II

(Acts whose publication is not obligatory)

COUNCIL

COUNCIL DECISION

of 11 February 1985

adopting the 1985 work programme for the European Strategic Programme for Research and Development in Information Technologies: ESPRIT

(85/141/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community,

Having regard to Council Decision 84/130/EEC of 28 February 1984 concerning a European programme for research and development in information technologies (ESPRIT) [1], and in particular Article 3 (2) thereof,

Having regard to the draft work programme submitted by the Commission,

Whereas, at talks organized by the Commission, industry and the academic world have given their opinions on the content of the projects to be launched and their priority;

Whereas the Committee referred to in Article 4 of Decision 84/130/EEC has been consulted;

Whereas the projects identified fall within the areas described in the Technical Annex to the Decision adopting the ESPRIT programme;

Whereas the actual needs regarding the Community's contribution to new projects falling below the threshold referred to in the third indent of Article 6 (2) of Decision 84/130/EEC have been carefully analyzed with the result that a certain range of flexibility is required,

HAS ADOPTED THIS DECISION:

Article 1

The ESPRIT work programme set out in the Annex hereto is hereby adopted for 1985.

Article 2

As a target figure, 25 % of the Community's total contribution to new projects may be allocated to new projects which fall below the threshold referred to in the third indent of Article 6 (2) of Decision 84/130/EEC.

Article 3

This Decision shall enter into force on 1 January 1985.

Done at Brussels, 11 February 1985.

For the Council

The President

G. GORIA

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(1) OJ No L 67, 9. 3. 1984, p. 54.

ANNEX

ESPRIT 1985 WORKPLAN

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INTRODUCTION AND RESOURCES BREAKDOWN

This section is an integral part of the ESPRIT 1985 Workplan and is necessary for the proper interpretation of the plan.

0.1. BACKGROUND

The European Economic Community has launched the European Strategic Programme of Research and Development in Information Technology (ESPRIT). The ESPRIT Programme is intended to promote precompetitive and generic research and development in information technology through collaborative projects within the European Community which the Community shall finance in part. A management plan, the annual workplan, has been established within ESPRIT to enhance the control and accountability of the programme. Updated by the Commission in consultation with the ESPRIT Management Committee, each year, the document is submitted to the Council for approval.

This is the second such workplan and it covers the period 1985-1989.

0.2. PURPOSE

The purposes of the ESPRIT 1985 Workplan are:

— to describe project areas and their interrelationships, and include descriptions of current work of 1984.

— to serve as a guideline to potential proposers by indicating the intended scope and content of the new work to be initiated in 1985;

— to provide a framework for assessment and review of projects under way, in order to appraise their progress individually and in relationship with each other;

— to act as a reference document for considerations relating to coordinating activities under ESPRIT and under other Community and national programmes, and to serve as a basis to relate ESPRIT to technological programmes outside the Community.

0.3. LAYOUT

After the introductory section, the document is set out in five main sections corresponding to the major technical subprogrammes of ESPRIT.

The partitioning of ESPRIT R & D into five subprogrammes is largely dictated by the need to be able to manage the task for the Community. In practice, the technical subprogrammes are interrelated and the Workplan indicates the significant interdependencies that exist.

Each subprogramme is split into a number of R & D areas and these are further subdivided into R & D topics and projects.

Each R & D topic is discussed in detail, indicating the anticipated continuation of work from previous years (in this case 1983/84), the work anticipated to start in 1984 and the new work required to be started in 1985 and further years.

0.4. THE ESPRIT APPROACH

The approach of ESPRIT is to create the *technological basis* which enables the Community to seize the opportunities associated with new information technology, to foster cooperation and to pave the way to standards of European origin.

ESPRIT is the Community programme which is specifically designed for R & D where *collaboration at the Community level* is purposeful and which is pre-competitive. Collaboration is in order to achieve critical mass efforts, or to bring together the necessary expertise otherwise scattered in the Community, or to create the potential to enlarge markets. In addition by providing the framework for concurrent technical approaches ESPRIT involves collaboration between companies and between companies and universities.

ESPRIT's precompetition requirement is for areas where market opportunities can be seized within 5-10 years, and in doing so ESPRIT stands between basic research, and applied industrial research and development work. The former is not normally determined by industrial priorities and the latter responds to specific short term needs.

In the selection and definition of IT areas that ESPRIT should address, two considerations have been important :

(i) to have sufficient command of basic technologies;

(ii) to have systems capabilities which are adaptable to changing market needs thereby permitting the knowledge of markets to have further influence on technology development.

Five areas or subprogrammes are of strategic importance to the Community.

SUBPROGRAMME 1 — ADVANCED MICROELECTRONICS

The major thrust is to develop the technologies of Silicon Metal Oxide and bipolar devices and Gallium Arsenide devices. Each has difference merits for specific applications. Associated CAD, CAM and other manufacturing methods are also addressed.

Interrelation with other subprogrammes will ensure rapid definition of required VLSI demonstrator circuits.

SUBPROGRAMME 2 — SOFTWARE TECHNOLOGY

The Software Technology subprogramme aims at making available at Community level efficient and cost-effective methods for the industrial production of high-quality software, and is intended to lead to more rapid introduction of new products and a reduction of life-cycle costs in software.

Work in the subprogramme addresses theories, methods and tools to put software production on a sound engineering basis, project management and industrial aspects to put these into the business and industrial context, a common integrated software engineering environment and the demonstration of the effectiveness of new software production methods.

SUBPROGRAMME 3 — ADVANCED INFORMATION PROCESSING

This subprogramme is seeking means for improving the performance and efficiency of computing systems by making use of advances in four key areas, namely, knowledge engineering, including the development of knowledge acquisition, representation and manipulation techniques; external interfaces, dealing with the recognition, understanding and synthesis of signals; information and knowledge storage, these advances are the developments in data and knowledge bases as well as the techniques of access to these bases, and deals with architectural characteristics and physical properties of advanced storage devices; computer architecture, i.e. the development of new computer architectures and their associated programming environments where particular emphasis will be placed on the use of concurrency.

SUBPROGRAMME 4 — OFFICE SYSTEMS

The challenges facing office systems development include understanding and supporting the tasks of office workers and not simply providing a technological update of traditional office functions, achieving improvements in man-system interfaces that allow productive use of office systems by a wide range of office workers, and the development of system oriented approaches to office problems.

The subprogramme has been divided into five areas:

Office system science and human factors

Advanced workstations

Communication systems

Advanced filing and retrieval systems

Integrated office systems.

SUBPROGRAMME 5 — COMPUTER INTEGRATED MANUFACTURE

The two main objectives of the CIM subprogramme are: one, the creation in the Community of an environment in which multivendor automated manufacturing systems can be implemented with the resulting integrated system having minimum functional overlaps and maximum connectivity, and two, to support indivual work on selected subsystems, interfaces and tools whose development or refinement is seen to be of strategic value to the Community industry, and whose design aims are consistent with the general architecture of the environment.

Work in the subprogramme relates to the total requirements of manufacturing activities, from the planning and design stage to real-time control of production. It then includes computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM), flexible machining and assembly systems, robotics, testing and quality control.

0.5. PROGRAMME EXECUTION AND INFRASTRUCTURE

The Commission will manage and monitor the execution of the programme.

It will see that the infrastructure needed for programme execution is set up. Part of this infrastructure is the information exchange system (IES). Another part is the dissemination of results and reports and the acquisition of information. A third part is concerned with the interrelationship between the R & D work and standardisation activities.

The ESPRIT Information Exchange System (IES) serves as a management tool. The IES is an IT based data communications system for the exchange of information between separated participants in ESPRIT projects, their own managements and policy making bodies, and the Community and national administrations involved in programme or project management.

A number of the research and development projects in ESPRIT will lay the scientific and technical foundations on which standardisation activities will be based later. Conversely, some demonstrations of the interworking of standards may require additional work; this work will be considered as part of the infrastructure. The work towards standardisation will be guided by the general IT standardisation policy established and not duplicate any of the existing organisations or actions.

The dissemination of results of and information acquisition for ESPRIT is an important element of ESPRIT. Its goals will be the quick application of research results from ESPRIT in the Community industry and to provide the best basis for the planning and management of the programme, and for project participants. For this purpose both classical mechanisms like publications or workshops or conferences and newer communication methods through electronic means, for instance the IES, will be used.

0.6. TELECOMMUNICATIONS

When the ESPRIT plans were originally drawn up, it was recognised that telecommunications formed an important part of information technology. However, the subject was not included per se at that time.

In September 1983, the Commission prepared a communication to Council, demonstrating the increasing economic importance of telecommunications to the economic development of the Community, and putting forward actions in this field. The Commission was then asked to detail proposals for the six lines of action so identified in the action programme.

The proposed second line of action recognises the key role of cooperative R & D, it calls for 'cooperative R & D and worksharing at the pre-competitive stage of the ESPRIT type'. Accordingly, the Commission initiated a Planning Exercise in Telecommunications (PET) in conjunction with major European companies and the national PTT laboratories. The aim was to enable proper assessment of the advantages that might stem from a Community approach in laying down the technical ground for a signi-

ficant implementation of Integrated Broadband Communication (IBC) by 1995 in the Community.

As a result, a Commission proposal for an inventory of R & D requirements in tele-communications, 'R & D in Advanced Communications Technologies in Europe (RACE)' is being made. The draft RACE workplan states that the work undertaken within ESPRIT must be taken into account.

0.7. TYPES OF PROJECT

Throughout the ESPRIT 1985 Workplan, a distinction is drawn between Type A and Type B projects. These are defined as follows:

Type A Projects are projects that are individually described in the workplan, with specified intermediate objectives. They usually require large resources, both human and financial, and considerable infrastructure with clear and constant perspectives.

Type B projects are covered by 'research themes' which are indicative but do not form an exhaustive listing. They usually require smaller resources and are not as amenable to milestone management and review cycles as the larger projects.

0.8. CURRENT STATE OF THE PROGRAMME

This workplan specifies the work that will be open to proposals in 1985. It also describes work in progress in 1984 or likely to start before the 1985 call for proposals. The steps leading to this work were as follows:

An advance notice for participation in the main ESPRIT Programme was published on 30 December 1983. The Council of Ministers approved the programme for an initial period of five years on 28 February, 1984. The 1984 Workplan was published in the Official Journal of the European Communities.

A first call for proposals for the main programme was issued on 21 March 1984. Nearly 450 proposals were received in response and were evaluated during May and June 1984. A shortlist was selected in July 1984 for detailed negotiations and final approval. In addition, much of the work carried out under the earlier Pilot Phase is expected to combine with the main programme. A direct consequence in the 1985 workplan is the inclusion of descriptions of projects already underway.

A further call for proposals should be expected in early 1985 and at proposal time about 120 projects will be underway already.

For participation in the IES development and services, a call for proposals was published on 14 July 1984 and has produced 25 responses which have been evaluated.

0.9. WORKPLAN COVERAGE AND INTENDED RESPONSE

The 1985 Workplan covers the period 1985-1989. This is sufficiently long to cover the duration of the longer projects. However, information technology is rapidly evolving and therefore the R & D objectives may well have to be modified in the course of yearly revisions. Accordingly, the intermediate objectives that are set out in this Workplan are less specific towards the end of the planning period.

Such intermediate objectives are, however, necessary to provide the framework and reference for evaluation, proper management, and further refinements. They have been introduced in the workplan as the best current estimate of how the overall objectives of the project may be achieved. They are indicators and checks against which concrete proposals for projects will be examined. Intermediate objectives shall, however, not be regarded as legally mandatory in the sense that proposals having perfectly acceptable end objectives should not have to be rejected only because they may have been designed to rest on different intermediate objectives than the ones proposed here.

Within each of the separate subject areas of ESPRIT there exist programmes of work which may depend on skills, techniques or technologies which are being developed within one or more of the other subject areas.

In individual cases this may lead to specific milestones in one area replacing identified

demonstrators in another area. Conversely demonstrations might be requested or started as a separate entitity in such cases.

Under each R & D topic, the workplan indicates where proposals for A-type and B-type projects are expected. To aid the presentation, the descriptions of current work are typographically distinguished. These descriptions are located under the most appropriate heading, but it should be realized that in some cases projects formulated in response to previous workplans overlap the subject boundaries currently used. There are some areas for which no new proposals are expected in 1985.

The best information on these projects available at the time of writing has been incorporated in the 1985 Workplan. However, it should be noted that at the time this workplan was drafted the Commission had not yet concluded final negotations on all this work and some modifications may prove necessary in some cases.

A-type projects are part of an explicit plan deemed necessary for the success of ESPRIT. This means that in a given topic area all A-type projects taken together must address the totality of the goals set for that area in the workplan. The evaluation and selection process of new A-type proposals is directed to achieve such coverage.

As B-type projects are covered by research themes, the response shall not necessarily be limited to the items explicitly mentioned. Proposals addressing additional related topics will be considered as well, and also (as a general rule) B-type proposals in support of the work described under the A-type headings will be considered. In spite of being less constrained by topic or result to be achieved, B-type proposals must have, however, a strong industrial orientation and lead to industrially exploitable results.

As regards topics or subdivisions thereof that are already addressed by A-type work and for which no new A-type work is invited this year, it must be noted that, if for any reason, the existing work should not be continued as expected, other major proposals addressing the same area may then be considered again.

A-projects or B-themes for which no proposals or no satisfactory proposals are received, or areas in which existing work is discontinued for some reason, will be considered again for inclusion in the workplan for the subsequent year.

0.10. RESOURCES BREAKDOWN

Allocation of the budget between the five subprogrammes will be a function of the work envisaged in the 1985 Workplan and of the final allocation of resources to the projects started in 1984. However, as an indication of a top-down allocation, the desired overall balance between the subprogrammes can be used. Since the 1984 proposals for Software Technology (subprogramme 2) fell significantly short of expectations, some allowance is made for this by allocating more resources for 1985.

The overall workplan breakdown of resources for each subprogramme is also subject to modification in the light of further technological evolution in the world. In particular, in the light of the industry response to calls for proposals, it must be possible to transfer resources between the various subprogrammes — after all the partitioning of ESPRIT into five areas is a management convenience and is not intrinsic to the nature of the work. It must be stressed that all subprogrammes are very heavily interrelated.

The resulting approximate distribution of effort to be supported, in man years expended each of the next five years, is as follows:

Subprogramme	Programme year				
	2	3	4	5	6
1. Microelectronics	400	440	430	430	440
2. Software Technology	340	390	400	400	440
3. AIP	370	420	420	420	440
4. Office Systems	320	360	340	320	360
5. CIM	200	230	230	200	240
Total	1 630	1 840	1 820	1 770	1 920

SUBPROGRAMME 1

ADVANCED MICROELECTRONICS

1. The major thrust of this subprogramme is to develop the key enabling technologies of silicon MOS and bipolar and GaAs with the associated CAD. These each have different merits for specific IT applications; these are listed in the table below.

	Speed	Power	Drive capab.	Cost per funct.	Level of integr.	Market size
MOS	***	*****	*	*****	*****	*****
Bipolar	****	**	*****	***	***	***
GaAs	*****	****	**	*	*	*

When associated with CAD, CAM and manufacturing methods, these will produce by 1988 a soundly based 1 μm industrial capability in a number of European sites, with substantial progress towards submicron capability. Also in place will be the necessary CAD to design VLSI circuits which use these technologies.

2. Communication with the other subprogrammes must be enhanced to ensure rapid definition of the required VLSI demonstrator circuits, their design and fabrication, funded from those subprogrammes.

3. The supply of scientific and engineering personnel trained in the specific skills of microelectronic process technology and design must be increased.

4. Support for longer range work, including optoelectronics, is provided for at a reasonable level.

5. Over and above the work started as part of the 1984 workplan there is a need for special attention to critical areas of technology and techniques. These are addressed in the new area 1.9 and include packaging, dry etching, resist technology, conductors, insulators and epitaxy.

In R & D areas 1.1 and 1.2 the MOS and bipolar process programmes have been retained for information though they have now been addressed by the projects listed. These programmes were structured as large integral projects rather than separate 1 μm and submicron projects. This has been done in the inter-

ests of efficiency, as each level of technology builds on the knowledge gained from preceding levels. Many aspects of a given process require continuous improvement, e.g. oxide quality in MOS, to meet the demands of each successive development of greater circuit complexity and high performance. This continuity of effort would be lost by having separate projects at 1 μm and submicron levels.

A new aspect of the strategy is the identification of the need for major coherent projects focussed as specific aspects of technology, supporting the main programmes where relevant. It is highly desirable that equipment suppliers be involved. These projects are identified in area 1.9.

The importance of CAD for VLSI to the overall success of ESPRIT cannot be over-emphasized. Given good technology and outstanding CAD, the highly innovative European industry will be able to compete successfully in world markets.

A total of some 13 CAD projects, involving about 650 man-years between 1983 and 1987, supported under the Microelectronics Regulation (EEC) 3744/81 and the Esprit pilot phase are already underway. In addition a new project is being launched this year (1984). The integration of the results of this work and extension to cover the design of several million component circuits for a wide range of applications is a major task.

Following detailed consideration of the work currently underway, the need for a major thrust forward in CAD has been identified and this is included in the workplan in R & D area 1.3.

There are far more organizations with a direct interest and competence in the CAD field than is the case with VLSI technology. The projects proposed here must be planned with sufficient flexibility to deal with the complex technical and organizational issues involved. The ESPRIT Information Exchange System will be a valuable aid in the area.

Computer control of manufacturing VLSI is seen as an essential part of the programme, not just a means of increasing manufacturing efficiency. The reduction in feature size and layer thickness place increasing demands on process control in a situation where the final device parameters are dependent on a larger number of variables. The minimization of human handling and an attack on the sources of yield limiting contamination are critical. For a given level of contamination, yield falls rapidly as feature size is reduced. The submicron MOS and bipolar projects will address computer-aided manufacturing aspects where appropriate. These could also be addressed under appropriate type B projects.

R & D area 1.1: Submicron MOS (type A)

Description

The requirement is to develop all the individual process steps such as lithography, etching, doping, etc., to achieve submicron feature size in MOS. The target is a process capable of making several million components per chip of logic and memory. It is envisaged that below about 0,7 μm other than optical lithography tools will be used. Process and device modelling will be included. To achieve these goals the critical techniques need to be developed. These are common to areas 1.1 and 1.2 and are addressed in 1.9.

Prerequisites

— experience with state-of-the-art processing;
— experience on advanced process steps;
— availability of functioning Computer Aided Design/Computer Aided Test (CAD/CAT) tools;

Programme (—) and Intermediate objectives (*):

Year 1:

— choice of process (CMOS or mixed C- and NMOS) and of design methodology;
— choice of optical lithography equipment;
— establishment of process steps.

Year 2:

— optimization of individual process steps;
— establishment of preliminary design rules;
— characterization of process steps;
— start research on novel process and structures for submicron technology.

* 18th month: design and evaluation of test vehicle of more than 1 000 transistors based on 1 μm design rules with a pitch (metal plus spacing) of 3 μm.

Year 3 :

— demonstration of feasibility with a 1 μm feature size, 0,5 million components circuit. The target is a figure of merit of 50 femto-joules and 1 ns delay time;

— evaluation of novel steps (gate material, isolation, interconnection etc.)

— evaluation of equipment for submicron processing.

* 36th month: first samples of demonstration circuit with 0,5 million transistors, 1 μm design rules, with data on figure of merit and delay time.

Year 4:

— choice of submicron lithography equipment;

— flow chart of a 0,7 μm process including design rules.

* 48th month: statistical data on homogeneity on a slice and yield for 1 μm design rules; and test vehicule with more than 1 000 transistors with 0,7 μm design rules and a pitch of 2 μm.

Year 5:

— evaluation of the 0,5 μm process;

— demonstration of the process feasibility;

— design of a demonstration circuit with more than 1 000 000 components, a figure of merit of 50 femto-joules and 1 ns gate delay.

* 60th month: first samples of circuits with more than 1 000 000 transistors, 0,7 μm design rules, with data on figure of merit and delay time.

Activities dependent on 1.1

VLSI microelectronics for information technology.

1.1.1. 'SOI Materials and Processing towards 3 D Integration' (Ref. 245: A/84)

The aim of this cooperative research is to study and develop new silicon technologies necessary for three dimensional integration. This 3 D approach will offer the possibility of higher density integration, higher speed of operation and multifunctional signal processing. Three main technological steps will be explored:

a) the growth of SOI active layers having electronic properties needed for the realisation of high quality devices and circuits

b) the stacking of two active levels in a way that avoids any degradation of already built devices

c) the single level SOI processing for the fabrication of individual components and for their connection; the development of a complete process incorporating two active layers.

1.1.2. 'Submicron CMOS Technology' (Ref. 554: A/84)

The project aims at developing the necessary building blocks for a 0.5 μm CMOS process, primarily dedicated to the production of high speed digital circuits. In order to allow the programme to proceed with the best chances of success, two main phases have been identified and organised: the first refers to an intermediate step at the 1.0 μm level; the second to the final 0.5 μm CMOS family. At the end of the project, the IC companies of the consortium will have, in their pilot lines, the building blocks of a CMOS process capable of realising IC's with 0.5 μm features.

1.1.3. 'Physical-chemical Characterisation of Silicon Oxynitrides in Relation to their Electronic Properties' (Ref. 369: B/84)

The aim of the project is firstly to establish the relation between the physico-chemical and the electrical properties of silicon oxynitride film and secondly the relation between the physico-chemical properties and

the growth parameters. This research will be carried out in view of the likely applications of silicon oxynitrides in i.c. technology, for instance in MNOS based non-volatile memories and in submicron MOS devices.

No further A-type proposals are expected for area 1.1.

Specific B type proposals are sought in support of the above projects in the areas identified in section 1.9.

R & D Area 1.2: Submicron bipolar (type A)

Description

The overall objective is to develop specific bipolar submicron process steps, leading to a complete processing sequence for very high performance ICs.

To realize this objective the following developments are included in the project area:

- overall circuit concepts which must evolve together with the technology;
- a vertical device structure appropriate to submicron lithography;
- a convenient multilayer interconnection technology;
- a suitable contact and multilayer interconnection technology;
- appropriate high dissipation, high pin count, electrically matched leads, packages;
- process and device modelling.

In addition the project area specifically depends on the availability of critical techniques covered by area 1.9.

Prerequisites

- experience with VLSI and advanced silicon processing; availability of CAD/CAT tools.

Activities dependent on 1.2

Fast VLSI microelectronics for information technology.

Programme (—) and Intermediate objectives (*):

Year 1:

- 1 μm technology : establish activity on process steps, circuit structures, modelling. Evaluate and choose critical equipment;
- first choice of process and circuit structures.

* 12th month: initial process design; evaluation and choose critical equipment.

Year 2:

- preliminary optimization of process steps;
- design rules at 1 μm;
- start design of demonstrator chips;
- start research on novel processes and structures for submicron technology.

* 24th month: establish final design rules at 1 μm.

Year 3:

- demonstration of 1 μm process feasibility for 10/20 Kgates, 100 ps gate delay chips;
- start work on multilayer 2 μm pitch in addition to pilot project continuation;
- continue research on submicron technology;
- preliminary design rules for 0,7 μm structures.

* 36th month: demonstrate 1 μm 10/20 Kgates, 100 ps gate delay circuits.

Year 4:

- start design of demonstrator chip at 0,7 μm;
- optimization of submicron process steps;
- choice of critical equipment;
- yield improvement of 1 μm demonstrator.

* 48th month: establish final design rules for 0,7 μm structures.

Year 5:

— demonstration of 0,7 μm process feasibility for 20/50 Kgates, 50 ps gate delay chips.

* 60th month: Availability of first samples of 20/50 Kgate circuits in 0,7 μm process.

1.2.1. 'Submicron Bipolar Technology — I' (Ref. 243: A/84)

The overall objective of this programme is to develop specific bipolar submicron process steps leading to complete processing sequences for the manufacture of very high performance integrated circuits. At the end of a five year period, the process feasibility for submicron structures will be demonstrated on a large test chip.

1.2.2. 'Submicron Bipolar Technology — II' (Ref. 281: A/84)

The goal of the project is the development of a bipolar technology for high-speed data processing products (gate delay smaller than 100 ps, power delay product smaller than 0,1 pJ, design rules smaller than 1 μm). To realise this, specific processes for component isolation, thin epi-layers, E-B structures, Schottky diodes, poly Si-resistors, multilayer-metallisation in excess of 4 layers, adequate packaging and testing techniques have to be developed. The feasibility, performance, yield and reliability will be demonstrated with specific test vehicles especially a gate array with 10 Kgates/Chip. The gate delay of less than 100 ps will be gradually attained in three steps: 200, 100, less than 100 ps.

No further A-type proposals are expected in area 1.2.

Specific B type proposals are sought in support of the above projects in the areas identified in section 1.9.

R & D area 1.3: CAD

GLOBAL OBJECTIVES

(a) to develop advanced CAD techniques to manage the ever increasing circuit complexities;

(b) to provide a capability for complex VLSI design widely accessible to the EEC IT community.

The overall aim is to develop within a common framework an integrated set of portable tools capable of handling VLSI circuits containing up to several million components.

This should:

— provide a fast response, user friendly facility that is readily adaptable to changes in technology;
— allow designers to achieve a rapid turnround of valid and testable designs and associated test information;
— be easily adaptable to changes in technology;
— provide facilities for reliability and performance optimization of circuits;
— include methodologies of cell-based design and libraries of adaptable building blocks;
— assimilate relevant results of CAD projects under Regulation (EEC) 3744/81.

Strategy

(a) A positive attempt should be made to encourage the emergence of an overall CAD infrastructure such that the majority of tools developed under existing programmes together with future tools can be combined to provide an integrated widely accessible tool capability.

(b) As far as possible, complex demonstrator chips will be used as a focus for each stage of the project.

(c) Device and process modelling is not considered as part of the CAD projects and is included in the projects concerned with the development of new VLSI processes (see areas 1.1 and 1.2); but compatability with CAD is required.

(d) Care should be taken to promote cooperative development between universities, industrial

groups and research institutions in order to transfer know-how and make CAD available to a broader community.

(e) Care will be taken to interface with, support and employ the results of other ESPRIT activities.

(f) the application of knowledge engineering techniques to CAD should be emphasised.

(g) dedicated CAD hardware should be incorporated where appropriate.

Major Projects to be launched

Work is required immediately in four key project areas. The aim is to simultaneously develop tools and techniques while promoting significant movements towards the adoption of a common framework.

A major difficulty arises out of the need to incorporate the results of current Euro projects which are in most cases difficult to quantify. The integration project will adress this issue and provide guidelines for future projects. New projects must define in advance their quantified goals and limitations in sufficient detail to allow them to be fully evaluated.

A fifth area covers smaller type B projects of a speculative and novel nature.

Much work needs to be done in the CAD area. Owing to the limited resources available the following projects have been carefully selected as those most likely to have a lasting and long term impact on European effectiveness.

Prerequisites

— Knowledge of the design process
— Access to results and tools developed in CAD and specifically under Microelectronics Regulation 3744/81 and the Esprit Projects
— Experience in algorithms used in VLSI design
— Technologies and demonstrator chips in the order of 10 million transistors

1.3.1. *CAD Integration project (type A)*

The requirement is for a wide and representative group of Design Automation (DA) tool developers to meet and jointly recommend the mechanisms and framework for better integration and wider accessibility of European CAD tools.

The project will produce regular study reports and will relate its findings to some specific programming work to support integration and linking of existing and Euro supported tools, and to define a framework of standards for future work.

The studies must take into account worldwide development (eg Electronic Design Interchange Format — EDIF) in information technology and DA system architectures.

Phase 1

Year 1:

Problems of bridging existing Euro tools, techniques for integration, impact of networks and distributed data.

Year 2:

Recommend data and portability standards, impact of special DA H/W (Hardware)guidelines for developers of DA tools.

Milestones:

a) Integration of tools and systems currently under development into a first generation system.

b) Definition of framework of standards for future work.

* A major review of achievements and a reassessment of the balance of the work to be made at this time.

Phase 2

Year 3 and Year 4:

extensions to incorporate impact of new developments in DA hardware, artificial intelligence and database technology.

Year 5:

Complete the integration of second generation system and review existing standards.

Milestones:

a) Integration of advanced tools into second generation system.

b) Review of existing standards with updates where appropriate.

1.3.2. *User interface project (type A)*

The objective is to promote more effective use and consistency of CAD tools from the user point of view. The work will be a combination of a wide ranging study and the practical adaptation of some existing programmes.

Year 1:

Enhance the user interface aspects in the ongoing CAD system projects along the whole design process:

Important characteristics:

— user friendliness
— quick response time
— portability
— consistency

Year 2:

Investigate the links on communications between intelligent work stations and the central computing units:

— Speed of transmission
— Protocol of transmission
— Partitioning of data and processes between work stations and computers

Years 3 and 4:

Study of man-machine interface with respect to CAD — new input/output techniques, for instance voice input (and see also other ESPRIT areas).

1.3.3. *Problems of very large scale integration (type A)*

The target is to develop new algorithms and architectures appropriate for VLSI circuits containing millions of transistors. The first step is to establish a formal understanding of the limits of the existing algorithms used today at different levels of the design process.

It is known that for 90 % of CAD problems an increase in complexity beyond a certain limit requires new solutions and it is certain that in the future a lot of different approaches must be applied to the algorithms.

The participants should combine joint studies and quantified evaluation with practical work on specific tools employing expert systems and special hardware that may support a range of DA problems.

Year 1:

Establishment of performance evaluation criteria especially with regard to:

— Layout generation tools
— Floor-planning tools
— Functional design tools

Year 2:

Experiment with existing tools, AI systems and special hardware providing:

— Limits in time-space complexity
— Pathological cases

Definition of a demonstrator system in which to make cooperative algorithmic tasks with AI techniques and any necessary special purpose hardware.

Years 3 and 4:

Implementation of the system and demonstration on a 'difficult' and large problem.

1.3.3.1. 'Description Language for VLSI' (Ref. 42: A/83)

This project will produce two new hierarchical IC design description languages for describing circuit networks and layouts. The main aim is to create a VLSI CAD infrastructure that aids in dramatically improving designer productivity and that allows for further development.

1.3.3.2. 'Advanced Algorithms, Architecture and Layout Techniques for VLSI Dedicated Signal Processing' (Ref. 97: A/83)

This project addresses the development of CAD tools and advanced CMOS circuit design techniques for

digital signal processing chips for bit-serial and mixed bit-serial-parallel or parallel architectures.

1.3.3.3. 'High Yield High Reliability Ultra-large Scale Integration System Through Reconfigurability' (Ref. 244: B/84)

Highly reliable ULSI can be achieved by introducing redundancy into a chip so that faulty cells or elements can be tolerated. But this area increase may lead to a yield decrease. The introduction of redundancy is proposed with the objectives of yield enhancement by means of end-of-manufacturing reconfiguration and the fault tolerance by means of on-line reconfiguration. Expertise in silicon yield analysis involving an understanding of failure mechanisms and their distribution, architectural strategies for partitioning, implementing redundancy and maintaining testability, silicon design methodologies enhanced to meet the above requirements, and specific manufacturing techniques to support the required physical restructuring and addressing the special requirements in testing and packaging are required for successful completion of the project. The project will terminate in a demonstration chip and the technology supported will be state of the art CMOS with adequate multilayer interconnections.

Additional type A proposals are invited.

1.3.4. *High level Design tools (type A)*

The requirement is to develop a set of integrated design tools for high-level design (specification, synthesis and verification) with a high degree of technology independence. These target designs are of the scale of ten million components per chip which may contain both memory and logic. The tools should assist the designer in partitioning a system into sub-systems, and in allocating the functions for implementation in hardware or software. Implementation details such as testability and layout must be addressed. The problems of mixed analogue digital designs should also be addressed.

Year 1: Design overall tool set

Year 2: Start implementation of tool set

Year 3: Complete implementation of tool set

Year 4: Test and demonstrate tool set on multiple chip sub-systems with logic, memory and analogue functions.

1.3.4.1. 'High Level CAD Design Systems for Interactive Layout and Design' (Ref. 10: A/83).

The objective of this project is to define and demonstrate the CAD system for the Design and Layout of VLSI integrated circuits, from the initial specification to the masks. Circuit complexity up to 1 000 000 transistors will be addressed. Reduced design times are the overall aim.

Additional type A proposals are invited.

1.3.5. *Specific novel design tools (type B)*

A number of small and highly innovative projects will be supported. There is a very wide range of possible topics covering the design of large scale VLSI circuits.

In particular, projects that address design problems in the following areas are invited:

— Very high speed VLSI circuits (e.g. 50 pico seconds)
— Wafer Scale Integration
— Fault tolerance for high yield
— Parallel architectures (e.g. systolic arrays)
— Specific technologies (e.g. GaAs)
— Special purpose hardware for CAD.

1.3.6. *Design and Characterisation of Cells (Type A)*

The objective is to provide cells which can be used to evaluate the silicon technologies and the CAD tools developed under ESPRIT in the context of working circuits. It is not intended to provide an exhaustive library of cells but to develop a proven methodology for the rapid design and characterisation of cells. One essential input is device modelling information from the process research projects.

Three categories of cells are included:

1. Primitive cells
2. Parameterised cells
3. Fixed cells

to include both analogue and digital functions.

For each cell there should be descriptions at the lay-out, functional and electrical level, with complete information for simulation and parameter extraction. The intention is to provide a minimal range of cells for each of the technologies. Each cell will be fully simulated and characterised.

Year 1:

Select provisional standards and develop basic cell design methodology.

Year 2:

Develop primitive cell library and techniques for parameterisation.

Year 3:

Design parameterised and fixed cells.

Year 4:

Characterisation and demonstration in representative circuits.

Note: During the course of the project appropriate standards will be implemented as soon as they become available.

R & D area 1.4: Compound semiconductor integrated circuits

Description

Integrated digital circuits in III-V compound semiconductor materials offer potential speed and/or speed power product advantages over silicon circuits because of higher electron mobility. Technology complexity is many years behind silicon and considerable materials and process research are necessary. Because of the increasing market for high-speed, low-power circuits many problems need to be tackled.

The technology encompasses GaAs circuits based on Field Effect Transistors (FET's) as well as GaAs/GaAlAs heterojunction structures using high electron mobility transistors (HEMT) or the heterojunction bipolar transistors (HJBT's). Basic research is required in materials preparation, ion implantation, and IC process technologies.

Remark: The achievement of the objectives of this programme needs very large resources which may not be available within the framework of ESPRIT. On the other hand these objectives represent a minimum target to remain competitive. Consequently complementary funding mechanisms and/or less ambitious programmes have to be accepted.

Prerequisites

- source of suitable substrate materials;
- CAD facilities;
- suitable laboratory and experienced team;
- capability for Ion implantation;
- and/or Molecular Beam Epitaxy (MBE);
- and/or Metal Organic Chemical Vapour Deposition (MOCVD) epitaxial growth;

Programme (—) and Intermediate objectives (*):

Year 1:

- Main emphasis on development of GaAs IC fabrication process on 2″ wafers arriving at submicron features with special concern for reproducibility and yield.
- Optimize materials growth and fabricate experimenal HEMT's and HJBT's in the GaAs/GaAlAs system.

* 12th month: demonstrate feasibility of MESFET based circuits with 1 000 gates and gate delay (tpd) of less than 100 ps.

- Demonstrate basic HJBT and/or HEMT circuits (other than ring oscillators).

Year 2:

- Continue work with main emphasis on GaAs IC fabrication process involving submicron features with special concern for reproduceability and yield. Establish 3″ process capability.
- Continue research into optimization of HEMT and/or HJBT IC's;

* 24th month: demonstrate at least 1 K memory (less than 1 ns access time, less than 500 mW dissipation) and/or equivalent complexity circuits.

Demonstrate feasibility of 100 gates HEMT and/or HJBT circuits.

Year 3:

— carry out yield and reliability improvement exercise on basic GaAs IC process;
— improve basic process steps for a GaAs/GaAlAs IC process based on the HEMT or bipolar transistor.
— determine applicability of HJBT/HEMT for digital IC eg for a fast 8-bit processor;

* 36th month: evaluate yield on a demonstrator circuit of 1 k or equivalent complexity, on at least 10 wafers.

Demonstrate feasibility of 1 K HEMT memory and/or comparable HJBT circuit.

Comparison of various technologies (if possible with the same circuit for each technology). Decision for selecting one out of them.

Year 4:

— improve and consolidate the selected process;
— fabricate experimental ICs and improve yield;
— develop circuits for fast 8-bit processor.

* 48th month: demonstrate 16 K memory (or equivalent) in the selected technology.

Year 5:

— Increase complexity;
— Design and fabricate other complex state-of-the-art IC's.

* 60th month: Demonstrate large circuit of 10 to 20 Kgates complexity, gate delay of less than 50 ps with figure of merit less than 100 femtojoules. This demonstrator could be a 16 Kmemory with an access time in the order of few nanoseconds or it could be defined during year 3 to fulfill needs of other ESPRIT areas (specially high speed data bus) or of telecommunication industry (signal processing circuits for instance).

1.4.1. 'Compound Semiconductor Materials and Integrated Circuits — I' (Ref. 232: A/84)

The overall objective of this programme is to establish gallium arsenide digital integrated circuit technologies using the GaAs MESFET, high electron mobility transistors (HEMT/TEGFET) and heterojunction bipolar transistors (HBT) as the active circuit elements. These circuits will be configured to enable the speed and power advantages of GaAs over silicon to be suitably demonstrated.

1.4.2. 'Compound Semiconductor Materials and Integrated Circuits — II' (Ref. 522: A/84)

The general objective of the research programme is to develop advanced aspects of GaAs digital integrated circuit process technology and associated expertise to enable the fabrication of fast, high performance digital circuits. Whole IC fabrication is not considered to be pre-competitive. Demonstrator digital IC's will be developed to evaluate the performance of the various logic circuit technologies.

1.4.3. 'CAD Methods for Analog GaAs Monolithic ICs' (Ref. 255: B/84)

The major emphasis of the research programme is the development of a full CAD library of theoretical models and experimental data for passive elements and active components required for the design of GaAs analog IC's. The work starts by deriving physical models and equivalent circuits for different types of MESFET and passive elements both for lumped and distributed approaches. The next step is CAD of groups of passive and active devices for the integrated implementation of elementary functions. Here besides

circuit analysis, coupling between adjacent elements and thermal distribution will also be simulated. In the successive phase, analog IC's defined as high level functional blocks have to be considered with special analysis programs. This final CAD program includes package effect evaluation and error sensitivity analysis. Interactive optimisation will be organised in a user-oriented, transferable package. The project starts with C and X band investigation to be extended to 18 GHz. The CAD capability will be proofed with different GaAs IC demonstrators, including submicron dimension devices.

Additional type A and B proposals are invited.

R & D Area 1.5: Optoelectronics

Description

Optoelectronic devices will be increasingly required for telecoms transmission, intra- and extra-computer connections, ultra wide band image processing and switching. Future generations of mono-mode communications systems may use coherent detection and multi-channel wavelength multiplexing and may be phase modulated. This will provide improved performance and be compatible with integrated optical logic. It will allow processing, combining and routing at very high speeds. In semiconductor form it will also be compatible with III-V integrated circuits providing a fast electrical interface.

Remark: The achievement of the objectives of this programme needs very large resources which may not be available within the framework of ESPRIT. On the other hand these objectives represent a minimum target to remain competitive. Consequently complementary funding mechanisms and/or less ambitious programmes have to be accepted.

Prerequisite

— source of suitable substrate materials;

— suitable laboratory and experienced team;

— capability in epitaxial growth.

This programme is not aimed at optics based computers but rather at providing components and subsystems for large bit rate transmissions. The two approaches are:

a) Integrated electronic and optical components on the same chip:

Programme (—) and Intermediate objectives (*):

Year 1:

— optimize materials growth and layer structures;

— integrate a photodetector with a front-end amplifying component;

— work on laser drivers in InP based materials;

— work on the development of an InP based IC technology, compatible with its optoelectronics.

* 12th month: demonstrate a monolithic photodetector with internal amplification.

Year 2:

— compare (both experimentally and by modelling) hybrid and monolithic integration for receiver module;

— continue to develop the InP based IC technology;

— develop isolation and interconnection techniques on InP based materials.

* 24th month: demonstrate a monolithically integrated receiver with bandwidth greater than or equal to 2.5 GHz.

Year 3:

— compare hybrid and monolithic integration of transmitter module;

— fabricate an integrated transmitter.

* 36th month: demonstrate an integrated transmitter with a bandwidth greater than 2.5 GHz.

After year 3, further optimisations of receiver, transmitter, and perhaps also repeaters have to take into account the progress and needs of the telecommunications industry and of the other ESPRIT areas.

b) Wavelength multiplexing (WDM) with integrated optics:

Programme (—) and Intermediate objectives (*):

Year 1:

— Optimization of epitaxial growth for lasers, detectors and waveguides;

— evaluate electron-beam and holographic produced gratings;

— demonstrate Distributed Feedback (DFB) laser.

* 12th month: demonstration of DFB laser with threshold current lower than 50 mA; demonstration of waveguide fed photodetector; low loss monolithic waveguide (smaller than 1 dB/cm).

Year 2:

— optimize DFB laser for direct modulation at high frequency;

— fabricate 2 buried heterostructure (BH) lasers at different wavelength on the same chip;

* 24th month: demonstration of 2.5 GHz bandwidth modulators in semiconductors.

Year 3:

— monolithic integration of 2 DFB lasers emitting at two different wavelengths:

— optimization of external modulators on semiconductors materials;

— fabricate demultiplexing detectors;

* 36th month: demonstrate an integrated transmitter with a bandwidth greater than 2.5 GHz.

Year 4:

— Integration of 2 DFB lasers together with an optical multiplexer;

— improve demultiplexing photodiode.

* 48th month: demonstrate integrated WDM transmitter and receiver modules.

At this point, some inputs from other ESPRIT areas and telecommunications industry are needed to implement a demonstration link at a several gigabit rate.

1.5.1. 'Integrated Optoelectronic Devices for Very High Bit Rate Optical Fibre Transmission Systems' (Ref. 263: A/84)

The general objective of the research programme is to significantly increase the data rate in information transmission systems, by the use of high performance devices and with a variety of multiplexing techniques, mainly with the use of different wavelengths. In the first three years, activity will be focussed on achieving and utilising single mode discrete functions suitable for subsequent hybrid and monolithic integration. Full hybrid integration will be worked on in year three and four. The work on these materials will be oriented towards reproducible growth of high quality, high homogeneity, large area heterostructures suitable for lasers with low threshold current density and well controlled wavelength, for photodetectors with low residual doping level and for waveguides with low losses.

1.5.2. 'Technology for InP Based Integrated Opto-electronic Circuits' (Ref. 546: A/84)

This programme is aimed at the development of the technology needed for the fabrication of the electronic devices in a form which can be integrated with the optical devices. A range of devices will be investigated and compared for use in a range of functions. As a result of the importance of longer wavelength operation all the work will be on InP-based semiconductor compounds. A very important potential benefit of the programme is that the materials to be studied are expected to have very high performance in conventional electronic circuits. Thus the programme may lead to improved electronic functions as well as sophisticated opto-electronic circuits.

1.5.3. 'Optical Interconnect for VLSI and High Bit Rate IC's' (Ref. 380: B/84)

This speculative research programme is undertaken to investigate the application of optical interconnection to reduce the package pin count and electro magnetic interference in VLSI and high speed integrated circuits and in sub-assemblies containing these components. The complete programme has a four year duration. During the first year design and study work will be undertaken. Activity levels will be higher in the second and third years during which the main experimental work will be undertaken. In the final year, demonstration devices will be completed, design and performance predictions finalised, and specific applications explored.

1.5.4. 'Molecular Engineering for Optoelectronics' (Ref. 443: B/84)

The aim of the project is the development of new organic electro-optic and nonlinear optical materials. There is an increasing requirement for such materials in the rapidly expanding fields of integrated optics and optical communications. The target of the project is to produce novel materials for the fabrication of devices utilising linear electro-optical effects, second-order frequency mixing effects and third-order effects.

Further A-type (and B-type) proposals are expected.

R & D area 1.6: Advanced Display Technologies

In many product areas eg workstations, electronic office equipment etc. there is a need for new

advanced display systems to replace and supersede the conventional CRT. Such displays would need to be of large size (A4 and above) and of medium to high definition. Colour capability would also be desireable/necessary.

Many approaches are currently being investigated. The problems of multiplexing, defect minimisation, materials, etc. become greater with increasing display size and definition. A clear identification of the specific problem issues and a definition of the optimum technological strategy for Europe to make an impact in this area is required. Such an initiative must link closely with national activities in this area.

A technology definition project in which major existing community practitioners would combine their knowledge and experience is proposed. This project would be of 12 to 18 months duration and would prepare the way for a significant co-ordinated European approach in this area. The expected results in this project would be reflected in a study report to be completed between months 12 and 14 whose recommendations would be supported by one or more demonstrators to be completed by month 18.

1.6.1. 'Materials and Technologies for High Mobility TFTs for LC Display Bus Drivers' (Ref. 491: B/84)

In current practice, the peripheral driver circuits for active matrix liquid crystal displays consist of external IC-chips. This project proposes to develop thin film materials and technologies for column- and line-bus drivers to replace the external IC-chips. The main task will be to develop a low temperature deposition process for the semiconductor thin film material compatible with the glass substrates used for the LC-display. The main material suggested is polycrystalline silicon, deposited in a high power glow discharge process. Furthermore elementary Thin Film Transistor (TFT) circuits suitable for bus driver shift registers will be developed and investigated and Driver prototypes of short length shall be combined with LC-matrix display and tested.

Proposals are invited in area 1.6 as outlined above.

1.7. **— (number not used)**

R & D area 1.8: General Type B Research Themes

This area covers B-type research themes not already identified in the microelectronics areas 1.1 to 1.6. These themes must of course be relevant to the objectives of the microelectronics subprogramme, and have a high intrinsic value in themselves.

Note: Since this research area is very wide ranging in its scope no detailed programme will be given in this document. In each case, however, type B proposals will be expected to provide closely measureable yearly targets against which progress can be measured.

1.8.1. 'Investigation of all aspects of the Interconnection of High Pin Count Integrated Circuits' (Ref. 199 — 544: B/83-84)

This project has the following aims:

1. *The development of alternative methods of connecting the integrated circuit to its interconnect medium.*
2. *The development of large area high density interconnect using multilayer polymer techniques.*
3. *The development of reasonably large area ultra high density interconnect based upon a combination of thick film dielectrics and additive base metal electroplating methods.*

It is the aim to realise all interconnect systems with just two layers, thereby achieving low cost through reduced handling and inexpensive materials. All parts of the project are designed to make optimum use of the packages being developed on the complementary programme 1.9.1.

1.8.2. 'Plasma Deposition Technology for Magnetic Recording Thin Film Media' (Ref. 334: B/84)

The objective of the project is to develop deposition technologies which combine the superior technical qualities of the thin film media with the high deposition rates required for industrial production. The goal of the project is to increase the thin film deposition rate by a significant factor.

Additional B-type research themes are invited. A non exclusive list of candidate topics for such proposals include:

— advanced physical analysis techniques
— sensors and transducers
— new technologies and techniques for advanced information storage
— new inorganic and organic materials.

R & D area 1.9: Projects in Support of more than one Microelectronic Area

Description

This area covers all those projects (A- or B-type) which support more than one of the major area 1.1 to 1.6. Such projects cannot be assigned to a specific area but, unlike area 1.8, they are directly connected to the main thrusts of the subprogramme.

Also this area represents a significant thrust to develop the technologies and the techniques required to help achieve the major goals of these areas 1.1 to 1.6, and to look forward beyond the early stages of these projects to the sub-micron final goals.

1.9.1. 'Advanced Interconnect for VLSI' (Ref. 14: B/83)

This project relates to the on-silicon interconnect problem. It will deal with multilayer and submicron geometries and will address the relevant materials technology and other related problems. Reliability, life-test and yield programmes will form an integral part of the project. (Off-chip interconnect is the subject of project 1.8.1).

1.9.2. 'Automatic Design Validation of Integrated Circuits Using E-beam (Ref. 271: B/84)

The project seeks to develop a methodology for the automatic design errors diagnosis of VLSI devices based on the observability facility given by an electron beam system, connection to the CAD environment, pattern recognition to automatically position the E-beam, global methodology, possibly based on expert systems to define the diagnostic strategy, new hardware circuitry to enhance the EBT performance. The areas of computer control of the electron beam system, interfacing to CAD software, identification of circuit elements, methodology for design error diagnosis, test pattern generation for electron beam debugging, design for electron beam testability, and electron beam equipment development, will be addressed in order to achieve this overall objective.

1.9.3. 'Assessment of Silicon MBE Layers' (Ref. 305: B/84)

This project is divided into three parts:

1. *Growth of silicon layers by molecular beam epitaxy (MBE).*
2. *Continuing in situ measurement of process characteristics.*
3. *Implementing and developing techniques for the characterisation of MBE layers. This information will then be used to optimise growth conditions.*

It is planned that four specific developmental tasks be undertaken on four specific techniques. The remainder of the programme will be concerned with the application of existing techniques and the interpretation of the totality of the results so obtained.

1.9.4. 'Silicon-on-insulator Systems Combined with Low Temperature' (Ref. 370: B/84)

In the project a number of techniques will be used and combined in order to obtain good quality single crystal layers with thicknesses varying between 0.5 μm and 50 μm for a variety of applications. These relate to both silicon-on-insulator (SOI) and to SOS (silicon-on-sapphire) for high performance integrated circuits, and also for the provision of alternatives to the currently used cumbersome dielectric isolation (DI) processing.

1.9.5. 'A High Performance CMOS Bipolar Process for VLSI Circuits' (Ref. 412: A/84)

This project aims at the development of a VLSI technology which combines, on a single chip, MOS circuitry of the highest density presently obtainable, with bipolar circuitry of similar density, but better suited to specific tasks, in particular, the interfacing with external equipment. In the project the main effort will fall on the technological side: development of methods

which allow both bipolar and MOS transistors to be made in compatible process steps, and this down to dimensions comparable to those presently obtained in MOS-only technology. In parallel with this technological work design methods have to be developed for the specific type of circuitry envisaged, along with a study to determine, for various types of application, the most appropriate division of subsystems between the two circuit technologies.

1.9.6. 'Improvement of Yield and Performance of ICs by Design Centering' (Ref. 456: B/84)

This project will apply the new method of Design Centering to optimise the performance of IC's. An already existing program for design centering and a program for the improvement of the circuit performance will be improved and adapted in the special problems occuring in the design of VLSI-circuits. The program-parts to be developed should include schematic input, output of relevant results and an improvement of the search strategy in order to cut down CPU-time eventually by increasing storage requirements. The program should be easy to handle and will finally be tested with various IC's provided by the companies.

1.9.7. 'Substrates for CMOS VLSI Technology' (Ref. 509: B/84)

Part 1: To set up an intrinsic gettering (IG) process for wafers with medium high oxygen concentration. The process should be independent of the type, p or n, of the substrate and should be able to produce:

— a highly defective bulk region

— a defect-free denuded zone

A thickness of this zone around 10-20 μm is identified as an optimum compromise for several factors (leakage current, insensitivity to latch up and soft error).

Part 2: to characterise epi wafers with diameter 4 and 6 inches. The thickness of the epilayer should be in the range 5-10 μm, both for p+ and n+ substrates. This thickness range is suitable for submicron CMOS. Finally, IG and epi process should eventually match to have intrinsically-gettered, low leakage epiwafers for submicron CMOS devices insensitive to soft errors.

1.9.8. 'Quantum Semiconductor Devices' (Ref. 514: B/84)

It is planned to

1. explore device structures where the carriers are controlled within and between layers by electric fields imposed by implanted/diffused regions, or by specially configurated gate structures (e.g. submicron pitch interdigitated fingers), and

2. support this programme with theoretical studies of basic semiconductor physics and of electronic and optoelectronic effects in novel structures.

1.9.9. 'Dopant Profiling for Submicron Structures' (Ref. 519: B/84)

The aim of this project is to realise the capabilities for the accurate determination of shallow dopant profiles as used in submicron devices. To achieve this the development of one electrical technique, i.e. spreading resistance, is proposed together with an intercomparison of this technique with two other non-electrical methods, i.e. Secondary Ion Mass Spectrometry (SIMS) and Rutherford Back Scattering (RBS). The primary emphasis of the project will be put on the development and use of the spreading resistance technique with the other techniques being used primarily for comparison. A major by-product of this approach will be the data enabling a better understanding of diffusion kinetics to be obtained. In addition the work will concentrate on profiling Boron Phosphorus, Arsenic and Antimony and will also involve the use of and assessment of novel annealing methods such as strip heater and flashlamp annealing.

1.9.10. 'High Resolution Plasma Etching in Semiconductor Technology-Fundamentals, Processing and Equipment' (Ref. 574: B/84)

It is widely recognised within the electronics industry that plasma etching will play a vital role in achieving submicron technology both in silicon and III/V semiconductor systems. However, much remains to be done to understand the complex chemistry and physics involved by applying suitable diagnostic methods. Until this is accomplished the full potential of plasma

etching will not be realised. The overall programme is necessarily interactive and brings together centres of expertise in plasma chemistry and physics, instrument manufacturers and a supplier of chemicals to the electronics industry. Collectively they possess a unique combination of knowledge and facilities which will assure success in this broadly based programme.

To achieve the programme goals a series of significant projects is required. In particular to achieve processing at feature sizes of 0.5 μm and below the following project areas are identified, and the deliverables of these proposals should be aligned with the 1.1 and 1.2 programmes

(a) 0.5 μm lithography with production throughput and associated resist development which should be compatible with dry etching processes

(b) anisotropic etching of wafers up to 150 μm with 0.5 μm feature sizes (Reactive Ion Etching -RIE, Reactive Ion-Beam Etching-RIBE, etc.)

(c) Process techniques enabling redundancy for very large area integrated circuits

(d) Modelling of processes and devices including experimental verification.

Additional proposals for B-type Research Themes are invited. The following lists are indicative of suitable topics but are not exclusive. Candidate subjects related to VLSI include:

— Semiconductor processing materials
— Resist technology
— Plasma and Reactive Ion Processing
— Ion Implantation
— Photo-assisted deposition technology
— Rapid Thermal processing of layers (E-beam, Laser, Heat pulse, etc.)
— Metallization: Silicide conductors, novel materials, novel processing methods)
— Organic insulators
— High Speed on-wafer testing
— Advanced Packaging Techniques
— high speed, materials, etc.
— Device and Process modelling
— Automated manufacturing and control.

Candidate B-type topics supporting areas 1.4 and 1.5 include:

— Crystal growth of large InP and GaAs single crystals
— Modelling optical elements
— Device modelling for GaAs
— Specific CAD for III — V integrated circuits
— Basic technological processes for
  — material assessment
  — ion implantation and anneal
  — dry etching techniques
  — dielectric and insulators
— reliability
— specific equipment

In addition a wide ranging type B programme is to be encouraged, seeking to support new and promising techniques across the whole microelectronics area as defined by the identified major project area.

— Lithography (Photo-, Electron-, X-ray-, Laser-, Ion-, etc.)
— Various active elements on high mobility semiconducting materials
— Device reliability and failure mechanisms
— Novel compound semiconducting materials, new semiconductors and novel (eg stacked) devices using them
— New display methods (for Flat Panel Displays — see Section 1.6).

SUBPROGRAMME 2

SOFTWARE TECHNOLOGY

1. Introduction

The 1985 issue of the workplan for the ESPRIT Software Technology subprogramme is not only an adaptation of the 1984 issue to current technological insights and trends. It also represents an attempt to improve the workplan as an instrument for project evaluation and selection, and as the main technical guide to potential proposers.

2. Objectives and rationale

Software Technology is seen as one of the major enabling technologies of the IT industry. Software development is a part of the design process of systems and is expected to account for an increasingly large proportion of total system effort. Therefore, possession of highly efficient, cost-effective methods for the production of high quality, reliable software will lead to more rapid introduction of new products and the reduction of total life-cycle costs. Europe must have free access to the best methods and tools and be at least equal to the rest of the world in their exploitation.

At the present time Europe probably is on a par technically with US and Japan but most of its expertise is in isolated centres of excellence and needs coordination and wider dissemination.

The overall objective of the Software Technology subprogramme is to reach a stage where the development of information systems (i.e. products including hardware and software solutions) would have the characteristics of an industrial design process and, to a larger extent, would be computer-assisted. The information systems envisaged cover in principle the whole range of application areas. Specific mention should go to the following: distributed systems (e.g. distributed databases), and real-time and embedded systems.

A major barrier to the introduction of existing and future methods is seen to be the lack of knowledge, by industrial middle management, of the benefits to be gained from these methods and the investment needed to introduce the methods (staff training, organizational changes, etc.). This is further re-inforced by the need to adopt a 'minimum-risk' policy for new industrial projects.

A new class of projects has therefore been considered in Software Technology. These will involve the industrial use (not the development) of current state-of-the-art in software technology. These projects can start immediately. An essential part of project proposals in this class must be analysis and dissemination of the effectiveness of the technology. The main activity is to assess software technology rather than to develop it (i.e. Case studies in usage). Some projects of this nature have been described under the R&D areas 2.1, 2.2 and 2.3; further proposals are invited in section 2.4.

3. Description of the subprogramme

In accordance with the accepted division of the software development task into three key areas (see also 1984 workplan), there are three main R&D areas in this subprogramme:

Theories, methods, and tools (2.1)

The activities in this area address the transition to an engineering approach to systems and software. A scenario is envisaged in which well-founded scientifically-based methods are gradually adopted to replace ad hoc techniques currently in use. In addition, there will be work on more advanced approaches to information systems engineering.

Management and industrial aspects (2.2)

Projects in this area are intended to consolidate understanding of, and effective means of support for, the management and industrial aspects of software projects. These aspects include the broader issues of the software product life cycle as it appears in the software and information systems industry. They also include issues concerned with software project management.

Common environment (2.3)

Projects in this area will develop a common environment to be used:

— as a primitive software development environment

— as the basis for the development of a complete integrated software engineering environment.

Other projects should provide the basis for the more advanced environments of the future.

A fourth section of the subprogramme addresses the need for demonstration and evaluation projects.

The projects to be executed under the ST subprogramme are intended to secure the best competitive position of the European IT industry by the collaboration of research establishments, software toolmakers and the industrial users.

In the overall activity cycle for improving the software technology base three phases can be distinguished, each type of collaborator contributing in different proportions according to the phase, as follows:

* Theoretical and empirical research

The aim of projects in this phase is to promote a better understanding of the nature of the software process within an economic context, and the underlying mathematical and computer-science theory. The industrial applicability of the research will be confirmed by prototyping and pilot applications.

* Development of enabling technology

Projects in this phase concern the development of industrially acceptable technology (typically methods and tools) which exploit the advanced in theoretical understanding. This phase requires the widest form of collaboration and the greatest mobilisation of resources, which in turn requires the adoption of a common tools architecture to ensure widespread applicability and inter-working of tools according to local requirements.

* Industrial application

This phase concerns the industrial application of the technology produced from the second phase. Collaboration in this phase is typically required to monitor the introduction of the technology, the impact it has on the nature of the software process, and the implications for future theoretical and empirical work. Thus the cycle begins again.

Projects with the subprogramme will have characteristics of one or more of the phases mentioned above and should therefore be assessed according to appropriate phase-oriented criteria, of which examples are given below.

* Theoretical and empirical research

Novelty, advancing state of the art, increasing understanding of the software process, potential impact on software economics, etc.

* Development of enabling technology

Industrial acceptability, actual impact on software economics, interoperability with existing industrial practice, width of applicability, adaptability, conformity to standards, integrability with other tool developments, etc.

* Industrial application

Impact on future research, tools standards, training, and overall approach to changing the technology base of the relevant industry sector, generalizability and dissemination of results, etc.

In order to maximize the industrial advantage of the development and introduction of technology, the ESPRIT Software Technology subprogramme includes not only the sponsorship of radically new approaches in the form of research which may take several years to mature. It also promotes the collaborative development of industrially acceptable technology, which exploits the existing knowledge as it matures. Within the constraint of remaining pre-competitive, it also promotes its introduction into industry and assesses its impact on the industrial users.

4. Current Work and new projects for 85

The currently accepted notion is that industrialisation of the Software development task will be via the introduction of integrated project support environments, i.e. collections of computer based tools and methods designed to work together and support all the technical and management aspects of the software process. The present ESPRIT work provides a good basic coverage of the tools and environments but requires further supporting projects to fill out the detail and to provide additional coverage of high-risk areas. In addition, new work is necessary in the following fields:

— Systems projects (the integration of the hardware and software design cycles).

— Alternative and complementary methods of software development, e.g. prototyping and the application of Artificial Intelligence techniques.

— Software methods and tools for small, highly critical software.

— Metrics for software and for the software production process.

— Man-machine interaction.

— Software engineering for broad application areas such as CIM and AIP.

— Evaluation projects to assess the real problems and the real benefits of introducing the new technology.

The workplan also contains work on Ada-related methods and tools, as well as on suitable environ-

ments for the development, maintenance and evaluation of distributed databases, in order to round out the work now foreseen for the extension of the Community multi-annual data processing programme.

R & D area 2.1: Theories, Methods and Tools

Description

The activities in this area address first of all the transition to an engineering approach to systems and software within the framework of current life-cycle views. A scenario is envisaged in which well-founded scientifically-based methods are gradually adopted to replace ad hoc techniques currently in use.

Industrial and academic collaboration is particularly relevant to this area, since academic researchers in Europe have produced a significant theoretical base which should provide the foundations of improved systems and software engineering methods.

One of these foundations is the work in the area of formal description. Because they adhere to well-defined mathematical practice, formal descriptions allow the unambiguous, concise and clear specification of a software product without constraining the implementation, and provide a good basis for such important concerns as functional analysis, verification, simulation, education, automatic implementation and testing.

The emphasis is on the development of improved methods for system construction. These methods must then be supported by integrated support tools. It is assumed here that the overall development approach, which the tools support, will employ multiple levels of representation with incremental verification and validation. Where possible, tools may be provided by re-work or enhancement of existing software rather than by completely new development.

In this context it is important to distinguish short and long term concerns:

— In the short term it is important to work towards unification and integration of the existing models and tools in software production. In this area the efforts will hopefully lower the threshold which still prevents even software engineers from using these tools.

— In the longer term one will need to stress the view of the system as a whole, and especially unite the classically separated processes of software production and hardware development. Thus profit can be drawn from the increased flexibility offered by the weakened borderline between hardware and software. (Consider the possibility offered by todays minicomputers to decide, depending on the actual needs, whether floating point arithmetic shall be done by software or by hardware).

With respect to the current phase-oriented models of the system development process, unification and upgrading of tools corresponding to individual phases and their sequencing is a more short-term concern, whereas the possibility to define new phases and/or a new sequencing of those is of more long-term interest.

All efforts should contribute significantly to the reduction of life-cycle costs, particularly in the areas of testing and maintenance, through earlier error detection and removal, and the development of more reliable and higher quality systems. There is also a strong interdependence with the management activities described in area 2.2. Management methods must take account of improved systems and software development methods and, similarly, system development methods must take account of management requirements.

The sub-areas included are first of all 'System Oriented Approaches' (2.1.1), which stress the problems of developing complete systems (hardware and software), then 'Improving Current Software Development Approaches' (2.1.2), followed by 'Advanced Software Development Approaches' (2.1.3), and finally 'Quality, Reliability, Conformity testing and demonstrating' (2.1.4).

2.1.1. **System Oriented Approaches**

Three main themes have been selected in this area:

— Hardware/Software synergy

— Requirements engineering.

— Design of secure systems.

2.1.1.1. **Hardware/Software Synergy** (Type A)

Objectives

(a) To develop common techniques, methods and tools for the whole (hardware and software) system development process, e.g. design languages.

(b) To develop an integrated approach for modelling the overall system (software behaviour, hardware performance, system utilization). This dynamic modelling must achieve cost-effectiveness and adequacy of the system as a whole, matching historical data; system characteristics to be observed are compactness, response time, reproducibility, robustness, flexibility.

(c) To enable automated transformation of formal specifications into silicon/software.

(d) To develop test and evaluation strategies regarding the increased complexity of such systems, e.g. considering bugs and failures as decreasing functionality over the system life cycle.

Rationale/Background

There is a need for an integrated approach in the design of systems with the aim of being able to realize each component in the best suited 'material'. This should lead to greater flexibility in design, and the possiblity of easier technology upgrade during product life.

Technical Approach

Integration of software methods and formalisms with those existing in hardware design. Analysis of the impact of non-functional requirements on system design methods (tailoring to target characteristics) such as fault tolerance.

Intermediate objectives

Year 3 — initial models and prototype tools

Year 4 — test and evaluation strategies

Year 5 — automated transformation of formal specification

Year 6 — demonstrate technology developed and show applicability to complete system design.

Interdependencies

Other projects in 2.1, CAD for VLSI (1.3), computer architectures (3.4).

2.1.1.2. **Requirements Engineering** (Type A)

Objectives

To develop a formal framework, methods and tools for the capture and description of system requirements.

Rationale/Background

This is a problem of fundamental importance to all IT product development. Failure to achieve effective requirements capture is at the root of many slips in project timescales and cost overrun.

Technical Approach

Interaction with the client/user of the system is essential to this issue. Therefore a variety of approaches may be required like natural language processing, audio-visual feedback (animation), in addition to formal methods which would be at the core of the solution.

Intermediate objectives

Year 2 — experiment with existing systems, draw up formal framework

Year 3 — initial methods and prototype tools

Year 5 — produce definitive methods and complete corresponding tool support.

Interdependencies

With AIP (natural language, cognitive psychology).

In view of the wide application area dependence, more than one project is expected to be launched.

2.1.1.3. **Public-domain techniques for systems integrity**

Objectives

To develop methods and techniques for designing and implementing systems that must be safeguarded from stated infringements, e.g. because they deal with sensitive data, or because resource usage must be strictly controlled for accounting purposes. An important requirement is that the methods and techniques must demonstrably provide the integrity properties.

The techniques must be capable of dealing with a distributed network of users with multiple levels of allowed access.

Rationale/Background

Techniques based on non-public, proprietary methods may not be socially acceptable in many areas (public telecommunication, medical, banking, . . .). One of the main reasons why they may be unacceptable is the difficulty of assessing the real level of security they provide. Therefore, there is a need for techniques that do not rely on their not being public.

Technical Approach

Formal methods should be adopted so as to be able to guarantee or prove the required integrity properties of the system. Specific characteristics to be measured for purposes of demonstration will have to be quantified.

Interdependencies

Relations to software/hardware synergy (2.1.1.1) and software quality and reliability metrics (2.1.4).

Proposals for B-type projects are invited, which may start in 1986.

2.1.1.4. **Other B-type Research Themes**

In the area of systems oriented approaches a number of smaller B-type projects are also envisaged in addition to the larger A and B-type projects mentioned above. An important one could be the study of technical means for effectively safeguarding the property rights in software (prevention of software piracy). Others are exemplified by design of software for embedded micros, and methods for the development of distributed processor system.

2.1.2. **Improving Current Software Development Approaches**

This sub-area is intended to unify and improve methods and tools corresponding to existing formalisms, with the aim of encouraging their use on a wider scale. Furthermore, techniques and tools for enhancing the efficient production of software should be developed as a direct aid to removing the so-called applications backlog.

In relation to the current orientation of the extension to the Community multi-annual data processing programme, attention is drawn to the subjects of Ada-related methods and programming tools, as well as distributed database techniques. Work on these subjects would contribute to rounding out the purely development oriented work that can be supported under that programme.

2.1.2.1. 'Rigorous Approach to Industrial Software Engineering (RAISE)' (Ref. 315: A/84)

The project aims at building a complete systems development environment based on an enhanced version of the VDM method. Present shortcomings of VDM will be corrected, a number of tools will be built (first in prototype form, then in production quality form), several industrial applications will be undertaken, and training and educational material will be produced.

2.1.2.2. 'Personal Workstation for Incremental Graphical Specification and Formal Implementation of Non-Sequential Systems (GRASPIN)' (Ref. 125: A/83)

The project aims at a personal software development workstation for incremental Graphical Specification and stepwise formal Implementation of Nonsequential systems. The workstation is to comprise a tool set supporting techniques for specification and documentation, testing and verification and coding simulation. GRASPIN is based on a well engineered merge of two widely accepted complementary methods: high-level Petri-net specifications of concurrent activities and axiomatic-algebraic specifications of abstract data types. Significant use is to be made of graphics and of

concepts such as focussing techniques, multiple windowing concepts, and simultaneous handling of different contexts.

2.1.2.3. **Component-based software system construction** (Type A)

Objectives

To develop techniques and tools for constructing software from re-usable software components.

Rationale/Background

It is expected that effective re-use of components will lead to dramatic improvements in software productivity for application software.

Technical Approach

Databases and knowledge bases for storage/retrieval of component descriptions; the retrieval process has to be integrated with the design cycle, and this is as yet a major topic of R & D.

Intermediate objectives

Year 3 — produce prototype of database for storage/retrieval of component descriptions

Year 4, 5 — incorporate results from AIP sub-programme and formal techniques
produce more advanced retrieval mechanism, extending complexity of component descriptions

Year 6 — final integration of techniques and retrieval mechanisms.

Interdependencies

PCTE (2.3.1.1), SPMMS (2.2.1.2), formal specification techniques for describing components, Knowledge-based systems.

2.1.2.4. **Software production by successive prototypes** (Type A)

Objectives

To derive methods, techniques and tools for developing software from a first prototype of a complete system to an implemented product by a succession of intermediate 'prototypes'. The aim is faster development than by 'classical life-cycle approach'.

Rationale/Background

Once a first prototype is available, which satisfies all the requirements, it is desirable to be able to systematically transform it into a realistic product.

Technical Approach

Possibly:

— successive replacement of components by ones better suiting the performance/reliability, etc;

— transformation techniques;

— simulation techniques;

— non-imperative languages.

Intermediate objectives

Year 3 — establish methodology
select more promising approaches

Year 5 — develop relevant tools, and carry out demonstration designs.

Interdependencies

With 2.1.1.2 (requirements engineering), and 2.1.2.3 (component-based system construction).

2.1.2.5. 'Program Development by Specification and Transformation' (Ref. 390: B/84)

The objectives of this project are to develop a strict methodology for program development by transformations from formal specification. The transformation rules are proved correct 'once and for all', and their application, supported by software, would guarantee the development of programs correct in relation to specification. The use of Ada as a standard language, and specifications using annotations in Anna, or an Anna-like language, will ensure portabilities between APSE's. In order to support the use of these tools in a workstation, a collection of additional tools would be developed.

2.1.2.6. 'Software Environment for the Design of Open Distributed Systems (SEDOS)' (Ref. 410: B/84)

This three year project is based on the formal description techniques currently under development in the framework of OSI. It aims at providing pragmatic and stable formal description techniques, applications of these techniques to standards, verification techniques, and a set of (prototype) tools to support the specification, verification, simulation, implementation and testing of OSI protocols and services in particular and open distributed systems in general.

2.1.2.7. **Other B-type Research Themes**

Proposals are invited in order to develop methods, tools and environment aspects around existing formalisms, which are not tackled by the other existing projects in area 2.1.2. They should in principle use PCTE (2.3.1.1) as an infrastructure.

B-type projects under this heading are those intended to investigate and exploit specific formalisms; the formalism itself is the centre of interest. The workplan also provides for alternative emphasis in the following sections:

— section 2.2.4, which considers the management implications of the use of the formalism;

— section 2.3.3.1, where the aim is to generate an interactive programming environment from a characterisation of the formalism.

2.1.3. **Advanced Software Development Approaches**

The objectives are to investigate the possibility of integrating the rigour of the 'software engineering' approach and the flexibility of the experimental and 'throwaway' style of software development exemplified by knowledge processing work; also to provide facilities for rapid incorporation of future developments in different classes of languages.

There is current work under this heading (see 2.1.3.1 below) based on formal methods; other projects could be based on (i) the exploitation of Expert Systems approaches or (ii) non-imperative languages.

2.1.3.1. 'An Integrated Formal Approach to Industrial Software Development (METEOR)' (Ref. 432: A/84)

The basic goal of this project is the application of formal methods to the process of developing industrial software. The current state of the art is not yet ripe for straightforward industrial exploitation and research work is needed on the integration of formal, yet not enough general, methods into a coherent and general method. In particular the project aims at integrating the object-based language paradigm, the algebraic approach to software specification, the relational approach and so-called formal heuristic. Industrial take-up, especially in the area of constructing real-time distributed systems, is provided by the planned construction of prototype environments.

2.1.3.2. 'Investigation of Performance Achievable with Highly Concurrent Interpretations of Functional Programs' (Ref. 302: B/84)

The purpose of the project is the investigation of the performance implications of the highly concurrent hardware architectures which are becoming available, on the use of functional programming approach to application development. The project will analyse large functional programs developed in industrial and research establishments and study highly concurrent hardware architectures. The goal is to understand how the functional approach should be used in order to thoroughly exploit the potentials of highly concurrent hardware architecture.

2.1.3.3. 'An Advanced Support Environment for Method Driven Development and Evolution of Packaged Software' (Ref. 510: B/84)

This project will develop techniques for the formal definition of methods used in the development of software. The project focusses on one main idea, namely that the building of a support environment should be parameterised by methods expressed in a development language. It will seek to achieve understanding and formal modelling of:

— *the software construction process*

— *the application domains*

— *the target systems*

and would continue with the definition, implementation and evolution of a prototype environment for software development based on formally defined methods.

2.1.3.4. **Expert-system based software systems construction**

Objectives

To investigate in detail the possible contribution of an extended expert system on the base of the collected, existing know-how on system development, knowledge acquisition on system development and prototype-generation by direct derivation from specification. Demonstration of the applicability of this approach to e.g. supporting the user guidance for a part of the system development process.

Rationale/Background

A method-based user guidance taking account of the completeness and consistency of the phases of the system development process will reduce the users burden with mechanical and non productive work. Additionally the use of production rules would yield a dramatic reduction of redundant information and work.

Interdepencies

With AIP.

Initially, B-type proposals are expected. This topic is expected to be the subject of A-type project work in later years of the programme.

2.1.3.5. **Development of system software using non-imperative languages** (Type A)

Objectives

(a) To design concrete formalisms and languages based on non-procedural and non-imperative approaches, such as found in the functional, applicative, logical and algebraic programming styles.

(b) To build support systems and systems for rapid prototyping, integrating the various abstract concepts for describing distributed systems (temporal logic, data-flow languages, calculi of communicating systems).

Rationale/Background

In system programming, especially in the field of concurrent processes and networks, etc., the inherent non-determinism does not allow validation just by testing. Support by formal tools for specification, design and verification is badly needed for increasing modularity, reliability and maintainability as well as reducing production cost. Recent research in this area shows that non-procedural and non-imperative languages, such as found in functional, applicative, logical and algebraic programming styles can make a considerable contribution in these areas.

Intermediate objectives

Year 2, 3 — design and validate formalisms
Year 4 — produce initial support system
Year 6 — build definitive support system

Interdependencies

Relations to prototyping projects (2.1.2), advanced environment work (2.3.3) and host/target issues (2.3.2).

A-type proposals are expected in this area. Research in the areas of modularity associated with functional and logic programming is in its early stages. Development of theories concerning modularity in this area is very important and may be the subject of 'B' type proposals.

2.1.3.6. **Interactive formal program development**

At present there is a significant gulf between the formal and structured style of program development, as advocated by the 'software engineering' community, and the experimental and throwaway style, as advocated typically by the AI community. B-type projects are invited that will investigate the possibility of drawing upon both styles to develop an approach which offers the rigour of the former and the flexibility of the latter. Significant issues include scoping appropriate to the task in hand, typing (strong typing, polymorphic typing, typeless languages), dynamic modification, and interfacing to both the hardware and the user. The differences between requirements for the two styles will have to be investigated carefully.

2.1.3.7. **Other B-type research themes**

Among the possible themes for B-type work in this area, the following can be explicitly mentioned:

— investigation of the convergence between programming languages and database manipulation languages

— new approaches in generation of system software from (formal) descriptions.

2.1.4. **Quality, Reliability, Conformity testing and demonstrating**

This subject broadly concerns the properties by which a software product's quality may be characterized and quantified and the means by which a software product's quality and reliability may be estimated and predicted. It further addresses the ways in which these and other properties of interest may be tested and demonstrated.

Two main approaches to quality and reliability assurance can be considered, namely close control over the development process, and measurement and corrective action; in each case, the aim is to provide techniques and tools that will assist the assurance controls both pre- and post-production.

Data collection and analysis should be addressed mainly from the short-term aspect (progress monitoring, analysis of error reports, etc., for individual projects).

2.1.4.1. 'REQUEST: Reliability and Quality of European Software' (Ref. 300: A/84)

This project aims to provide the techniques, tools and procedures sufficient to specify, predict, measure and assure the quality and reliability of computer software. The areas of work include the following:

— *definition of the term 'quality' with respect to several attributes, identification of methods of measuring quality and investigation of the criteria for validity for those metrics, and construction of a quantitative model for the prediction of quality;*

— *definition of reliability and identification of a model and tools to measure and predict reliability, considering both software systems in general and also the special needs of systems in which ultra-high reliability is essential;*

— *definition and provision of a data base for storage of measures of quality and reliability, and specification of procedures for data collection and analysis;*

— *analysis of the impact of using formal methods on reliability prediction and demonstration;*

— *definition of a methodology for the certification of software products, providing criteria for the delivery of warranties.*

2.1.4.2. **B-type Research Themes for product metrics**

B-type proposals are invited which could tackle aspects which are not covered by 2.1.4.1; e.g. performance prediction.

Objectives to meet are, e.g.:

— cost effectiveness

— control, tuning, calibration

— efficiency

— execution time for real time systems

— accuracy

— flexibility

through observation, analysis and modelling.

2.1.4.3. **IT reference testing and demonstrating**

Objectives

To develop techniques, methods and tools allowing for I.T. reference testing and demonstrating.

This objective is multiple:

— improving specification in order to facilitate the automatization of at least part of the process of testing

— developing specific techniques methods and tools for conformity testing, quality and performance testing, as well as usability testing.

Rationale/Background

In view of the increased usage of software in highly critical applications, as well as the gradual recognition of product liability for software, conformity to

specification is becoming more and more an important objective with the ever rising trade in software, quality and performance will be crucial for market viability.

Technical approach

Mostly formal specification, theorem proving, program generators, and some AIP techniques (expert systems), . . .

Interdependencies

The results can be exploited in different sectors of the ESPRIT programme.

B-type projects are expected in this area.

R & D area 2.2: Management and Industrial Aspects

This area is intended to consolidate understanding of, and effective means of support for, the management and industrial aspects of system and software projects. These aspects include the broader issues of the software product life cycle as it appears in the software and information systems industry. They also include issues concerned with project management in general, as it applies to the production of information systems. In both cases, the relationship of these issues to the technical aspects of the Software Technology workplan (see 2.1.) must be addressed. Projects are indicated to develop solutions to the proper integration of technical developments within the broad framework of the industrial process. Effective support for management roles is addressed by projects concerned with information control and visibility, with tools providing information pertinent to management activities and with tools carrying out tasks necessary for management activities. Within an integrated process, the collection of data for use by management activities is seen as important and, again, relationships are seen with product metric activities in area 2.1.3.

The sub-areas included are 'Software production and maintenance support' (2.2.1) which deals with the support system aspects, 'Industrialization aspects' (2.2.2) which addresses the introduction strategy, 'Development of Project Management tools' (2.2.3), and 'Management of advanced software production' (2.2.4).

2.2.1. **Software production and maintenance support**

2.2.1.1. **Short-term solutions to management support** (Type A)

Objectives

(a) To produce a system providing integrated management capabilities with software engineering tools based on available or near term technology.

(b) To evaluate through practical use the effectiveness of such a management support system as representing the current, or very near term, state of the art.

The management capabilities to be provided by such a system can include support for such activities as:

* planning
* project control
* maintenance management
* quality assurance
* management database
* project models.

Rationale/Background

The major feature of this item in the workplan is the provision of an integrated software management capability for evaluation by industrial projects. A major result is the outcome of such evaluation.

The emphasis is on the provision of such a system to support the needs of Software management without relying on as yet uncompleted research.

Technical Approach

It is anticipated that the system will be provided by combining existing capabilities with perhaps some new production or development. This is essential to allow adequate possibilities for evaluation and demonstration. The means of demonstrating the effectiveness of the capabilities provided by the system must be clearly stated to convince middle management of the benefits of using such an environment.

Intermediate objectives

Year 3 — produce initial system

Year 5 — evaluate full system.

Interdependencies

There are no strong dependencies on other projects in the workplan. However, the results will be relevant to other activities in the 2.2. area.

2.2.1.2. *'Software Production and Maintenance Management Support (SPMMS)' (Ref. 282: A/84)*

The project aims at designing and implementing a system supporting all management activities in the life cycle of software. One of the most important requirements the system is expected to fulfil is the adaptability to different management methods. The project plans to reach this objective by building a basic generic SPMMS Kernel which should be easily customizable. Customization will be provided by generic modules, and possibly by a rule based approach.

Technical Approach

The project should gain some guidelines from the PCTE (2.3.1.1) and SPMMS (2.2.1.2) projects.

Intermediate objectives

Year 2 — develop models

Year 4 — product initial support system apply and validate models

Year 6 — build definitive support system.

2.2.1.3. **Support for software production in special areas** (Type A)

Objectives

This work addresses the issues which arise by the specific requirements of support and maintenance of Information Technology in special areas. Such areas include:

* Software embedded as firmware for example in larger Hardware-Systems;
* high volume Software products, for example in consumer products.

For those areas, the objectives are to:

(a) develop and apply quantitative management models of Software production and maintenance;

(b) provide support for the major functions of Software production and maintenance management for planning and control of Software projects and products and maintenance management.

The application in these areas should be supported specifically on such aspects as:

* high reliability assurance
* extensive test facilities
* attacking system (hardware/software trouble-shooting) instead of merely software problems
* enabling flexibility concerning changes in the surrounding components
* ease of use for non-professional programmers, for example in smaller projects of mixed hardware/software development
* maintenance policies, especially in high volume markets.

2.2.2. **Industrialization aspects**

A main handicap to the usage of software technology in industry is seen to be the difficulty of introducing the technology into the existing managerial and economic scene of a particular company. Little work has been done in methods and tools that successfully take this problem into account.

The issues raised cover a wide range of topics and overlap with other areas of the current ESPRIT programme. In particular the work relies upon the evaluation of the efficiency of software technology methods. Although many of the projects being funded under ESPRIT have the requirement to be evaluated, it will be a considerable number of years before results are available.

It is considered necessary to undertake earlier work to establish more firmly the experience gained to date by companies introducing software technology.

It is recognised that the confidentiality of such data is a major problem in this investigation. Proposals should indicate how such problems will be overcome.

2.2.2.1. **Software Technology introduction strategies** (Type A)

Rationale/Background

To introduce a given level of software technology to a company or a project requires a great deal of planning and, in many cases, a major investment in equipment and training. The necessary steps are not well identified or understood in the field of software technology. Similar problems arise however in the introduction of other forms of technology to industry. It is important that software technology does not re-investigate, unnecessarily, problems for which well-tried solutions already exist. However, the introduction of software technology environments will have a major impact upon many of the activities of a company. It is necessary to have the issues involved in the introduction of this technology clearly identified and appropriate strategies and tools developed.

Objectives

(a) Develop models of the full software development process, taking into account all peripheral activities such as management, personnel, training and investment strategies. These models should, as far as possible bring together existing models from other disciplines.

(b) Develop and assess alternative strategies for the introduction of software technology into the commercial environment. The alternatives should include central software factory, decentralised specialist units, workstation based strategies including incremental growth from a small number of units.

(c) Produce case studies which support the model in a variety of industries.

(d) Develop techniques and, where appropriate, tools to help industry adopt software technology.

It is suggested that two A-type projects are launched covering different areas of industry together with a number of B-type projects covering particularly sub-models and addressing objectives (c) and (d).

The A-type projects should complete tasks (a) and (b) within two years. Tasks (c) and (d) should be completed by year 4. B-type projects in support would be undertaken at all stages.

Technical approach

A wide variety of skills and techniques will be required to carry out these tasks. As far as possible quantitative models should be developed and formal methods introduced where appropriate.

Intermediate objectives

Year 2, 3 — develop models
assess strategies

Year 3 — produce initial techniques and tools

Year 4, 5 — complete case studies
build final techniques and tools.

Interdependencies

Some links are seen with the Office Systems activity 4.1.1 'Office Systems Analysis'.

2.2.2.2. **Evaluation of the problems experienced in adopting software technology**

Objectives/Programme

— To gather data upon and draw conclusions from the experience of companies, working in a variety of different application areas, who have introduced, attempted to introduce, or are introducing software technology.

— Specifically:

  * to attempt to identify why specific projects failed or succeeded;
  * to recommend a set of requirements which are needed to ensure the success of a software systems development project. It must be assumed that these are beyond the normally accepted good practice for project management;
  * attempt to draw general conclusions regarding successful strategies which have been adopted by companies;

* to advise methods to assist in the evaluation of future projects.

Since it is important to obtain early results in this field, it is suggested that a survey of existing experience should be complete within two years. New projects should be complete within 3 years.

Technical approach

It will be necessary to identify companies who are prepared to share their experience. It is most likely that the most information will be obtained from consortia formed to introduce a specific technology to a group of companies. A satisfactory proposal for a survey of existing experience should also be considered. The specific technology is to be of a level currently available commercially, and not necessarily 'state of the art'; the primary of the project is to *evaluate* the introduction of the technology not to introduce the most advanced technology available. However, the technology should be on an evolution path towards an integrated support environment or a methodology to be used in the future.

It is expected that at later stages of ESPRIT similar projects will be called for to evaluate transfer of environments produced by the ESPRIT programme.

Interdependencies

There are links with the evaluation activities in other programme areas.

B-type proposals are expected.

2.2.3. **Development of Project Management Tools**

Objectives/Programme

To develop specific tools for project management, in the form of linked sets of tools for specific application areas. The tools should complement the work done by the SPMMS project (2.2.1.2) and use, wherever possible, the PCTE (2.3.1.1) defined interfaces.

Rationale/Background

Many of the problems of system and software project management are similar to those of any large, complex labour- intensive project. However, the innate flexibility of software development and the relative lack of methods of measuring its progress create special problems. It is particularly important that the issues involved in the management process are well understood. This indicates a need for a major project to create a set (or sets) of linked tools for one or more application areas.

Technical Approach

Tools must be developed paying particular attention to the man-machine interface. It is particularly important that the design of the tools is based upon a extensive experience of the real problems of software management, as well as industrial product management for the complete system.

Interdependencies

Must be closely linked to the SPMMS (2.2.1.2) and PCTE (2.3.1.1) projects.

Both large and small B-type projects can be envisaged.

2.2.4. **Management of advanced software production**

Objectives/Programme

The objectives of projects in this area are:

(a) to establish the impact on the relationship between the technical aspects of software development and management features: the current way of managing resources (computing, human and others) taking into account time and volume constraints would be modified by the use of formal methods, techniques associated with AIP or the specific use of non-imperative languages;

(b) to evaluate risks and help decision makers through the software product life cycle;

(c) to demonstrate and evaluate advantages to the software product life-cycle of the use of the advanced techniques;

(d) to identify and satisfy management requirements which result from the use of the advanced techniques. Examples will include identification of appropriate metrics;

(e) to achieve performance management and capacity management in the new setting.

Rationale/Background

Successful introduction of more advanced techniques of software and information systems development requires that the relationship of these techniques to the requirements of industry and management be identified and appropriate integration activities pursued.

Technical Approach

The approach to be adopted will require identification of the software product life cycle as it is affected by the use of advanced techniques and in particular the areas of concern to software management. This might well be achieved by comparison with an industrial perception of the life cycle as it is with existing (i.e. non-advanced) software techniques.

Interdependencies

There will be dependencies between a project in this area and projects developing advanced software techniques. Such projects are addressed in area 2.1. of the Software Technology workplan, including some which are already underway. There may also be activities on development techniques in the Advanced Information Processing workplan. Cross fertilization of ideas a project in this area and other projects in the 2.2. area might be beneficial.

Rather large B-type proposals are invited in this area, each concentrating on a specific technique, particularly those developed by projects under 2.1. or under AIP. In addition there could be smaller B projects investigating specific management aspects of advanced techniques (for example cost models of AIP based methods). The projects should start in 1986.

R & D area 2.3: Common Environment

General introduction

Within the sub-programme, the word 'environment' is used to cover a wide spectrum. At one extreme there are environments that aim to build a *total* environment to support a particular methodology. Such environments can e.g. be built on the basis of results produced by projects under section 2.1.2 of this workplan. All such total environments need to cover common issues like tool composition, object management, and user interface, and also to supply basic method-independent tools such as editors, document formatting, compilers, and graphics handling. These common issues should be addressed by projects that build 'common environments' that can be used as bases for the total environment projects. This R & D area deals with such common issues.

Projects in sub-area 2.3.1 will thus contribute to the development of a common environment to be used:

— as a primitive software development environment;

— as the basis for the development of a complete integrated software engineering environment.

An area of major importance to European industry concerns the development of embedded systems. This necessitates use of special environments which can deal with host/target interworking. Projects in sub-area 2.3.2 address these issues.

Projects in 2.3.3 should provide the basis for the more advanced environments of the future.

The evolution to more advanced environments must consider both the application of AIP techniques to the problems of software engineering environments and the application of software engineering techniques to the problems of environments suited to AIP project developments. For example, support for special life cycle models of AIP projects may be necessary.

The more advanced environments might be

expected to play an active rather than just a passive role in assisting the users.

It is desirable that appropriate interfaces between these environments and the initial common environment are provided.

2.3.1. **Common Tool Environment**

Since multi-national development of software is a central feature of the whole ESPRIT programme, the common environment is an important building block for many projects promoting standardization of tool interfaces, functions and tool portability. There will be an early general publication of all interface definitions so that widespread exploitation of the environment is facilitated.

The common environment will consist of an infrastructure which provides the basic framework and a set of tools and components which will be of relevance in all instances of the environment. In particular, the tools and components are intended to assist the development of new tools and the conversion and enhancement of existing tools, thus promoting extension to a complete, flexible, integrated environment.

2.3.1.1. *'A Basis for a Portable Common Tool Environment (PCTE)' (Ref. 32: A/83)*

The project will provide a common base for Software Engineering Environments aimed at supporting European cooperative research and development and at fostering widespread dissemination and exploitation of emerging technologies, methods and tools.

The project will exploit and advance state-of-the-art technologies in particular in the areas of User-Environment interface and of management of Information bases:

— *The User Interface is a window system which draws on enhanced interaction facilities (bit-map display, mouse, menus) to shield both the user and the tool-writer from the knowledge of detailed aspects of the interaction protocol.*

— *The Object Management System (OMS) is the information repository for the entire project life cycle. OMS is a true distributed DBMS implementing a specialisation of the Binary Entity Relationship Attribute data model. Structural and semantic properties of the Information base can be incrementaly described via the OMS Schema mechanisms. The OMS provides a means of integrating tools and tool-sets in the framework of a hierarchy of Software Engineering Environments by supporting multiple levels of subschemas.*

— *PCTE distribution services provide a transparent access to processes and information items over personal workstations and servers connected in a Local Area Network through ISO-OSI standard communication services.*

For its wide availability UNIX is expected to play the role of the 'initial common environment' for the time being. PCTE implements a well suited strategy to support the easy migration from UNIX by providing a compatible emulation of the 'System Calls' functional level of UNIX System V.

2.3.1.2. **Common Environment Tools and General Services** (Type A)

Objectives

This project concerns the construction of an integrated tool set, based on PCTE, of interest to most professional software developers.

It involves:

(a) Definition of the tool set.

(b) Acquisition and adaptation of existing tools to run on PCTE.

(c) Development of new tools.

Tool examples (not complete)

* document handling
* mail, bulletin, diary
* database query
* data dictionary
* graphics editing
* multilanguage interfacing
* use of tool statistics collection and analysis.

Rationale/Background

The ultimate goal is to provide European industry with an advanced environment to be used for the development of reliable software products. It must be both immediately acceptable (i.e. at least as good as existing systems and providing an easy migration

path from existing practices) and geared towards its later evolution. In addition, it must support distributed project teams and promote standardized approaches to tool construction and interworking.

This project is necessary to provide the essential minimum common tool set built on PCTE.

The value of this project area to IT industry in Europe is very high since it enables project development consistency by supporting multidisciplinary teams and subjects.

Technical Approach

The project is essentially a consolidation of existing techniques. As such the approach is straightforward. It is important that the basic facilities and languages supported by the PCTE are used in developing and adapting the tools.

Intermediate objectives

Year 2 — define tool set
Year 2, 3 — acquire and adapt tools
Year 3, 4 — develop new tools.

A-type proposals are expected for this topic. A set of smaller B-type projects in this area is a possibility provided that they are carefully managed by an 'overseer'.

2.3.2. **Host/Target Issues**

In the embedded systems area the host computer used for system development and the target computer on which the system is to run are generally not the same. This division between host and target causes additional problems which the projects in this area attack.

In embedded systems development one is often faced with the problem that the systems run on special hardware configurations (special I/O interfaces, no disk storage, etc. . . .). Therefore it may be difficult or even impossible to use an existing operating system on the target.

It should be possible to connect the Host and Target for development purposes as well as for maintenance purposes. This may cause special problems with non-stop systems where it may be necessary to replace software components with new ones 'on the fly'.

To attack these problems the concept of a target environment is introduced. The target environment acts as a framework for operating system and application components and as an interface to the host.

A number of B-type projects are envisaged covering amongst others the following themes:

2.3.2.1. Implications for host and target architectures:

— external interfaces
— non-stop considerations
— application domain dependencies

2.3.2.2. Host/Target connection:

— protocole performance evaluation
— remote debugging
— target emulation
— target maintenance
— non-stop considerations
— rescheduling techniques on synchronization points
— testing of distributed target systems

2.3.2.3. Relations to programming languages:

— relations between target components and language constructs
— component structure

2.3.3. **Evolution to more advanced environments**

The emphasis in this area is on capturing the demands on the common environment that come from advanced methodologies, their tool sets and their information structures. The urgent need for a common tool environment has meant that the current work has, inevitably, taken a rather conservative approach. The PCTE is designed 'bottom-up' from the facilities it can offer rather than 'top down' from the uses to which it will be put. In order to avoid this in the next generation, projects in this area will explore various issues that have an impact on the architecture of the more advanced environments of the future.

2.3.3.1. 'Generation of Interactive Programming Environments' (Ref. 348: B/84)

The main objective of the project is to investigate the possibilities of automatically generating interactive programming environments from language specifications. Such an interactive environment will be generated from a complete syntactic and semantic characterization of the formal language to be used. A prototype system will be designed and implemented.

2.3.3.2. **Advanced human interfacing**

Objectives

To explore the impact and possible exploitation of advances in man-machine interfacing for the professional software developer.

Technical Approach

Relevant technology that may contribute to improved man-machine interaction in this area may include:

— graphics
— (pseudo) natural languages
— voice and image processing
— AI techniques.

Interdependencies

Is related to the human factors work described in subprogramme 4 (Office Systems).

B-type proposals are expected.

2.3.3.3. **An experimental interactive environment**

Objectives/Programme

There is a need for rapid deployment of an experimental programming environment to support a formal interactive style of program development (see 2.1.3.6).

The environment must provide integrated support for existing languages from several classes, including those geared to formal development (such as the functional languages with strong polymorphic typing), those geared to experimental interactive development (such as LISP and PROLOG), and the object oriented languages (such as SMALLTALK), as well as vectorial languages suitable e.g. for large scale scientific applications.

Rationale/Background

This work may provide the first environment for the 'personal knowledge workstation'. As such it is a forerunner of the advanced interactive environments envisaged in the AIP subprogramme (3.5).

Technical approach

In view of the need for rapid deployment, serious consideration should be given to issues of re-use of existing developments. Communication and window-management facilities are to be provided by PCTE (2.3.1.1), and part of the results from 2.3.1.2 may be integrated as well.

Interdependencies

With 2.1.3.6, 2.3.1.2 and 3.5. B-type proposals are expected.

2.3.3.4. **Flexible Environment Models to Support Advanced Methods and Tools**

Objectives/Programme

To investigate the spectrum of possible future environment philosophies and organisations.

Issues may include:

— Application domain implications
— Uniform application writers' interface
— New paradigms for software life cycle
— Support for component reuse
— Support for non-procedural knowledge
— Support for highly parallel execution
— Support for large scale scientific calculation
— Support for the development, maintenance and evaluation of distributed databases
— Management of projects
— Support for distributed project teams

— Use of non-imperative languages
— Active rather than just passive roles
— Requirements on schema tools/data dictionaries, as derived from the need to integrate tools at the semantic level.

Interdependencies

With 2.1.3.6.

Proposals for one or more B projects are invited to examine these issues which may have major impact on the structure of future environments. An example is the impact of software engineering environments on systems which support AIP developments.

2.3.3.5. **Knowledge-rich Environments to Support Software Engineering**

Objectives

Provide a framework for environments which play an active rather than a passive role.

The environment must provide the knowledge base management system necessary for software development.

Techniques and structures which permit an active role must be designed and implemented.

An example of the way in which an active role may be played is in the retrieval of software components. For example a user may have defined his needs formally. An active system can then search available component descriptions to find possible close matches to those needed. The system can then suggest to the user a set of components which the user can then adapt to his specific requirements.

Technical Approach

This could be through advances in conventional database technology, for example via the use of AI techniques concerning knowledge representation, manipulation and consistency.

Additional techniques such as search and inference could be applied.

Proposals for B-type projects are invited to start in 1986, and there may be an opportunity for a number of B projects leading to a consolidated A project in subsequent years.

R & D area 2.4: Evaluation and demonstration projects

As mentioned earlier, there is a significant barrier to the introduction of new methods and tools into industry. This can partially be overcome by promoting evaluation and demonstration projects. Several projects and research themes mentioned in sections 2.1 to 2.3 contain elements of evaluation and/or demonstration, in particular 2.1.4, 2.2.2 and 2.3.1. It is felt, however, that additional proposals should be encouraged whose main interest for the ESPRIT programme would be to contribute to the production of reliable information (where possible in quantitative form) about the usability of software technology results in the widest sense in typical industrial situations. Thus these projects could contribute also to the emergence of an empirics for software technology, which is seen to be lacking as yet.

The intention is *not* to call for artificial projects solely to demonstrate or evaluate some particular approach, but rather to use real projects as an evaluation and demonstration vehicle. The financial support could then cover the additional costs that are incurred in performing the evaluation and demonstration role. In particular, it might cover training and familiarization overheads at the start of the project, and the preparation of reports and critiques of methods and tools for the benefit of the ESPRIT community as a whole. Acceptability of demonstration projects is conditional upon the production of such reports and critiques, which should be made freely available to interested parties.

For an evaluation or demonstration project to be effective, it is paramount importance that the results to be produced for the ESPRIT programme are of relevance to a significant sector of the industry, both in terms of the application area that is envisaged, and of the working mode that is addressed. The representativeness of the project for a class of similar projects will therefore be a major factor. It is equally important that the results of such projects should be seen to be valid and conclusive; this requires, among other things, that the design and planning of the work should be evaluated from the perspective of the statistical theory of 'design of experiments'.

The proposals expected under this heading may relate to any of the items indicated in section 2.1 to 2.3 as forming part of the software technology.

SUBPROGRAMME 3

ADVANCED INFORMATION PROCESSING (AIP)

Advanced Information Processing is central to future developments in Information Technology. The main theme concerns means for improving the effectiveness of computing systems. In order to achieve substantial progress, work in the following four key areas is needed:

(i) Knowledge engineering: concerned with what the computing system processes. This area represents the change from processing of data to processing of information and knowledge. Particularly important is the development of knowledge acquisition, representation and manipulation techniques, also vital in improving human access to conventional databases.

(ii) External interfaces: concerned with how the computing system communicates with its environment. This area deals with the recognition, understanding and synthesis of signals. These signals include those exchanged with humans.

(iii) Information and knowledge storage: concerned with how the computing system organizes its store of data and knowledge. This area deals with developments in data and knowledge bases as well as with techniques of access to these bases and with new hardware devices.

(iv) Computer architectures: concerned with configurations used by the computing system to do its processing. This area deals with the development of novel computer architectures and their associated programming environments. Particular emphasis will be placed on the use of concurrency.

Each of these four areas are vital for the development of AIP systems. Accordingly they are assigned equal priority and roughly equal resources. However, any given AIP system or application will involve a different balance of techniques from the four areas. To aid in the development and demonstration of complete AIP systems, two further activities have been identified.

(v) Design and system: this area is concerned with standards, specification and verification techniques, design methods and general system methods, which are relevant to the other activities within the AIP subprogrammes.

(vi) Focusing projects: the purpose of these is to act as demonstrators, and to provide foci for the interdisciplinary aspects of the work. Ideally these would span the ESPRIT subprogrammes to demonstrate the integration of the topics in a total systems environment.

A major emphasis of the workplan is the implementation of practical systems. Much of the work proposed will build on the existing technological bases, and is accordingly described on a stage by stage basis in the workplan. However, aspects are also identified, particularly in knowledge engineering, where substantial research is required.

Advanced information processing systems in general will benefit from inputs from the micro-electronics and software engineering subprogrammes. The former will supply faster hardware components, while the latter will aid in development of appropriate programming environments. Equally, AIP systems and techniques will find substantial applications in Office Systems and Computer Integrated Manufacturing, as well as in many other markets.

R & D Area 3,1.: Knowledge Engineering

Description

This R & D area is concerned with the tools and technologies which will be needed for the practice of Knowledge Engineering in order to realise commercially and socially acceptable Knowledge Based Systems applications, of which Expert Systems, Decision Support and Computer Aided Instruction are examples.

Knowledge Engineering involves the practice of:

— Decision Analysis to determine the viable domains for Knowledge Based Systems (KBS) application.

— Knowledge Acquisition in the chosen domain about the objects of reasoning, their taxonomy, lines of reasoning, Heuristics, Facts, Rules and Dialogue.

— Classification of the Domain Characteristics and selection of the most appropriate corresponding Knowledge Representations and Inference Models, later to be extended to include knowledge transformation facilities.

— Realisation of the KBS applications on the most appropriate delivery vehicle in terms of MMI, Computational Engine capability, Data/Knowledge Base capabilities, and Storage capabilities as well as communication facilities.

— Customisation of the system for users by providing an adaptive interface which minimises cognitive load in terms of the dialogue with the system.

— Manipulation of Knowledge for maintenance of installed systems, and for transformation of Knowledge for the construction of new KBS applications.

— Dealing with complexity and its implications.

R & D Topics

Work will research, specify,and implement the tools and techniques of Knowledge Engineering, including:

3.1.1. Knowledge representation and inference techniques
3.1.2. Knowledge acquisition and learning techniques
3.1.3. Knowledge manipulation
3.1.4. Dialogue and natural language
3.1.5. Implementation languages
3.1.6. Interpreters for high level knowledge representation formalisms
3.1.7. Knowledge-based systems and their metrication
3.1.8. Advanced generation KBS applications

Work in the first five years will concentrate on gaining experience building KBS, particularly Expert Systems, using conventional equipment, so as to understand and extend capabilities. This would be followed subsequently with building an advanced generation of KBS, incorporating the results of all associated AIP research and results from the Software Technology programme.

Topics 3.1.7. and 3.1.8. jointly represent a rolling programme of Demonstrators for early and advanced KBS. It is expected that Demonstrators during the first 5 years will continuously feed problems and weaknesses into the above group of research topics, and conversely, each new rolling Demonstrator can use early research results current at the time of inception, which it will then keep frozen for its 2-3 year duration.

3.1.1. **Knowledge Representation and Inference Techniques** (Type A)

Description

Knowledge Representation is a key factor analogous to Data Modelling in conventional processing. Because of its complexity, it requires Engineering, Modelling and Transformation of tools of high sophistication. It is not expected that any one language will emerge — rather that there will be a wide range of standards and techniques, which vary according to Domain classification, paradigms employed, and to Inference/processing Models used. A comprehensive effort is needed to differentiate, classify, and extend Knowledge Representations for these requirements. It is expected that more sophisticated applications will need to work with multiple differing, but co-operating, knowledge domains, and thus research on interworking KRS and inference models will be essential. Inference mechanisms provide operational semantics for knowledge representation languages.

Existing KBS applications use tools and methods which largely incorporate simple rules of inference — especially, little (meta) knowledge is applied to the use of Knowledge and to control of inference. This leaves a lot to be desired in exploiting high quality Knowledge and Heuristics, which are often the key to KBS effectiveness rather than brute force hardware speed. Basic research should include:

— Development of new Knowledge Representation paradigms

— Cognitive modelling

— Natural deduction technique not requiring special implicative form

— Non classical logics such as temporal and fuzzy logic

— Knowledge based control of the inference process itself

— Non-monotonic reasoning, including constraint propagation and reason maintenance, especially for real-time applications

— Exploitation of Contextual Knowledge

— Classification of Inference Tools and Methods against Domains, KRS and Paradigms

— Time-dependency in general

— Qualitative reasoning on time and causality in physical reality

— Machine and device models as a basis of reasoning on physico-technical systems

— Schemes of cooperation between distributed knowledge sources.

It is essential that the tools developed for KR are exploited for knowledge acquisition in order to provide feedback and to keep these two basic issues in step. It is also essential that any problem solving paradigm should be tested on real problems.

Milestones

Year 1986/87:

— Introduce new KRS tool kits and methods into project 3.1.7 for 'rolling' exploitation.

Year 1987/88:

— Publish European guidelines for components of KRS tool kits.

— Reference 'production' implementation of new KRS.

— Deliver inference models to the Demonstrator and Metrics programmes.

3.1.1.1. 'Expert System Builder' (Ref. 96: A/83)

The aim of the project is to provide a system enabling expert systems to be developed and tested by personnel inexperienced in artificial intelligence. A ring structured model has been identified for the system to allow progressive development and extension of the facilities within the individual layers. The system has been designed on the basis of the inner rings being completely independent of the domain. The test system provides the integral tool set for the upper layers, with the capability for later extensions. A particular domain has been chosen, that of diagnosis of electronic systems, because of its increasing demand in equipment and manufacturing, and labour intensiveness of the methodpresentlyemployed.

3.1.1.2. 'Knowledge Integration & Management Systems' (Ref. 112: A/83)

The project is designed to investigate key areas of information processing such as knowledge representation, inferencing techniques and human computer interfaces. Emphasis is on a language for knowledge representation and management based on LISP and PROLOG; an expert system suited to assist sales engineers in designing computer configurations; an expert system serving office personnel to perform complex office procedures (e.g. resource planning). These complementary tasks focus on the development of hardware and software components to manage the problems resulting from the size and complexity of large knowledge bases and the associated reasoning mechanisms.

3.1.1.3. 'Knowledge Representation and Inference Techniques in Industrial Control' (Ref. 387: A/84)

The aim of the project is to design and implement an Expert System to assist maintenance, fault diagnosis, optimisation of data flows, and control in an industrial process-control environment. Control is considered as:

— *a highly time-dependent environment where input channels are numerous (well over 1 000)*

— *very high in complexity.*

Therefore an Expert System that either has to maintain a process-controlling device or help the operating personnel with their decisions must have some additional features:

— *the reasoning procedures must take the time-dependency into account;*

— *the capturing of input data must be accomplished automatically;*

— *to assist in overcoming complexity barriers in such devices, a machine learning capability is necessary.*

The application area of process control, including the process to be controlled as well as the controlling device itself, establishes an entire class of applications to all of which the proposed system may be applied. Advances over existing Expert Systems lies in:

— *making process-control in critical areas more secure by assisting the operator in his decisions and by reducing the drop-out rate of the controlling devices;*

— *permitting the users to more fully exploit inherent features of complex systems in both maintenance aspects and control of data flows.*

3.1.1.4. *'An Architecture for Interactive Problem Solving by Cooperating Data and Knowledge Bases' (Ref. 316: A/84)*

The main goal of the project is the design and implementation of an expert system architecture for advice-giving. Advice-giving is special among knowledge based activities in that the original goal of a user seeking advice may be ill-defined and there may be a huge number of potential solutions for the user to choose from. The purpose of an automatic advisor is to help the user articulate his goals and then to generate candidate solutions for the user to accept or reject. The main computational problem to be solved is one of controlling the cooperative functioning of several sources of knowledge, which may use different representational schemes interpreted by different inference engines. A promising architecture appears to be one which considers each knowledge source to be an independent agent, which only communicates with other such agents via a global data structure, under the supervision of a flexible scheduler capable of reasoning about control. In addition to architectural issues, the project emphasizes the importance of user modelling in man-machine dialogue and the use of large databases to provide an advisor with comprehensive information.

3.1.1.5. **Supporting B-type Research Themes**

B-type proposals in support of area 3.1.1 are invited. Some of these may lead to A-Type projects later. Candidate topics include:

— differentiation, classification and extension of Knowledge Representations for various domain classifications, paradigms employed and inference/processing models used

— experimental approaches to Knowledge Representation, their specific ranges of application and their integration

— inference techniques, especially for KR formalisms that have no known proof algorithm

— meta-level reasoning,including problems of self-reference and system 'self-awareness'

— real-time inference techniques

— techniques for planning and programme synthesis

— structuring of inference techniques, and the role of meta-knowledge

— automatic adaptation and enhancement

— inference under conditions of conflicting and uncertain knowledge

— the impact of Knowledge Representation on inference techniques

— default and closed world reasoning

— non monotonic, and proportional dynamic logic

— bypassing mechanisms for dealing with inconsistencies

— reasoning in terms of physical objects and images

— parallelism of KBS and its representation

Note that proposals related to this area are also invited in areas 2.1.3.4, 4.4.3.1, 5.5.2 and 5.4.2.

3.1.2. **Knowledge Acquisition and Learning Techniques** (Type A)

Description

The knowledge acquisition process is complex and a major effort is required in this direction to speed up the development of KBS. It is important to differentiate here between (a) the knowledge extraction from human experts to set up a particular KBS, (b) learning by the KBS and (c) the optimization of the KBS. Although interrelated, they are distinct processes. Therefore it is mandatory to develop concepts to support the development of systems for knowledge elicitation and modelling. A multidisciplinary approach, which takes into account cognitive and psychological aspects, is needed to develop a set of toolsranging from knowledge editors to automatic KB constructors. KR tools will be presented with a valuable test bed in this area. This task covers the extraction or elicitation of knowledge, the identification of appropriate models of learning and the investigation of learning techniques appropriate for AIP systems.

Milestones

Year 1984/85:

— Idenfication of models and tools; early implementation for testing

— Design of internal data structures and operations for a program which learns.

Year 1985/86:

— Preliminary testing of KBS which learns from the expert

Year 1986/88:

— Full-scale commercially valuable learning experiments with the program.

Proposals for A-type (and supporting B-type) projects for area 3.1.2 are invited.

Candidate B-type research themes include:

— development of techniques for knowledge extraction

— concepts, algorithms and techniques to support the development of programs and machines which learn

— identification of appropriate models of learning

— investigation of learning techniques appropriate for AIP systems

— advice transformation systems

— capabilities of an advanced system to measure its own performance and to improve such performance.

Note that proposals related to this area are also invited in areas 4.1.2.5 and 5.4.4.

3.1.3. **Knowledge Manipulation** (Type A)

Following early work on Knowledge Representation (3.1.1), experience from early Applications and studies of Knowledge Engineering measures (3.1.7), and studies of Dialogue (3.1.4), the needs for methods and tools associated with the practice of the Knowledge Engineering skill will become clear. The environment for Knowledge Manipulation will of course be completely interactive, and be aided with Graphics. Work in this area will include:

— Knowledge revision and retrieval

— Consistency checkers

— KRS proof checkers

— Knowledge Dictionary systems

— Knowledge Compilation

— Constraint propagation and truth maintenance systems

— Knowledge Transformation (different views of common Knowledge)

— Knowledge Abstraction from external sources

— Knowledge Acquisition/Process Analysis

— Guide and Tutor for Knowledge Engineering itself

— KBS Distribution and Automated Knowledge Maintenance

— Integration of Multiple Knowledge representation

This developing set of capabilities should be integrated into recommended 'European' tool kits for handling Knowledge. This project area is complementary to the larger ones in 3.1.1 and 3.1.2. A-type (and supporting B-type) proposals are invited for area 3.1.3.

3.1.4. **Dialogue and Natural Language** (Type A)

Description

A programme is required on the tools and methods for dialogue and communication languages which are natural to the domains in which KBS applications are to be competent. Included in this is the application of Knowledge and Context to the conduct and understanding of two-way dialogue, and of 'intelligence' to the interchange of dialogue initiative between system and client users.

The dialogue itself should enhance the quality of system behaviour by offering co-operation, understanding and modelling of personal behaviour and preference and paraphrase (all of which are Knowledge Based): it should also allow clients to interact with the system at various meta-levels whilst keeping track of all the context which may have to be returned to by system or client, following error or confusion. Explanation of KBS behaviour is absolutely critical to acceptance of such systems; this can be enhanced by interworking of the Knowledge about the user with that of the application.

Dialogue is more general than character string communication; it extends to the use of high bandwidth graphics, explanatory pictures and films, and audio support.

There is a need for a holistic, broad-coverage approach to communication through natural language, in order to support the construction of knowledge based systems and natural language front ends.

Milestones

Year 1985/86:

— Deliver Generators and Parsers for a variety of dialogue languages.

Year 1986/87:

— Specify and implement Knowledge Based Language processing tools

— Integrate Knowledge Based Language processing/dialogue tools into KBS applications.

3.1.4.1. 'ACORD: Construction and Interrogation of Knowledge Bases Using Natural Language Text and Graphics' (Ref. 393: A/84)

The ACORD project focusses on a trilingual system for the automatic construction of a knowledge base out of a natural language text and an intelligent retrieval and manipulation system aimed at casual users. The knowledge base will be built from documents combining text and graphics (encyclopedia or technical type) and will be logic oriented. The deep representation will be accessible from several components of the systems interface. The analysis of texts will be based on recent results in theoretical linguistics (discourse representation theory and functional grammars).

To support dialogue, the system will select appropriate presentation of output, text or graphics, and identify relevant information for output, in a symbiotic interplay of graphics and natural language. The graphic module will build on recent work on knowledge representation of graphical operations and on graphics linked to text dialogue. The programming environment will be PROLOG.

3.1.4.2. 'Communication Failure in Dialogue: Techniques for Detection and Repair' (Ref. 527: B/84)

The first task of the project will be to identify the circumstances in which dialogue participants fail to communicate, to discover how participants detect communication failure, and to discover what techniques they use to re-establish communication. The dialogues considered will be of two types: person-person and person-machine. Both their verbal and non-verbal aspects will be studied. The next stage of the project will be the development of a formal model, encompassing both the above aspects, and embodying useful detection and repair strategies. Finally, a computational implementation will be used to develop language-processing tools which can be incorporated into knowledge-based systems.

3.1.4.3. 'Knowledge and graphics based system for dynamic environment' (Ref. 600: B/84)

This project will investigate dialogue principles on the background of the following application. Supervision and control is in many respects equivalent to access to a data base containing historical plant data, being continuously updated. The aspects of dialogue, which will be studied in this context are:

— *principles for dialogue, where dynamic generation of graphics is an essential element;*

— *principles for adaptative dialogue, where the system adapts to the situation;*

— *principles for the description of industrial plant, which can be used as 'data dictionary' for the historical data base.*

The project will be based on the implementation of a prototype, which will be used for experimentation and thereby for identification of research topics. Research into these areas will be pursued in parallel.

Proposals for additional supporting B-type proposals are invited for area 3.1.4. Candidate research themes include:

— natural language systems architecture

— application of existing and developing techniques in cognitive psychology and psycholinguistics to dialogue and natural language processing

— efficency-oriented, broad coverage approaches to the natural language interface (including context and semantics)

— natural language approaches to knowledge representation

— empirical user studies on mixed language-graphics interfaces

Further A-type projects may be invited after 1986.

Note that proposals related to this area are also invited in areas 4.1.3.6, 4.2.4.5, 4.2.5.2 and 4.2.5.6.

3.1.5. **Implementation Languages and Environments** (Type A)

Description

Evaluation of, recommendations on, and extension of, candidate implementation languages for tools of the research programme and as tools for Knowledge Engineers engaged in the construction of KBS applications. This should include languages for Knowledge Modelling and for specification/design prototyping of KBS components. Later work should concentrate on establishing standards, which manufacturers will then treat as a safe base for significant hardware investment. An important aspect of language evaluation is the richness and utility of their embedded development environments. It is expected that the Software Engineering portable common tools programme (PCTE) will address portability.

Milestones

Year 1984/85:

— Identify and evaluate candidate languages (for example Smalltalk, LISP, PROLOG, POPLOG) environments and architectures

— Publish critiques and recommend changes e.g. language extensions to exploit parallelism

— Implement extensions

Year 1985/86:

— Issue guidelines to ESPRIT

— Make reference language systems available.

3.1.5.1. 'Advanced Logical Programming Environments' (Ref. 363: B/84)

To study and develop the tools necessary to a very high level Programming Environment for a Logical Programming language like PROLOG. The project merges several academic and industrial research groups working on this subject. Besides the usual Programming Environment facilities it aims at improving the programmer's reliability by taking advantage firstly of the relational nature of Logical programming which allows clear executable, but maybe inefficient, specifications and, secondly, of its good behaviour relative to theorem proving which allows much better verification and validation possibilities.

Proposals for A-type projects in area 3.1.5 are invited. Proposals for supporting B-type projects are also invited and candidate research themes include:

— higher level implementation languages for Knowledge Representation and inference

— adaptation of formalisms for real-world knowledge to practical implementation languages for KBS

— languages and environments for concurrent processing and for the integration of formal, structured 'software engineering' with KBS requirements.

Note that proposals related to this area are also invited in areas 2.1.3.5 and 2.3.3.3.

3.1.6. **Interpreters to support high-level knowledge representation formalisms** (Type A)

The objective is the rationalisation and re-implemenation and improvement of interpreters (compilers) for the various knowledge representations and manipulation methods developed from ad-hoc implementations in areas 3.1.1 and 3.1.3. This project area will not commence before 1986.

3.1.7. **KBS and Their Metrication** (Type A)

The objective is an on-going programme, over at least 5 years, of construction of Demonstrator KBS applications, using state-of-art facilities (hardware, software and large databases) available at the time, so as to maintain an up-to-date pool of expertise on Knowledge Engineering Skills and on classification of domain characteristics against available tools and methods. It will be a vehicle for learning about the strengths and weaknesses of the tools and methods used for Process Analysis, Knowledge Representation and Manipulation, Inference and Processing, Problem Solving Paradigms and Human Factors/MMI.

This particular project covers the first phase of the on-going Demonstrator Programme, with a switch over of resources from the fifth year into project 3.1.8 for the second phase of the Demonstrator Programme.

Since the tools and methods vary for domain classes showing major differences in character, Demonstrators should include widely varied examples in fields of Creative Design, Production Control, Diagnosis, Systems Modelling, Signal Processing, Decision Making and Software Engineering. As such, this programme will be a crucial source of education, and of direction for on-going/future research programmes, and of experience for making marketable KBS applications.

Almost nothing is known about the practice of Knowledge Engineering as a human skill, or about KBS performance, evaluation, measurement and acceptability in terms of client productivity. It is necessary to identify those metrics which are of significance and to establish methods and tools for their measurement — quality of knowledge is crucial but difficult to metricate. This work must also create a 'tools and methods' kit for Knowledge Engineers to size KBS applications in terms of construction and client usage resources, and in terms of the most appropriate system components. It is important to coordinate the development of toolkits and to ensure the distribution of tools within Esprit, but also to be aware of the dangers of too-early standardization.

The metrication part of this project cannot be overstressed: for industrial and commercial use of knowledge engineering to become properly established, it will be crucial to be able to predict both the costs and the benefits of KBS applications.

Knowledge Engineering will be a bigger bottleneck than software production if the issues of human productivity, as well as system performance, are not understood. As such, this work is very important in the top down design of KBS applications. Since new tools and techniques are added continually to the Knowledge Engineering repertoire during the ESPRIT Programme, this metrication work should be organised as a continuously rolling programme.

Milestones

Year 1984/85:

— Identify metrication aspects for evaluation
— Develop concepts and methods for solutions
— Make initial measurements on available KBS applications.

Year 1985/86:

— Develop metrication Tools and Methods
— Assemble KBS Demonstrator
— Record Construction Methods and Results.

Year 1986/87:

— Measurement and Analysis of Productivity and performance for the target applications
— Carry out experiments on Demonstrators to determine acceptability, impact on 'client' productivity and Life Cycle aspects.
— Report on Construction productivity and recommend new Tools and Methods.

Year 1987/88:

— Publish productivity and performance recommendations, and guidelines for Knowledge Engineers
— Demonstrate new automated metrication methods.

3.1.7.1. 'Real Time Knowledge Based Monitor for Business Processes' (Ref. 296: B/84)

KBS may be used to monitor the progress of a business system, such as production planning in manufacturing. In order to achieve this, the Knowledge Base must be a model of the production planning process, and the Fact Data Base must be a model of the status of this process. The task of the Control Engine consists of matching the status against the model of the process in order to identify the next action which has to happen. The control engine of the proposed system has features that go beyond those of traditional inference engines:

— *it is a real time system that responds to any change of the business status. Therefore the proposed KBS must handle real time objects;*
— *it has to be operational continuously.*

In order that the knowledge base be a model of the production planning process, this process has to be formally described. The concepts of activity, state and agent will be used. Mapping this formal model into the knowledge base poses representational issues, and

several techniques will be investigated. The project defines three types of knowledge acquisition tools, according to the source of knowledge (Business procedure, task sequence description including programmes, and user's mind).

3.1.7.2. 'Knowledge Based Assistant for Electromyography' (Ref. 599: B/84)

The aim of the project is to develop a knowledge based assistant to support physicians in all stages of an electromyographic (EMG) examination of patients with neurological disease. The result of the project will be a demonstrator system. In the short term expert assistance will be implemented on two separate, well-defined and important aspects of the EMG problem ; in the longer term a more ambitious system will be developed to provide more comprehensive assistance to the physician.

Proposals for A-type projects under 3.1.7 are invited. Also, proposals for B-type supporting projects are invited. Candidate research themes include:

— application of existing and developing techniques in cognitive psychology to KBS
— representation and use of general and specific real-world knowledge
— complexity metrics for KBS
— measures of completeness, consistency
— applicability of General Measurement Theory
— whole life-cycle of KBS; human acceptability and productivity aspects for both developers and clients as well as technical performance issues.

Note that proposals related to this area are invited in areas 2.1.3.4, 2.1.4.3, 2.2.4, 5.4.3 and 5.4.4.

3.1.8. **Advanced Generation KBS Applications** (Type A)

This project will cover the development of advanced Expert and Knowledge Based Systems incorporating learning, approximate and meta reasoning with common sense capabilities. KBS applications will have to be exploited by non-specialists who will expect from these systems not only formal and approximate reasoning processes, but also common sense reasoning processes similar in effect to those of humans.

Many applications where reasoning is needed involve some kind of approximate reasoning. For instance, applications of modelling where qualitative heuristics characterise most learned human experience.

The advanced generation of KBS applications will be expected to exploit the lessons of first generation attempts (3.1.7), the fruits of KRS and Inference research (3.1.1), the tools of Knowledge Manipulation (3.1.3), the latest languages and engines (3.1.5/3.1.6), the fruits of Natural Language processing research (3.1.4), and the fruits of the External Interfaces programme (3.2) for handling Speech and Images. Therefore no project in this area is intended to start before 1989.

R & D Area 3.2.: External Interfaces

Description

This area is concerned with how the computing system communicates with its environment, with particular reference to the use of speech or visual signals. Thus the work in this area deals with recognition, interpretation and synthesis of signals.

Two types of external interface occur. Those that extract their information by direct natural communication, and those that acquire knowledge by means of their sensors. In either case the system will need to process the signals to understand and interpret their significance. Aspects concerned with human factors, e.g. user-friendliness, are covered by Area 4 — Office Systems.

R & D Topics

Work in this area falls under three main headings:

3.2.1. **Image processing**

— Two-dimensional picture processing
— Depth and motion analysis
— Picture synthesis

3.2.2. **Speech recognition**

3.2.3. **Other**

— Multi-sensor signal processsing
— Optical signal processing

3.2.1. **Image processing**

3.2.1.1. **Two-dimensional picture processing** (Type A)

This topic is concerned with processing of 2-D images, concentrating specifically on the information contained within the image in the form of features such as edges, texture, shape, etc. Techniques that treat the image merely as sampled data are not included. This area is an essential prerequisite for all high-level image processing work, as well as having many direct applications.

Milestones

Year 1985/86:

— Demonstrate improved feature extraction techniques

— Determine performance measures

Year 1987/88:

— Implement efficient hardware modules

— Construct systems for chosen applications.

See 3.2.1.2 for ongoing A-type project. Supporting B-type proposals are invited.

Proposals related to this area are also invited in 4.2.2.1.

3.2.1.2. 'Advanced Algorithms and Architectures for Signal processing' (Ref. 26: A/83)

Main objective of the project is to develop a real time signal processing system that is designed to be compatible between first (i.e. feature extraction) and successive (i.e. recognition and understanding) levels of computing functions. The work has therefore been planned to run in three parallel areas : speech analysis, image analysis, signal recognition and understanding. To have a realistic framework for the project, specific applications will be identified and a system breadboard will be assembled and used as a demonstrator unit to provide benchmarking and testing. An identification of different processing levels with defined interfaces stresses possible degrees of commonality, and is aimed to encourage harmonisation and standardisation.

This project covers the topics of 3.2.1.1, and 3.2.2.

3.2.1.3. **Depth and motion analysis** (Type A)

This topic helps to bridge the gap between image analysis/feature extraction and scene understanding. The techniques for depth and motion analysis have considerable commonality, although the applications may be as diverse as video coding or robotics.

Milestones

Year 1985/86:

— demonstrate analysis techniques e.g. binocular stereo and optic flow.

Year 1986/87:

— Design and implement efficient hardware modules.

Year 1988-89:

— Demonstrate in real time application.

Proposals are invited for A-type and supporting B-type proposals, in addition to the ones described in 3.2.1.4 and 3.2.1.5.

Candidate research themes include:

— geometric reasoning

— generation of sparse reliable image representations suitable for correlation in stereopsis and optic flow.

Proposals related to this area are also invited in 4.2.3.7 and 5.5.1.

3.2.1.4. 'Image and Movement Understanding' (Ref. 419/420: B/84)

The project is concerned with the construction of a machine vision system, via a 3D model of scenes of moving objects. This concerns the integration of low level features for 3D shape and motion analysis, the iconic representations and matching techniques and the study of cognitive modelling. The project also aims at understanding the writing process by acquiring knowledge about the mapping from lingiustic material to hard trajectories. A signal processing stage will aim at building an appropriate symblic description of cursive script in terms of primitive elements such as strokes.

3.2.1.5. 'Real time generation and display of the 2.5D sketch for moving scenes' (Ref. 532: B/84)

The project will develop and implement a fully engineered demonstrator prototype of an imaging system which is capable of producing a form of 2.5 D sketch directly. This sketch, in which image intensity will be related to range, will be in one-to-one pixel correspondence with an illumination intensity representation which will simultaneously be generated. The geometric characteristics of the proposed system permit range accuracies of a small number of millimeters at range of one metre to be achieved theoretically. Statistical operations performed on successive range estimates should permit a marked improvement over the single measure resolution.

3.2.1.6. **Picture Synthesis** (Type A)

Picture synthesis is especially important in a scenario where computers simulate parts of the real world.Very fast graphics processing techniques are as important as flexible storage techniques for images.

Supporting B-type proposals are invited.

3.2.1.7. 'A study of Real-time Perspective Synthesis' (Ref. 411: A/84)

The purpose of this R & D work is to study picture synthesis through an intercommunicating man-machine system. Based on prior R & D work, it will be possible to design a very compact 20 Gigabits sequential/random read only memory and high speed processors which can supply picture Synthesis techniques in real time at the end of the 80's. The main work will be to establish the interface hardware and software techniques which are required for the completion of an experimental system. As a representative model, to identify desired design features, the picture synthesis will be used on a 3D map display mix of computer graphics and images.

3.2.2. **Speech Recognition** (Type A)

Flexible input of data into systems by speech is needed as this is man's most natural signal. Because speech is normally produced in connected form it is not enough to recognise only isolated spoken commands. Speaker independence and insensitivity to noise are other important requirements. The AIP research in this field is expected to cover the more fundamental aspects, while the parallel work in the Office Systems programme is part of the development of an integrated office workstation, including also speech synthesis from text.

Milestones

Year 1985/86:

— Demonstrate algorithms for ca. 1 000 word speaker dependent recognition and ca. 100 word speaker independent recognition.

— Report on architecture definition.

Year 1986/87:

— Simulate specialized integrated circuits.

Year 1987/88:

— Demonstrate use of specialized circuits in real-time recognition system for above specifications.

See 3.2.1.2 for ongoing A-type project.

Supporting B-type proposals are invited.

Candidate research themes include:

— phonetics

— syntax, semantics and context (see 3.1.4)

— psycho-acoustics.

Note that proposals for related work are invited in areas 4.2.4.3 and 4.2.4.5. Text-to-speech work is in 4.2.4.4.

3.2.3. **Others**

3.2.3.1. **Multi-Sensor Signal Processing** (Type A)

This topic is concerned with the processing and correlation of multiple streams of signal information, a problem of increasing importance in many areas where multiple sensors are used to acquire information at different points or about different aspects. Examples occur in the areas of process control, CIM, earth resources and biomedical signals.

Milestones

Year 1985/86:

— Establish techniques for correlating between different signal sources

— System design for specific application.

Year 1986/87:

— Construct demonstrator.

Year 1987/88:

— Complete and evaluate demonstrator.

Proposals are invited for A-type and supporting B-type projects.

Note that related work is described in 5.5.1.

3.2.3.2. **Optical Signal Processing** (Type A)

Optical processing offers a potentially enormous bandwidth with processing at the speed of light. It is particularly suitable for global operations involved in pattern recognition e.g. filtering, correlation, convolution. Work is required to develop a high performance electro-optic interface and to develop real-time 2-D processing techniques. A non-linear process known as degenerate four wave mixing (DFWM) also has considerable potential. Also research into optical processing architectures and system design is needed.

Milestones

Year 1985/86:

— Specify performance requirements for likely processes

— Evaluate and implement into system.

Year 1986/87:

— Extend systems e.g. include Mellin-Fourier Transforms. Implement improved materials/ architectures.

Year 1987/88:

— Construct compact practical processors for identified applications. Highlight areas for future research and development.

Proposals for A-type and supporting B-type projects are invited.

Note that related work is described in area 1.5.

R & D Area 3.3.: Information and Knowledge Storage

Description

Knowledge based systems are designed to derive information from r stored data and to indicate their line of reasoning in arriving at a conclusion. The effectiveness of any knowledge based system is determined by the quality of its knowledge base (its completeness, validity and accessibility) and of the architecture, function and performance of its knowledge store and its deduction mechanism. These concepts will also be useful in improving the accessibility of more conventional databases to the human user, so coordination is needed with the evolutionary improvements in database management systems (DBMS) proposed in Software Technology projects.

This R & D area investigates the new forms of organisation which will be necessary to hold and process representation of data, knowledge, and meta knowledge.

The main objectives of this area are:

— the definition of information and knowledge storage organisations, especially machine aspects;

— the identification of functional partitions, structures and mechanisms including distributed and very large knowledge bases;

— the development of new storage structures and devices;

— the introduction of new physical principles to support new storage devices (e.g. optical, biological);

— the realisation of adequate interactive techniques, especially for the non-expert user;

— automatic or semi-automatic construction of very large knowledge systems.

Work in this area will strongly depend on advances in knowledge engineering and memory technology.

R & D Topics

The topics to be covered by this area are as follows:

3.3.1. Interface between Storage and Environment

3.3.2. Data and Knowledge Bases

— Knowledge Bases for AIP

— Distributed Data Bases and Knowledge Bases
— Advanced DBMS and KBMS

3.3.3. Storage Structures and Architectures
— Database and Knowledge Base Oriented Architectures
— Performance Models for Storage Structures
— Storage Architecture

3.3.4. Medium-term research on applications of new magnetic and semiconductor storage media

3.3.5. Long-term Research on Optical and Biological Storage.

The work in the early years will concentrate on gaining experience in knowledge storage and corresponding access/dialogue techniques.

3.3.1. **Interface between Storage and Environment** (Type A)

3.3.1.1. 'A Logic-oriented Approach to Knowledge and Data Bases Supporting Natural User Interaction' (Ref. 107: A/83)

This project covers:

— *A user/machine interface in natural language (German and English) enriched with graphical facilities;*
— *A human oriented high level representation for malism based on (an extension of) first order logic;*
— *A machine oriented representation formalism also based on logic but intended for efficient reasoning;*
— *A 'machine' integrating data and knowledge stored in the machine oriented formalism with the knowledge and data stored in existing tools.*

3.3.1.2. 'Intelligent Help for Information System Users' (Ref. 280: B/84)

The project proposes to investigate approaches towards helping users of information systems learn optimally to exploit the functions of those information systems. These approaches will be operationally implemented in the form of a prototype HELP system to provide guidelines, instructions and explanations to user requests for IES facilities.

Major components of a HELP system are:

(a) a set of Information System Paradigms (ISP's), which are conceptual representations of the system helping the user to understand it;
(b) a set of generic user models, related to the ISP's;
(c) a library of explicit and implicit teaching and coaching strategies;
(d) a set of explanation facilities to provide specific information and explanation to heterogeneous types of users;
(e) a control structure for the organization and management of the helping process.

The development of an intelligent HELP system requires extensive empirical research on the naive conceptual models of information systems held by many users, on the potential value of the users of ISP's, on the acquirability of such a new paradigms, on the effectiveness of various coaching strategies and explanation procedures. It is also necessary to consider the appropriate underlying knowledge representation formalisms.

Candidate research themes for supporting B-type projects in area 3.3.1 include:

— security and associated issues in group usage of common knowledge bases
— behavioural and cognitive studies.

3.3.2. **Data and Knowledge Bases**

Evolutionary developments of conventional databases are dealt with under Software Technology (2.1.2); it is expected that work in this section of AIP will incorporate new approaches from other directions.

3.3.2.1. **Knowledge Bases for AIP** (Type A)

Studies are proposed to establish the interfaces, formalisms, languages, hardware and software components which are required for the construction, distribution, functional partitioning and hierarchic structuring of KB,including formulation of inference and data query access at levels ranging from human-visible to those internal to the new generation of sys-

tems. The focus of this work is to investigate commonalities and specifics in the architectural models of database and knowledge management systems.

Milestones

Year 1986/87:

— Develop KB specifications and model on a computer

— Define system standards and structure and supporting specialised hardware.

Year 1987/88:

— Prototype implementation.

3.3.2.1.1. 'Advanced Data and Knowledge Management Systems' (Ref. 311: A/84)

The project establishes a connection between the methodologies developed for data base (DB) management and organisation and the techniques developed in the Artificial Intelligence (AI) community for representing and using knowledge bases (KBS). The project aims at the definition of an advanced system which allows an intelligent and efficient management of large amounts of information stored in it. The following topics will be addressed:

1. *Definition of information and knowledge storage organisation for effective deduction and retrieval of facts from a specific domain using possibly incomplete and inexact knowledge about the domain (and related meta-knowledge).*

2. *Definition of optimisation techniques at the domain independent level as well as at the domain dependent level for efficient access.*

3. *Verify completeness, adequacy and efficiency of the proposed solutions, construction of a natural language interpreter.*

The project will also address issues related to logic programming, with the goal of comparing the two approaches and, eventually, of finding out criteria in favour of the adoption of one of them, in order to start the design of a system embodying the selected approach.

3.3.2.1.2. 'Advanced Knowledge Base Management System' (Ref. 530: A/84)

The project aim is to study and develop a prototype of KBMS, obtained by integrating the data base technology with an inference component, based on logic programming technology. The first of three parallel tasks will focus on the relevance of the data base technology to the overall performance of KBMS. Different integration mechanisms and different strategies for knowledge partitioning will be evaluated with respect to performance and reusability of existing data bases. The outcome of this research activity will be the definition of requirements on architectural models for integrating inference and data base machines and a software KBMS prototype. The second task will study the basic problems related to distributed KBMS and very large knowledge-based systems. Options using distributed DBMS and/or defining the distributed architecture at the inference component level, will be considered and a structure will be chosen for prototyping. The possibility of using the data base technology to store the deductive knowledge will also be studied as a possible solution for very large knowledge-based systems. The third task will focus on tools (typically concerned with various user interfaces) for building and using knowledge-based systems and on the use of metaknowledge.

3.3.2.1.3. 'Knowledge Based User Friendly Interfaces for the utilisation of Information Bases' (Ref. 641: B/84)

The project is to define and develop a knowledge-based system to provide user-friendly interfaces to existing and new databases and knowledge bases. The system will:

— *Refer to a semantically rich high-level representation describing both the conceptual content of the knowledge base and databases and the man-machine dialogue;*

— *Provide an interface to existing databases stored in a network of heterogeneous nodes. Extracted data may be organised in the local database of the system. The schemata of existing databases will be described by semantic data models;*

— *Provide a user friendly interaction in order to support the navigation of a user through the conceptual description and the querying of databases and to allow the end-user to develop advanced applications using both knowledge and data.*

The work consists of:

— *Selection of the appropriate formalism;*

— *Development of a standard interface to heterogeneous distributed databases based on a conceptual data model;*

— *Development of an interaction methodology between the user and the system based on logical independence;*

— *Development of an advanced application environment for end-users concerned with modelling some reality, handling existing data and knowledge and creating solutions to standard or unexpected problems;*

— *Feasibility study, logical design and prototype implementation of a system based on the above described principles that provide an optimal execution;*

— *Testing of the quality of the system by means of some realistic applications.*

3.3.2.2. **Distributed DB and KB** (Type A)

There will be a study in parallel to 3.3.2.1 aimed at establishing additional 'access' formulation languages, formalisms, interfaces and technology which are required for distributed knowledge based information systems. The study includes investigations on very large knowledge bases and its impact on (e.g. parallel) storage architectures. Distributed structures will be modelled and standards developed. Note that work in this area should maintain close liaison with related work in Software Technology (2.1.2) and take note of the requirements of Office Systems and Computer Integrated Manufacturing.

Milestones

Year 1986/87:

— Lay down hierarchical structures for distributed DB and KB and selected inference mechanisms.

Year 1987/88:

— Implement model on realistically-sized application.

3.3.2.3. **Advanced DBMS and KBMS** (Type B)

It is expected that distinctions between DBMS and KBMS will gradually disappear as advances from both directions influence each other. The last part of the project area therefore emphasises some advanced topics of Data and Knowledge Base Management Systems which are not realised in present systems and which will be useful in future DBMS/KBMS. These include the representation and manipulation of complex objects, exploitation of inference mechanisms, realisation of view mechanisms, semantic control and validation of queries. Proposals are invited for B-type projects, which may lead to later A-type projects.

3.3.2.4. **Other B-type Research Themes**

Candidate topics for additional B-type projects supporting area 3.3.2 include:

— comparative studies of knowledge representations with respect to the construction and use of very large and quasi-permanent knowledge bases;

— investigate relevance of formalisms utilised in knowledge representation, including issues of coexistence and conversion of different representations;

— investigate fundamental architectural issues, i.e. logical inter-relationships between the component 'machines' of a KBS such as:

  — KBM Machine

  — advanced interface machine

  — inference machine including impact on systems architecture of above issues:

— efficient utilisation of bulk data through hybrid interfacing of DB and KB systems;

— preliminary investigations on storage structures and architectures.

Note that related proposals are invited in 2.3.3.4 and that related work is described in 4.3.3.1, 4.4.2.1, and 5.4.4.

Advanced Storage Structure

The following subsections 3.3.3 to 3.3.5 describe research themes which are regarded for the time being as Type B, but which may well become Type A in the later years of Esprit. B-type proposals are invited, some of which could lead to later A-type projects.

3.3.3. **Storage Structures and Architectures**

In the last decade, different database-oriented architectures (intelligent controllers, software backends,

database machines) have been investigated. The motivation behind the approaches is essentially to free the powerful and expensive main computer from the burden of handling large amounts of data involving quite simple operations. This research theme will develop the potential for an integrated data and knowledge base architecture.

Performance Models for Storage Structures specify and target a system of metrics for, and quantification measurement of, the effectiveness of storage system structures.

Also, the storage architecture for the evolving semantic models of data definition, computation, inference, knowledge base and operational environment arising from project areas 2.1.2 and 3.3.2 need definition.

3.3.4. Medium-term research on applications of new magnetic and semiconducutor storage media

This list is not intended as exhaustive, but tries to identify current candidates, the selection criterion being those devices underpinning the requirements of advanced DBMS/KBMS best.

— *Discs with Thin Film Head Technologies.* Research is required for very high density recording both over floppy and over rigid discs; research will concern both new recording modes (vertical, transverse, isotropic) and technology for basic components (heads, media, substrates). Topics could include vertically anisotropic media, thin film heads with very small gaps, probe heads, Hall effect or magneto-resistive sensors. Concentration will be on physical access techniques to achieve random access inclusive of latency in the range 2-3 msec and latency in the range of 1-2 msec. Capacity should be from 1-10 Gbytes and non-volatile.

— *Embedded Search Logic in Thin Film Heads.* To achieve compact high performance disc systems development is needed of embedded parallel CMOS search logic in multiple thin film heads capable of parallel fuzzy search on multiple criteria in file store and of byte write operation.

— *Non-Absolute Content Addressable Memory.* Very large capacity fuzzy/non-deterministic/probabilistic matching content addressed memory of capacity greater than 200 Mb.

— *Mixed Logic High Density RAM.* Physical structures for word-wide memories, mixed logic and high density RAM on the same chip for ultra high speed storage/processing networks suitable for reduction on data flow networks.

The initial emphasis here is to define practical requirements and technological opportunities early enough to influence the development of the new devices for the latter phases of ESPRIT.

Proposals for work on new storage technologies are invited in Area 1.8 in the Microelectronics sub-programme.

3.3.5. Long-term Research on Optical and Biological Storage

There is considerable potential for large storage capacity using optical or biological techniques. Optical discs are already demonstrating potential as read-only memories. Biological methods of fabrication should allow very fine interconnection paths and thus highly compact construction. Current feature sizes used in RAM are of the order of 10 000 angstrom and are limited to 2-D construction. It is claimed that logic and storage elements of organic materials can be made with feature sizes of 20 angstrom and in 3-D structures using biological and genetic engineering construction techniques.

Research is required to provide read-write facilities using such techniques as magneto-optic, thermo-magnetic and amorphous crystal transitions. Basic research on materials is invited in Area 1.8; in this area of AIP proposals are invited for developments including parallel gigabyte memories, matricial read-write and internal codes.

R & D Area 3.4.: Computer Architectures

Description

This R & D area investigates the potential for new forms of computer architecture. While the traditional von Neumann architecture has a number of serious disadvantages the programme allows a gradual evolution of this well established architecture to extend the performance of established systems. However, VLSI technology provides the means of

creating alternative architectures using a large number of parallel processors running concurrent tasks. There are a variety of such architectures and many different types of applications which would benefit from these multiple processor approaches.

These alternatives cannot be considered as watertight compartments never influencing each other. In order to evaluate the alternative approaches, and the attributes, utility and performance of the demonstrators which will be built, metrics for computer architectures will be studied.

The results of this programme will provide a basis for the introduction of new computer architectures into appropriate application areas. In all these studies software aspects will play a central role. The impact of architecture evolution on programming environments will be carefully studied. Thereafter, an actual environment will be developed.

R & D Topics

The topics to be researched in this area are:

3.4.1. Ultracomputer, Multiprocessor Machines

3.4.2. Non von-Neumann Architectures

— highly parallel computer architecture
— dataflow machines
— reduction machines
— inference machines

3.4.3. Programming environments for non von-Neumann architectures

3.4.4. Machine interconnection architectures

3.4.1. **Ultracomputer Multiprocessor Machines** (Type A)

Description

The availability of VLSI has provided a means of constructing machines with large numbers of interconnected computing elements capable of concurrent operation. Each element is as powerful as machines currently in use. It is required to study architectures for such arrangements and identify their attributes, utility and performance in different applications. A demonstrator will be built capable of supporting one or more applications. The impact on software environment is a fundamental problem to be solved. The application will include large scale modelling and simulation (weather forecasting, hydrodynamics and economic modelling), as well as new algorithms for large vectorial and structure calculations.

Milestones

Year 1985/86:

— Feasibility study of design strategies.

Year 1986/87:

— Study and selection of architectural strategies.

Year 1987/88:

— Design and implementation of prototype.

3.4.1.1. 'Message Passing Architectures and Description Systems' (Ref. 440: B/84)

On the hypothesis that a message passing model of computation is the best way to achieve the capabilities of the next generation computers, the project will develop techniques for implementing message passing that overcome the deficiencies of currently existing implementations. These deficiencies not only concern performance or inadequate treatment of concurrency. One problem that will receive a lot of attention is persistence: how can one create actor-systems that continue to exist instead of being turned off and reloaded? The project will construct a package of knowledge representation primitives which includes formalisms, advanced control structures, flexible primitives for inheritance, and modules for implementing user interaction. These primitives will fully exploit the power of a message-passing framework. At a higher level, a description system will be designed and implemented based on the knowledge representation primitives. A description system is closer to natural communication and therefore to advanced user interaction. New styles of programming such as programming by example will be demonstrated. At the end of the project, there will be:

1) a solid implementation of message passing;

2) techniques for exploiting specialised concurrent hardware to implement actors efficiently;

3) a package of knowledge representation primitives, and

4) a description system and related interaction tools.

Proposals for A-type projects in area 3.4.1 are invited, together with additional B-type support projects. Candidate research themes for B-type proposals include:

— development of symbolic processing machines

— optical computers

— machine architectures to support actor-based languages

— optimization of strongly pipelined structures

— application to large-scale scientific calculations.

3.4.2. **Non-von Neumann Architectures** (Type A)

Description

The availability of VLSI has provided a means of contructing machines with very large numbers (e.g. greater than 1000) of interconnected computing elements capable of concurrent operations. It is required to study interconnection architectures and special components for realistic and cost effective solutions. The application targets are signal recognition and understanding, large scale modelling and logic programming. This study looks at the exploitation of interconnect strategies which will define an architecture and special associated components. A demonstrator will be built including the software to support the chosen languages.

Data flow machines use the principle of single assignment i.e. they restrict the number of values of each manipulated object to one. The architecture is characterised by a parallel data-driven control structure and a 'by value' data mechanism. Data Flow offers the possibility of increased performance in AIP. This part of the project area will consider the attributes in a range of applications and provide a basis for design choice in the application of data flow machines. A demonstrator will be built. Impact on software will be examined.

Reduction machines (well suited to the execution of applicative languages, such as pure LISP, Backus FP, KRC) can be demand-driven i.e. a function application is 'fired' when its result is required by a surrounding function application. The data mechanism can be 'by value' (string reduction) or 'by reference' (graph reduction).

Inference machines are special purpose machines dedicated to deductive operations. They are important because logic programming is one of the foundations of knowledge engineering and also because of the power of inference and pattern matching techniques in deductive systems used in expert systems. Currently inference mechanisms in languages like Prolog are realised through software on conventional computers. Parallel execution of these languages is required. Appropriate hardware mechanisms will be proposed after study of related algorithms.

Milestones

(a) Highly Parallel Architecture:

Year 1985/86:

— Feasibility study and selection of interconnection strategies.

Year 1986/87:

— Simulations and definitions of basic VLSI components.

Year 1987/88:

— VLSI component development and simulation.

— Produce operational mock-ups.

(b) Data Flow Machines:

Year 1985/86:

— Develop and simulate alternative architectures

— Select application(s) and candidate architecture(s) for demonstrator.

Year 1985/86:

— Specify and design data flow computer demonstrator.

Year 1986/88:

— Complete implementation of demonstrator.

Year 1988/89:

— Make initial assessment of attributes, utility and performance. Relate results back to application studies.

(c) Reduction Machines:

Year 1985/86:

— Select application(s) and candidate architecture(s).

Year 1986/87:

— Design reduction mechanisms.

Year 1987/89:

— Implementation in application domain; evaluation.

(d) Inference Machines:

Year 1985/86:

— Specify parallel inference machine as research tool.

Year 1986/87:

— Implement parallel research tools. Select applications for detailed study. Select approach to design of experimental parallel inference machine.

Year 1987/88:

— Specify and design experimental parallel inference machine using results of 3.4.1, and 3.4.2.Implement while continuing studies of mechanisms using research tool.

3.4.2.1. 'Parallel Architectures and Languages for AIP — a VLSI Directed Approach' (Ref. 415 + 313: A/84)

The prime objective of this project is to reduce the execution times required by A.I. applications by a substantial factor. This project aims to exploit a high degree of concurrency involving a large number of identical processing elements implemented in VLSI. A major criterion for the design of such an architecture must be that the cost of parallelism remains less than its advantages, except possibly in the very worst cases. An integrated system with hardware and software is therefore proposed. Programming the system is the crucial problem. It should be possible to use the parallelism of the hardware efficiently and at the same time to reason about the program. Ideally, a concurrent machine should support all three programming styles (object oriented, functional and logic) which will allow the full exploitation of concurrency, but the principles upon which such a machine could be based are not yet fully understood. All three styles will be explored through studies into machines which support each programming style separately, and through common working groups which will explore several areas of general relevance. There will be working groups on semantics, proof techniques, specification and design, etc, and five subprojects investigating the design of object-oriented, functional (both data driven and demand driven) and logical machines separately, and a machine which combines logic and functional programming.

These subprojects have a lot in common: all are based on message passing between identical units, here called PCMs, consisting of communication hardware, processing hardware and local memory. In addition to the subprojects and working groups, an application study group will be formed to select applications with which the various styles may be evaluated and their suitability for various fields of application established. Finally, special attention will be given to the dissemination of the results obtained by the working groups. This will take the form of seminars and workshops in which a number of people outside the project will be invited to participate, both as presenters and attendees.

Note: this large project addresses almost all the topics listed in area 3.4.2.

In order to ensure adequate coverage of this extremely important set of topics, additional Type A proposals are invited, as are Type B proposals in the revelant research areas, including signal processing architectures, flexible topology and reliability.

3.4.3. **Programming environments for non-von Neumann architectures** (Type A)

The environments for these new architectures, may have a structure quite different from conventional environments, and should offer facilities that assist the programmer in handling the implicit and explicit parallelism in the program. Of course a very close collaboration with the architecture studies of 3.4.2. is essential, and compatibility with the P.C.T.E (2.3.1.1) is highly desirable.

Milestones

Year 1986/87:

— identify facilities needed.

Year 1987/88:

— Feasibility study; identify design strategy. Study to what extent facilities can be common to the environments of the various parallel machines.

Years 1988/89:

— Design and implement prototype environment.

Proposals are invited for A-type and supporting B-type projects, including study of compilation techniques for vectorial and other novel algorithms.

Note that proposals for related work are invited in 2.3.3.3.

3.4.4. **Machine connection architectures** (Type A)

While the changes in processor architecture may be dramatic, the changes in computer systems will be evolutionary, partly because of the need to utilise existing hardware and software and partly because the concept of a non-von Neumann system is not yet fully formulated. The way to achieve this evolution is by the continuous prototyping of closely cooperating computer systems to benefit the application areas in ways such as improved performance, cost-effectiveness, ultra-reliability and graceful degradation.

The requirements are to establish the system architecture implications of the Office Systems and Computer Integrated Manufacturing programmesandtotaketheopportunities offered by developments in Microelectronics, as well as attempting to incorporate the moving boundary between hardware and software to ensure high-level end efficient implementations.

In order to keep in step with advances, projects in this area should be designed to produce prototypes in a very short time. As this project attempts to bridge the gap between component development and system application, very close coordination with the other sub-programmes of Esprit will be essential.

Programme

Continuous production of prototypes in various areas, with individual systems rarely taking more than one year from initial specification to prototype implementation.

Proposals are invited for Type A projects and for supporting Type B projects in this area. Candidate research themes include:

— system architecture opportunities and problems caused by advances in Microelectronics, AIP and other areas of Esprit.

— high speed bus development.

— networking of heterogeneous systems.

Note that related work is described in area 4.3.1.1 and related proposals are requested in 4.2.1.1. and 5.4.4.

R & D Area 3.5: Design and System Aspects

Description

This R & D area covers the urgently needed standards, special specification and verification techniques, design methods, general system methods, and catalogues of information and technical monitoring which are relevant to the other activities with the AIP sub-programme.

There are two key objectives here:

— to produce order out of the current diversity of approaches to AIP

— to develop techniques for producing reliable and trust-worthy AIP systems and for maintaining them as they adapt to changing circumstances.

Corresponding motivations exist in the Software Technology area and this activity will be co-ordinated with 2.1.3; however certain features of AIP justify the emphasis here. These are:

— the lack of any existing work which is attuned to AIP

— the need for such work, in view of the complexity, indeterminancy, adaptability and self-monitoring potential for AIP systems.

3.5.1. **A life cycle model of AIP systems** (Type A)

Description

This task covers the aspects of:

— Requirements definition and validation

— Design

— Implementation

— Testing

— Maintenance

— Configuration and project management and their associated techniques.

An important aspect of the approach which is adopted here is the introduction of a level of system specification intermediate between that of the external requirements and the internal software and hardware specifications. This intermediate level should reflect the nature of AIP systems, adopting appropriate primitive notions and relationships for specifying inference techniques, knowledge representations and other aspects, so that relevant AIP concepts can be described clearly in a way which may guide the design of software and hardware. However, it should be noted that the software-hardware level and the AIP conceptual level are often tightly inter-connected, so that the formalisms for either cannot be laid down without continued reference to the limitations imposed by the other.

The objective is to:

— identify an adequate range of effective methods and techniques of AIP systems production and maintenance, giving reliable, secure and tolerant systems.

— Provide tool support for these methods and techniques, assuming several levels of representation with incremental verification and validation.

Milestones

Year 1985/86:

— Reference model of system development and evolution.

Year 1986/87:

— Identify cohesive techniques and generic tools.

— Implement specific tools in a project environment.

Year 1987/88:

— Apply total Life Cycle Model to a representative (and possibly a focusing) project.

Year 1988/89:

— Update the method, techniques and tools following the practical evaluation, and publish final model.

3.5.1.1. 'Design of Techniques and Tools to aid in the Analysis and Design of Knowledge Based Systems' (Ref. 12 : A/83)

The main objective of this project is to develop a standard method for the analysis and design of knowledge based systems. This will lead to the definition of a Knowledge Representation Formalism which could handle concepts with a high level of abstraction and with a sensible efficiency. In areas such as medical diagnosis, structural analysis and recipe generation there will be major applications, allowing evaluation of techniques and the design of a functional classification of the different domains of human expertise.

Proposals are invited for a further A-type project covering all of area 3.5.1; close liaison will be necessary with area 2.2.4. Projects addressing individual parts of the life cycle, which should be prepared to act in concertation with other projects to cover the domain, are also invited.

The R & D topics to be addressed in this area include:

— Conventions for AIP Projects

— Security/Confidentiality of Knowledge and Data in AIP Systems

— State-of-the-art Intelligence Unit in Critical Basic Areas.

Due to their supportive nature, these topics can be characterised as type B. For some of them, an explicit partnership with one or several of the most appropriate type A projects (e.g. other AIP projects,

Software Technology) will be desirable in order to optimise overall synergy within ESPRIT.

Related areas include 2.1.4.3, 2.3.3.4, 4.5 and 5.1

3.5.2. **Advanced interactive environment for AIP** (Type A)

This task will develop advanced environments to support the formal interactive style of program development, as investigated by tasks in 2.1.3.6. Work is not expected to start before 1987.

Note that the work in the Software Technology area on environments for AIP is vital to progress in both areas so will be the subject of close liaison between them.

R & D Area 3.6: Focusing Projects

Concepts

The previous five R & D areas cover individual aspects of the advanced information processing (AIP) field. In addition to detailed programmes of work relating to the basic techniques, it is vital to the success of Esprit that the programme eventually include a number of integrated inter-disciplinary projects that span not only aspects of AIP, but also the other areas of the ESPRIT programme. Thus, where appropriate, these should be merged with other sub-programmes to achieve the size required consistent with the interdisciplinary nature of the focusing project. This section is concerned with these 'focusing' projects, but at the present stage of ESPRIT it is not possible to identify inter-area projects, so focusing is restricted to the AIP area itself.

It is intended that these projects should provide a set of goals that will act as foci for the interdisciplinary aspects of the work. Although the goals should be clearly visible at all times, their non-achievement within the timescale should not be construed as failure since many of the rewards will come in the form of a large number of small developments in the different fields. As a concept, they have been endorsed by all sections of the ESPRIT community.

Examples of criteria focusing projects are given in outline below. It should be stressed that these are merely examples chosen to illustrate the concept for focusing projects. It is important that the ESPRIT Programme include resources and effort to cover such projects. It is considered that initial focusing projects might well concentrate on preliminary studies for larger, strategic, demonstrator projects later in the programme.

Criteria

In formulating the criteria for choosing focusing projects it is possible to include wider aspects than those mentioned above. Some of the essential criteria for such work are discussed below. However, an overall consideration of flexibility should allow this programme to proceed to best effect.

(a) The project should indeed 'focus'. This could mean any combination of aspects such as:

— it utilises and brings together results and findings from multiple other areas of ESPRIT, both from within AIP and outside it (e.g. Software Technology, Office Automation, etc.)

— it combines and integrates results and findings of other ESPRIT areas

— it emphasises the interdependencies and anticipates and resolves potential conflicts between ESPRIT areas

— it provides for a two-way interaction between its own area and other ESPRIT areas.

(b) The project should be substantially realisable (feasible, realistic, achievable) within the proposed time frame, and have a clearly identifiable end point with that time frame.

(c) The project should at least exploit the state-of-the-art, or rather be at the leading edge, or, at worst, promise to bring forward the state-of-the-art substantially in ESPRIT.

(d) Some focusing projects should have relevance for the public at large, such as promising to be socially beneficial, or being socially attractive.

(e) The project should identifiably feed back information to other areas of ESPRIT, of two kinds:

— technological/scientific information

— 'realism' information.

(f) The project should have an applied nature, rather than be concerned with pure science.

(g) The project should result in at least a demonstrable prototype.

Example of large demonstrator (within AIP)

A project with clear public impact could be defined in the area of health care, where the knowledge engineering results from sub-area 3.1, those on multi-sensor signal processing and speech recognition from 3.2, knowledge storage from 3.3, architectures from 3.4 and project life-cycle from 3.5 could be brought together.

Programme for Area 3.6

In Year 1985/86 B-type proposals are invited to carry out surveys which will elucidate the foreseeable effects of the successfull implementation of information technologies in areas with clear public impact or with important implications for the quality of working life. The object of these surveys will be to define the requirements to be fulfilled by large demonstrator projects in the second phase of Esprit, and the management techniques which will be required to carry such projects through successfully in the multinational environment.

In Years 1986/88 A-type proposals may be invited to combine the results of work in areas of the Microelectronics, Software Technology and AIP sub-programmes, and possibly in Office Systems and Computer Integrated Manufacturing. It is hoped that large demonstrator projects could be started with sufficiently strong support from all sections of the Esprit community, and with sufficiently thorough preparation from the preliminary focusing projects outlined above, to proceed with confidence to the public demonstration of the achievement of Esprit.

SUBPROGRAMME 4

OFFICE SYSTEMS

Introduction to the Office Systems workplan

THE OFFICE DOMAIN

Information is an important instrument of competition. This concept is now widely recognised. Office Systems provide a major vehicle through which information can be applied as an aid to navigation through the present turbulent changes in business, technology, commerce and government.

While the potential contribution of information technology to improve effectiveness can be easily recognised, the delivery of solutions to the information problem areas is an entirely different matter. The problems are 'fuzzy' and frequently the solution processes appear to be artistic rather than scientific. The users of information frequently have little or no knowledge of the technological content and necessary technical processes that are involved in processing information.

The majority of users require solutions and not products. These solutions have to be reasonably complete and this implies that systems must be provided, not only in the sense of the interrelationship of the technical components (both hardware and software) but also in terms of the functions that these components perform as an application that yields a solution.

The challenges facing Office Systems development include:

— Understanding and supporting the non-deterministic tasks of a wide range of office workers and not just providing a technological update of traditional and limited office functions.

— Achieving major improvements in human-system interfaces that realistically allow productive use of office systems by a wide range of office workers.

— The development of solution/system oriented approaches to office problems. Delivering product elements and some services, and expecting

the user to create the total own solution cannot continue.

The market opportunity is large, particularly if the problems noted above can be solved. The European market is viewed by the IT industries of USA and Japan with great interest. Because of the size and homogeneity of the USA and Japanese markets, indigenous suppliers can develop sharply focused products, achieve economies of scale in their home markets, and then overwhelm foreign markets; such as Europe. Thus products and solutions from the USA and Japan, because of their wide acceptance, can establish de facto 'standards' that force European suppliers into a defensive copycat posture.

The key European opportunity relates to the development of system solutions. The implications of European requirements must be that these solutions have an adaptability, flexibility and inbuilt interworking capability that will be a real strength outside Europe. This will only be true if the application of technology reflects a degree of user sensitivity in advance of our major competitors.

Research aims of the subprogramme office system

Research work in the field of Office Systems can be characterized as follows: on the basis of fundamental and methodological developments in VLSI, software technology, and advanced information processing and some other fields, integrated and applied system solutions are developed which take into consideration user requirements and foreseeable modifications in the technical, social and economical field.

Office Systems are the key elements in the development from classical data processing to integrated information processing in administrations and industrial and service enterprises, by which the future work environment will be characterized. For that purpose, systems and communication networks with standardized interfaces are necessary.

In developing these systems which are very important for our industrial companies, aspects of human factors have to be considered in the early stages of planning. Only in this way can we ensure that the systems will be accepted later on by the users and that economic expectation will also be met. European industry is particularly well suited for this development because of its historical and cultural tradition.

Taking into account the abovementioned integrated approach, the subprogramme has been divided into five research areas. The aims are:

1. Office system science and human factors

(a) To analyze current and predicted office activities to determine how information technology might be applied to improve the effectiveness of office work and organization and of the enterprise as a whole. Besides automation of various functions and the use of knowledge-based methods, this means better support particularly for clerks, professional and managerial staff in executing their judgemental tasks.

(b) To improve understanding of human factors in the office and to ensure high performance of users when interacting with the systems, whilst at the same time offering optimal working conditions and ensuring adequate organization and individual acceptance.

2. Advanced workstations and human-machine interfaces

To establish major new human-machine interface technologies, peripheral technologies and document representation technologies and information. manipulation relevant to the development of advanced office work-stations for use in advanced office systems.

3. Communication systems

To create the basic technologies required for advancedoffice communication systems including technical fundamentals in communication systems architecture, optical technologies as a particularly significant technology, the management of resources connected by networks, and system aspects of value added services.

4. Advanced multi-media storage and retrieval systems

To acquire the system and applications expertise related to storage and retrieval of all forms of office information in electronic storage systems in a user organization in an adequate way.

5. Integrated office information systems

To create the possibility to check the validity of the total information concepts that are advocated, in environments that are realistic and allow quantitive evaluation.

INTERDEPENDENCIES WITH OTHER RESEARCH AREAS

Micro-electronics is a provider of basic technologies and hardware components to be used in office systems. General requirement characteristics are high speeds and capacities, very high reliability, and flexibility of the design processes. The need for basic technologies development is not confined to pure micro-electronics: opto-electronic technologies for transmission, storage and display that may increase capacity while reducing physical volume and price are equally as important.

Software technology is to provide an environment and the tools that should improve control of the office application development process. This is a prerequisite for the development and maintenance of the enormously complex future applications, if functional, performance and reliability requirements are to be met at acceptable cost.

The Advanced Information Processing area embraces researches into technologies and procedures that will be adopted directly in the system integration processes that are characteristic for the office systems programme. Of particular importance are the firm establishment of the discipline of knowledge based or 'intelligent' methods to solve problems, as well as the development of computers that are capable of processing vast amounts of information in real time, or fast enough to please the human user.

In Computer Integrated Manufacturing, certain techniques will be developed to high degrees of perfection, for instance those that adapt the computer systems to the dynamic physical environments in plants. Undoubtedly, the techniques developed will spin off to such domains as office system security and human-machine interfaces.

R & D area 4.1: Office systems science and human factors

DESCRIPTION

This research programme has been devised to give a better understanding of the office environment. Offices are the 'nervous system' of any enterprise. These must be organized, staffed and equipped for effective and efficient operation, and interfaced with other branches of the enterprise (such as research laboratories and manufacturing) and the external environment.

At present the understanding of this field is patchy. There is no formal science of office automation as there is for production automation. This programme, however, makes possible coherent approaches to on the problems, ranging from empirical studies to consistent operational classifications and definition of computer-based analysis and design tools.

Consistent with this approach, the main areas identified are (a) office systems analysis, (b) office systems design, (c) human factors and (d) the possible application of knowledge based methods. The analysis part of the programme delivers useful input for the design oriented phases.

It is evident that the incorporation of human factors, especially into a technology-oriented programme is an essential prerequisite for effective use and a broad acceptance of the envisaged systems and thus for their final economic success. The research programme therefore includes specific research projects on human factors related to the office environment and this leads to programmes for cognitive aspects together with work structuring, qualification and training. Human factors laboratories are also seen as key competence centers and katalysers, offering the possibility of unbiaised judgment about experimental systems and on commercial products.

R & D AREA TOPICS

The topics to be studied in this area include:

4.1.1. Office systems analysis

- operational and functional analysis of office requirements
- benefits analysis
- a glossary of agreed terminology
- analysis of human tasks within the office

4.1.2. Office systems design

- office system design methodology
- modelling and simulation of office information systems
- transaction monitor

— deterministic and judgemental functions
— techniques for user interface design

4.1.3. Human factors

— human factors laboratories (type A)
— human-machine cognitive compatibility
— qualification and work
— user aids and learning tools
— human-machine interface specification language
— natural language interpretation and production

TOPIC DESCRIPTIONS

4.1.1. **Office systems analysis**

4.1.1.1. **Operational and functional analysis of office requirements.**

Standard functions in an office are identified to reduce the requirements for customization. A classification of functions and their interdependencies is to provide clues for technological developments.

4.1.1.1.1. 'Functional analysis of office requirements' (Ref. 56 : B/83).

The primary goal of this project is the investigation and analysis of office functions through the application of a new method being developed. The project will provide guidelines for the evaluation of available office systems, and it will support the manufacturers choice of facilities to be integrated into the system. The project includes development of methods to assess key qualitative and quantitative benefits to be gained through the use of computer-based office systems.

The method developed will be applied to the analysis of information system requirements and to information technology assessment for important OS application domains.

B-type proposals will be checked against on-going work.

4.1.1.2. **Benefits analysis.**

This topic concerns both financially non-quantifiable factors (e.g. speed as compared to flexibility), as well as both concrete and abstract benefits (e.g. cost as compared to job satisfaction).

B-Type proposals will be checked against on-going work.

4.1.1.3. **A glossary of agreed terminology.**

Provision of a glossary on office system science is a prerequisite for harmonization and standardization of European research in the field.

B-type proposals are invited.

4.1.1.4. **Analysis of human tasks within the office.**

Projects shall produce a method for the analysis of human tasks within an office, in quantitative and qualitative terms. The method should be used to investigate human activities in a representative sample of office types and to predict the changes in task structure that could occur due to the introduction of integrated office systems.

New B-Type proposals are invited in this area.

4.1.2. **Office systems design**

4.1.2.1. **Office system design methodology.**

Overall design methodologies of computer-based office systems will be studied, implemented and the results validated in trial systems. The effect of human factors will be taken into account.

B-type proposals are invited.

4.1.2.2. **Modelling and simulating of office information systems**

Formal methods for the specification of office information systems; modelling and simulation of these systems.

4.1.2.2.1. 'Office support systems analysis and design' (Ref. 286+285: B/84).

The project aims to create a model for an integrated office system, based on the most recent studies, but going as far as possible in a total integration. In particular the following subjects will be addressed: modelling office tasks and activities, developing a language (grammar and vocabulary), developing a method for the specification and measurement of performance, producing design procedures for office system, assessing requirements for user-oriented information management systems.

B-Type proposals will be checked against on-going work.

4.1.2.3. **Transaction monitor.**

Description and definition of a system monitoring the transactions traffic in an office.

B-Type proposals are invited.

4.1.2.4. **Deterministic and judgemental functions.**

The specification of tools for the implementation of automatic, semi-automatic or human-interactive support processes in office systems applications.

B-type proposals are invited.

4.1.2.5. **Techniques for user interface design.**

Designers of office systems need to draw upon knowledge about techniques (e.g. icons, windows, menu selection, voice command, etc) for human-computer interaction. The systematic specification and classification (with respect to domain of application) of such existing and required techniques is necessary, to assist designers and to identify potential for new techniques.

B-type proposals are invited.

4.1.3. **Human factors**

4.1.3.1. **Human factors laboratories.** (type A)

This topic is concerned with the establishment of close cooperation of European Human factors laboratories, where research can be fruitfully and economically conducted, guidelines be developed, R&D personnel trained and advice given to development laboratories.

The work aims at the creation of managerial, organisational and legal structures to formalize the cooperation and the elaboration of a well-selected set of research topics by the laboratories cooperating and the distribution of the experiences gained.

Programme (–) and Intermediate Objectives (*):

Year 1:

— Elaboration of managerial, organizational and legal structures that consolidate the cooperation;

— Start of cooperation work in selected research areas.

* 12th month: Establishment of managerial, organisation and legal structures;

Years 2 to 5:

— Elaboration of training programmes, setting up and (re)allocation of specific research tasks among the partners, the elaboration of procedures for internal and external consultation, the execution of selected research.

— Development of standardized test — and evaluation procedures for Office Systems

* 24th month: Establishment of the first training programme in human factors;

* 48th month: Results of specific human factors research available.

4.1.3.1.1. 'Human factor laboratories in information technologies' (Ref. 385+455+560: A/84).

The project aims at providing a focussing point for human factors activities in Europe. Three major fields of activity can be distinguished:

The development of a methodology for the integration of Human Factors knowledge into IT products as an essential contribution to all parts of the design process cycle.

The expertise that will find its way into 1) will be gained in:

Investigation of interaction modes of the man/machine interface, and construction of a multi-modal MMI

to achieve optimal interplay from the point of view of human factors.

The expertise gained in 1) and 2) will be made available to the European industry as a whole by a) developing a software package for an integrated decision support system and b) by organising a broad programme of publications, seminars, workshops and consultancy activities throughout European IT industry.

In the pursuance of these objectives, the primary subject for study will be how people use information and for what purposes. User reactions to existing equipment will provide essential evidence for such studies.

The output of the work is expected to be an understanding of intrinsic human requirements independent of equipment, that can be applied at every stage in product design from abstract conception to the resolution of concrete design issues. There will be explicit recognition that as a consequence of the open-ended nature of the human use of information, conscious attention must be given to the interface between an information system and its human designers as well as its users. Some emphasis is given to user learning processes and their support by means of IT systems.

Proposals are invited that contribute to the on-going work.

4.1.3.2. **Human-machine cognitive compatibility.**

To develop and formalize description methods for cognitive task representation and problem-solving processes for knowledge workers.

4.1.3.2.1. 'Cognitive simulator for user interface design' (Ref. 234 : B/84).

This two-year project is aimed at the development of a simulation tool to assist designers in assessing the human cognitive compatability of particular interface designs for comparative purposes. Deliverables include the software package and user guide with a review of cognitive modelling and dialogue design guidelines derived from validation trials. The produced software must be compatible with the results of standarisation of e.g. operating systems.

No new proposals are invited.

4.1.3.3. **Qualification and work.**

The impact of the introduction of office systems on user qualification has to be studied; methods to increase user skill, especially in the sense of self-improvement by the user, should be implemented and evaluated.

B-Type proposals are invited.

4.1.3.4. **User aids and learning tools.**

The services, accessible for the user, especially on-line learning and help functions, will be investigated, defined and tested from a human factors point of view. Special emphasis shall be given to the tool character of the services.

B-Type proposals invited.

4.1.3.5. **Human-machine interface specification language.**

In order to study the full range of cognitive and physical interfaces between humans and integrated office systems, a language for the specification of the human-machine interface shall be defined, that will increae the effectiveness and efficiency of the study and the design of interfaces.

B-Type proposals are invited.

4.1.3.6. **Natural language interpretation and production.**

The aspects of natural language usage in the office environment are to be studied, in connection with automated office information systems. This includes the parallel usage of a number of natural languages. Guidelines shall be given as to how the problems that are identified can be solved. Solutions may be demonstrated by suitable experiments of limited scope.

B-Type proposals are invited.

R & D Area 4.2: Advanced workstations and human-machine interfaces

DESCRIPTION

The workstation is the user's gateway to the office system. User acceptance and user performance

depend on the design of the corresponding human-machine interface.

The most important channel for information input to the human user is the visual channel. This channel, as well as the bi-directional vocal channel, have evolved to provide information for motoric activities which should be adequately integrated in operating the interface. In consequence, VDU's and touch keyboards and speech receptors will emerge to form an integrated input/output device suitable to manipulate text and images by direct manual and vocal control. Preferably the screens should have the dimensions and portability of paper (electronic paper). Another approach to a more comfortable 'visual input' will be the large screen display. The need for multi-functional capabilities will require the development of devices which allow graphic input and editing, on-line handwriting and ideogrammatic conversation.

As long as there is no portable paperlike display, printing will be necessary and the need will be growing for faster, more versatile (text, graphic, colour) printers at low cost.

The provision of human-machine interfaces which support the complete range of functions traditionally carried out by pen or paper is necessary.

A high proportion of telephone or face-to-face communication indicates that visual and spoken information will be preferred whenever it is applicable. Visual communication will require the development of high definition colour video scanning devices with the necessary processing capabilities for efficient storage and transmission and the use of the multifunction flat panel display.

The vocal channel cannot handle as much information as the visual channel but is our most efficient carrier of natural language. Voice communication will require the development of sophisticated processing for improving the acoustic environment, and the development of coding schemes. Voice communication between man and the office system will require the development of efficient speech recognition and of a natural speech synthesizer.

An important aspect of facilitating the standardization of the interface with the human world and the paper world is easy-to-use formalized languages. These are to be designed in a way which allows the user, rather than the computer professional, to specify his needs directly to the system.

The implementations and testing of user decision support functions are considered to be imbedded in the workstation. Availability of these functions is supposed to be a key-factor in the competition among office products.

The development of specific system interface components should lead to a general architecture which will allow the integration of the subsystems in an architecturally homogenous solution. Although the work items are phrased in terms of integration into a physical workstation, proposals should not necessarily be confined to those which assume that all the associated functionality is resident in the workstation. Solutions involving distributed functionality accessed over communication links are equally relevant. Connections to local area networks and/or public networks should be considered.

Much of the software that supports the user will reside in the workstation. Any rules that are, or will be, agreed upon in order to improve portability of software, should be implemented. This applies as well to rules and agreements with respect to other aspects of the system.

R & D AREA TOPICS

The following R & D topics are identified:

4.2.1. System aspects

- System aspects of workstation design (type A)
- Workstation security
- Advanced multi-media human-machine interfaces

4.2.2. Vision

- vision interface (type A)
- flat panel workstation design (type A)
- high resolution video imager
- image coding

4.2.3. Paper

- paper interface (type A)
- advanced scanner
- advanced printer
- microfilm interface

— graphics coding
— graphics recognition
— intelligent graphics recognition

4.2.4. Speech

— speech interface (type A)
— speech coding
— speech recognition
— speech synthesis
— intelligent speech recognition.

4.2.5. Office languages & procedures

— office document architectures and languages
— office interface languages
— multi-media document manipulation
— intelligent user function support
— user to user multimedia communication

TOPIC DESCRIPTIONS

4.2.1. **System aspects**

4.2.1.1. **System aspects of workstation design.** (type A)

The elaboration of a general architecture which will allow the integration of the subsystems handling the multimedia input/output (viz. vision, paper, speech, language), the filing subsystems, expert systems and the network interfaces in an architecturally homogenous workstation both from the hardware, the software and the human factors point of view. This includes design of interfaces based on new technical solutions for user input/output.

Prototypes shall be developed and tested thoroughly in adequate environments and in sufficient numbers to allow qualitative and quantitative evaluation on a statistically sound basis.

Workstation is a generic term for a range of devices — including software — that serve as the active interface of the information system with the human user in a wide range of applications. For reasons of effectiveness of this programme, the projects selected are likely to address wide application areas or applications with versatile requirements.

A special case that required rapid development because of it's utility for the R & D itself is the research workstation, that itself may be an experimental prototype for another generation of office workstations.

Programme (—) and Intermediate Objectives (*):

Year 1:

— definition of a model of human-machine interaction;
— definition of computer performance, storage requirements;
— definition of the requirements of advanced interfaces;
— definition of workstation architecture, research workstation definition;
— impact on external communication services (if any)

* 12th month: specification of experimental workstation architecture;

Year 2:

— assembly of subsystems and start software development for experimental workstation and research workstation.

* 24th month: experimental workstation operational;

Year 3:

— completion of software experimental workstation and research workstation;
— test of workstation; evaluation of results.

* 36th month: experimental and research workstation evaluation;

Year 4:

— continued evaluation of experimental workstation in a number of environments (links with network and servers required);
— definition and construction of advanced workstation interface to multimedia input/output, filing system, network etc . . .
— completion of language interface.

* 48th month: specification of advanced workstation interface (multimedia network);

Year 5:

— assembly of advanced workstation;
— identification of test-sites, requirements.

* 60th month: advanced workstation operational.

4.2.1.1.1. 'Secure open multimedia integrated workstation' (Ref. 367+347: A/84).

The project involves the design and implementation of an office workstation (WS) which is based on the 'open systems' concept allowing the generation of standard protocols for communication media. It is thus possible to link the WS with different types of networks and with ISDN. The WS will be capable of

processing different types of information including: text, fixed and moving images, graphics, voice and hand drawings. The WS will use a network-oriented operating system to control multiwindows and a distributed database management system. Its main 'hardware' parts will involve: a 32-bit CPU, intermediate capacity of disk, high resolution screen, mouse, camera, digitizer and compressor of speech, loudspeaker, optical character scanner and appropriate networking circuits. These will be complemented by a device and procedures to control access.

A-type proposals are invited.

4.2.1.2. **Workstation security**

This area concerns the specifications and implementation of severe security requirements, at the workstation level, including user access and authorisation. This will also provide protection of confidential information.

B-type proposals are invited.

4.2.1.3. **Advanced multi-media user interfaces.**

The project involves the design and development of an experimental input/output device as part of a multimedia integrated workstation. The interface should provide the user-dialogue in simulation of office procedures, definition of office routines and the execution of advanced office tasks.

4.2.1.3.1. 'Intelligent workstation' (Ref. 82: B/83).

The goal of this project is to provide the office worker with an integrated workstation which is inexpensive enough and which can provide sophisticated services ranging from speech and graphics to expert level decision aids and automated report generation. The prototype workstation to be developed will be tested in environments providing communication facilities and connected file servers (see also area 4.2.5.2).

B-type proposals are invited, but will be checked against on-going projects.

4.2.2. **Vision**

4.2.2.1. **Vision interface** (type A)

The aim is to develop the advanced hardware and software that allows the digitization, coding, manipulation, decoding, visual presentation of images. An important consideration concerns the user acceptance of the image quality and the manipulation procedures for images. Colour, brightness, resolution and grey levels are important aspects in promoting human friendliness.

A substantial part of the research on vision is specified under flat panel workstation design.

Programme (–) and intermediate objectives (*):

Year 1:

— state-of-the-art study in image and video (entry, manipulation, storage, transmission
— specification of still video codec (64 kbit/s)
— specification of image manipulation functions at the user interface
— analysis of technological implications of videoconferencing requirements
— analysis of moving video requirements in enterprises
— specification of moving video codec (256 kbit/s)

Year 2:

— implementation of still video codec (64 kbit/s)
— implementation of image manipulation functions
— specification of videoconference experiment
— specification of a moving video information system
— analysis of impact of office document architectures

* 18 months: image handling state-of-the-art study
* 21 months: still video codec experimental prototype (64 kbit/s)
* 24 months: moving video requirements study
* 24 months: videoconferencing technological implications study
* 24 months: image handling at the user interface, experimental prototype

Year 3:

— continuing work on human friendly image handling

— requirements analysis for image generation in offices

— implementation of moving video information system

* 30 months: moving video codec (256 kbits/s)

* 36 months: videoconference demonstration

Year 4:

— development of advanced image handling system

— integration of image generation software

* 48 months: moving video system demonstration

Year 5:

— continuing developments

* 60 months: demonstration of advanced comprehensive image handling system

* 60 months: demonstration of small scale system, integrating most aspects of image and moving video: entry, storage, communication, generation and manipulation.

4.2.2.1.1. 'Interactive handling of digitized images at the user interface' (Ref. 79 : B/83).

This project will cover the different aspects of picture handling at the user interface in an office environment : processing, storage, presentation and manipulation. Among the aims of the project are the identification of user needs for picture handling in a multi-media interface, and the development of uniform descriptors for the picture properties.

4.2.2.1.2. 'Modelling and simulation of the visual characteristics of modern display technologies under office work conditions' (Ref. 612 : B/84).

The project aims at designing, engineering and building a simulator in order to test properties of the displays based upon new technologies. Specific objectives are: comparison of displays simulated according to user acceptability criteria; conducting a limited number of ergonomic experiments designed to simulate prolonged office work conditions to obtain more insight into architectural and technology factors related to quality and 'visual confort'.

A-type proposals are invited.

4.2.2.2. **Flat panel workstation design.** (type A)

Objectives

The objective is to contribute, through the emergence a variety of advanced flat panels, to the improvement of ergonomy and cost-effectiveness of O.S. workstations, and to the re-evaluation of the workstation concept that will lead to several classes of workstations such as 'classical' multi-media workstations, large wall displays and planning-panels, mobile workstations, write-view tablets, etc.

The objective is to achieve these goals in the medium and long term by a wide research programme that leads to a series of experimental prototypes of such stations.

The results of intensive research on new display technologies suggest, that a series of displays will become available with a variety of steadily improving characteristics in terms of size, resolution, speed, colour, grey levels, direct data entry, energy consumption, robustness, viewing angles, price.

Programme (—) and intermediate objectives (*):

Year 1:

— classifying future (work)stations incorporating flat panel technologies

— identification of display characteristics needed for a first generation of prototypes (definition, colour, grey levels, direct data entry)

— identification of the state-of-the-art basic technologies necessary to satisfy the identified requirements

— trade-off and adjustment of requirements and available basic technologies, leading to display specifications for prototyping

— feeding results of analysis of appropriate basic technology research into a future generation of flat displays

* 12 months: classification of future flat panel (work)stations

Year 2:

— completion of first generation experimental prototypes of flat display stations based on available technology

Year 3:

— test and evaluation of the experimental workstations integrating the first generation prototypes of flat displays

— identification of improvements to be made for next generation flat display prototypes

— establishment of specifications of a second generation of flat panel display prototypes

* 25 months: demonstration of first experimental flat panel workstations

* 36 months: updated classification of future flat panel (work)stations

Year 4:

— prototyping the second generation of flat panel display (work)stations

Year 5:

— completing the integration of the second generation of flat display prototypes

* 50 months: demonstration of second generation flat panel (work)stations

A-type and B-type proposals are invited.

4.2.2.3. **High resolution video imager.**

The research into high resolution scanners and their integration into office information systems.

B-Type proposals invited.

4.2.2.4. **Image coding.**

Devices for bit-rate reduction of video signals to 64 kb/s and 256 kb/s.

B-Type proposals invited.

4.2.3. **Paper**

4.2.3.1. **Paper interface** (type A).

The development of devices for the scanning, the hard copying of graphic information (like typewritten, printed, handwritten and combination thereof; including text and images of various kinds), and the processing at different levels (e.g. uncoded digital I/O, coding with redundancy reduction etc. . . .)

Programme (—) and Intermediate Objectives (*):

Year 1:

— study of the state-of-the-art of the technology for scanners; bit-map printers, graphics coding and recognition

— specification of omnifont recognizer

— specification of graphics coder.

Year 2:

— specification of a multicolour scanner

— specification of a multicolour printer

— realization of omnifont character recognition.

* 24th months: optical character recognizers.

Year 3:

— development of coding algorithms

— development of a multicolour scanner.

* 36th months: demonstration of scanner.

Year 4:

— development of a graphics coder

— development of multifont character recognition

— development of experimental multicolour printer.

* 48th months: demonstration of multicolour printer.

Year 5:

— development of a handwriting recognizer

— development of a multicolour printer-scanner.

* 60th months: demonstration of handwriting recognition; demonstration of multicolour printer-scanner.

4.2.3.1.1. 'The paper interface' (Ref. 295: A/84).

This project addresses the role of paper and paper-related processes in the context of advanced electronic office systems. Research will be conducted into techniques that efficiently handle information on paper, and that will promote the ultimate reduction of paper use.

Particular techniques considered are:

— *the electronic reading of previously prepared paper documents to encode image, and encode and recognize text and graphics;*

— *electronic representation of documents regardless of the original means of creation;*

— *the processing to reproduce an electronic document for different output media (soft copy, hard copy, and transmission);*

— *the encoding and recognition in real time of textual and graphical information as typically produced by man.*

The results will be implemented in a research machine for the purposes of evaluation and demonstration.

Proposals contributing to the existing project may be submitted.

4.2.3.2. **Advanced scanner**

The characteristics of the scanner should meet the physiological requirements for a continuous visual impression: a minimum of 50 grey levels, true colours and a resolution corresponding to the type of input. For A 4 documents, this implies at least 8 pixels/mm.

B-Type proposals are invited.

4.2.3.3. **Advanced printer.**

The characteristics of the printer should meet physiological requirements for a continuous visual impression: a resolution sufficient to translate via halftoning a minimum of 50 grey levels or true colour intensities, with at least 6 pixels/mm.

B-type proposals are invited.

4.2.3.4. **Microfilm interface**

The objective is the development of advanced scanners and digital production for microfilm/microfiche, with a resolution corresponding to the supported documents: a minimum of 8 pixels/mm for A 4 facsimile documents.

B-type proposals are invited.

4.2.3.5. **Graphics coding**

Hardware implemented intelligent coding algorithms with very high compression ratio.

B-Type proposals are invited.

4.2.3.6. **Graphics recognition**

Algorithms for the recognition of omnifont and multifont characters, handwriting and line graphics.

B-Type proposals are invited.

4.2.3.7. **Intelligent graphics recognition**

Identification and implementation of appropriate level of proven knowledge based methods systems to remove recognition ambiguities by post-processing of static and dynamic recognition algorithms. The enhanced recognition of handwriting has a particular interest.

B-Type proposals are invited.

4.2.4. **Speech**

4.2.4.1. **Speech interface** (Type A).

The development and evaluation of devices and functions for the processing of human speech to and from the workstation. The R & D will be aiming at reliable recognition and coding algorithms and high-quality speech output, guaranteeing user acceptance of the speech interface.

The recognition process shall be enhanced by integrating knowledge based techniques, to a level of 1 000 words recognition of isolated words in limited application domains.

To support the research on speech processing, data banks are to be set up that contain relevant linguistic information: in it's orthographic, phonetic and spoken form.

Programme (—) and Intermediate objectives (*):

Year 1:

— specification of speaker independent recognition of isolated words.

— specification of software for speech synthesis.

Year 2:

— demonstration of feasibility of speech synthesis

— implementation of speaker independent recognition of connected speech.

— evaluation of knowledge-based techniques relevant for the recognition process

* 24th month: speaker independent isolated word recognizer for limited (100-200 words) vocabularies; hardware implemented speech synthesizers for one language; 16 kb/s codec.

Year 3:

— implementation of 8-4 kb/s codec

— demonstration of feasibilty of speech synthesis in all EC languages, Spanish and Japanese

— specification of speech recognition in all EC languages, Spanish and Japanese.

* 36th month: speaker independent isolated word recognizer for limited vocabularies in at least three languages.

Year 4:

— implementation of 2,4 kb/s codec

— specification of speaker independent speech recognition of connected speech

— implementation of speech synthesizer for at least three languages.

* 48th month: speaker independent connected speech recognizer for restricted syntax speech; hardware implemented speech synthesis for at least three languages; 2,4 kb/s codec.

Year 5:

— integration of knowledge-based recognition

* 60th month: 1 000 words isolated word recognizer for limited application domains

4.2.4.1.1. 'Speech interface at office workstations (SPIN)' (Ref. 64+303+340: A/83/84).

The objective of this project is to develop the basic components of, and integrate these into, a comprehensive speech interface at the workstation. The components are: speech analysis, speech recognition, speaker verification, speech coding and decoding, and speech synthesis.

For the integration of the components it is important to have an understanding of the usage of the speech in human-machine communication, and the quality/functionality aspects that make that the interface is accepted by the human users. These two aspects will be studied extensively.

As concerns the coverage of different natural languages, these are at present: Italian, French, Dutch and German.

4.2.4.1.2. 'Investigation into the effective use of speech at the human-machine interface' (Ref. 449: B/84).

This project will identify the requirements for effective voice interfaces in particular for CAD/CAM/CAE workstations. The partners are user research associations, end users, and firms that are suppliers in the voice and computer fields.

The project results are fundamental for a number of other projects, in particular those dealing with the natural speech and language.

Proposals submitted should contribute to the ongoing projects.

4.2.4.2. **Speech coding.**

Hardware implemented algorithm for speech bit rate compression to 16, 8, 4 and 2,4 kb/s respectively.

B-type proposals are invited, but will be checked against ongoing work.

4.2.4.3. **Speech recognition.**

Recognition of speaker independent isolated words and speaker dependent and speaker independent connected speech.

B-type proposals are invited, but will be checked against ongoing work.

4.2.4.4. **Speech synthesis.**

Text-to-speech synthesis of satisfactory naturalness and resolution quality.

B-type proposals are invited, but will be checked against ongoing work.

4.2.4.5. **Intelligent speech recognition.**

Identification and implementation of appropriate knowledge based language techniques to remove recognition ambiguities by post-processing of speech input using real time recognition algorithms.

4.2.4.5.1. 'Linguistic analysis of the European languages' (Ref. 291: B/84).

The final objective of this project, that will start with a specification phase, is to provide in the form of computer data files and of computer method files coded in high level language, the following concerning a number of European languages:

dictionary lemmata, flections, grammatical categories;

algorithms and tables for converting the orthographic form into the phonetic one and vice-versa;

algorithms and tables for the word stress assignment;

statistics, ranking lemmata and flections by frequency of use;

texts, suitable for extracting further statistical information.

The project results are fundamental for a number of other projects, in particular those dealing with the natural speech and language.

B-type proposals are invited.

4.2.5. **Office languages and procedures**

4.2.5.1. **Office document architectures and languages.**

Definition and implementation of a family of formal architectures and languages to represent documents, as well as translators between such languages. Acceleration of the standardization in this area is a key factor for the advancement of other ESPRIT projects in the OS area.

4.2.5.1.1. 'Handling of mixed text/image/voice documents based on a stadardised office document architecture' (Ref. 121: A/83).

Basis for this work is a sophisticated object oriented document architecture being standardised up to the first basic level by ECMA, ISO and CCITT. By the project, concepts and architectures will be elaborated and verified that support the easy and natural processing of documents. The project will define and test bridges between the essentially paper-oriented office world and the electronic document world of tomorrow. (see also area 4.2.5.3).

B-type proposals are invited.

4.2.5.2. **Office interface languages.**

Definition and implementation of languages for easy user interaction, implemented for the natural language environments in the EC and other major linguistic regions.

B-Type proposals are invited, but will be checked against ongoing work.

4.2.5.3. **Multi-media document manipulation.**

The development and demonstration of techniques for the manipulation and editing of multi-media documents. This could comprise special hardware and/or software to perform high level information manipulation functions, together with a language or procedure to define the specific required manipulations.

B-Type proposals are invited, but will be checked against ongoing work.

New B-type proposals are invited.

4.2.5.4. **Intelligent user function support.**

The objective is to define and implement a set of tools that will allow the application system designer to effectively and efficiently implement user support functions, a large proportion of which will regard non-deterministic processes requiring user interaction.

B-type proposals are invited, but will be checked against on-going projects.

4.2.5.5. **User to user multimedia communications**

The objective is to improve the effectiveness of communications between persons in pair and

groups, by taking advantage of simultaneous use of voice, handwriting, dataprocessing, document display and slowscan video. Provisions should be made for direct communication between workstations, irrespective of their relative place in the local and/or public network. Develop a prototype and evaluate its effectiveness in various communication contexts.

B-type proposals are invited.

R & D Area 4.3: Communication systems

DESCRIPTION

Office communication presents a number of possible long lead time research topics. Technological advances are needed in microelectronics and in fibre optics, and research is necessary on the principles of future communication systems such as wideband local area networks (LAN), the interconnection of LAN's and the gateway facilities for multimode functionality. R & D should lead to new systems and to standards consistent with the ISO reference model for open systems interconnection (OSI). Besides these technical problems, there are non-technical problem areas which have to be addressed 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 system design. The special aspects of human interface with communication have to be studied, and the future relationship of the PTTs to new local communication systems has to be considered. New languages and operating system facilities are necessary in connection with distributed systems.

Within this scope of possible research activities, four main topics which cover some key issues have been determined.

The first topic 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.

The second topic addresses the wide band LAN, including the application of optical fibres, and all the technological problems related to this. It is also concerned with the role of switched communication in the office. It addresses the problems of advancing from current single service switching techniques towards multiservice variable bandwidth switching which will allow the interconnection of all office peripherals and resources.

The third topic deals with resource management in a distributed environment.

The fourth topic intends to advance the standardization of value added communication services in the office e.g. in the form of mail box messaging for text, image and voice, and for multi-media information systems such as advanced videotex.

R & D TOPICS

4.3.1. Architecture

- — communication system architectures (type A)
- — security in communications
- — harmonisation issues in communication

4.3.2. Technology

- — optical wideband LAN (type A)
- — advanced switching techniques (type A)

4.3.3. Resource management

- — distributed systems (type A)

4.3.4. Services

- — multi-mode messaging
- — ISDN-based advanced videotex
- — advanced services

TOPIC DESCRIPTIONS

4.3.1. **Architecture**

The current office environment comprises a quantity of disparate proprietary equipment which is generally only able to communicate to other like equipment. Further different systems have very different data speeds and performance requirements which can be met by different architectures.

An office system architecture is urgently needed which supports all devices according to their needs. There is likely to be integration of PABX circuits, LAN's and wideband links to support the various classes of equipment. Signal and protocol concentrators or gateways consistent with the OSI reference model will be required between these classes, and to other remote systems over public carrier circuits.

With the proliferation of information equipment the demand for good interworking in the office is most urgent. There is a unique opportunity for European manufacturers to agree on common protocols for interworking allowing the specifications of VLSI communication chips in economical quantities and thus in turn reducing equipment costs.

In order to produce a durable solution that not only enables interworking of current disparate equipments but also encourages and eases the adoption of developed techniques in future predictable equipments, the range of work is expected to be extensive.

4.3.1.1. **Communication system architectures** (type A).

Determine the topologies most appropriate for typical office situations including local, distributed and long-haul linked offices, given by traffic requirements and distance. Define gateways, communication servers, network access protocols and multiplexing schemes, exploring the possibilities of network error recovery, reconfiguration and overall control. The architecture should provide for gateway functions to take account of future developments in the public network and also for privacy and security requirements.

The industrial interest for the development of standards and the execution of conformance tests is part of the project definition.

Programme (–) and Intermediate objectives (*):

Year 1:

— study alternatives of architecture with particular respect to distributed working, technologies to be expected, traffic characteristics, requirements for monitoring and logging network management and control and for security of access and data transfer.

— define gateways, access protocols and multiplixing schemes.

* 12th month: network architecture requirements analysis.

Year 2 to 5:

— design basic architectures (e.g. LAN-based, PBX-based) on the knowledge acquired above

* 18th month: specification of network architecture for implementation.

— first statements on economics, performance, standards

— study alternatives for cabling architecture and multiplexing schemes, taking into account existing plant environment, buildings, existing cables, floorspace, maintenance, vulnerability, security, etc.

— definition of communication server and other gateway functions, including functions which convert the different types of protocols into a common LAN protocol for intra-office networking, inter-office open system interconnection, data-base access and remote information centres

— refinement of architecture (e.g. routing); standardization activities preparation of experimental implementation as far as appears necessary (e.g. pilot communication server)

— standardization activities; realization of experimental implementation

— evaluate architecture by results of experimental work.

Year 3:

Work on tools to be started in Year 3:

— identification of tools required. Identification of relevant standard communication interchange and management protocols (session, transport and network). Identification of relevant equipment architectures. Definition of tool architecture.

— specification of individual tools. Design and construct tools.

* 42nd month: tools and methodology specification.

* 48th month: pilot network implementation(s).

* 60th month: evaluation report pilot network(s); report on tool specification methodology.

4.3.1.1.1. 'Broad site local wideband communication system' (Ref. 73: A/83).

This project is concerned with the research and development of a local area wideband communication system for broad sites. The prototype system developed will meet the anticipated future communication requirements of large industrial, scientific and administrative organisations. The project will take into account data, text, voice and graphics communication needs, and it will provide backbone networks and gateways for heterogeneous LAN's.

4.3.1.1.2. 'Communications systems architectures' (Ref. 237: A/84)

The emphasis of the project is on the development of new architectures for the interconnection of terminals and resources in an integrated multi-service environment. The network developed in this project will reflect the open systems policy by providing interfaces following OSI standards. A top down approach is proposed in three phases:

Phase one will identify the needs for communication by analysis of user requirements. A logical model of communication will be developed. A proposal will be made for the integration of a distributed operating system within the open system structure.

Phase two will develop the physical architecture by mapping the logical model from phase one onto actual communication technology.

Phase three will be the development of those system elements identified in phase two to achieve a pilot network demonstration. The pilot network will be benchmarked for performance to evaluate system design decisions in phase two.

4.3.1.1.3. 'An integrated network architecture for office communications' (Ref. 395+95: A/83-84).

The project is to design and define an architecture for office communications, and to demonstrate a pilot implementation. The architecture will be capable of including all types of local and wide area networks, such as optical LAN's, CATV broadband networks, PABX's, packet-switched networks and the emerging integrated services digital network (ISDN).

The integrated architecture will be demonstrated in a pilot integrated network including the broadband network and a variety of other available local and wide area networks, and linking the project partners' sites. The demonstrated applications will include an enhanced version of the document handling environment.

No proposals are invited, unless they contribute to the on-going projects.

4.3.1.2. **Security in communications**

Definition and demonstration of security improvements in networks. Implement on available networks.

B-type proposals are invited.

4.3.1.3. **Harmonisation issues in communication**

As communication means linking transmitters and receivers, a large number of compatibility issues is to be dealt with. This topic provides a means for reaching pre-standard agreements on such issues, in the context of existing agreements such as the ISO/OSI reference model and of on-going international standardisation efforts, and testing of the resulting specifications.

'Standardisation of integrated LAN services and service access protocols' (Ref. 43: B/83)

The aim of the project is to define the services to be provided by an integrated traffic LAN and to define a stable, LAN-technology independent interface between DTE and LAN access unit. This interface will comprise the physical interface and the service access protocols by means of which the services can be used.

B-type proposals are invited.

4.3.2. **Technology**

Any form of integrated office will require an underlying communication infrastructure of sufficient capacity and reliability to carry all the traffic on an instantaneous (or fractional delay only) basis. Current estimates suggest that capacities well in excess of 100 Mb/s will be required to handle inter-computer, inter-workstation and inter-CAD equipments. They will be expected to support concurrently speech, data and static and moving image.

Both co-axial and fibre technologies offer the required capacity, but fibre optics transmission properties are better suited to the Gb/s range. Fibre optic technology is currently employed mainly for point to point working. Improved techniques are needed for the passive coupling of equipments into a fibre link and also for the switching (or routing) of signals in a network architecture, preferably by optical switching techniques. With this achieved, there should then be sufficient capacity headroom (more than 1 Gb/s) for foreseeable future applications, limited only then by current fibre optic termination technology.

4.3.2.1. **Optical Wideband LAN**

Identify and formulate architectures and standards for optical wideband local area networks, define the design requirements of VLSI chips and demonstrate the functional and economic feasibility.

Programme (–) and Intermediate objectives (*):

Years 1 to 5:

— architectures and protocols for optical wideband LANs defined.

* 3rd month: specification of architectures and protocols for optical wideband LAN's.

— examine and design transmission and interface equipment for fibre optic techniques

* 12th month: specifications for optical LAN transmission techniques.

— define the design requirements of VLSI chips to implement the protocols for network interfacing; guaranteeing good levels of reliability and security.

* 18th month: specification for VLSI chips for network interfaces.

— evaluate demonstrator designs, carry out necessary developments for demonstrator

* 36th month: specification for demonstrator.

* 48th month: implement demonstrator to show functional and economic feasibility in an operational in-house environment.

* 60th month: evaluation report of demonstrator.

4.3.2.1.1. 'Local integrated optical network (LION)' (Ref. 169: A/83)

The LION project aims at implementing a wideband local area network based on optical fibre technology, with major application in the office environment, including such applications in industrial research laboratories, universities, hospitals and manufacturing plants. The LION will guarantee multiple access to a number of independent users with the requirements of distributed processing and distributed intelligence, and handle voice, data, text and video traffic. Very high bit rates are foreseen, requiring new technologies in integrated optics and very high speed electronic components.

4.3.2.1.2. 'Ultra Wideband Coherent Optical LAN' (Ref. 249: B/84)

The project aims to investigate the feasibility of utilising coherent optical techniques in a local area network by addressing both technical and system issues. It will consider new machine architectures to implement high bandwidth transmissions of order of several Gbits/sec for different types of information including voice, text, image, etc.

No proposals are invited, unless they extend the on-going projects.

4.3.2.2. **Advanced switching techniques** (Type A)

Identify the requirements influencing switched architecture design. Propose and design a switched communication physical architecture to interconnect single service and multiple integrated service users in an office, with office system resources and wider networks.

Design and implement a demonstration to evaluate feasibility and performance.

Programme (–) and Intermediate objectives (*):

Year 1:

— Identify and evaluate fundamental parameters influencing switched architectures.

Years 2 to 4:

— Define physical and logical architecture for switched interconnection.

— Design system elements (switch, and interface elements) for the physical architecture defined above.

— Preliminary statement on feasibility of a common switching technology.

— Define VLSI requirements (performance, device density).

— Specify demonstration and design in detail elements for it.

— Implement demonstration (it is desirable that this should be as an element of a wider architecture).

Year 5:

— Evaluate demonstration (it is desirable that this should be as an element of a wider architecture).

— Revise physical architecture definition.

— Revise VLSI requirements.

A-type proposals are invited.

4.3.3. **Resource Management**

In integrated office and factory networks, there will be an increasing need and opportunity to share remote resources and also to seek and use spare processing capacity.

Considerable research has been done or is underway in the general area of distributed systems and distributed databases. The general nature of this work implies that highly skilled staff must be involved in the setting up and management of these systems, particularly in dynamic environments (especially where direct demands on the system are changing).

The fundamental requirement is to provide mechanisms for the construction and management of such systems by relatively unskilled staff.

This requires significant programmes of work to be undertaken concerned with parallel processing within a network of several discrete machines, distributed data base management and techniques for the interconnection of applications processes.

4.3.3.1. **Distributed systems** (type A).

Identification of the application level primitives for the transfer of data and/or program modules for remote processing or data access, including authority for access. The concept of singularity or integration of data and programs and automatic updating of these items in a distributed environment should be addressed and practical solutions found.

Devise a support language to allow users, applications and operating systems to programme the movement and access of software resources. Specific commands may include down-stream loading, remote run requests, remote procedure calls, data base updates.

Devise an infrastructure mechanism to manage the resources of a network including knowledge of resource availability, resource integrity, fault recognition and automatic recovery.

Programme (–) and Intermediate objectives (*):

Year 1:

— Identification of sub-classes of application and resource interaction. Definition and proving of primitives to control resource access by applications. Exploration of techniques for updating distributed programs and database, whilst retaining consistency. Outline requirements specification for a distributed computerised support language. Outline requirements specification for an infrastructure management system.

* 12th month: Distributed computing primitives. Specifications for a distributed computing support language and environment management system.

Year 2-3:

— First language implementation on a simple infrastructure (as a test bed) to fully test the techniques of distributed resource access and control in a network of intelligent workstations. Validation of primitives and management techniques. Effective database management technique to balance concurency and consistency in a distributed environment, including recovery techniques.

* 24th month: Data base management demonstration.

* 36th month: Support language implementation on a test bed of distributed workstations.

Year 4-5:

— Full language implementation and full infrastructure management implementation for the autonomous distribution and co-operation of processing requests. Validation of concurrency and consistency parameters. Validation of failure identification and automatic recovery. Consideration of effectiveness in a non-stop environment.

* 48th month: Pilot resource management environment.

* 60th month: Fully validated demonstration of a distributed workstation environment.

A-type proposals are invited.

4.3.4. **Services**

Study and specification of the functional expansion of videotex services on the basis of future ISDNs (narrowband and broadband digital networks); presentation of text/graphics/images/speech/moving video and the extended two-way user interface. Set up of experiments and their evaluation.

4.3.4.1. **Multi-mode messaging.**

Formulate the requirements for office messaging services (text, image, voice, video frames, moving video). Evaluate feasibility of messaging of mixed-mode messages. Stadardisation issues are to be addressed.

B-type proposals are invited.

4.3.4.2. **ISDN-based advanced videotex.**

Study the improvement of videotex services on the basis of extended applications and future networks. Multi-mode presentation of text, graphics, images, moving video. Interactive human-friendly functions are required, as well as standardisation of interfaces and protocols.

B-type proposals are invited.

4.3.4.2.1. 'A high compression picture coding algorithm for photographic videotex' (Ref. 563: B/84)

The purpose is to develop with a group that is representative but small enough to be effective, a high compression picture coding methodology that can be applied to television signals. The final goal of the work is the definition of a selected coding technique as a possible European standard for photographic videotex on ISDN.

B-type proposals are invited.

4.3.4.3. **Advanced services.**

This topic provides a possibility that proposals for innovative work are made, unconstrained by specific references in this workplan.

B-type proposals are invited.

R & D Area 4.4: Advanced multi-media storage and retrieval systems

DESCRIPTION

Information technology and office automation are fundamentally concerned with the storage, accessing and movement of information, covering data, text, graphics, voice, images and other forms. Investigations leading to the definition of an advanced data-base model for office applications and studies of the security, privacy, authority of access and information distribution are fundamental to a wide range of office systems research.

The proposed research is oriented toward construction of a number of experimental prototype office information servers, and the operation of these in realistic conditions, alone and in association with each other, to gain practical experience in the systems implications of building these servers, loading them with practical information and using them in a realistic way.

The work is therefore divided into three general classes: systems issues, usage and needs, and components.

Systems issues: these cover the design and operation of office information servers, including high-performance filters and investigations of new information models and the development of metrics relating to these. Servers must be considered in relation to the other components of a comprehensive office system including other information servers and the distribution of information and functions between them. Work on the filing interface-related aspects of

query languages and declarative content languages is identified.

Usage and needs: this topic addresses the nature of the information (data, text, graphics, images etc. . . .) that will be held in office information servers in terms of quality, quantity and combination and the usage of that information. An internal adaptive interface is to be investigated, that responds to the needs and experience of users.

Components: the development of hardware, software and systems elements that will be incorporated into advanced filing systems, primarily in information servers, but also in advanced workstations. These include filters, the systems management issues relating to using optical discs in advanced office systems, the systems techniques required to achieve very high perceived reliability, and the application of advanced information processing techniques to advanced filing and retrieval systems.

R & D TOPICS

The topics covered by this R & D area include:

4.4.1. File server architectures

- — office information server design and evaluation (type A)
- — very high security systems

4.4.2. System issues

- — new information models
- — file query and declarative content languages

4.4.3. Usage and needs

- — nature and usage of filed information
- — user-file adaptive interface
- — performance considerations

4.4.4. Components

- — file filters
- — optical storage systems concepts

TOPIC DESCRIPTIONS

4.4.1. **File server architectures**

4.4.1.1. **Office information server design and evaluation** (type A).

This area will define and document the system functions and attributes of a range of office information servers and the logical interfaces of a range of subsystems with other components of a total office system. These will be translated into designs and implementation plans and several representative models will be constructed as laboratory prototypes. These will be used, alone and in combination, to evaluate the practical operation of these servers. The issues involved in distributing information between multiple servers and handling the interactions between these servers is an essential part of this work.

Programme (—) and Intermediate objectives (*):

Year 1:

- — describe a range of multi-mode servers and their functional attributes
- — establish the systems design and components requirements.

Year 2:

- — detail implementation plan and design
- — simulate performance
- — establish component availability
- — define system distribution issues and approach.

* 18th month: Specification of information server(s).

* 24th month: Performance estimation.

Year 3:

- — definition of a work programme to validate system concepts;
- — desk assessment of designs based on available devices
- — detailed implementation plan for distributed implementation.

Year 4:

- — implement designs, including optical disc and first phase file filters
- — commence construction of distributed facilities.

* 48th month: Prototype(s) of information server(s).

Year 5:

— operate, evaluate and improve implementations, including distributed information and functions.

* 60th month: Evaluation of server(s).

4.4.1.1.1. 'A multimedia filing system' (Ref. 28 + 436: A/83)

The goal of this project is to develop a system that provides filing services for multimedia documents using magnetic and optical storage media. Particular attention will be paid to the needs of the office environment. The system will be implemented on a dedicated server that accepts requests from clients such as workstations or other devices. The units of communication between server and client will be multimedia documents rather than physical records or blocks.

The services provided by the server are those traditionally found in an information retrieval or database environment. However, the dual demands of a multimedia capability and application to offices introduce research issues. The server will be implemented by increments. The first prototype will deal with text and attribute data only, subsequent versions will add image and voice data.

4.4.1.1.2. 'Design and Operational Evaluation of Office Information Servers' (Ref. 231: A/84)

The objective of the project is to design, demonstrate and then evaluate a family of working prototype office information servers capable of holding in digital electronic form representations of all office information currently committed to paper. A global model will be established both for the information held in the servers and the functions needed to manipulate and manage it. Key to the project is the consideration of the issues involved in distributed information, architecture and use in the office environment. Two major demonstrations of the capabilities of Office Information Servers are planned during the project. A pilot demonstration at the end of year 3 and a main demonstration at the end of year 4. A full year is then available for a full evaluation of the system prior to final reports.

No proposals are invited, unless they extend the on-going projects.

4.4.1.2. **Very high security systems.**

Since information contained within servers will frequently represent critical assets to users, the protection of information from corruption due to system failures and intrusion by unauthorised and unqualified users will be critical. Technical and system approaches to the problems need to be developed, (possibly using expert systems techniques) leading eventually to highly fail-safe and fail-free filing systems, that are protected against unauthorised use.

B-type proposals are invited, but will be checked against on-going work.

4.4.2. **System issues**

4.4.2.1. **New information models.**

New information models of an office environment particularly one in which the users are shielded from awareness of the operation and design of the information systems, applying AI methods and experience.

4.4.2.1.1. 'New information models for Office Filing and Retrieval' (Ref. 59: A/83)

The project deals with research into new information models for office filing and retrieval. The emphasis will be on research of the theoretical issues of a model which characterises all forms of office information. A number of models will be developed and related to techniques of filing and retrieval of information.

Many key problems are being investigated, the majority of these dealing with aspects of human acceptability, or more precisely: speed and accurateness of the retrieval process for the skilled and unskilled user.

The models developed will be constructed and validated in a software environment which emulates the interaction of an office filing and retrieval system.

B-type proposals will be checked against on-going work.

4.4.2.2. **File query and declarative content languages**

The filing related aspects of these languages should be investigated. Particular attention must be given to the extension of these languages that may be

required by the developing complexity of the filing systems and user needs, and the application of new processing techniques as components of the file servers.

B-type proposals invited.

4.4.3. **Usage and needs**

4.4.3.1. **Nature and usage of filed information.**

Theoretical studies and interviews with advanced office systems users to establish a range of scenarios covering the nature and the quantity of the objects that will be contained in practical office information servers, and the usage that will be made of them.

The project No 285 addresses some problems in this area.

B-type proposals are invited, but will be checked against on-going work.

4.4.3.2. **User-file adaptive interfaces.**

Study of interactions between workstations and information servers in realistic user environments. Development of an adaptive interface between these subsystems that presents a common and potentially standard user interface to the filing system.

B-type proposals are invited.

4.4.3.3. **Performance of office information servers.**

Develop a set of methods for evaluating, predicting and testing the performance of office filing architectures and algorithms.

B-type proposals are invited.

4.4.4. **Components**

4.4.4.1. **File filters.**

Identify needs and develop extensions to existing file filter technology to satisfy predicted office information storage and retrieval requirements. Study the implications of searching large multimedia files and propose new hardware or firmware filters to improve searching efficiency.

B-type proposals are invited.

4.4.4.2. **Optical storage system concepts.**

This project concerns the development of systems application and management techniques, and the creation of relevant software aids, taking advantage of optical storage devices ensuring that they are available for practical use at an early date.

B-type proposals will be checked against on-going work.

R & D area 4.5.: Integrated office information systems

DESCRIPTION

The research and the prototype development of components for office systems has to be supplemented by the research and evaluation of integrated office systems concepts for a variety of office environments. In an industrial R & D programme the testing of prototypes, against requirements that are representative for market conditions, is the most important check on the relevance of the research done.

Two topics are identified in this area that are complementary but not necessarily mutually dependent.

First: the design, development and evaluation of advanced office system prototypes, based upon state-of-the-art components developed in Europe, possibly under the ESPRIT programme (area 4.2 to 4.4), and based upon the results of structured analysis in the office systems science and human factors areas (area 4.1).

Second: the creation of test- and evaluation environments for office system components and integrated office system prototypes, that allow qualitative and quantitative validation in a variety of simulated offices and enterprises. This work would also use the products of area 4.1 as well as other standards, performance and integration work.

R & D AREA SUMMARY

The topics to be studied in this area include:

4.5.1. Information system architecture.

- system architectures (type A)
- systems security.

4.5.2. Test and evaluation.

- office system test and evaluation facilities (type A)
- office systems application test beds.

TOPIC DESCRIPTIONS

4.5.1. **Information systems architecture**

4.5.1.1. **System architecture** (type A).

The definition of a system architecture specifying interworking between the different system components from the physical level up to the application level in order to guide the integration. The actual design and implementation of an experimental integrated system is to be based upon the defined system architecture, upon state-of-the-art subsystems, preferably developed under the ESPRIT programme, and upon results of structured analysis in the office system science and human factor areas. Their subsequent integration and evaluation should be done in an environment that represents realistically office and business conditions, including the short and long haul communication requirements of todays businesses.

The work is to be limited to the demonstration of generic functions, i.e. those functions that are not specific to a particular type of business or organisation.

The number of iteration cycles shall be limited, and not be extended byond the stage of experimental prototype.

Some aspects to be covered in this area are, amongst others:

- integration of components from different origines
- system reconfiguration
- overall system security
- transparency of the system for the user
- identification and application of instructional primitives
- management infra-structure.

Program (–) and Intermediate objectives (*):

Year 1:

- Definition of laboratory model & test specifications

* 12th month: system specification.

Year 2+3:

- Implement Laboratory test configuration
- build laboratory models
- define and implement test tools and test equipment.

Year 3:

- Laboratory test and evaluation.

Years 4+5:

Modify and retest

* 60th month: fully tested experimental prototype.

A-type proposals are invited.

4.5.1.2. **System security**

The analysis and design of secure systems. Implement and test on available systems. The system should include user access control procedures that guarantee confidentiality of data if required.

B-type proposals are invited.

4.5.2. **Test and Evaluation**

4.5.2.1. **Office system test and evaluation facilities** (type A).

The creation of test- and evaluation environments (or centres) for Office System Components and Integrated Office System Experimental Prototypes, that allow qualitative and quantitative validation for a variety of offices and enterprises.

The availability of such facilities is of infra-structural significance, as qualified services can be provided to a large number of small to large organisations, that will not be in a position to create these

facilities on their own, because of the substantial budgetary and intellectual resources required on a continuing bases.

Program (–) and intermediate objectives (*):

Year 1:

— specification phase: detailing the nature and extent of services to be provided, and setting up a scheme for their gradual development in the subsequent years;

— defining criteria and conditions for the use of the services;

— defining management structure.

* 12th month: scenario for setting up and exploiting the facility.

Year 2:

— implementation of an experimental test facility, followed by tests of system components to demonstrate the initial feasibility of the approach.

Year 3:

— performance of realistic tests, to demonstrate the overall feasibility of the test facility.

* 45th month: report demonstrating the feasibility of the proposed facility.

Year 4-5:

— gradual expansion of the test facility;

— execution of tests and evaluations.

* 60th month: Report demonstrating that the facility could be run without a need for Community support.

A-type proposals are invited.

4.5.2.2. **Office systems application test beds**

The analysis of application areas and the design of adequate performance evaluation criteria, in order to prepare the ground for Office Systems field tests that may reveal weaknesses and strengths of such systems under development.

To derive general conclusions that may lead to improved technologies and systems, particularly with respect to their human friendliness.

Projcts have to be of limited size, need not necessarily lead to an application system development, and should emphasize the pre-competitive nature of the work.

B-type proposals are invited.

SUBPROGRAMME 5

COMPUTER INTEGRATED MANUFACTURE

This area relates to the total range of manufacturing activities including computer aided design (CAD), computer aided engineering (CAE), computer aided manufacturing (CAM), flexible machining and assembly systems, robotics, testing and quality control.

The reason for selecting this particular subject area is the following: its potential impact on the methods and economies of production, which are vital to Europe, calls for a strong indeginous involvement in CIM systems development.

The objectives in CIM are to create an environment in which multi-vendor systems can be implemented in a progressive manner, and in which Community IT suppliers can compete effectively. To achieve this, effort will be concentrated in two main streams. Firstly, work is needed on infrastructures, which concentrates on the development of design rules and architectures leading to a common reference frame. Relevant international standards activity must be continuously assessed, and areas identified in which European action could be supported. The second stream involves action on those sub-systems, interfaces and tools whose development or refinement is judged to be of strategic value for European Community industry (both users and vendors).

In order to stimulate and facilitate the transfer of new information technology concepts to the engineering industries within the Community, and properly to support, utilize and demonstrate the proposed research activities, it is strongly recommended that as part of the ESPRIT programme as demonstrators three or more advanced CIM systems should be established within designated centres of excellence. Such systems would provide an important focus for the coordination of effort and the exchange of information among the various and sometimes disparate parts of the CIM R&D programme.

R&D area 5.1.: Integrated system architecture

Introduction

The resources needed to define standard architectures, and the market strength necessary to gain acceptance of such architectures are beyond the reach of all but the largest and most influential organisations. However the desirability of developing a reference model, which would allow users to develop multivendor CIM systems, and which would avoid exclusive market domination by American and Japanese de facto standards and frameworks is readily apparent. This is an area where the potential for significant advances through a unified approach are high, and it is therefore particularly suitable for effort on a Community scale.

Description

In the next decade, one can expect that a wide variety of CIM systems will be implemented within manufacturing industry. To be effective, each system must serve its specific application in an optimum manner. In order to remain competitive and to preserve flexibility, effective design methods for CIM must be developed so that new technologies can be exploited as they become available. At present, there are some guidelines but no international standards available for the design of system architectures for CIM.

New and innovative conceptual approaches are required in order to fit appropriate system architectures to the total manufacturing process from initial product development, product design, production planning and control, real time control of production equipment, materials handling, through to inventory control and sales. To support the total systems approach, it is necessary to develop strategies for data, communications, and processing, which address both physical and logical requirements.

To encourage the wider use of CIM systems by reducing the risk of failure, methods should be developed to allow the representation, specification and testing of proposed systems prior to installation.

The overall approach covers:

— impact of CIM system on strategy and organisation of the company

— architectures

— elements supporting the architectures

5.1.1 and 5.1.2, System Architectures for CIM (1)

Description

Preliminary work has already been carried out in several pilot projects on 'Design Rules for CIM', and is nearing completion. Experience has shown that a major difficulty in this area is that of combining technical progress with a wide degree of concensus for the eventual results. In order to try and ensure a broad base of acceptability, a special interest group (SIG 5.1) has been convened and is already in operation. The purpose of this group is to provide comments, feedback, and guidance to teams undertaking project work. At the time of writing, SIG 5.1 has produced a list of aims for work in 5.1. These are:

— to provide guidance and support for users and potential users of CIM systems

— to provide the Community IT industry with support in the form of advice and information, and where necessary, tools to exploit effectively the expanding market for CIM systems

— to monitor relevant developments in international standards, and to make recommendations for united action where necessary

— to maintain relations with other sub-areas of CIM, with other areas of ESPRIT, and with relevant national programmes.

(1) The project is classified as 'B' because at the time of writing, it is largely unspecified. However, the total resource for area 5.1 is more in line with a type 'A' project.

— to promote a common awareness and improved understanding of the concepts of CIM, for example, by establishing a common terminology

It should be clearly understood that this is a list of *aims*, and is not a specification of project work. The means of achievement are still under discussion, and it is likely that a project definition phase will begin in the last quarter of 1984.

Thus the area will be subject to a two-phase approach:

5.1.1: project definition

5.1.2: development and implementation

It is clearly of paramount importance that work in other sub-areas of CIM and the outputs from relevant pilot projects be taken into account by 5.1.

Programme (5.1.1)

Year 0: — produce first draft of design rules for specific areas of manufacturing

Year 1: — 6th month:
Present design rules, and produce final recommendations.

— 6th - 8th month:
Maintaining close links with the special interest group, SIG 5.1, present project definition for future work.

Programme (5.1.2)

Years 1-5: — Development and implementation of projects defined in 5.1.1 above.

5.1.1.1. 'Design Rules for CIM Systems' (Ref. 34: A/83)

The objective of the project is to make detailed recommendations for a set of European design rules for Computer Integrated Manufacturing Systems.

5.1.1.2. 'Computer Integrated Production Insula, Design Rules and Standards' (Ref. 92: A/83)

This project concentrates on the data and dataflows within a Computer Integrated Production Insula, CIPI. It will produce design rules relating to CIPIs. A CIPI in this context can be envisaged to include some or all of a design system, NC systems, production units, automation units (robots and handling equipment), test systems and systems for production planning and control.

5.1.3. **Graphics subsystems** (Type B)

Graphics are an integral part of CAD/CAE, but other areas of CIM can make extensive use of graphics, at management and shop-floor levels. Examples of application areas include simulation (e.g. work flow, what-if costing), performance information (on suppliers, production levels, costs) and management information (work schedules, resource allocations). This project area is to identify the differing requirements for graphics within the many areas of CIM but excluding CAD/CAE, and to develop software prototype subsystems where appropriate (for subsequent transfer to VLSI, see section 5.5.2.).

5.1.3.1. 'Design and specification of configurable graphics subsystem for CIM' (Ref. 496: B/84)

The project has two primary goals:

1. *The identification and classification of the differing requirements for graphics in the many areas of CIM.*

2. *The development of software/hardware prototype graphics subsystems that meet the requirements of 1. above.*

To attain its first goal, the partners will carry out an exploratory survey covering hardware, software, and man-machine interface requirements for graphics of CIM systems currently in use. To attain the second goal, the partners envisage the use of well-defined standards upon which to build. For example, the Graphics Kernel System (GKS) and the programming language Ada are two obvious candidates.

R&D area 5.2: CAD/CAE

Description

The importance of computer aided design is that it:

— reduces the design time and facilitates optimization of the design,

— facilitates storage of all relevant aspects of the design, and rapid update and retrieval of information,

— generates data which is used by the whole manufacturing process including robot and machine tool programmes.

Current CAD systems include facilities for designing and drafting parts, calculating physical parameters and simulating kinematic and dynamic behaviour. Future developments should aim at CAD/CAE systems which take full advantage of using computers as a means for representing products in the design process. Such systems should include facilities for designing products with optimal performance and economy, supporting all design phases starting from the conceptual phase, which is recognized in being critical in the design. Ultimately these CAD/CAE systems have to support multi-disciplinary, geographically dispersed consortia of organisations co-operating in the design process.

Modular structures for CAD/CAE subsystems (which include generalized 3D-modellers, geometrical design systems, engineering computational programs, simulation programs) must be developed in order to allow the designer access to different software packages and data bases. Such systems supply data that is readily usable for all interacting engineering and production activities, as well as good display quality and capabilities.

This requires integrated CAD/CAE systems which can generate the information needed to select, define, verify, simulate and optimize the production process in terms of generalized manufacturing operations.

The role of AI techniques in product and production system design must be continuously reviewed.

Unless very strong reasons can be shown, all projects in area 5.2 should be consistent with relevant architectures developed in area 5.1, the interaction of CAD/CAE with CAM (5.3) and FMS (5.4) systems must also be taken into account.

R&D TOPICS

The R&D topics in this area are:

5.2.1. CAD/CAE facilities for product and process design.

5.2.2. Use of AI techniques in CAD/CAE.

5.2.1. **CAD/CAE facilities for product and process design (Type A)**

— formulate possible CAD/CAE systems structures, consistent with the design rules of 5.1, and define a development and integration programme;

— survey available subsystems and general tools. Identify those which are usable and where necessary specify and develop additional items or modifications;

— develop subsystems and tools and integrate into overall system structure(s);

— based on CAD/CAE general tools, adapt or develop further tools and subsystems to support integrated CAD/CAE activities, e.g.:

  * product design activities such as project management, concept design, preliminary design, analysis and simulation, final design, product documentation management, product configuration management.

  * process design activities such as process selection, process modelling, process planning, process plan simulation, process plan optimization, process quality assurance planning,

  * tools specific to different classes of products and processes, and to 'group technologies' concepts (geometry, dimensions, materials, tolerances, process operations type).

Programme and intermediate objectives

A typical project could have a time scale as indicated below. Depending on the nature of specific projects, the time scale may vary. The use of prototypes in all stages to show the adequacy of work performed is encouraged.

12th month:

— identify requirements for product design methodologies;

— complete survey of available systems and hardware.

24th month:

— functional and requirements specification of tools,

— formulation of CAD/CAE system structures and definition of development and integration programme;

— definition of product and process design methodologies;

— definition of coding and classification methodologies.

36th month:

— start of tool development;

— development of application software for product design system, CAD/CAM tool integration and coding and classification system;

— first output of coding and classification recommendations.

48th month:

— finalize development of CAD/CAE general tools;

— finalize development of application software for product design system, CAD/CAM tool integration and coding and classification system.

— final recommendations on coding and classification.

60th month:

— finalize integration of general tools with other CAD/CAE activities.

5.2.1.1. *'Reference Architecture for Implementation of Integrated Data and Methods Bases for CAE Systems' (Ref. 536 : A/84)*

A reference architecture will be developed from a functional point of view, which embraces the following levels:

communication, data transfer, data base and methods-base. The functionality of the coresponding communication protocols, metafile formats, engineering data bases, methods data bases, user interface managers and method interaction specification languages will be specified in detail and tools for their implementation developed. From here, a general purpose CAE-(H/S)-System Architecture will be proposed and implemented for different application environments.

5.2.1.2. *'CAD Interfaces (Ref. 322: A/84)*

This project concentrates on important interfaces of cad/cam systems: the cad data exchange interface, the cad data base interface, the interface to finite element analysis and dynamic model optimization, and the AI-based advanced high-level modelling interface. The design and implementation of these interfaces will be closely coordinated with the international standardization in this area.

5.2.1.3. *'Development of an Integrated Process and Operations Planning System with the Use of Interactive 3D Modelling Technology' (Ref. 409: B/84)*

The objective is to develop an interactive graphics-based system for process and operation planning within a manufacturing environment. To reduce development costs, the overall system would be built from existing and proven system components of the project partners. The approach will be to achieve a uniform user interface for CAD and CAM-systems and secondly to provide a complete simulation of the manufacturing process.

5.2.2. **Use of AI techniques in CAD/CAE**

Review developments in artificial intelligence which might be applicable to CAD/CAE. Carry out development work in appropriate areas.

5.2.2.1. *'Knowledge and Decision Support for Material Handling Systems' (Ref. 293: B/84)*

The project aims to investigate the applicability of expert systems for decision support and to develop a knowledge base for modelling material handling systems. The objectives are to analyse and define the knowledge necessary to achieve valid assessments for system designs and of system operation. The knowledge would be implemented in decision support systems and would be used by engineers planning a material handling system.

R&D area 5.3: Computer-aided manufacturing (CAM)

Description

A computer-aided manufacturing system in this context addresses the management of factory opera-

tions. In principle a CAM system acts as a high integrity information network that monitors a broad spectrum of inter-related tasks and asserts consequent control on the basis of an overall management strategy (ideally in real time).

Design aims of a CAM system should include:

(i) maximise assistance to human supervision and intervention for individual process tasks;

(ii) processes to be individually programmable;

(iii) interfaces to overall systems architectures as defined in 5.1, and other related production activities.

(iv) possibility for introducing modifications and extensions without violating total systems concept.

CAM software is an interrelated set of computer programs able to process, monitor and control the flow of manufacturing data needed at the various stages of production. In this context only the software elements of CAM systems are considered.

A clear rationalization effect can be expected if design data prepared with computer assistance are used directly for computer-aided preparation of production data and instructions such as workshop drawings, parts lists, process sequence plans, NC-programs, quality control programs, product test programs, etc.

The requirements for the data base systems and data base management system for CAM should be carefully identified and formulated during the conceptual system definition and design phases.

Programme (–) and Intermediate objectives (*):

Year 1 (third and fourth quarter):

— define and specify in detail the structure and modularity of CAM system hardware and software. This work should be tightly coupled to area 5.1.1, particularly the 'system structure' and the 'design rules' topics;

— the consequent CAM definition should include such generic activities as planning, scheduling, machine programming, tool design and management, flow control, monitoring, data collection, materials handling, warehousing, inventory control, testing, repair, quality control, documentation, costing and purchasing;

* 12th month: definition of CAM subsystems; recommendations for subsystem tool development (with emphasis on real-time operation) ; definition of development and implementation plan.

Years 2 to 4:

— develop selected CAM subsystems with an emphasis on high-integrity real-time operation, and integration in test-bed environment.

* 24th month: phase 1 subsystem/tools ready for integration and testing.

* 48th month: phase 2 subsystem/tools ready for integration and testing.

Year 5:

— conduct comprehensive tests of the overall integrated CIM system(s) using software developed in years 2 to 4.

* 60th month: prototype CAM system demonstrable in test-bed application.

5.3.1. 'Open CAM System allowing modular integration into factory management of a workshop structure in functional cells with various levels of automation' (Ref. 418: A/84)

The purpose of the project is to develop a CAM System with an open architecture. This CAM system will be applicable to machine as well as assembly activities. Although the system will be targetted at a specific manufacturing environment, the implementation methodologies and tools evolved in the course of the project will be applicable to a diverse range of manufacturing environments. The system will be implemented in two pilot shops (machine shop and assembly shop), consisting of several cells with various levels of automation. As implementation proceeds, a new flexible machining cell, consisting of a group of machine tools, measuring machines, materials buffering equipment and feeder robots will be incorporated into the system.

5.3.2. 'Control Systems for Integrated Manufacturing: the CAM Solution' (Ref. 477: A/84)

The project will be focused on production activity control (PAC), the role of which is to close the loop between production planning and execution. The

results will be especially applicable to small batch manufacturing environments. The goal of the project is to design, develop and test the software modules required to close the control loop, reducing human intervention and reaction time as much as possible, and relying on data automatically captured from the plant.

R&D area 5.4: Flexible Manufacturing Systems

Description

For industries specializing in the manufacture of a wide variety of parts in low and medium volumes, the development of highly flexible, high productivity systems is an important goal. The major task of the suppliers of CIM equipment is to enhance the technology required for flexible automation.

Machining centres for automatic machining of metal parts, systems for automatic loading and unloading of workpieces, and conveyor systems for automatically transferring workpieces from one machining process to another, are already available from many sources. A problem which still has to be attacked is the integration of machining centres into overall CIM systems, with proper acknowledgement of human factors.

Further development is required in the area of automated assembly systems, and to enhance the capability of robots beyond the simple operations at present carried out. Major benefits would be obtained if effective communication with the design process could be achieved. It is also necessary to take advantage of developments in Advanced Information Processing (AIP), and simulation systems.

Research and development is also needed to reach two of the principal, and often conflicting, goals of all future automated plants, namely maintenance of consistently high product quality and maximum plant availability.

R&D TOPICS

The R&D topics to be addressed in this area are:

5.4.1. Flexible manufacturing systems:

- — definition and general structure of flexible manufacturing systems;
- — communication and data transfer,
- — interface technology and human interaction.

5.4.2. Automated assembly:

- — automated assembly systems,
- — robot systems.

5.4.3. Plant availability and quality optimization:

- — basic plant diagnosis technology,
- — diagnosis formulation,
- — action planning,
- — automated quality control and inspection

5.4.4. Advanced control systems and concepts

- — specification of computing requirement
- — incorporation of Advanced Information Processing (AIP).

5.4.1. **Flexible manufacturing systems** (Type A)

Description

- — a general structure for flexible manufacturing systems including materials handling has to be defined. The major subsystems have to be identified, designed and implemented,
- — design and implementation of communications among subsystems on the basis of the Open System Interconnection (OSI) model,
- — definition of specific micro-electronic subsystems and components to be implemented in special IC's.

Programme (–) and Intermediate Objectives (*):

Year 1:

- — definition and specification of communication and interfaces among automatic equipment and other subsystems including human interaction.

— definition of general architecture and subsystems of FMS.

* 12th month: define specification for interfaces between automatic equipment; define FMS system architecture and subsystems.

Years 2 and 3:

— continuation of Year 1 (decisions on communication interfaces)

— definition and functional specification of dedicated microelectronic circuits.

— design of major subsystems for FMS.

* 24th month: specification of dedicated microelectronic circuits for machine control systems; initiate major subsystems for FMS, (including software for control systems).

* 36th month: analysis of the application of automatic equipment to a variety of processes; develop major subsystems in FMS.

Years 4 and 5:

— selection and analysis of manufacturing processes and machines where automatic systems can be applied and implementation of new applications with an assessment of human factors.

— implementation of major subsystems for FMS.

* 48th month: develop automatic equipment for processes previously identified; complete development of major subsystems in FMS.

* 60th month: develop automatic equipment with integrated process optimization; implement major subsystems in FMS.

5.4.1.1. 'The integration of welded fabrication within CIM' (Ref. 595: A/84)

The project is concerned with the development of subsystems and control frameworks for the application of welded fabrication in CIM. A co-ordinated programme is planned in which methods will be developed for generating, structuring, storing, and manipulating control and output data at all stages of the fabrication process. To enable an integrated development approach, the project will concentrate on a specific industrial sector and limited product range and the area chosen is shipbuilding. However, results generated in this project will have a much wider application within fabrication industries, and the rules for integration developed in this project will be applicable to the automation of other fabrication processes, e.g. high energy electron beam welding, laser welding and friction welding.

5.4.2. **Automated assembly** (Type A)

Description

Computer automated assembly systems (CAAS):

— extend existing systems to part identification, part mating;

— algorithmic description of the assembly process;

— application of AI in order to provide 'self-referential' control environments.

Robot systems:

Based on the preliminary design rules developed in 5.1.1 and the development paths outlined there, there is a need to realize some systems for the integration of robots in CIM. These include:

(a) a system to integrate the data flow between CAD and the robot.

the CAD area includes the design of single parts and assemblies as well as the graphics/geometric simulation of production processes and the linkage to process planning;

(b) a system which provides a set of tool/procedures to deal with the planning and installation of robots into production systems. This includes AI, support systems and simulation systems;

Programme (–) and Intermediate objectives (*):

Year 1:

— review the draft design rules from 5.1, assess and comment;

— review development paths in robotics identified in 5.1;

— propose formal design rules for robots, in cooperation with R&D item 5.1.1;

— identify and formulate strategies for safety requirements.

* 12th month: evaluate AI strategies for robot systems.

Year 2:

Identify requirements for:

— CAD to 'robot process' linkage,

— robot languages,

— robot control systems,

— graphic simulation for robot planning,

— safety,

— sensors,

— prepare rules for interface with CAM systems.

* 24th month: establish rules for interfacing automated assembly systems with CAM; application of AI strategies to robot systems.

Year 3:

— consideration of the requirements identified in Year 2, in terms of multi-robot systems;

— development of robot subsystems based on identified requirements and the use of AI;

— development of generalized robot planning/integration system within the framework of robot applications in CIM.

* 36th month: incorporate AI strategies into automated assembly systems; develop generalized robot language.

Year 4:

— continuation of work for Year 3 and realization of priority subsystems.

* 48th month: develop algorithmic structure for supervision of automated assembly systems.

Year 5:

— realize the generalized robot planning: integration system.

* 60th month: develop integrated automated assembly system using real-time sensor-driven control.

5.4.2.1. 'Integrated Information Processing for Design, Planning and Control of Assembly' (Ref. 384: A/84)

This project aims to demonstrate the principle of an integrated process for design, planning and control of small batch assemblies. The emphasis of the project will be on defining and automatically assembling the product, rather than on the manufacture of the piece parts. The project also aims to demonstrate the concept of an integrated system for the complete assembly process including design planning, scheduling and control aspects, considering all interdependencies and feedbacks from related assembly objects and processes.

5.4.2.2. 'Development of a Flexible Automated Assembly Cell and associated Human Factors Study' (Ref. 534: A/84)

The project is concerned with all aspects of the evaluation and development of a programmable flexible automated assembly cell for mechanical objects of typically 0.5 metre cube size. The concept is based upon the perceived needs of an intended user but the project includes an assessment of the application of the system to industry generally. The project comprises five technological and two human factor sub areas.

The technological factors are the use of robots with various other devices, including software development, the development of integrated sensors for robotic vision and optical data processing, the development of contactless inspection including integration, systems integration and a study of the applicability of the technology to future manufacturing. The human factors are concerned with work organisation and job design within the cell, skill levels, supervision, quality assurance, maintenance and training issues and a study of the involvement of engineers and scientists in planning for human needs in the cell's operation.

5.4.2.3. 'Operational Control for Robot System Integration into CIM' (Ref. 75-623: A/83-84)

The project is intended to improve the integration of robots into computer integrated manufacturing (CIM) systems. Based on the design rules and the development paths derived in the pilot phase of ESPRIT (Ref. 75) the project will establish automated integration facilities for the operational areas of planning and programming. For typical industrial applications it is expected to implement a prototype of a computer aided planning system and of a CAD-Robot linkage by means of an off-line programming system for robots. Graphical simulation to aid robot planning and programming as a basic tool of the system will be

analysed and implemented. A data management strategy will be derived to link the robot application into the CIM-framework. The possibilities for using AI techniques for robotic applications, including implicit programming methods, will be explored.

5.4.3. Plant availability and quality optimization (type B)

Research, develop and finally integrate the group of diagnostic/decision-making technologies essential for the design of fault-tolerant systems. The principal, and often conflicting, aims of maintaining both high product quality and maximum plant availability must be pursued in order to achieve reliable, high integrity CIM systems.

R&D is foreseen under four headings:

1. Basic plant diagnosis technology involving methodologies of sensor signal data compression, system/machinery fault modelling, architecture and design of diagnostic systems, etc.

2. Diagnosis formulation involving methodologies able to rank system/machinery faults thought to be either threatening plant availability or causing a fall-off in product quality.

3. Action planning in the areas of initiating actions to avoid system shutdown, maximizing utilization in the case of partial failure, user guidance and maintenance planning.

4. Automated Quality Control and Inspection to detect injurious product defects, ensure acceptable product quality and provide potential diagnostic information

5.4.3.1. 'A Systems Technology for Optimising the Tradeoffs between Plant Availability, Product Quality and Safety' (Ref. 504: B/84)

The aim of this project is the development of a systems technology for automating the management of discrete parts manufacturing plants based on maximising their availability, product quality and safety. A high percentage of the proposed R&D effort relates to the on-line processing of plant machinery health, tool performance, product quality and safety data. The enabling technologies include signal processing, expert systems, system modelling, action planning, sensor network and computer system design.

5.4.4. **Advanced Control Systems and Concepts** (Type B)

Description

— This topic is concerned with the development and implementation of new computing structures to facilitate real time control and intelligence in CIM systems.

The table below represents a possible approach:

Year 2:

— Analysis of computing structures to implement on line integrated CIM control systems.
— Analysis and simulation of adaptive techniques
— Analysis of hierarchical control strategies
— Analysis of possible use of A.I.P. techniques to hierarchical control

Year 3:

— Design and implementation of new computing structures in Advanced Control Systems
— Assessment of new network concepts to facilitate remote modeling and identification into the control concepts.
— Design and implementation of the software support (stand alone or distributed control system)

Year 4:

— Evaluation of the real time control systems
— Development of the software modules in relation to the programme objectives.
— Assessment of the control system performance.

Year 5:

— Realisation of an integrated control system in relation to the manufacturing process
— Incorporation of the advanced control identification and intelligent knowledge based systems concepts in the final central systems package
— Implications on the design and assessments of manufacturing equipment configurations.'

R&D area 5.5: Subsystems and components

Description

A number of subsystems and components are required to implement CIM. Two topics have been

identified as requiring colloborative effort. These are:

5.5.1. Sensor Systems.

5.5.2. Microelectronic subsystems.

5.5.1. **Sensor systems** (Type A)

Real time capture and interpretation of sensor data represent a major challenge, both in terms of hardware and software.

Prime application areas for sensor development include:

— flexible parts feeding
— force controlled assembly
— monitoring in CNC machinery
— 3 D measurement
— manipulative control
— testing and inspection
— tool condition detection and measurement
— automatic diagnosis and repair

The requirement is for:

— real time capture and processing of complex images, especially 3 D images
— tactile sensor feedback and real time sensor data processing
— integration of multi-sensor information in complex machining or assembly tasks
— application independent sensor programming and standards developed with regard to integrated VLSI chips.

Programme and intermediate objectives

12th month:

— specification of high-speed algorithms which can be implemented in VLSI;
— start specifications of VLSI combinations of imaging sensors and programmable pre-processors. Regarding algorithmic processors, the algorithms may be based on the preliminary outcome from AIP (3.2);
— commence development of demonstrator model;
— investigate AI techniques for sensor signal processing;
— specify hybrid electronic architecture.

24th month:

— development of sensor output processors;
— development of the demonstrator models.

36th month:

— incorporation of VLSI processors;
— continue development of sensor output processors;
— incorporation of hybrid processing.

48th month:

— implementation of AI techniques and sensor demonstrators in, for example, control systems and image processing.

60th month:

— continue development and evaluation;
— undertake exploratory work on advanced techniques for inspection and image processing such as holographic methods
— implementation of some selected pilot operations on the factory floor on projects initiated under 5.4.4.

5.5.1.1. 'Exploitation of Real-time Imaging for Arc Welding' (Ref. 9: A/83)

This project involves:

— *the evaluation and development of prototype image analysis systems using approaches already evolved by the contractors, or novel methods indicated by the image analysis survey and results of an industrial study;*
— *the identification, selection and specification of two initial industrial arc welding sensing tasks which will form the basis for applications-oriented development of adaptive control systems involving image analysis.*

5.5.1.2. 'General Purpose Sensory Controlled Systems for Parts Production' (Ref. 118: A/83)

This project addresses the problems related to the production of intelligent industrial robots. Sophisticated sensors for 2½D and 3D imaging of objects and scenes using a variety of contact and non-contact techniques will be developed. These will be integrated into a demonstration set-up and a full system evaluation completed.

5.5.1.3. 'Integrated Sensor-based Robot System' (Ref. 131 + 278: A/83-84)

The objective of this project is to develop a sensor-based system prototype (vision and tactile), intended for real time applications, in cooperation with industrial robots for intelligent handling and/or assembly. Test-bed applications are bin-picking, and workpiece handling on a moving conveyor belt.

5.5.1.4. 'Computer-aided thermal Image Technique for Real-time Inspection of Composite Material' (Ref. 197: A/83)

This project is concerned with research into imaging and image processing techniques using thermal scanners for the development of a real time system for on-line inspection and monitoring of composite materials and products, in a mass production environment.

5.5.2. **Microelectronic subsystems** (Type A)

In order to compete successfully in the world markets for plant automation systems, it is essential to make maximum use of microelectronic technology.

The objective is to realize subsystems required for the control of machines, robots or assembly systems on specialized chips. This will require close collaboration of automation specialists and semi-conductor designers.

Programme and Intermediate Objectives

12th month:

— design specification for functional areas of control systems suitable for custom integration

24th month:

— design and fabrication of chips

36th month:

— incorporation of chips into control systems
— start definition of graphics primitives in VLSI
— first results of design methodology for control systems and the functional mapping onto VLSI chips

48th month:

— test circuits in control systems and issue any specifications required
— develop graphics primitives in VLSI
— issue design methodology

60th month:

— finalize/review/refine graphics primitives in VLSI.

5.5.2.1. 'Integrated Electronic Subsystems for Plant Automation' (Ref. 179: A/83)

Within this project the functions performed by NC and Robot control systems are analysed and divided into subsystems. These will then be realised as general purpose subsystem integrated circuits which would be suitable for a broad range of applications in NC and Robot control. In addition a common language for communication between the IC's and the system will be devised.

R&D area 5.6: CIM systems applications

Description

In order to promote and support the more widespread application of CIM, it is desirable to establish suitable support centres where work on CIM development and application can be carried out. In order to fulfil the needs for education, research and development, and demonstration, at least two such sites are thought to be necessary, one with an academic infrastructure but with a proven record of technology transfer, and one in a real manufacturing environment.

To achieve this objective, the following projects and themes have been identified:

5.6.1. CIM application and development centres.

— preparatory study
— establishment of ESPRIT CIM application and development facilities

5.6.2. General topics for CIM support:

— product design guidelines for automatic production;

— methodologies for selection and configuration of CIM components
— economic methodologies for evaluating investment in CIM systems;
— interaction of CIM systems with organisation, infrastructures and skill requirements
— interaction of CIM systems with management information systems.

5.6.1. CIM application and development centres (Type A)

5.6.1.1. **Preparatory Study**

Evaluate alternative approaches by which the objectives associated with the establishment of CIM application and development facilities may be achieved. The full range of possibilities should be explored within the context of Community and nationally based programmes, so as the optimum approach may be adopted.

5.6.1.2. **CIM Application and Development Centres**

Establish ESPRIT CIM development and application sites where CIM technology and tools can be tested, demonstrated and developed.

Programme (–) and Intermediate objectives (*):

Year 2:

— Preparatory study for CIM application and development sites.

* 24th month: Complete preparatory study for establishment of sites.

Years 3 and 4:

— Formulate plans and select sites for:

* 36th month: Formulate plans for development of CIM application and development facilities.

* 48th month: Select suitable sites.

Years 5 and 6:

— Establish CIM application and development facilities.

* 60th month: Complete detailed plans, undertake preparatory work in establishing facilities.

* 72nd month: Complete the establishment of the facilities.

5.6.2. **General Topics for CIM Support** (Type B)

The following topics are given as examples, but the list is non-exhaustive:

— Product design guideline for automatic production:

  Create an understanding and ability to design mechanical products for automatic manufacturing.

— methodologies for selection and configuration of CIM components.

  Develop tools and methodologies for selecting CIM components and tailoring CIM systems to meet specific company needs.

— Economic methodologies for evaluating investment in CIM systems:

  Develop tools and methodologies for a correct economic evaluation of investment in CIM systems.

— Interaction of CIM systems with organisation, infrastructures and skill requirements.

  Determination of the required charges in organisation, infrastructure and skill requirements consequent upon the introduction of CIM systems.

— Interaction of CIM systems with management information systems:

  Definition of data interchange between CIM systems and 'management information systems' (MIS).

The purpose of these activities is to develop tools and facilities to promote successful CIM applications.

5.6.2.1. 'Product Design for Automated Manufacture and Assembly' (Ref. 338: B/84)

The objectives of this project will be two-fold. Firstly it is necessary to determine the range of manufacturing information which must be made available to the designer so that products are designed which are compatible with automated manufacturing and assembly techniques embodied in flexible machining and flexible assembly (including robotic assembly) systems. Secondly it is necessary to establish the basis on which this information is best made available to the designer using for example CAD systems.

5.6.2.2. 'Data Transfer Between Computer Integrated Manufacturing Systems and Management Information Systems' (Ref. 319: B/84)

The project will address the linkage of CIM and MIS systems in the context in which they must operate, namely, the management, technological and operational infrastructure of the enterprise and will relate this to the trends in information technology, the functional requirements of both hardware, software and operating systems, and the CIM vendor industry itself. Advances in computer technologies have created the opportunity for medium sized enterprises to apply sophisticated MIS-CIM techniques and hardware/software tools which were, up to very recently, only affordable by the largest enterprises. It is proposed therefore actively to test design concepts, techniques and prototype sub-systems in medium to small sized manufacturing environments.