modification, archiving, and reporting.

e) Prototype implementation on a conventional architecture.

Note: For budgetary reasons, this project will run for the second half of the year only. Leading up to this time there will be a coordinating activity with the Portable Common Tool Environment project.

The project aims at completion in four years.

ADVANCED INFORMATION PROCESSING

3. To start cooperative research and development work three initial projects are proposed:

- Advanced algorithms and architectures for signal processing

- Knowledge information management system

- Interactive query system

3.1 Project: Advanced Algorithms and Architectures for Signal Processing

Signal processing, leading to signal understanding, will be an essential part of future information systems. They will provide man-machine interfaces that will enable input and output information (signals) to be spoken and visual. To achieve this capability it is necessary to develop hardware and algorithmic structures, as well as highly parallel computer architectures to handle the additional complexity of visual signals, and to make processing in real time possible. These architectures can be realised by general purpose programmable structures or, preferably, by specialised VLSI modules. Thus one of the objectives of this project is to study how to combine efficiently significant numbers of VLSI modules, in order to achieve high computing power and low cost.

The project depends upon collaboration between:

- specialists in image processing and related algorithms
- engineers with experience in parallel architectures
- experts in advanced programming languages
- professionals in hardware realisation and technology
- VLSI specialists

In the context of the ESPRIT programme as a whole, successful completion of this project will open up a wide range of opportunities. In addition the parallel architectures that are developed should have applications outside the field of signal processing.

First Year Milestones:

A. Selection of appropriate applications

Image processing for earth resources analysis, robotics or medical imaging are typical examples.

B. Analysis of the algorithms necessary for selected applications

A programme of work on algorithms engineering is required in order to determine the best choice of techniques for analysis, and the integration of these techniques into a system package. Potential parallelism is a major aspect to be considered. This work will be done by simulation.

Subsequent Review Milestones:

From this point two separate branches of the programme evolve. the first (C1 - C3) focusses on flexibility, while the second (D1 - D2) focusses on performance. they are complementary for sorting real-world problems - a typical implementation will use elements of both.

C1 Study of possible architectures

C2 Definition of a programming language

C3 Realisation of partial breadboard

D1 Design and selection of appropriate VLSI modules

D2 Development of prototype systems

Note:

- Stage B requires access to a computer and a means for inputting image frames and frame sequences. There is a wide variety of work involved and it can be done at a number of centres. The work should include a study of theoretically optimal techniques (for example maximum likelihood and relaxation) even it these are too slow to be implemented in a real-time system realisation, in order to compare practically achieved results with those that are theoretically possible.

The project aims at completion in five years

3.2 Project: Knowledge Information Management System

Until now Data Processing systems have been designed to optimise the execution time of procedural programmes for numerical and commercial applications. The architecture of most present Data Processing equipments reflects this objective directly.

Knowledge information systems will be based on completely different grounds:

- they process "knowledge", that is facts, and assumptions using rules of inference.
- they handle imprecise information as well as performing arithmetic operations on numbers.
- in communicating with the user they do not depend on procedural instruction by users, in the form of classical programs.

The aim of this project is to take a first step towards acquiring the knowledge , technological capability to realize practically applicable systems by defining and constructing experimental prototypes of a first generation system for non-numeric knowledge information processing. A number of experimental systems and prototypes exist, some of which are used for production purposes. Much technology needs to be developed before industrial exploitation is feasible.

Description of Project

- Select and/or define a powerful knowledge representation formalism which should as far as possible be domain independent.
- Select and/or develop families of knowledge representation and manipulation languages.
- Identify or implement a work-station supporting software environments for non procedural languages like LISP or PROLOG. The work will build on existing systems in this area. Provision should be made to interconnect such work stations on a European Network.

- Implement on appropriate available hardware a knowledge base management system oriented toward specific domains. The system should allow for the invocation of deduction mechanisms.

- Implement one or more expert systems using the knowledge management system to represent specific knowledge from e.g. the areas listed below:

  VLSI CAD; Software production efficiency;
  Medical Diagnosis; Systems Modelling;
  Decision Making, e.g. Air Traffic Control.
  Configuration Control Support, System failure diagnosis

- Incorporate measurement points to analyse and evaluate the performance of the whole system in order to propose the structure of high performance hardware.

<u>First Year Review Milestones</u>

a) Availability of basic common tools (symbolic language environment)

<u>Subsequent Review Milestones</u>:

b) Availability of:

  - knowledge representation formalism
  - knowledge representation language
  - knowledge base management system
  - experimental prototype of one significant expert system

c) The production of two or more experimental expert systems

The project aims at completion in five years.

3.3 Project: Interactive Query System

The object of the project is to develop necessary sofware and software tools to create truly easy-to-use on-line interactive query systems; and to demonstrate this on a working system. Technically the work is concerned with developing a dialogue handling system that is geared to the non-specialist user, possibly a natural language interface system to ease access still more, to make it unnecessary for the user to know techniques of information retrieval, a query optimizer, perhaps based on an expert-system approach, would have to be provided. All these would allow the efficient use of large data bases by non-expert users.

In a second phase more general tools will be developed: a parser-generator for dialogue languages; a generator for dialogue handles based on dialogue models, a generator for query optimizers and the associated methods. This second phase could partially overlap the first phase.

Description of the Project

A first phase will consist in developing a system such as that described in the previous paragraph:

- starting from a classical relational data base system

- interfacing it with a language in which the facilities to be added will be easy to write; this language is likely to be Prolog as it is known to offer many of the required mechanisms (e.g. deduction);

- developing specific software (probably mostly in the above language) for quasi-natural querying adding semi-graphic facilities;

- developing specific software for the optimization phase (expert system).

A second phase will consist in using knowledge gained in the first phase to develop more general tools, i.e. generators.

Examples (non limitative) of such tools could be:

- generator of a parser for the dialogue language (e.g. from a grammar whose formalism would have to be agreed upon)

- generator of modules handling dialogues if it appears that standard dialogue models could be exhibited
- generator for the optimizer

<u>First Year Review Milestones:</u>

Specification of the system to be developed

<u>Subsequent Review Milestones:</u>

Working system (after 3 years)

Specification of generalized tools
Generalized tools available (after 5 years)

The project aims at completion in five years.

OFFICE AUTOMATION

4. Definition of objectives for office automation and the translation of these objectives into product and service opportunities is difficult because we lack a scientific discipline for expressing objectives, measuring performance, testing hypothesis, and establishing theory. The interplay of individual human factors, technological possibilities and their sociological and industrial consequences require the deployment of skills and methodologies seldom previously required by the Information Technology Industry. A primary objective must therefore be to obtain a theoretical understanding of the potential for office automation to provide a framework for identifying more specific research areas, for guiding technological developments and to help industry to decide what office automation products to make.

This area of research now appears in the programme with the title "Office System Science", and the Pilot Project Proposal. "Functional Analysis of Office requirements" is a first important step in this programme.

The other three pilot projects cover those equipments and system areas which are believed to be most essential for the future of the European Office Automation Industry.

These are:
- Multi-media User Interface at the Office Work-station
- Local Wideband Communication System
- Office Filing and Retrieval of Unstructured Information.

4.1 Project: Functional Analysis of Office Requirements

Office Automation is a new and fast growing field. Product planners in this field need to know the many and complex functional requirements that new products will have to satisfy in order to compete successfully in world markets.

Objectives

The primary objective is to derive a classification of office types by high level function, such as the paying of salaries, or the management of an engineering department. These functions may be non-deterministic (functions such as word processing are not implied).

First Year Review Milestones:

1. Establish criteria for classification.

2. Define a statistically valid world-wide survey related to a methodology for describing the operation of an office in a concise manner.

Subsequent Review Milestones:

3. Carry out the survey.

4. Identify common functions suitable as standards for office automation.

5. Identify the effect of external influences, such as tax law and banking practices, on the models of particular industries.

6. Identify technology advances required to implement the chosen standard functions.

The project aims at completion in two and a quarter years

4.2 Project: Multi-media User Interface at the Office Workstation

The office environment is a multi-media environment. The introduction of wide band communication networks will make possible the transfer of integrated text, graphics, moving pictures and voice. At future office workstations electronic support for handling these different media will be used to integrate or compose the received inputs into "information packs" made up of appropriately mixed outputs. User friendly interfaces must be developed to make these new methods productive and acceptable to office workers.

The two aims of this project are:

1. To develop methods, standards and software for easy handling of office-like documents mixing text picture and voice.

   First Year Review Milestones:

   (a) analysis and definition of data structures for electronic representation and for easy processing.

   (b) definition of methodologies and algorithms for processing.

   (c) definition of communication languages: quasi natural languages (eventually using voice input) and graphic languages will be investigated.

   Subsequent Review Milestones:

   (d) Develop methods, standards and software.

2. To determine desirable ergonomic features of terminals which may require technology research, in particular a multi-functional flat screen. This will involve studying the present state of the available technologies in this field, and proposing an R&D programme by which the state of the art can be advanced to produce an appropriate technology.

First Year Review Milestones:

1. Define targets and study state of the art

2. Select appropriate technology

Subsequent Review Milestones:

3. Demonstrate feasibility of intermediate flat panel and define new target and programme of work

Note:

R&D work for the multifunction flat screen that will be defined by this project is envisaged in the advanced micro-electronic technology R&D proposals.

The project aims at completion in three years

4.3 Project: Local Wideband Communication System

This proposal is dedicated to the fundamental question, how to provide a common communication system for all office communication needs. This question is now urgent since non-voice communication is becoming a standard requirement and video communication is on its way. The aim of the project is to define and take to prototype stage a European standard local area wideband communications system embracing speech, data, text, graphics and video.

First Year Review Milestones:

1. The definition of architectures and protocols for wideband local communication systems and the selection and design of suitable transmission and interface equipment.

2. The definition of design requirements of VLSI chips to implement the various levels of protocols for network interfacing, guaranteeing good levels of reliability and security.

Subsequent Review Milestones:

3. The demonstration of functional and economical feasibility of the developed wideband communication technology in an operating inhouse environment in the form of a pilot project.

The project aims at completion in four years

4.4 Project: Office Filing and Retrieval of Unstructured Information

Future electronic filing systems for widespread use in the office environment will have to store mixed mode information of text, graphics, voice, images etc.

These filing systems must be truly easy to use by unskilled workers and the general technical background to this project is supported by the R&D envisaged for the project "Interactive Query System" described in paragraph 2.3.3 of this Annex. However the nature of the mixed media information to be handled by the office user for day to day business operations requires the specialised R&D effort proposed here.

At the present time no standards exist for these different media and their combined functional use.

Specific Objectives

There is a correlation between the foregoing standards, requirements, functions and methods that are to be defined or established and the functional specifications that will be derived from the project "Functional analysis of office requirements".

1. Define a coherent set of filing standards for mixed media.

2. Establish practical requirements for retrieval capabilities and functions, and methods of addressing these.

3. Define the standards required by office systems to satisfy projected social and business expectations for security, privacy and authorisation.

First Year Review Milestones:

1. Agree detailed project specifications

2. Review state of the art and report

Subsequent Review Milestones:

3. Produce preliminary proposal

4. Define trial project

5. Stimulate and assess

6. Produce final proposed methodologies and standards

The project aims at completion in four years.

COMPUTER INTEGRATED MANUFACTURING (C.I.M.)

5. A priority goal of the proposed long lead time R&D programme is to acquire the basic knowledge from which to establish the principles and rules by which future components of total CIM systems will be designed. The first Pilot project described, "Design Rules for Computer Integrated Manufacturing Systems", is a first urgent and important step towards this fundamental goal.

The two other projects that are proposed are:

- Integrated Microelectronic Sub-Systems for Plant automation. This will be implemented in conjunction with the Advanced Microelectronic Technology R&D programme.

- Process and Production Control based on real time imaging systems. This project requires support from work proposed in the field of Advanced Information Processing and Advanced Microelectronic Technology.

5.1 Project: Design Rules for Computer Integrated Manufacturing Systems

Future advanced manufacturing "supersystems", such as the "Automated Factory", will comprise a number of specialised systems, integrated as subsystems into a functional computer integrated manufacturing system (CIM). The specialised systems presently visualised are:

- Computer Aided Design (CAD) for geometric design and modelling, engineering computations, simulation, drafting, etc.

- Computer Aided Manufacturing (CAM) for inventory control, process planning, tool design, material resource planning, manpower and machine resource planning, general scheduling and programming etc.

- Computer Aided Testing(CAT) for testing mechanical, electrical, electronic components or complete products.

- Flexible Manufacturing Systems such as an Automated group of machine tools or a process line for Integrated Circuit production.

- Automation Assembly systems.

- Automated Warehouse systems.

In order that these systems will be designed in such a way that, when integrated as subsystems into a CIM, they will interact appropriately and with complete reliability, it is necessary to establish acceptable standard "design rules" which will cover all aspects of manufacturing system design, installation and use.

The aim of the project is to prepare a comprehensive report which makes detailed recommendations regarding a set of European "design rules" for computer integrated manufacturing systems. The areas covered will include all hardware and software aspects of the CAD, CAM and CAT systems.

This work is extremely urgent. Much of the system driven aspects of the main CIM R&D programme is dependent upon the application of these rules.

The report will include a detailed study of manufacturing system design for the automated factory, covering such topics as flexibility, modularity, optimum operating rules, transfer systems, production control, methodologies, productivity and economic factors.

First Year Review Milestones:

a) Draft design rules for all areas stated above

It is aimed to complete the project within 18 months

5.2 Project: Integrated Microelectronic Sub-Systems for Plant Automation

The object of this project is to produce prototype microelectronic devices that can be tested and proven in machine tool and robot control systems. The proven design can then be made available to European Integrated Circuit manufacturers who wish to transfer the technology to production devices.

The project will be carried out by automation specialists in cooperation with an organisation operating an appropriate I.C. design and fabrication process and one or more machine tool/robot manufacturers.

Aim:

To develop, initially as a three-chip set, a single-chip integrated three-axis continuous-path interpolator, a single-chip integrated axis contoller and a single-chip integrated servo interface.

Description:

(i) Three-axis Interpolator

Suggested design targets:

Number of axes.............................3 (minimum)

Accuracy and speed of interpolation:

Machine tool application $\pm$ 1 um per axis over a 0-10 m range

$\pm$ 2 um per axis over a 10-30 m range

Maximum speed) 20 metres/min.

Robot application	$\pm$ 0.5 um per axis within a 3 m cube. Maximum speed)1 meter/ second.

There should be provision for at least two programmable levels of interpolation accuracy, under external control, which may involve the use of a speed-accuracy trade-off.

Interpolation algorithms.........	stored in on-chip ROM/PROM

There should be provision to store a number of different algorithms on chip which are selectable at run-time. (In practice linear and circular interpolation will probably be the main requirements).

Inputs	Start/end coordinates Velocity vector Control signals
Outputs	Coordinates and Speed (speed-rate)for each axis Control signals
Synchronisation	It should be possible to easily and transparently use the chips in parallel so as to provide 6/9 axis continuous path interpolation.
Interface Protocols	Interpolator should be capable of operating in a multi-processor system, using a suitable standard bus architecture.

(ii) Axis Controller

Suggested design targets:

Number of axes	1 or more
Accuracy	To match interpolator specification.
Processor	General purpose integrated central pro-cessor with on chip RAM/ROM/PROM for programme storage.
Inputs	Position and velocity vectors from interpolator chip. Feedback from servo encoders. (position, speed and accelleration) Sensor inputs (general purpose) Control Signals.
Output	Interface to servo driver chip.
Interface protocols	Controller should be capable of operating in a multiprocessor system, using a suitable standard bus architecture.

(iii) Servo Interfaces

They should be capable of interfacing between the axis controller and power drives for DC servo motors, AC induction motors, linear drives, etc. The silicon technology suitable for combining high voltage and/or high power on the same chip as fast data processing is the subject of the Advanced Microelectronics R&D project "Interface Technology".

First Year Milestones:

a) Detailed specification of chip-set

Subsequent Review Milestones:

b) Design and prototype fabrication
c) Incorporation of chips into machine tool and robot control sub-systems for testing purposes
d) Finalise design
e) Complete testing/proving and initiate arrangements for commercial production.

The project aims at completion in four years

5.3 Project: Process and Production Control based on Real-Time Imaging Systems

For future flexible manufacturing systems to be truly flexible and capable of complex automated assembly and inspection operations, real-time sensor based imaging and control sub systems must be developed to perform the sensing and control operations required in a fully automated factory. The notion of imaging is used here in its broadest sense, in that it could be derived, inter alia, from visual, tactile acoustic or thermal imaging systems.

The aim of the project is to develop the hardware and software needed to demonstrate three or four complex, real-time, image-driven, pattern directed control applications in actual or simulated production environments. In the long term, competitive commercial exploitation of these systems will depend upon the availability of advanced algorithms and architectures for signal processing.

Description

To demonstrate three or four complex real-time image-driven pattern-directed control applications in actual or simulated production environments.

First Year Milestones:

a) Establish at the outset a number of target applications involving 2/2½ and 3D imaging utilising visual, tactile, sonic and thermal sensing. Define hardware and software development.

Subsequent Review Milestones: Complete hardware and software development and:

b) Demonstrate prototype 2½D systems.

c) Demonstrate prototype 3D systems.

The project aims at completion in four years

INFORMATION EXCHANGE SYSTEM

6. Collaborators in ESPRIT projects need to communicate by means of an effective Information Exchange Data Communications System. The system will make it possible to overcome geographical separation with the result that quite small teams will be able to collaborate efficiently in a community-scale activity.

The uses vary widely. At one extreme the basic community needs for collaboration on the programme will be satisfied by electronic mail and information retrieval. On the other hand, collaborating workers on individual projects will need to exchange and work on, a wide range of data files. They will need to use each other's computing facilities, possibly in a distributed manner. Software documentation and code, and complete geometry for VLSI designs, demonstrate the differences that must be catered for. These same workers will also have the same requirement for electronic mail and distribution of reports.

A joint Commission/Industry Working Group has been established to identify and define the functional requirements of the system. Further studies will identify the various options by which these requirements can be met in the framework of the time-scale. The progressive operational needs to be accommodated are:

I The absolute necessity to have a minimal service in place by the time the Pilot Projects start at the beginning of 1983.

II The need for the majority of the functional requirements to be incorporated as soon as possible to meet the requirements of the ESPRIT projects.

III The desirability of the proposed facility forming the basis of an eventual system open to the whole European Research Community. This will have to incorporate all the functional requirements initially identified, together with others which can be incorporated as a result of the experience gained after the system has been in use for some time.

Thus the system must be open ended, conform to European and international standards and adapt to their evolution.

7. EXPENDITURE TO FIRST YEAR REVIEW MILESTONES (MECU)

		MECU
7.1	Advanced Interconnect for VLSI	1.3
7.2	High Level Computer Aided Design for Interactive Layout & Design	2.5
7.3	Portable Common Tool Environment	3.1
7.4	Formal Specification & Systematic Program Development	1.1
7.5	Software Production & Maintenance Management system (SPMMS)	0.7
7.6	Advanced Algoriths & Architecture for signal Processing	0.8
7.7	Knowledge Information Management System	1.5
7.8	Interactive Query System	0.5
7.9	Functional Analysis of Office Requirements	1.0
7.10	Multi-media User Interface at the Office Workstation	2.4
7.11	Local Wideband Communication System	1.4
7.12	Office Filing & Retrieval of Unstructured Information	0.5
7.13	Design Rules for Computer Integrated Manufacturing Systems	2.3
7.14	Integrated Microelectronic Sub-Systems for Plant Automation	1.9
7.15	Process and Production Control based on Real-Time Imaging Systems	1.4
7.16	Design & Implementation Information Exchange System	0.6
		23

ANNEX II to COM(82)486

Working paper only: not to be regarded as in any way committing the Commission of the European Communities or any of its services.

ESPRIT

Outline of Main Programme

NOTE: This document is a preliminary draft and is only intended to serve as a basis for further technical discussions. The objectives and the background of ESPRIT are described in two Communications by the Commission of the European Communities to the Council, COM(82)287 and COM(82)486, and this document is an Annex to the latter. It should only be read in the context of the statements made therein.

INDEX

PREFACE

Over the last thirty years, public appreciation of a computer has changed from almost total ignorance to a wide acceptance of its useful and cost effective role in daily life. There are many explanations for this change. Amongst the most important are greatly reduced price and size together with an improvement in reliability and ease of operation. Perhaps the most important single cause of these improvements is due to the introduction and explosive development of microelectronic technology that saw an increase from around 10 circuit functions per chip in 1960 to 100,000 functions for the 64,000 bit Random Access Memory in 1980[1]. This increase of 10,000 times is approximately matched by the reduction in cost per function. This technology together with parallel developments in software and computer technologies made it possible for the average cost per calculation to fall by a factor of 104 from \$0.26 in 1958 to \$0.0025 in 1978[2].

Public consciousness and interest in information systems has been strongly encouraged by the convergence of computer, telecommunication and space technologies that enable a wide range of data services to be

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1 IEEE spectrum vol. 17 June 1980 and vol. 19 Jan. 1981, VLSI/LSI

2 Federal Data Processing Reorganisation Study. Basic Report of the Science and Technology Team, Washinton DC, June 1978.

accessed on a worldwide basis. The 1980's therefore are seen as the beginning of a new, information rich era that could, wisely employed and distributed, raise the quality of life for all mankind. To achieve these ambitious societal objectives, new technologies will be needed. These will aim to continue the pattern of constantly improving information systems at constantly reducing costs that has characterized the evolution of the computer/communication systems that are available worldwide today.

Because the objectives are ambitious, so also is the R&D programme needed for their achievement. The outline of ESPRIT that is described in this annex is aimed towards these new objectives. The problem areas that are identified and the approaches to solutions that are proposed are the result of a substantial and intensive study by the European scientists and engineers on the expert panels that were formed for this purpose. They also take full account of a very large researched body of information that is available on U.S. and Japanese R&D programmes and objectives in the same fields of Information Technology.

OUTLINE OF TECHNICAL CONTENT

1. Introduction

The following outline is based upon the studies carried out by teams of scientists and engineers from a number of the major European Information Technology Companies. The studies are focussed on the technological needs of the telematic sector of the information industry. In broad terms this sector is concerned with hardware and software products and systems that are evolving very rapidly from the convergence and merging of electronic data processing and telecommunications technologies supported by the introduction and continuing rapid development of microelectronic technology.

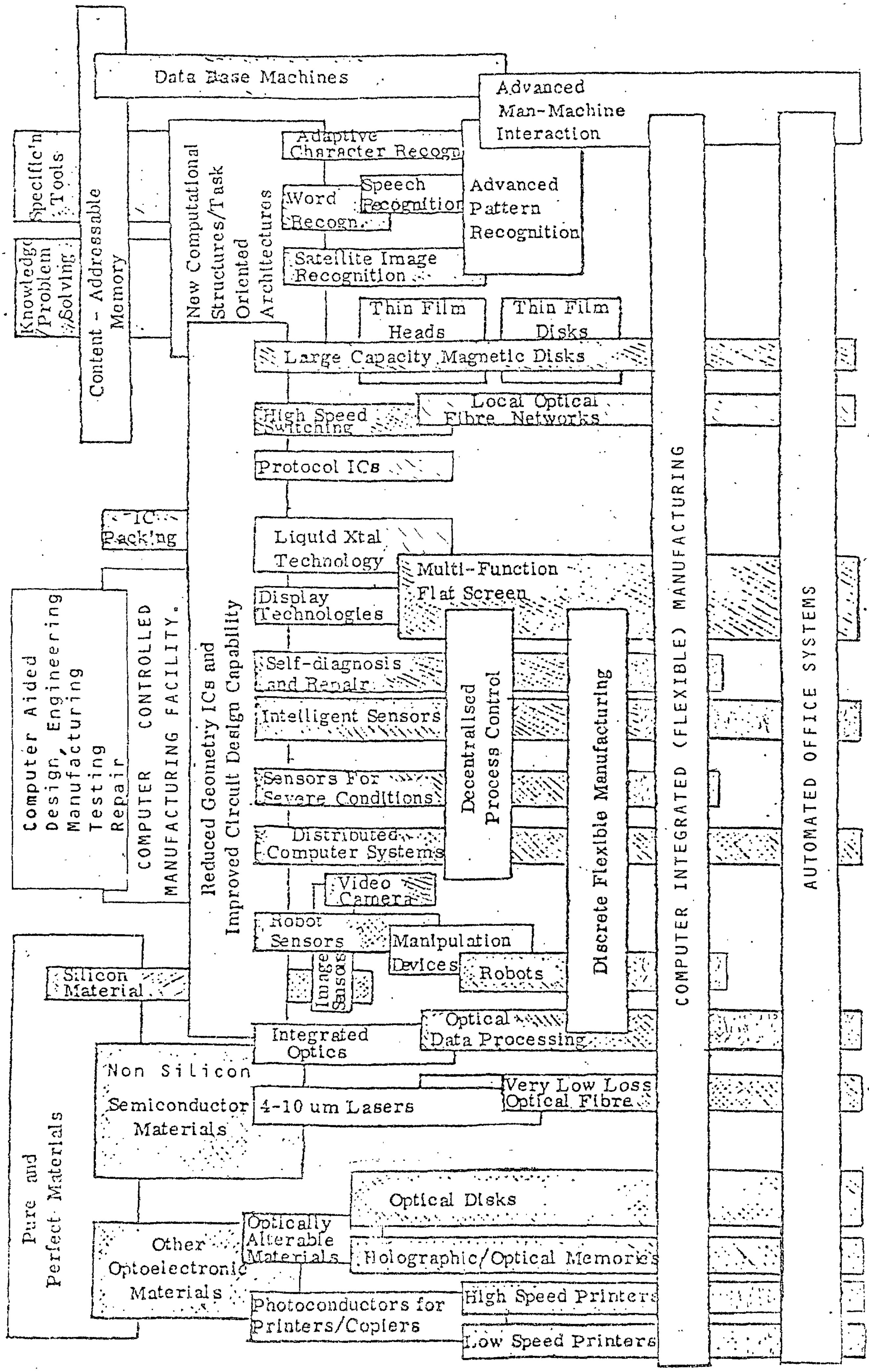
ESPRIT aims to identify the problems faced by this sector and which must be overcome in order for it to be competitive on the world markets. The further object is to establish an R&D programme to study these problems and derive solutions that will be available to the whole of the Community I.T. industry.

As a practical way of identifying the problems, the studies on which this outline is based were divided into five inter-dependent subject areas, covering the whole field of science, technology and human factors concerned. These are:

- ADVANCED MICROELECTRONICS – Hardware capability
- SOFTWARE TECHNOLOGY – Software capability
- ADVANCED INFORMATION PROCESSING – Hardware & Software Systems capability
- OFFICE AUTOMATION
- COMPUTER INTEGRATED MANUFACTURING (CIM)

The outline of the R&D framework embracing these areas is shown in Figure 1. This indicates the wide range of disciplines and technologies that are to be covered and their complex inter-relationship. The two fast growing and rapidly evolving user areas that were studied, Office Automation and Computer Integrated Manufacturing, will be supported by R&D programmes designed to determine, on a scientific basis, the way in which the new hardware, software and systems capabilities will be employed in conjunction with the other specialised disciplines to be developed, that are demanded by the functional requirements of the user.

Fig.1 OUTLINE OF R&D ELEMENTS OF ESPRIT



Other application areas for Advanced Information Technology such as home and leisure, wide area (public) telecommunication systems and defence systems, although not studied or included in ESPRIT will, of course, obtain the full benefits of the programme.

Each of the five subject areas was studied by an expert panel with the object, as stated above, of identifying problem areas and setting objectives for their solution for which long lead-time R&D actions are required. The overall criteria by which it was decided to judge the benefits of such actions were:

- the relevance to major national and societal objectives and needs in the Community

- the strategic importance of European capabilities

- the significant advantage of European scale (critical level of effort needed to succeed) including productivity of R&D and use of technology assets

- the reinforcement and complementation of Member States actions in the fields

- the compatibility with a systems driven approach to the subject

- the pre-competitive nature of long- lead time R&D

In addition, the panels were asked to:

- Identify the technology options for the major objectives

- Analyse, specify and where possible, quantify the R&D requirements

- Evaluate the position in Europe compared with competition and assess advantages of a European R&D programme as opposed to purchasing technology

- Define the long lead-time requirements suitable for European R&D projects.

- Prepare operational specifications and outlines of implementation concepts

- Appraise manpower, infrastructure and budget resources needed
- Identify dependences on R&D areas being studied by other panels
- Identify standardisation issues.

The projects are to constitute a complete R&D programme of a European scale, offering European industry the opportunity to catch up and become competitive with the USA and Japan. Each panel was also asked to identify at least one pilot R&D project that could be implemented immediately.

2. Pilot Projects

When relating the foregoing criteria to the topics that are proposed as pilot projects, it should be recognised that these projects do not constitute a whole programme but are essential elements that will be subsumed into the whole during the implementation of ESPRIT. However even in isolation from ESPRIT, their fundamental character is such that the results obtained will stand alone as important and practical extensions of present knowledge and capabilities in the I.T. areas for which they have been specified. In addition, and most important, the projects are also deemed to be very suitable as vehicles for working out and proving the arrangements for effective cooperation that must be established if ESPRIT is to achieve its goals.

The pilot projects proposed to achieve these objectives are described in Annex II.

In accepting this framework, the panels also derived practical selection criteria reflecting the industrial environment in which the programme will be implemented. These are:

- The requirement for long lead-time is satisfied if, for any given topic, free mutual exchange of ideas is possible.
- It should require cooperation because its scope exceeds the capabilities of any one company.
- It should be challenging to research people because they have to be enthusiastic to succeed.
- Although not leading to a short term product, the disciplines to be exercised should be of significant strategic importance to the future of the industry.

- Partitioning in sub-topics should be possible without requiring daily contacts.

- It prepares the ground for future standardisation.

- It provides sufficient perspective in relation to R&D in the USA and Japan.

- It stimulates the generation of new ideas that, all other things being equal, could provide a competitive edge to European industry versus the US and Japan.

Information and Data Exchange System

Modern data communications facilities and services provided by the Community telecommunications Administrations will be used to carry a powerful information and data exchange system between cooperating participants in ESPRIT. This system will make it feasible and economic for quite small nationally located R&D teams in different countries to collaborate efficiently by working as one powerful Community team, bringing together the knowledge, disciplines and experience needed to succeed.

Standards

ESPRIT provides the opportunity to anticipate future needs for I.T. standards that can be implemented by the Community.

3.1 Technology Objectives for Advanced Microelectronics

Introduction

Microelectronics is the core technology that has made possible the explosive development at economic prices of the vast range of computer and communication systems that have established themselves in common use over the last five years. Very large, application directed, R&D programmes have taken the US and Japanese microelectronics industry some way ahead of European companies in this field. ESPRIT proposals to generate European capability are calculated to close this gap and achieve a healthy competitive position by the end of this decade. The proposals aim to meet the requirements for Long Lead Time Research and Development in techniques and technologies for Information Technology within the framework of:

(a) VLSI (silicon) and silicon material
(b) Directly related products, e.g. sensors, optical transmission and switching systems, compound semi conductor devices, flat panel CRT replacement, packaging

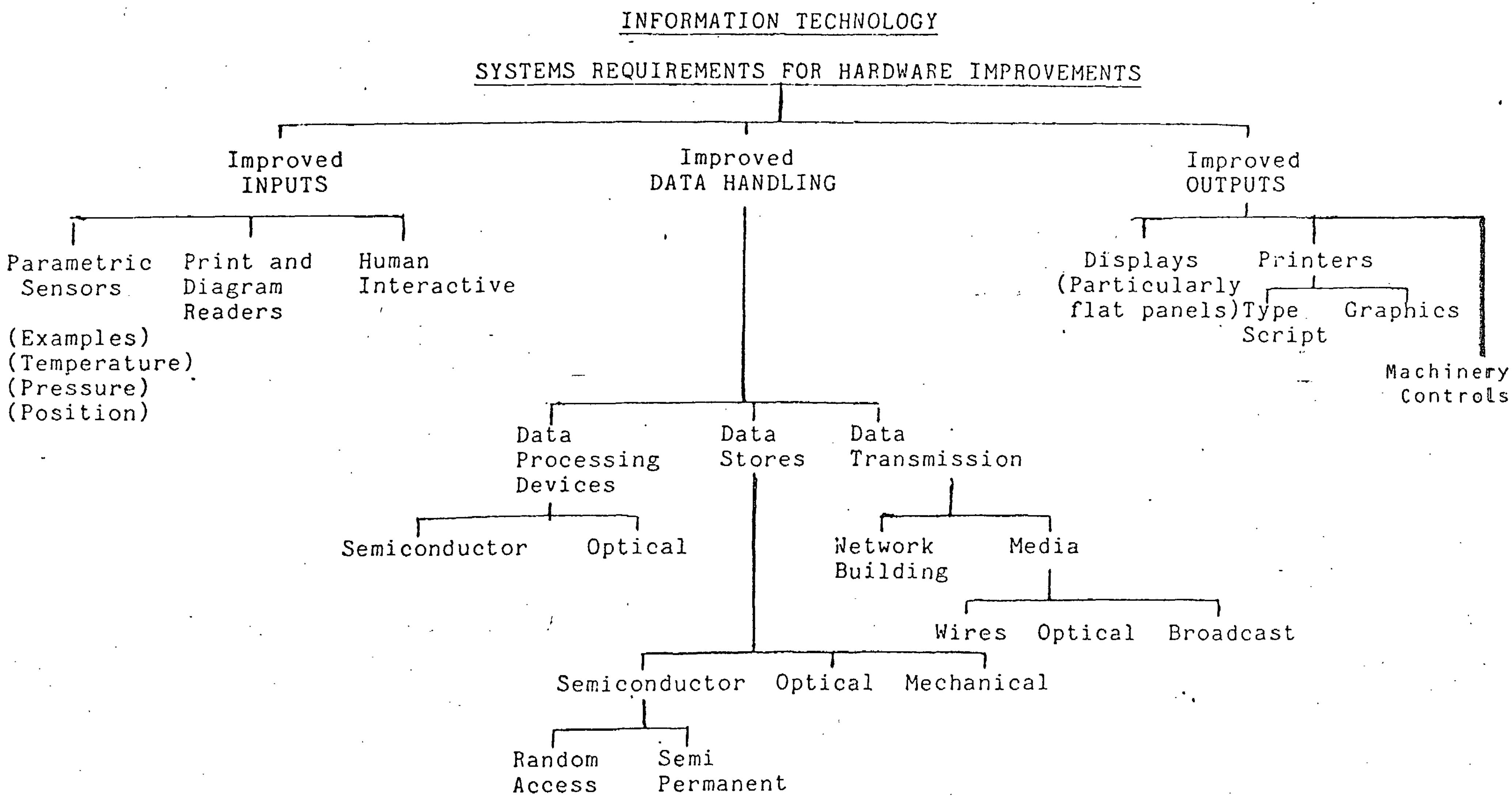

INFORMATION TECHNOLOGY
SYSTEMS REQUIREMENTS FOR HARDWARE IMPROVEMENTS
Improved INPUTS
Improved DATA HANDLING
Improved OUTPUTS
Parametric Sensors
Print and Diagram Readers
Human Interactive
(Examples)
(Temperature)
(Pressure)
(Position)
Displays (Particularly flat panels)
Printers
Type Script
Graphics
Machinery Controls
Data Processing Devices
Data Stores
Data Transmission
Semiconductor
Optical
Network Building
Media
Wires
Optical
Broadcast
Semiconductor
Optical
Mechanical
Random Access
Semi Permanent

Fig. 2

A. Figure 2 indicates those areas of Information Technology systems for which new and improved hardware is envisaged.

3.2 Background to the Topic

(a) The growing preponderance of the Silicon slice in the context of any electronic equipment and the increasing proportion of the equipment that it will be possible to contain within one VLSI chip, means that to be successful in information technology it is essential to have a capability to design, manufacture and test VLSI circuits efficiently so that a variety of VLSI chips can be produced in medium quantities at an acceptable cost to the system manufacturer and in a timely fashion. With increasing integration of circuits onto the semiconductor chip, the proportion of standard chips used in professional electronic equipment will decrease in favour of chips designed to carry out a particular series of operations to a tight functional specification. In order to protect his system design, the equipment manufacturer will have to control the design of the VLSI chips.

(b) The majority of integrated circuits will continue to be based on Silicon with, as far as information technology is concerned, an increasing involvement in circuits made to the CMOS process to meet the requirements of the transmission networks and the system application areas for low power consumption. There will also be an increasing demand for higher speed circuits in Silicon, with a possible smaller subsidiary role for III-V materials, such as Gallium Arsenide, a range of materials of importance because of their role in the production of microwave and optoelectronic devices. Bipolar Silicon VLSI chips are still likely to be required in sizeable quantities for the new information processing systems.

(c) Thus an initiative on Information Technology must be spearheaded by the hardware developments primarily, VLSI. In general, the major competitors to the community, i.e. USA and Japan, have a significant current lead in both equipment and device production.

It is believed, however, that European capability in many aspects of Computer Aided Design may be superior to that in the USA or Japan and therefore this advantage should be built upon to maintain and increase whatever advantage it give European Industry.
The programme proposed is designed to provide the complex integrated circuits that will be needed in the next two decades. It is aimed to meet the requirement that has been identified in the system sectors for

reduced geometry (down to sub micron structure) IC's of low cost, high speed and low power consumption characteristics, and to provide the other essential supporting technologies.

Going from the present state-of-the-art 3-5um processes to processes based on 1um dimensions will provide increases of a factor of 10 in speed, reduction by a factor of 10 in power consumption, and improvement by a factor of 8 in packing density. The packing density improvement above will result in cost reductions of the same order, while the speed and power consumption improvements will provide faster and cheaper system performance.

This report therefore (A) identifies the major technology routes to be followed to 1um (B) proposes technology tasks with associated product examples to use as technology packages for the technology routes and (C) identifies the future technology push below 1um together with CAD and Testing including a computer controlled I.C. factory project. The following sections cover this wide range of technologies, including packaging, wafer scale integration and product examples as well as non-silicon hardware topics. The indigenous European semiconductor processing, design and testing equipment manufacturers will benefit substantially from the spin-off from this programme in the construction of advanced facilities and provision of new research, development and production tools.

3.3 Silicon VLSI

(A) Major technology Package to 1um - Silicon Very Large Scale Integrated Circuits will undoubtedly be the mainstay of the Information Technology age. The panel has identified the major technology routes to 1um dimensions. These are:

- 3.3.1 1um MOS Technology
- 3.3.2 1um Bipolar Technology for logic, memory, analogue
- 3.3.3 Mixed MOS/Bipolar developments

Together with

3.3.4 Packaging for VLSI
3.3.5 Chip to Chip Interconnect
3.3.6 Interface Technology
3.3.7 Wafer Scale Integration

Also included in the Technology drive are

3.3.8 Silicon Material
3.3.9 CAD including Layout, Modelling, Architecture, Languages, Testing
3.3.10 Data Networking

3.3.1 One Micron MOS Technology

This will be the key technology for very high density memory, logic and microcomputing, and will also be used for wafer scale integration, for analogue circuits, and for the controlling substrates for intelligent sensors. This development has to focus on increasing packing density by fine line lithography, as well as clever device and circuit design. New architectures, new technological methods for reconfigurability are also vital. Combination of logic and memory with concurrent low power consumption is vital. Achievement of better than 100K gates/chip at 50 femto-joule/gate and 1nsec propagation time for loaded gates should be within reach. The real world and its interfaces are analogue. There is a clear need for analogue MOS development, with programmes including response function tailoring, and new A/D and D/A converters of wide dynamic range, new concepts in filters, correlators etc., made possible by the high packing density of 1um circuits. This technology programme will provide the key capability for the Community in memories, microprocessors, signal processing and integrated sensor substrates.

3.3.2 One Micron Bipolar Technology

Existing bipolar technology already provides sub-nanosecond gate delays in e.g. ECL. Scaling to 1um will provide dramatically reduced power consumption and improved packing density giving, e.g.50,000 gates on 50mm2 chip with 100 pSec gate delays. This will give VLSI capability for computing, signal processing and logic where the highest speed is essential. Additional attention to the linear aspects of the processes, requiring much tighter control of all process parameters will give in addition capability to make the fastest high precision A/D converters, and linear and mixed linear/digital functions at near theoretical speeds.

3.3.3 Mixed MOS/Bipolar Developments

This project gives the high packing density of MOS with the drive capability of Bipolar. It will allow a simple process assitional to current capability.

3.3.4 VLSI Packaging and Chip to Chip Interconnect

These projects cover VLSI packaging and the interconnection of the packages together. New types of package handling chips of up to 250K gate complexity, up to 400 pins, capable of transmitting signals at speeds of up to 0.1 nSec/gate and over 5W power handling. Good thermal modelling of the heat flow in the package and between packages will be vital. New bonding methods, face -up, face-down, TAB etc., must be included. Special bipolar packages at up to 100W dissipation will be needed and special packages for wafer scale integration. Standards in Europe for TAB are a vital consideration and European packaging standards should be established.

Other packaging requirements specific to given systems will be accommodated within the programmes put forward from the other panels.

3.3.5 Interface Technology

This package covers all aspects of a technology suitable for combining high voltage and/or high power on the same chip as fast data processing, with associate package developments. Stability and reliability are vital elements.

3.3.6 Wafer Scale Integration

This comprehensive package covers the concept of whole wafer processing either MOS or Bipolar technology, by interconnection of devices over a whole wafer by a variety of methods. It could, for example, be covered by interconnection of as many elements as possible over an array of similar devices or a programmable interconnection of different types of devices. Packaging of whole wafers is totally different in concept to packaging individual dice - new methods will have to be developed. So will new design aids and architectures. The benefits will be very large memories, or other single systems per wafer.

3.3.7 Silicon Material

Improved silicon material quality is a vital requirement for most 1um and sub-micrometer silicon devices. Support for crystal growth, new methods of bulk doping such as NTD, and materials evaluation are necessary to provide the material quality required. There already exists a good European base for this work both in major semiconductor users and material suppliers.

3.3.8 Computer Aided Design and Test (CAD/CAT)

A major R&D programme is required to achieve a comprehensive CAD/CAT system that will meet the needs of the widespread application of information technology to keep up with the activity in the US and Japan. It is extremely likely that the new design techniques being developed in those countries in their micro-electronic programmes will not be available to Europe.

Thus included in this technology drive is a total initiative building on the regulation 3744/81 in the following areas:

Architecture	- Data Structure, Interfaces, New Methods Verification.
Testing	- Testdata generation, Testability design factors, Data verification.
Modelling	- Numerical, Physical, Analytical, Table.
Simulation	- Device Level Simulation, Process Simulation, Thermal Modelling, Pin Count Optimisation, Routing Optimisation, Logic Simulation (forward/ reverse), Timing, functional simulation.
Languages	- High level language development, High Level to Low Level interface, Database Communication upwards and downwards.
Layout	- Includes Database standards, Modular packaging, Libraries, user friendliness, placement, routing, tracking.

Thus we would expect, under the auspices of the cross-panel task-force, a common tool environment for cross-company CAD to be provided.

(B) Demonstration Examples

The practical route to achievement of these high technology goals is by construction of Demonstrator examples. To prove the developing technologies emerging from the technology packages in any part of the programme it would be preferable for an example to be associated with a Technology Package. The examples listed in Table 1 could be augmented or superseded by other examples in the final programme.

TABLE 1

Demonstration Examples

1. Microprocessor and Microcomputer
2. Gate Array
3. Programmable Signal and Speech Processor
4. Array Processor
5. High Speed Memory
6. High Density Static Memory
7. High Speed A/D converter
8. Ultra High Speed A/D converter

They have been chosen from a technology viewpoint to give as wide a demonstration as possible of technology capability. Other developments will be suggested by the work of the other technical groups.

(C) Silicon Technology Beyond 1um

The panel has identified the major areas for long range funding beyond the 1um level as being

3.3C.1 Sub micron MOS technology
3.3C.2 Submicron Bipolar Technology

These topics are too long-range to permit definition of specific associated demonstrator product examples. These work packages provide the framework for wide ranging research and development, in new device circuit and technology concepts where European manufacturers of fabrication machinery, high technology equipment, as well as the devices and circuits, really have the opportunity to jump ahead of Japanese and US competition. Major motivations are improved speeds, packing densities and power consumption, using new technology methods. it is essential to realize the very long term nature of many aspects of this sub-micron research programme. Therefore, we are, in this technology package, addressing only the limited problems of sub-micron research which it is practical to tackle within the proposed five-year span of the total programme.

Associated also with these technology packages is the need for Research and Analytical tool development keeping pace with the technology.

(D) Computer Controlled VLSI-Fabrication Project

The central core of a future manufacturing complex will be the semiconductor plant which will have a flexible semiconductor process line in which each stage is fully characterised and under computer control so that the line can produce a variety of semiconductor technology circuits to demand and not require constant resetting by semiconductor process experts.

Thus, in the future a manufacturing facility will not be constructed on the basis of operating a portfolio of semiconductor process lines which has been the approach adopted by the semiconductor manufacturers to date. The aim should be a portfolio of process steps, each step completely defined and held in the memory of the microprocessor controller. Each processor controlled module of the semiconductor line (mask-making lithography, etching and doping etc.) will have a portfolio of process programmes to achieve the type of device required (Bipolar, NMOS, CMOS. etc.). Many of the industrial modules are available on the market, almost entirely from the US.

The panel has therefore identified a computer controlled VLSI fabrication project, primarily concerned with the design of the computer control systems, the development of related software and its implementation into an actual production environment, with the goals of full attainment of computer control on the single process-steps as well as complete processing lines to minimise the probability of incorrect processing and achievement of a high degree of flexibility regarding different processing sequences as well as equipment items.

3.4 Other Microelectronics Topics

While the main thrust of the total programme must be silicon VLSI, there is a range of non-VLSI topics which are also necessary for Information Technology. The topics which have been identified as prime candidates for support as part of JEPE-IT are:

- Integrated Sensors, Optoelectronics, Flat Panel CRT replacement, and Compound Semiconductors.

3.4.1 Integrated Sensors

The increasing usage of electronically automated systems has led to an upsurge in demand for sensors of various types. It is therefore envisaged that the proposed developments would fulfil needs for which there exist no current solutions and provide great enhancement to the range of available devices. In particular, development of clever silicon-based sensors of high complexity in advanced technologies would be supported.

3.4.2 Optoelectronics

Optical devices are becoming of increasing importance in the application of 'new' text technologies, particularly in information systems. Information transmission systems will use optical fibre systems to provide the bandwidth needed to handle the mass of data, text, graphics, etc., which will need to be transmitted. Data links in applications such as plant automation systems will use optical fibres to benefit from freedom from electrical interference and enhanced safety in hazardous environments. These applications require transmitters such as laser diodes, high speed modulators, repeaters and receivers, and low loss fibre transmission media.

Currently systems are being assembled from discrete components but the drive is towards integrated optoelectronic assemblies on a single substrate with the devices and high speed logic for modulation and demodulation constructed in III-V materials such as Gallium Arsenide and Indium Phosphide and their ternary and quaternary alloys. The technology of III-V materials is many years behind that of Silicon, consequently major fundamental research and development efforts are required to bring it forward to an operational state during the next decade. To achieve the required performance, sub-micron geometry structures will be required and a detailed study and development of the basic materials is needed.

As advances are made in integrated optoelectronics, a number of potential applications appear, such as:

- Optical data processing
- Optical switching
- Optical memories

Major R&D programmes on integrated optoelectronics are underway in the USA and Japan but are not far advanced, so that it is possible for European activity to achieve effective and competitive results.

Future generations of single mode communication systems may use coherent (heterodyne) detection and multi-channel wavelength multiplexing and may be phase modulated. This is for optimum performance and also for compatibility with integrated optical logic. This allows processing, combining and routing at very high speeds- optical devices are projected to be the fastest room-temperature logic system known. In semiconductor form they are also compatible with developing technologies in III-V integrated circuits providing a fast electrical interface.

Optical storage, both in waveguide and imaging forms may be compatible with such systems, and is also a technology in which Europe is in a good starting position.

3.4.3 Flat Panel CRT Replacement

The new techniques being considered for visual displays exploit effects in gasses, liquids, solids, and vacua. The range of applications in which displays will be used is broad; it will for example spread from a small 20 or 40 character image required for an intelligent telephone set, to a large wall display displaying pictures. Consequently, it is unlikely that any one technique will meet all requirements.

The objective is to achieve a range of multifunction flat displays for alphanumeric and graphic information and eventually images. Physical sizes required will range from, say 3 x 5 cm to a large wall display of 1 x 1.5 metres obtained by projection. Typical specifications that might be aimed at are:

		Pixels
3 x 5 cm	4 rows of 20 characters	7,000
7.5 x 10 cm	12 rows of 40 characters	40,000
20 x 30 cm	24 rows of 80 characters	150,000
40 x 50 cm	48 rows of 160 characters	600,000
1 x 1.5 m	3000 line resolution	9 x 10 6

These are stated requirements for Office Automation workstations.

3.4.4 Compound Semiconductor Devices

For the highest speed logic circuits on the one hand, and for high performance optoelectronic devices on the other, combined with requirements for "intelligent" optoelectronic devices, it is necessary to develop materials, technology and devices in GaAs, InP. and their ternary and quaternary alloys. GaAs Integrated Circuits are today only at a primitive level (1000 gates/chip) and it is envisaged that UHS A/D converters will use the higher speeds of GaAs devices to advantage. In addition, provision of switching and logic on amplifiers suitable for very wide bandwidth application, and built-in amplifier on optoelectronic receivers are envisioned.

3.5 Education and Training

Recruitment of appropriately qualified staff is a major problem in the Microelectronics industry. largely because of the lack of relevant material in conventional education courses. This arises from the fact that few teaching institutions have the necessary practical facilities to support such subjects in their courses. Thus students lack specialist knowledge and motivation towards microelectronic technology.

The training and retraining of personnel in a fast-moving technology is also a problem owing to the cost in terms of instructional staff resources and the difficulty of releasing equipment for such purposes.

A need exists for appropriate education and training at all levels from operator - technician - graduate engineer. The nature of the courses will vary from major, ab initio, full-time courses to short "top-up" or specialist training periods.

There is also a distinction to be made between courses oriented towards fabrication and those concentrating on design, although an appreciation of cross-disciplinary matters is often important.

4. Software Technology

4.1 The Problems

Research into Software Technology in Europe lacks community of thinking, and unity. Research teams in industry, universities and research institutes hardly communicate. Technology transfer between research and practical application in Europe is much slower than in Japan and the US. A persisting aversion to early standardization prevents interworking of products. Smaller companies cannot afford any research of their own for lack of revenue. As a result, with the future competitiveness of European products depending upon information technology, either for their development or manufacture or embedded in them, with the market for data processing expanding rapidly, with a structural change of this market to smaller decentralized and embedded systems., the future demand for software cannot be satisfied in quantity or quality unless a coordinated European approach is taken.

Software production is very expensive and almost unmanageable with current methods. The so-called software crisis is widely recognised. It was first diagnosed fifteen years ago, and still exists today.

This can partly be explained by the fact that a young and immature technology is subject to economic and consumer pressure and asked to solve problems of an as yet unmastered complexity. This means in particular that managing software development amounts to managing a creative activity in an engineering framework but as yet without engineering rules.

In the industry a wide spectrum of methods are used - from outdated programming practices to modern, theoretically founded and computer assisted software development processes. Personnel qualification ranges from general practitioners, whose education and professional experience predates the advent of computers to highly specialized graduates with sound theoretical education, though frequently inexperienced in industrial problem solving and production. In the user industry, qualifications of staff engaged in technical or management activities differ still more widely.

4.2 Towards a Mature Industry

To remedy the software crisis is to create a mature industrial field in software technology, with common understanding of the basic problems and of their solutions. From such a common understanding, fruitful information exchange, cooperation, subcontracting, etc., can be established.

Only such a mature software industry will be able to fulfil its role as a key industry within the whole industrial structure in Europe: it must ensure the availability - on time - of the software to support other high technology developments, such as computer aided design in microelectronics or software for computer aided manufacturing and for office automation. The quality of software will have a decisive influence on the competitiveness and on the cost structure of products from all of European industry.

The lack of cooperation and mutual information in Europe is currently recognised and deplored among those involved in software. Presently however, the only common ground found between hardware manufacturers and software houses, between industry and users, between academia and practitioners is the agreement that something must be done.

It is hope that ESPRIT, being a cooperative effort involving companies and research institutions, will contribute to solving the cooperation problem. The ultimate goals of ESPRIT are industrially applicable results. A number of technical problems have been identified whose solutions are necessary steps in reaching these goals.

As a part of ESPRIT, a coordinated Research and Development Programme in Software Technology is necessary on a major scale. It should contain the scientific, technical, managerial, technology transfer and educational areas set out below.

The general objective is to create an environment in which the production of information systems composed of hardware and software components would have the characteristics of an industrial process and be largely automated.
A number of non-technical problems must be solved as well. Education of software personnel is among the most important ones; cooperation and commonality will increase personnel mobility and ease the problems of education. Standardisation, legal affairs and software depreciation are additional areas of concern. Solving problems in these areas partly depends on the solution of technical problems in the specification of software products.

Software production is currently labour intensive. In the longer run, to make software production more capital intensive by creating tools that support this production, large investments in research and development are necessary; these investments entail great risks since the needed tools are themselves complex systems beyond our current abilities. To reach that objective in time, cooperation on European scale is necessary to spread the risks and to gather sufficient knowledge and expertise.

4.3 Type of and Solutions

Adequate models of programs and their construction will be sought, so that programs can be subjected to logical reasoning, composition, selection, prediction, etc. Cooperation at this level of basic research will make progress faster and less expensive for each company by setting a common basis for understanding and sharing of expertise.

Industrially usable tools will require large investments, made possible by cooperation.

Techniques are required for more rigorous management of software production, reaching a point where economic influences of management decisions are well mastered and where a cost/benefit analysis of alternative solutions is meaningful. Recent work in software cost estimation has indicated that insufficient emphasis has been placed on the improvement of the environmental constraints of software production. Among these are human factors, organisational and management structures, system structures and complexity. These have proved to be substantial factors in productivity, and it is therefore important that a sound understanding of the problems is gained. Empirical and analytical work, from which guidelines can be obtained, is therefore an important and integral part of the programme.

4.4 Theories and Methods for Program Development and System Construction

This R&D area is concerned with development and improvement of techniques for software modelling, specification, construction, transformation and verification, including requirements specification as an example of a process translating informal ideas into precise terms. Topics will be: formal system description languages, semantics of specification & programming languages, theorem proving, program complexity, system structures, process structures. Work in this area will have to begin with programs as objects of reasoning. It will have to progress to a stage at which whole (distributed) systems and their relationships with the environment (of men and machines) in which they are embedded will be the object of formal mathematical reasoning

Methods and notations for communication between users and developers that lead to a common understanding between them concerning requirements and solutions must also be addressed Work in this area will be partly of a research character, but oriented very closely to early practical application

4.5 Methods and Tools in Software Engineering

This R&D area considers software development as a technical engineering activity It is concerned with tools and processes by which (specialised) software engineers design, develop and maintain (large) systems in many versions and variants Individuals and small project teams, as well as industrialized software production by large teams must be supported.

The starting point is the creation of a portable common tool environment to allow exchange of tools and as a technical basis for cooperation between the companies involved. This environment may be useable as a framework in application areas like software development for CAD and office system building, computer integrated manufacturing and microelectronics. Such an environment would also include software engineers' workstations, possibly specialised to different tasks. Other work concerns specialised tools supporting individual methods for specific phases in the life cycle (e.g. requirements analysis and specification, design) or tools supporting the consistent execution of entire sequences of steps in the life-cycle Individual tools will either be design and construction aids for engineers, or information processing aids for communication, coordination and management. They will operate on a common database containing product and production information.

The long term goal is the creation of integrated software engineering environments for specific application areas. To reach this long-term goal, a unified theoretical foundation, a framework of concepts and descriptive notations and a comprehensive set of engineering and formal standards will be necessary. Appropriate monitoring and re-examination of this research and development programme should aim at achieving progress in this direction.

In addition to tools for more traditional approaches, like program generators and system builders operating on libraries of rigorously specified components, a long term goal is the development of a prototype expert system for software development, with a knowledge based programming assistant as an intermediate step

4 6 Economics of Industrial Software Production

This R&D area is concerned with the overall organisation of the software development process as a commercial and entrepreneurial activity, and focuses on the product characteristics of software, investigating the mutual dependencies between commercial goals for, and technical characteristics of, software products

The goal is to gain insight into the effect of economic, market and business policy constraints on the software production process, to ascertain what quantifiable criteria exist to make choices concerning organisation, method and tool support for technical development, and to develop computer assisted methods and tools for managing the software development process.

R&D activities will include modelling and models of product life cycle, roles of participants in the development, i e developers and prospective users, rules for their collaboration, identification and classification of influence factors, e g technical, managerial, commercial, social, definition and control of quality requirements Initial results will allow the development of experimental tools for analysis and planning of software development projects This approach to a software development data and influence factors database will later be extended to provide a Management Expert System

4 7 Education and Technology Transfer

The lack of competent software engineers is a problem for the industry In the field of information technology, European universities have fewer working contacts with industry and governmental users than in the US There, close contacts between academic and industrial research, between theory and practice, between research and education are of benefit to all parties involved In these contacts, a flow of new scientific results into practice is assured, providing feedback to researchers about applicability and practicability of research results

In the context of ESPRIT, universities and research institutes must be involved in the work to create an environment for cooperation and technology transfer comparable to that which exists in the US Participation in industrial R&D projects by students will assure reality-oriented academic education

As part of ESPRIT, professional profiles for software engineers should be determined and their influence on university education should be discussed with all concerned.

Substantial improvements are needed in technology transfer. Surveys have shown that software developers are generally unsure of how to improve their software development processes. They have no criteria to choose between different approaches or even justify any change. Large manufacturers are sometimes tied down by the need to maintain large amounts of existing software developed without the aid of modern tools and methods. In order to address this issue tools will need to be developed incorporating as much as is feasible from modern techniques, to keep the additional costs of maintaining old software within reasonable limits so that its coexistence with new software is economically feasible and its replacement can occur in a planned way.

5. Advanced Information Processing

5.1 Contemporary computer applications can be roughly classified as business, scientific, process control and office automation. The basic functions performed are computations, or storage and retrieval of data. These traditional systems are about to give way to an entirely new range of systems with fundamentally different capabilities.

Advanced information processing (AIP) systems will perceive information directly by means of sensors, relate it to knowledge already stored and create new knowledge using rules and inference.

Today's computers can solve instances of problems when given a solution, that is a program. AIP systems, guided by their human users and exploiting their internal knowledge base, contribute to the choice of the solution, before applying it. AIP systems will provide the automation if the perception and processing of signals and the automation of reasoning processes and combine these functions in a single system.

In the front end or external interface of AIP systems highly parallel processors perform signal recognition and processing, e.g. speech recognition, in real time. Signal understanding occurs by relating the signals recognized to knowledge stored in a knowledge base. An expert system performs the reasoning processes. It consists of several components. A knowledge base holds facts and rules of inference expressing reasoning steps. These encapsulate the expertise of the system. An inference or deductive machine can combine and apply the rules to solve a given problem. Knowledge engineering tools allow editing, validating, consistency checking and structuring of the facts and rules in the knowledge base. An interface system acquires information from the front end and transmits results to the user through it.

There have so far been only few and only moderately successful attempts to exploit "artificial intelligence" (AI) research results for practical applications.

Some of the conditions for industrial exploitation of AI are changing now. Advances in microelectronics and new processor and system architectures make it feasible to employ and further improve computational techniques in artificial intelligence. The point has been reached where practical research and development can be taken up in both main areas: signal perception and processing, and knowledge representation and inference. In addition, work on cognitive ergonomics must lead to design principles for man-computer systems that are geared to full support of the user in the communication process, and do not suffer from artificial limitations imposed by inadequacies of the computing equipment, its architecture and software. A factor changing the conditions for exploiting AI research is the Japanese fifth generation computer project which is precipitating the commercialization of AI principles and techniques.

So far, expert systems and related applications of AI seem to be taken up by companies newly formed for this specific purpose, especially in Britain and the USA. The Japanese fifth generation project is a notable exception involving a broad cross section of Japanese industry and academia. In Europe, industrial work is starting slowly so that a major impetus is clearly necessary to bridge the existing gap with the US as well as the potential one with Japan.

Also, work in Europe has so far been extremely fragmented. Some work was done at universities and in research laboratories of larger manufacturers. All over the world, the early work in artificial intelligence was surrounded by much controversy. In part this was due to a mismatch between the goals of AI and practically applicable results. In recent years, however, experimental systems and prototypes, for instance for mathematical problem solving and goemetric reasoning, for learning and simple dialogues, have been presented. Some of these show a considerable potential for enhancement. Europe appears to lag behind in this area.

The goal of this programme is to reach a stage at which the industrial exploitation of the technology of advanced information processing is possible in Europe. For this, research and development in the following areas is proposed:

Information & Knowledge Engineering
Signal Processing & External Interfaces
Information & Knowledge Storage & Usage
Computer Architecture
Design Objectives & Methods.

Information and Knowledge Engineering

To reach a stage at which industrial products can be based on expert system technology, research and development in the following areas is required:

- Selection of forms of representations for knowledge based systems (KBS) convenient and appropriate for human use or for presentation to the KBS.

- Methods of capturing data and deriving facts from data, whether sensed directly or entered from keyboards by users. Signal processing will be essential to the man-machine interface in the future. Special hardware and algorithmic structures will have to be developed.

- Synthesis of new and efficient hardware/software architectures to support knowledge-based systems. The theoretical structure of inference machines has been studied in some detail, and small-scale representations are now available. Major development is needed before real-life applications using large amounts of data can be generally available.

- Design of KBS's in specific areas, followed by investigation of their practical behaviour and utility.

- Design and evaluation of tools, including languages, for design and implementation of expert systems.

- Methods for design, exploitation and evaluation of expert systems.

- Experimental expert systems should be built, initially using conventional machines; examples are automated failure diagnosis, automated computer maintenance, CAD for microelectronics, robotics and plant monitoring, software development. This would be a short term activity. In the long term, systems for approximate reasoning, models of common sense and learning expertise should be constructed. Architectural aspects would be a medium term task.

Signal Processing and External Interfaces

The interface of an AIP system must provide certain functions in the signal processing and recognition area so that it can gather information, rather than having to rely on conventional data entry with laborious data preparation. A further aim of the research programme in signal understanding is to enable computers to transform sets of observed data into knowledge by processes of abstraction and inference. This will have to be extended to include the formation of new rules for the recognition of objects or states of the perceived world. Typical signals are optical signals like pictures, sound signals (e.g. speech) and directly generated electric signals (e.g. process data, medical data).

Studies of natural systems in their own right are also of importance in two distinct ways. First one may expect to derive many useful lessons from the study of natural systems for signal processing and unerstanding, since the human being is, and is likely to remain for some time, the best system for speech and image understanding. Secondly, there may be useful components that can be, at least partly, based on biological materials.

The architecture of AIP systems and the functionality of the interface must be geared towards human cognitive processes. They must support and encourage the team behaviour of groups of people using AIP systems.

The demand for personal workstations for a wide spectrum of application has led to a strong demand for superior human interfaces: wider display of context, more control by the user, consistency of command structure must be provided and learning by doing must be supported.

Research into architectures and interfaces with desirable characteristics will have to be based on results of applied psychology which will have to be complemented by further research. Models of cognitive behaviour of individuals and social behaviour of groups must lead to design guidelines capable of practical use.

Specific research areas proposed are:

Short-term: studies of human behaviour to identify desired design features and undesired weaknesses in interface products,

studies of natural systems to ensure optimum design of feature extraction and understanding logic,

studies of alternative formal representations of knowledge about the external world,

algorithms and architectures for signal analysis,

pattern matching techniques, e.g. dynamic programming and relaxation,

recognition of connected spoken words drawn from large vocabularies.

multi-dimensional signal processing for process automation

Medium-term: scene and movement analysis,

ideal speech synthesis from text,

selection of 'candidates' for recognition with associated probabilities,

feedback over stages in a recognition process,

correlation between physical characteristics and extracted features, and the information content of those features,

automated description of complex signal patterns.

Long-term: feature extraction under control of an expert system,

general-purpose image understanding system,

role of inference in human recognition processes,

description of observed scenes in linguistic terms,

extraction of the semantics of inflexion, intonation etc. of human speech.

Information/Knowledge Storage and Usage

Database technology has reached considerable maturity, with large distributed databases at an early stage of exploitation. In knowledge bases information is stored that embraces judgement of significance and value, together with rules for interpretation; meta-rules may control the application of rules. In pointer structured databases or relational data bases, access methods perform dereferencing of access criteria; methods for automatic dereferencing in knowledge bases are not yet clear.

The main work will be to establish the interfaces, languages, hardware, and software technology which are required for the construction, distribution, functional partitioning and hierarchic (or other) structuring of data bases and knowledge bases, including formulation of inference and data query accesses, at levels ranging from human visible to those internal to the new generation of systems.

There is a shortfall in filestore device performance visible even now; with 50 MIP processors which will be on the market within a decade, filestore device performance will become a serious bottleneck. Data transfer rates must be improved, with drastic reduction in random access times even for large filestores in the 1-10 G byte range.

Some new technologies of file storage calling for research include optical store, possibly using holographic techniques, and stores made of organic materials using "biological" methods of fabrication that should allow very fine interconnection paths and thus highly compact construction. A reduction of feature sizes from the current 10000 Angstroem to 20 Angstroem, and in three dimensional structures, would allow volumetric capacities for RAMS 10**8 better than the best current VLSI components.

Computer Architecture

The completely new economics of logic, storage cells and their interconnection brought about by VLSI make it promising to look for processing and data handling models with the following properties:

- few cell types with a high degree of replication
- computational locality in (groups of) cells
- short and regular control and data flow
- minimal use of high fanout/wire or routes
- highly contextual inter-cell/group/node communication
- high degrees of asynchronous concurrency among cells/groups/nodes.

The conventional approach to programming using classical algorithmic languages may be inadequate to cope with the size or complexity of applications using knowledge based systems.

Applicative or functional languages (LISP is an early and still outstanding example) are based more firmly on mathematically well understood foundations. They map into computational models free of side effects and with a high degree of locality of reference. Their attributes match closely with the characteristics required to exploit the opportunities and to avoid the physical limitations of VLSI;

Some advances have been made in the development of algorithms, logic and functional languages, in numerical processing and in software engineering to support the use of parallel architectures. However, in order to exploit very highly parallel architectures that are made available by VLSI, considerably more research in this area is needed to develop algorithms that allow for parallel evaluation and languages and environments and support this.

Parallel architectures, particularly using VLSI, call for a high computing/communication ratio. Therefore, the information communicated (within a chip, between chips, between units) must be highly contextual (to constrain its bulk), and only very simple mechanisms for effecting communications will be acceptable. Many interconnection forms are known, and will be evaluated to establish the best cost/performance compromises.

It is proposed that the research be focused on five specific categories of machine architecture:

- database machines, based on new architectures;
- ultracomputers, consisting of thousands of interconnected elements, each being as powerful as today's computers;
- data-flow machines, using the principle of single assignment;
- inference machines, special-purpose machines dedicated to deductive operations;
- highly parallel dedicated non-programmable special purpose functional units.

Particularly relevant will be the development of languages and interfaces which provide an optimal method of expression of computational and inferential models, based on "reduction" and "data flow" techniques. These languages and models will have to include capability for fuzzy, non-deterministic and probabilistic problem specification and solution; they also need mechanisms for highly efficient and secure object sharing in high performance systems.

Design Objective and Methods

The use of computers increasingly has direct effects on the lives of individuals and groups, on the business of corporate bodies and on the conduct of government. Aspects of trustworthiness, correctness and reliability as qualities of computing systems attain prime importance.

Rigorous approaches to specification and design that can be turned systematically into provably correct implementations, auditing of actual systems in use and high level consistency checks are areas in need of work. technology assessment of risk rules, expert system validation mechanisms and methods of formal proof must also be studied. As continuous operation of systems must be provided, fault tolerance and online monitoring and repair techniques of systems at all security levels need to be provided: computer system security has to be improved to counter penetration attempts.

In the area of VLSI design, circuit complexity is growing to a level very hard to master. Formal design methods and tools need to be developed to allow rapid design of complex chips. Only with "silicon compilers" which incorporate substantial engineering knowledge and enable designers to specify their circuits at a high level of abstraction from the physical implementation will it be possible to develop chips of increasing complexity for information technology e.g. in consumer goods.

Conclusions

- The sheer scale of resources, the dependence on other large programmes like VLSI and consideration of second sourcing make action on a European level necessary.

- The work can only be done on a European scale since a market of the size of the whole European Community is required for an adequate return on investment.

- An early agreement on common standards to be used in the programme is vital.

- The research should be started now, in spite of the fact that businesses have barely started to analyse potential markets for the new types of products that must emerge.
- The early stages of European AIP research will have to concentrate on establishing communication between the few highly qualified groups of researchers in the field in Europe as a whole. In the later stages of AIP development, increased levels of investment will be needed.

(Text deleted)

6. Technology Objectives for Office Automation

6.1 Office Environment and Needs

The long term challenge for Office Technology is to support the wide range of non-deterministic tasks performed by "knowledge workers". A prerequisite to that end is an in-depth understanding of the related functions and processes. Knowledge workers will expect office technology to augment their intellectual capability and so to extend their own performance and improve their effectiveness. This implies easy-to-use and safe equipment, including integrated handling of various forms of communications - data, text, voice, graphics, video, and value added facilities in terms of work management as well as decision-making processes (knowledge management), together with better access to external (including public) information when working in the office or to information in the office when outside. By contrast with secretarial and clerical employees, professionals work on a wide variety of tasks that change dynamically with business conditions and perceived demands and opportunities. The way in which their complex tasks interact within overall office procedures involving mutual support of various interrelated functions is poorly understood.

6. Definition of Objectives

6.2 The definition of objectives for office automation and their translation into opportunities is highly dependent upon local cultural considerations and is made difficult because we lack a related scientific discipline. To understand the interplay of human factors, technical possibilities and their educational, sociological and industrial consequences requires skills seldom previously encountered in our organisations. Technology alone is not sufficient. Human beings are intimately involved with the systems we envisage and attempts to introduce them without taking account of the cultural background and the expectations of the users will result in failure.

While research on hardware technology will still be needed to provide adequate support to office system concepts, it is becoming clear that architectural and software considerations will require most attention from the research community before information technology can be widely accepted in the office.Beyond this, it is the impact of the integration of man and information technology which is the most critical unknown in determining the rate of introduction of new office equipment.

Interfacing man and computer and computer networks will change the world dramatically if we look into the further future. Therefore, it seems unacceptable to start intensive research and development on man machine interfacing without also studying its impact on the individual (e.g. education, self-respect of the human being), on the professional environment (e.g. number of jobs, quality of work) and on society (e.g. impacts on the educational system, on democracy).

With this perspective, five main research areas are considered:

- Office system Science a prerequisite to the structural analysis of office procedures and the design of well conceived office products and systems; ;
  Three product areas, which cover the three basic office activities (creation/distribution, transmission, and storage/retrieval of information);

- Office Work-stations where document creation and distribution and man/machine interfaces are prime concerns;

- Office Communication Systems including integrated text-voice-image-video communication and value-added functions;

- Office Filing and Retrieval Systems with emphasis on ease of access to and retrieval of the "Knowledge", not just the information, that is stored in the system.

And a fifth area:

- Human Factors, encompassing all aspects of the interactions between man and information handling systems.

Interrelationships between all five areas are reflected hereunder:

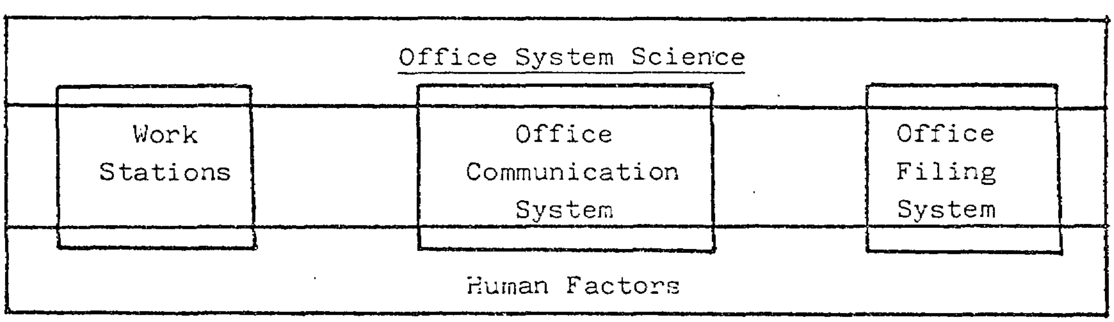
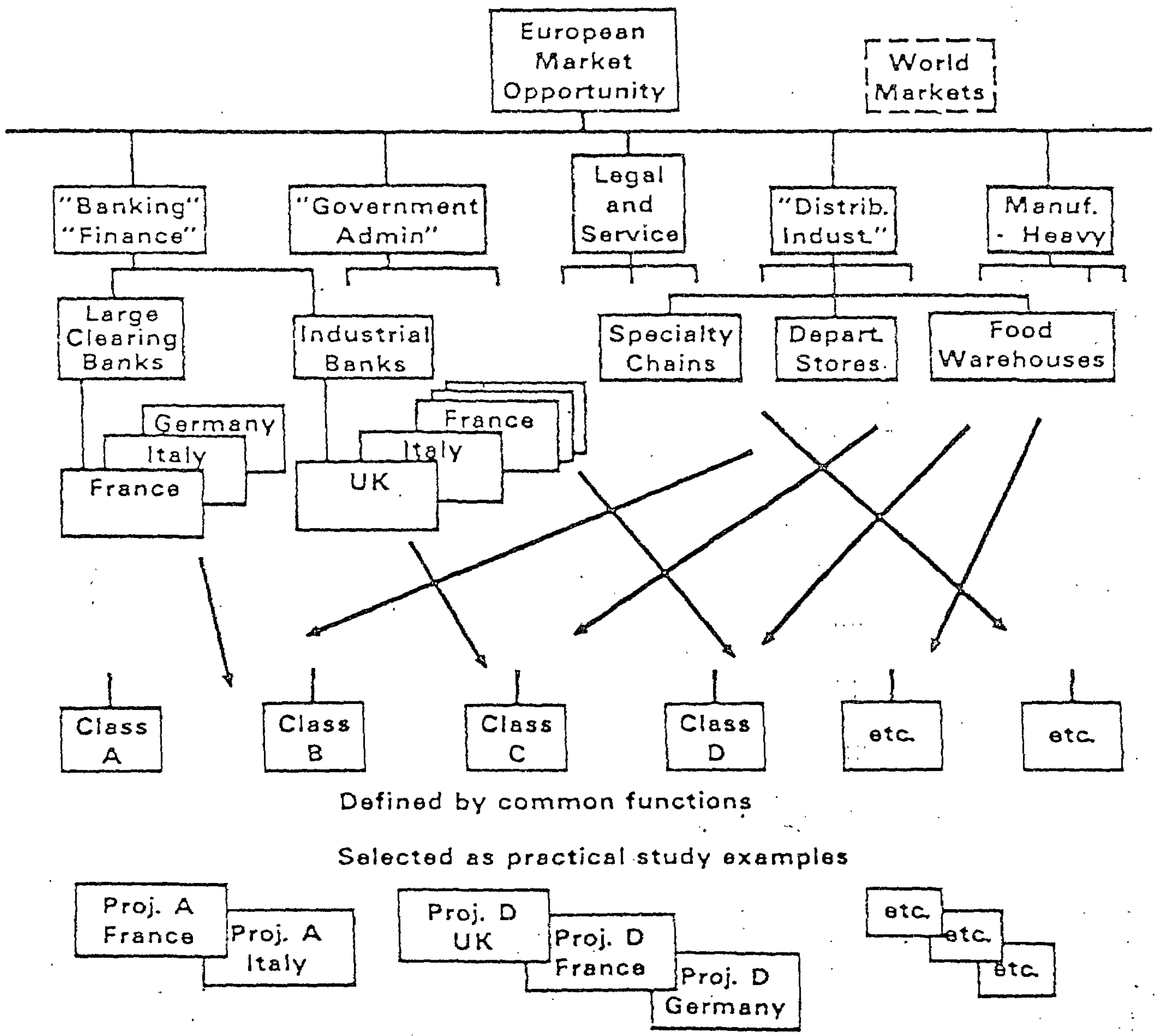


FIG. 1.1

CLASSIFICATION METHODOLOGY



6.3 Outline of R&D (subprogrammes)

It has been said earlier that there is no formalized science of office automation. Even a clear definition and an agreed glossary of terms are lacking. This deficiency has resulted, so far, in:

- unstructured approaches to individual customer problems
- implementation of office aids for the more mechanical tasks rather than higher level automation
- inability to measure resulting cost effectiveness

To overcome this situation, there is a clear need to develop a coherent approach that would help:

- analyse office functions and classify office types accordingly
- prioritize requirements and optimize resulting development schedules
- develop products to be more easily tailored to a given office type and allow for standards to reflect more closely the user needs
- define turn-key offices in which terminals and software would be supplied for a given set of users with minimal requirement for customization.

6.3.1 Office System Science

Five subprogramme elements will be considered under the Office System Science programme:

1. agree an initial Glossary of terms for Office system Science
2. develop a Classification of Businesses. Functional analysis of office functions will lead to the definition of a library to be used as a basis to classify European, North American, World businesses into classes featuring maximum commonalities in the functions they contain

3. Develop High Level Languages of two types:

   - a Functional Description Language to describe the functions of an office
   - an Office Specification Language to be used for turn-key office design

   The definition of these languages should be based on the analysis of the requirements of existing and future offices and validated against them.

4. Create an Office Simulator based on the Functional Description Language above and allowing for the various classes of offices to be modelled for the purpose of simulation of existing or future offices, cost/benefit analysis, ...

5. Conduct several Field Trials in diversified office environments to verify the correctness of the analysis and results of the overall programme. Trial systems should also include testing sociological effects and make a prediction of wider economic/social consequences of office automation.

6.3.2 Subprogramme 2 - Office Workstation

Work stations will have to interface with a variety of users and systems and encompass a wide range of characteristics/functions/technologies:

- Input/output technologies in the form of
  - multifunction (flat) displays
  - paper interface (printout and scanning)
  - voice input/output ranging from voice command to full speech interpretation

- Local high density storage (text, graphics, voice, images)

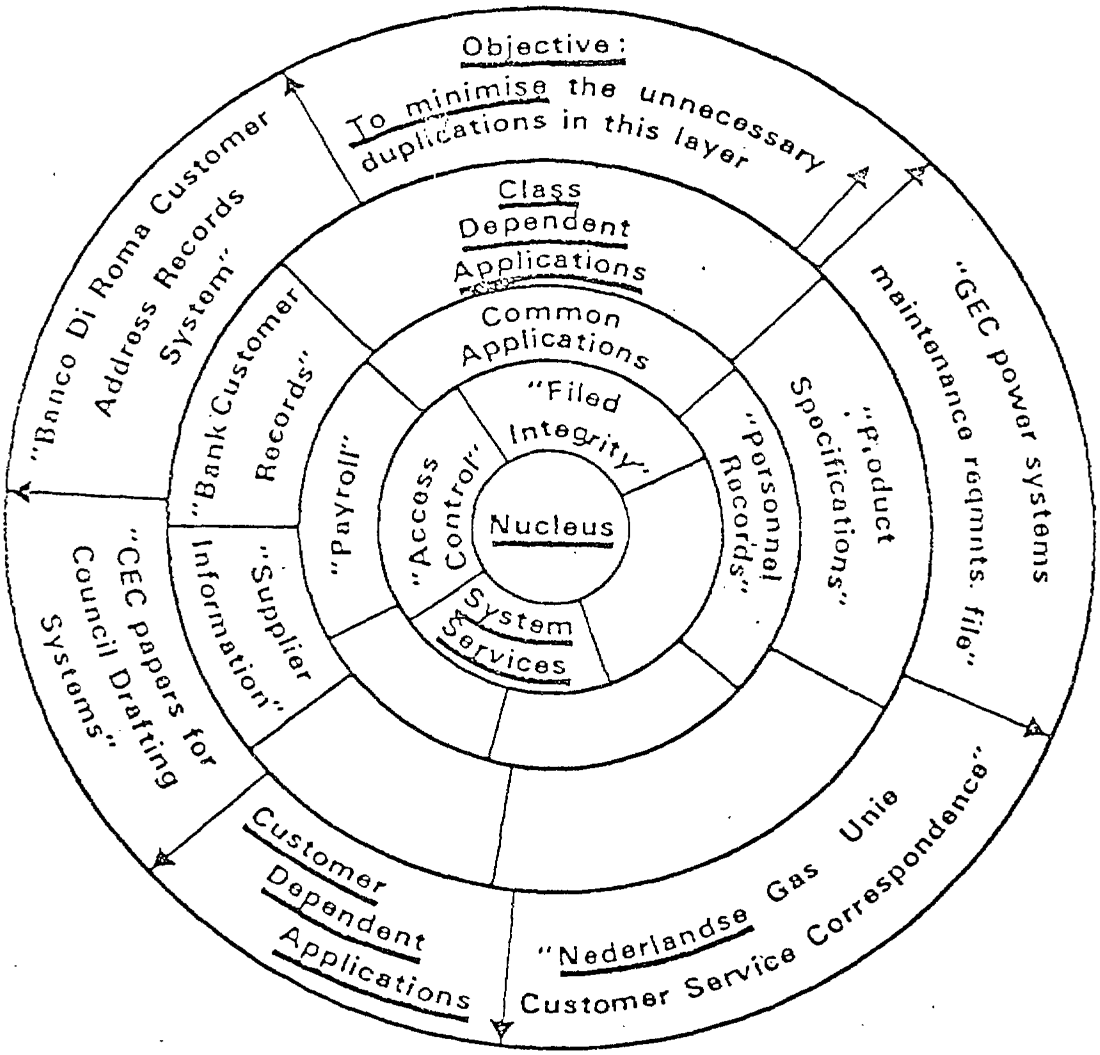
- Ergonomic considerations for good user acceptance

- High level languages suitable for document description or "natural" interaction with the system.

In all cases the main motivation is to provide the user, by an easy adaptation of normal work habits, with improved support, compared with the tools and human assistance previously available,

FIG. 1.2

OFFICE SYSTEMS SCIENCE PROGRAMME



Underlined Phrases = Layer title

"Phrases in quotes" = Examples on the layer

- Input/output technologies should provide the supporting media to enter/retrieve "electronic documents to/from the system with reduced requirements for physical paper support; this ability to combine the use of several modes (handwritten or vocal annotation of texts, documents etc.) will be another attractive feature.

- Local high density storage will provide the user with an electronic document cabinet of his own under his full control with minimal dependency on the more comprehensive system(s) to which he may be connected.

- Ergonomics, by their very nature, are meant to provide for attractive equipment that will fit comfortably into an office environment and feature well designed man/machine interfaces.

- High level languages for easy document description (textual, vocal or pictorial) and "natural" user interaction with the work station are prerequisites to broad user acceptability.

Sub Programme Objectives

Eight sub programme elements will be considered in relation to Office Work Station input/output technologies.

- Multifunctional Flat Display, a long term project with the ultimate objective to develop prototypes of both "paper-like" and large fixed high definition screens.

- Hard Copy Printout to explore the various technologies involved in the design of small, low cost, silent, fast, high resolution printers.

- Scanning Devices including basic technology and pattern recognition functions for a prototype which would match the characteristics of the printers above.

- Voice Input/output with objectives ranging from discrete vocal commands/prompts to full free speech recognition.

- High Density Storage encompassing research on optical disk systmes and media as well as feasibility assessment of new magnetic and electronic storage techniques.

- Ergonomics with the recommended implementation of an interdisciplinary ergonomic laboratory.

- Office Document Languages for the definition (in close cooperation with the related Office Filing System research project) of a family of formal content-driven languages for the representation of a broad spectrum of actual documents.

- Interface Languages including "natural" languages (that is natural to the user), graphic languages to handle pictorial data bases and research on knowledge architecture.

6.3.3 Office Communication

Office communication presents a wide range of possible long lead time research projects. These are technological advances needed in microelectronics and in fibre optics, and there is research necessary on principles of future communication systems like the wideband LAN. However, beside these technical problems, there are non technological problem areas, which have to be worked at in order to support the progress of office communication systems: the requirements of office communication have to be explored more systematically to get a more solid basis for future telecommunication systems design, the special aspects of human interface with communication have to be studied, the possible future relationship of the PTT's to new local communication systems have to be considered, there are new languages and operating system facilities necessary in connection with distributed networks and finally strategies have to be found for structuring communication networks in the non PTT regulated private office area.

Within this scope of possible research activities the panel formulated four proposals which were believed to cover some key issues on office communication.

One of those proposals is dedicated to the fundamental question, how to provide a common communication system for all office communication needs. This question becomes more and more urgent, since non-voice communication will be needed at almost every desk in the future and video communication is on its way.

Another proposal addresses the application of optical fibre in a decentralized LAN and all the technological problems related to this.

The third and fourth proposals intend to advance the standardization of value added communication services in the form of mail box based messaging for text, image and voice and for public information systems inaugurated using interactive videotex.

6.3.4 Subprogramme 3 : Office Filing Systems

Adequate filing/retrieval capabilities are perhaps even more crucial to satisfactory office operation than any other major function (document creation/distribution or communications).

The substitution of electronic/magnetic/optical technology for paper filing has hardly occured however as data storage management techniques have proved to be inadequate for office filing systems.

Problems to be overcome encompass:

- extensive range of the types of information to be stored in the system (text, graphics, but also large amounts of non-coded information like voice and image)

- need to access loosely structured, mixed information viewed as part of the same entity by the user

- unstructured retrievals implying content defined linkage between entities

- untrained "intolerant" users, unwilling to accept system characteristics that do not appear "natural".

The definition of a formal language for describing documents of different types is key to the necessary generality, portability and machine independance of documents (see also 4.3.2, "Office Workstation").

Improvements to office operations resulting from the use of electronic filing could be numerous:

- faster access capability from (remote) work stations

- content-addressability of the stored information (ability to retrieve a document, for example, "on biogenetics and published by Stanford University ... probably around February 1981" instead of having to specify file index XYZ)

- automatic "hidden" management of the stored information (journalising, archiving, purging, ...)

- reduced dependency on human memory of relevant material

- better control of information access in terms of security or in respect of the relevant distribution of information.

Sub Programme Objectives

The Office Filing system programme will focus on five areas:

1. Development of Data Base Model allowing for the description of both the content and the structure of objects (images, documents, vocal comments, ...) within an integrated framework, and for the development of adequate access techniques (access conflicts, access control, ...)

   A prototype system involving work stations and services will be developed and actual experiments will be conducted

2. Very High Speed Filtering of large unstructured files providing for content addressability including full text search, graphics and sketchy images, fuzzy matching, file relationships between documents, ...

   Prototypes of personal and centralized filing systems will be built at the term of this 6 year project.

3. Office Filing Ergonomics with the objective to define requirements for easy use of the filing system by the average office worker and to implement the tools to satisfy these requirements.

4. Optical Disk technology will be further explored (encoding techniques, error corrections mechanisms) as an answer to requirements for the storage of large amounts of (non-coded) information. Another objective will be to demonstrate a rewritable digital optical disk that will combine the benefits of currently available magnetic and optical techniques.

5. A family of Office Document Languages for the description of a wide range of actual office documents will be developed that will be representative of the document content rather than the document presentation. This effort will be complemented through the implementation of language processors for the translation from one office document language/dialect into another.

6.3.5 Human Factors in the Office

Human cognitive capabilities can be extended by using an appropriate approach of interfacing information technology to the human brain. Whereas in traditional areas of automation the motoric skills of the human have been analyzed in detail and machines have been built knowing these facts, in cognitive processing our knowledge of the human brain and the human information processing is very limited. To set up the base for a complementory technology a programme on man machine interface is urgently needed to consider both computers and human beings in all their common aspects.

1. Studies on cognitive psychology

   In depth studies of rational information processing in the brain are needed.

2. Developing knowledge engineering

   Research projects should be started to investigate knowledge concepts in modern applications of information technology (e.g. consumer oriented data banks (viewdata), home banking, CAD, etc.).

3. Designing context accepting languages

   Research in context accepting languages has to be stimulated.

4. Implementing machine image handling

   Research is necessary to allow for more complex operations on the total image available to the user.

5. Approaches to systems thinking in ergonomics

   Research is necessary to establish a concept for designing man machine interfaces considering all relevant factors.

6. Training of robots

   People at work stations will increasingly control processes instead of bit patterns. Research in this area is needed. To avoid the danger that cognitive and motoric information processing will not be sufficiently integrated in the future.

7. Designing self-explaining systems

Research is needed to establish common agreed rules and strategies for self-explaining machines.

8. Projects on artificial intelligence

Activities are needed stimulating research in artificial intelligence as a basic discipline from which new conepts will spread to computing.

7. Technology Objectives for Computer Integrated Manufacturing

7.1 Introduction

The general concept of computer integrated manufacturing (CIM) refers in a generic sense to the overall and systematic computerization of the manufacturing process. The automatic factory is the ultimate result of the application of this concept to manufacturing plant and ancillary equipment.

7.2 The specific goals of the proposed long lead time R&D programme are:

1. To acquire the basic knowledge from which to establish the principles and rules by which future components of total systems for cost effective computer aided discrete parts manufacturing will be designed.

   Significant progress towards reaching this goal must be achieved before the problems to be studied in the area of Integrated Systems Architectures can be fully defined. It is planned to meet this need by means of the Pilot project "Design Rules for computer Integrated Manufacturing Systems" that is described in the Annex II.

2. The generation of total system architectures allowing users to adapt easily to computer integrated manufacturing in a progressive manner, according to their own specific needs and situations.

3. To ensure that the new CIM technology can be used with equal benefits by small, medium and large companies, manufacturing in small as well as in large-scale mass production modes.

7.3 Outline of R&D

The programme covers the following problem areas for Research and Development.

A. Integrated Systems Architecture

There are at present no guidelines or international standards available for the design of CIM system architectures (see goal 1 above).

New and innovative conceptual approaches are required in order to closely match the overall system architecture to the total manufacturing process from initial product development, product design, production planning and control, real-time control of production equipment through to inventory control and sales.

B. System and General Software

This is the largest area in terms of R&D effort. A common, well structured approach to all of the topics covered, (see 7.3.2 below), is concerned with:

- identifying classes of methodologies and rules for all of the production processes for which it is envisaged that aided design and control facilities can be provided.
- developing techniques for formulating and specifying such methodologies and rules.

- defining requirements for integrating appropriate methodologies and rules into CIM systems and sub systems.

- defining and formalising, by methodologies and rules, the interactions between different parts of the total production process.

- identifying and formulating modular structures (system architectures) for, and modules/sub systems of, the various major system elements (e.g. CAD, CAE, CAM, CAT/CAR) of the total production process.

C. Machine Control

Some of the key problems to be addressed in this area are centred on:

- Real time capture and processing of complex three dimensional "images". These "images" will be used as "sensoring inputs" for a large range of applications in CIM systems.

- Methods for interpreting complex "images" at speeds which make feasible closed loop control, testing and inspection.

- Methods of integrating complex image and other sensor derived control information into the overall control structures of automated production processes and systems, e.g. assembly, machining, forming.

- Development of high speed "algorithmic" VLSI process on elements. Adapting A.I. techniques for "factory floor" implementation e.g. coordinate robot systems.

- Definition and realisation of sensors and measuring systems for real time applications.

- Methodologies for designing computer process control algorithms for assembly and other processes and machine control.

A considerable amount of R&D in this area is being undertaken by both industry and university groups within the Community. However there are very few signs of actual industrial systems. There is plenty of evidence that American and Japanese efforts in this general area are well in advance in this respect. Pilot Project "Process of Production Control based on Real Time Imaging Systems" will bring together and significantly extend the present, disparate and uncoordinated, efforts in this area. The project has two very important long term benefits:

1. It requires and encourages a high level of scientific and industrial collaboration because it calls upon a number of disciplines to be brought together in a systematic approach to the solution of some very important problems affecting all the areas of R&Din this field.

2. The results will be of great value to the whole I.T.community in terms of knowledge and capability and also in methods of future collaboration.

D. Advanced Components

This area is concerned mainly with problems in the fields of sensors and microelectronic sub systems.

- Sensors. It is crucial for the development of advanced manufacturing systems that the requisite sensors (with their concomitant signal processing and computational facilities) are available when they are needed. Progress in this area is pivotal to the future development of realisable advanced manufacturing automation systems. Typical problems are those of non-contact digital output sensors for 3 dimensional imaging and measurement for real time applications; sensors for detecting tool wear under real time conditions; robust high resolution tactile sensors, etc.

- Microelectronic sub systems aimed at integrating entire control sub systems onto single I.C. chips. The innovation of such devices ,is a key to competitive realisation of many CIM sub systems, particularly in the field of Flexible manufacturing. It is planned to specify, build and test experimental devices as Pilot project No. 7.14. "Integrated Microelectronic Sub-Systems for Plant Automation" described in Annex II.

A further area for investigation and implementation is

E. Advanced Development Centres

Models of operation are proposed as a stimulus for keeping the recommended R&D programme properly goal oriented, and as a consequence of the multi-vendor nature of CIM development and manufacture. It is suggested that a number of advanced development centres be implemented and, where they already exist, be augmented, in order to demonstrate advanced computer integrated manufacturing systems. The advanced development centres would eventually form the basis for more permanent research centres or centres of excellence, where further research and development could evolve and also an industry advisory service would be provided. These centres would also serve as test benches for experi- ments and evaluation of computer integrated manufacturing techniques and for training and education. Work at the centres should be undertaken as a collaborative effort between private companies and universities or other public research institutions. By locating such centres in different member states long-term cooperation between researchers from within the Community and elsewhere would be facilitated and enhanced.

7.3.1 Integrated Systems Architecture covers:

- identification and development of overall integrated system structures for data processing and data transmission in and control of CIM systems for discrete parts,

- data-base systems for engineering data of total product models,

- data-base management systems aiming at ensuring the required data communication between the components of the integrated manufacturing system and the data-bases.

7.3.2 System and General Software covers:

- computer aided design/computer aided engineering systems aiming at an improved design process both in respect of starter design time and accuracy, and at establishing total product models for subsequent use in various stages of the manufacturing process,

- computer aided manufacturing systems aiming at formulating modular CAM system structures allowing for all types of applications in all sectors of industry,

- computer aided testing/computer aided repair, aiming at cost-effective improvement of product quality,

- command languages aiming at developing software modules capable of generating control programmes from design/production/test simulation data for robot manipulators, computer numerically controlled machine tools and flexible manufacturing systems.

7.3.3 The Machine control area covers:

- automated assembly and asembly operating systems aiming at establishing fully automatic assembly systems,

- robot operating systems where future areas for robot applications will pose different requirements from those being met today,

- imaging (global and control) where future systems will be required to use complex images as "sensory input" for CIM applications in such areas as assembling, machining, testing, etc.

- computer numerically controlled machine tools (CNC Machines) where new application areas within metal forming and other mechanical engineering industries are expected to take place.

7.3.4 The Advanced Components Area covers:

- sensors, where progress is considered necessary for the future development of advanced automated manufacturing systems,

- microelectronic sub systems aiming at integrating entire control sub systems onto single chips (Pilot Project No....).

7.3.5 Advanced Development Centres
should initially cover at least three important areas such as:

- production of heavy, precision machined parts or sub-assemblies for machine tools or engines,

- batch production of electromechanical products such as household appliances,

- production of high precision components or sub-assemblies such as medical instruments,

and will also provide "on the job" training and education services for engineers, technicians and management.

ANNEX III

COUNCIL RESOLUTION
of

on pilot projects for research and development in the new information technologies

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community,

Whereas by its Resolution of 14 January 1974 the Council invited the Commission to define projects of interest to the Community in the field of science and technology ;

Whereas the need to develop scientific and technical research at Community level was stated by the Council of Ministers on 9 November 1981 and the Heads of State or Government on 26 and 27 November 1981 ;

Whereas the overall Community strategy results from the creation and implementation of a general framework programme of common scientific and technical activities ; whereas amongst the basic options proposed by the Commission for the framework programme the "promotion of industrial competitiveness" calls for special support measures ; whereas the development of the new information technologies is a special objective, especially as they must back up and enhance the efficiency of the Community's research and innovation capability, essential factors for European industrial competitiveness ;

Whereas it is necessary to make an urgent start on a strategic Community research and development programme on the information technologies in coordination with national programmes, as requested by the heads of State and Government on 28 and 29 June 1982 and by the Council on 30 June 1982,

HEREBY ADOPTS THIS RESOLUTION :

1. The Council notes the Commission's intention to submit as soon as possible a proposal for a strategic research and development programme on the information technologies and will take a decision on this proposal in time to allow the programme to be launched at the beginning of 1984.

2. The Council is of the opinion that pilot projects will enable the Commission to obtain the necessary experience for the implementation of this Community programme and views with favour the Commission's intention to undertaking in 1983 the pilot projects detailed elsewhere.

CONCLUSIONS OF THE EUROPEAN COUNCIL OF 28 AND 29 JUNE 1982

Economic and social situation, investment policy

The European Council discussed the economic and social situation on the basis of the Commission report. It confirmed the conclusions it had reached in March regarding a co-ordinated policy for combating unemployment by promoting productive investment, increasing competitiveness and productivity as well as the development of a Community industrial strategy based on a technology and innovation policy. It agreed to step up efforts in the following area:

Modernization of European economic structures

This objective can be attained only if investment is developed purposefully. In line with its conclusions in March, the European Council welcomed with interest the guidelines proposed by the Commission in its report.

It calls upon the Member States to take account of the priority to be given to developing investment when formulating their economic and budget policies. It asks for practical proposals for its December meeting.

In addition it looks forward to proposals for the development of new technologies, particularly on the basis of the Communication of the Commission on information technology.

CONCLUSIONS OF THE PRESIDENCY OF THE RESEARCH COUNCIL 30 JUNE 1982

On the basis of a communication from the Commission on a strategic research programme in information technology, the Council held a policy debate on this area, which is crucial for the future of European industry.

At the close of the debate, the President drew the following conclusions:

1. The Council noted the need for a Community programme for R&D in information technology, co-ordinated with national programmes, in order to increase the competitiveness of the industries concerned.

2. The Council similarly took note of the need to get such a programme off the ground as a matter of urgency, given the state of competition on world markets and the fact that Europe is falling behind in this field.

3. The Council recorded its interest in receiving the detailed proposals, to be submitted by the Commission in July 1982, for pilot schemes which are due to be initiated in January 1983.

   The Council should therefore act before the end of the 1983 budgetary procedure on the proposals for pilot schemes.

4. The Council noted with satisfaction that the Commission intends to consult the circles concerned when it draws up the programme and to make sure that relevant undertakings, including small and medium-sized undertakings, as well as research institutes and universities take part.