II

(Acts whose publication is not obligatory)

COUNCIL

COUNCIL DECISION

of 28 February 1984

adopting the 1984 work programme for a European programme for research and development in information technologies (ESPRIT)

(84/157/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 services, industry and the academic world have given their opinions on the content of the projects to be launched in 1984 and their priority;

Whereas the projects forming part of the work programme fall within the areas described in the Annex to the Decision on the ESPRIT programme,

HAS DECIDED AS FOLLOWS:

Article 1

The ESPRIT work programme as set out in the Annex is hereby adopted for 1984.

Article 2

This Decision shall take effect on the day of its publication in the *Official Journal of the European Communities*.

Done at Brussels, 28 February 1984.

For the Council

The President

L. FABIUS

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

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INTRODUCTION AND OVERALL RESOURCES BREAKDOWN

This section is an integral part of the ESPRIT 1984 workplan. It is necessary for a proper reading and interpretation of the plan

1. Background

In such a fast-moving sector as IT, where the average life of a product is three years, it would be illusory and misleading to try and define *ab initio* detailed activities, objectives and time schedules for the next five years to come and particularly so in the case of R & D activities, although of industrial and essentially applied character.

This is why it was decided that a more detailed programme of work, necessary for the day-to-day implementation of the programme be established, and updated as required, by the Commission in consultation with the ESPRIT Management Committee, and submitted every year to the Council for approval. This is the first of such a 'workplan'.

2. Purpose and characteristics

The main purpose of the workplan is to provide the essential guiding elements for:

(a) drafting the call for proposals and selecting the projects to be launched;

(b) reviewing the individual projects under way and appraising their progress individually and in relationship with each other;

(c) coordinating activities under ESPRIT and under national programmes in the domain of IT;

(d) appraising the results of the programme as a whole and for evaluating the suitability of its technical objectives and options to meet the strategic objectives: this to be done in the light of the results obtained and of the technological programmes within as well as outside the Community;

3. Type A and type B projects

The existence and need of different kinds of projects for the character of work and the size of effort in a large R & D programme of the nature of ESPRIT is a fact of life; industrial R & D is acknowledged to rest essentially on two broad classes of projects:

(a) Projects that require large infrastructure and resources, both human and financial, as well as clear and constant strategic perspective to ensure continuity of actions and the breadth necessary to reap the long-term benefits. Such medium- to long-term 'system driven' R & D activities, that will be referred to in this document as 'type A projects', will represent the backbone of ESPRIT and are expected to account for some 75 % of the overall resources.

(b) Projects that rely mainly on flexible infrastructure and on individual thinking rather than on a system approach, and require relatively much smaller resources. Such activities, that will be referred to as 'type B projects', could range from very long term, very speculative R & D to specifically oriented R & D which may well be of shorter duration, and are expected to account for some 25 % of the overall effort under ESPRIT.

Essentially type A projects are big, complex, system-oriented whereas type B are small, idea-oriented.

The pursuit of strategic objectives of common interest requires that a number of well-identifiable major activities are undertaken and carried out according to agreed, and in some cases mutually interrelated, time schedules: type A projects are designed to represent these activities. In order to optimize resources allocation and provide the best conditions for synergism, proposals for such projects will therefore have to be invited giving detailed descriptions precisely identifying the objectives and the expected timing of their achievement, whereas the particular approach or the choice of the technological options would, as a rule, be left free.

Since B type projects are designed to fill possible gaps between the A types; tackling alternative, or complementary, or more speculative activities, the level of their definition would have to be more general in order to maximize flexibility and leave maximum room to innovation. Their timing, as a rule, could also be less critical. As a consequence and by contrast with the type A projects they are identified as a rule by theme only.

The definition of the type A projects and the identification of R & D domains within which type B projects may be invited is done in the light of the objectives to be pursued. In principle, topics that are part of a specific type A project could also be the subject of a type B project if, e.g., this latter proposes an alternative or competitive approach. Whenever type B projects will be proposed in such conditions, however, care must be taken to verify that such 'subset of type A project' remains meaningful in itself.

The workplan clearly indicates the distinction between type A and type B, so that the proposers will be able and will have to decide beforehand to go either for one or the other. No ambiguity should therefore be possible as for the character or 'type' of any particular proposal during the selection phase.

Both types of projects will be part of the same strategic effort, planned and executed as one single programme.

4. Pilot projects

The continuation of the work started under the pilot phase is possible within the ESPRIT programme and is, implicitly or explicitly, included in the programmes that are presented in the workplan. Such continuation will not, as a rule, be subject to a call in the strict sense but the information and the proposals gathered in response to the general call for proposal may generate modifications, widening or restriction (down to zero in extreme cases) of the activities originally foreseen in order to make the projects best suited to meet the revised objectives as they emerge from the workplan.

5. Validity of the workplan

In order to fulfil its purpose the workplan has to span over a reasonably long time, sufficient to cover the whole duration of the longer projects: five years was deemed to offer a good compromise between an accurate aiming (that would suggest short-term indications) and development perspective that require a wider time framework. Such five-year workplan shall be reviewed every year.

In the light of the above, the intermediate objectives that are set in the workplan are specified with less accuracy and reliability as one looks further ahead at the years to come and it must be stressed that since we are aiming at a moving target even the closest objectives may have to be changed in the course of the yearly revision, in the light of the progress within as well as outside ESPRIT, in Europe and elsewhere in the world.

Such intermediate objectives are, however, necessary to provide the general framework and as reference for evaluation and further refinements. They have therefore been introduced in the workplan as the best estimate of how, at this moment in time, the overall end-objectives of the project may be achieved. In this sense they are indicators and first-instance check points against which concrete proposals will be examined. They 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.

6. Estimated resources required and existing capabilities

The workplan formulates a number of objectives and proposes a number of R & D themes. Each of the main objectives would require for their achievement projects of a minimum 'critical size' that would at the same time justify the joint transnational approach and give it reasonable chances of success.

The preparation of the draft workplan in the present form is based on the work of some 300 specialists selected amongst almost 1 000 who had declared their readiness to contribute in industry, university and research centres.

It was the common feeling of these contributors who had the opportunity of meeting and debating their views, that the work that is being proposed is both essential for the achievement of the ESPRIT objectives and realistic in terms of the availability in Europe of the financial and human resources as well of the scientific capabilities to carry it out successfully.

7. Resources breakdown per area

The overall workplan breakdown of resources per area, as results from this first iteration is, like all other elements of the workplan, subject to modification in the light of the response as well as of the technological evolution on the world scene that might influence industries.

In particular, in the light of the response of industry to the first call for proposals, transfer of resources between the various areas will have to be possible.

With respect to this it is to be stressed that the partitioning of ESPRIT into five areas is incidental and dictated by management need and not intrinsic to the nature of work, that on the contrary is very heavily interrelated.

This will become more apparent in the next issues of the workplan when sufficient data concerning work actually under way will be available.

The following breakdown of resources is now envisaged:

(Man-years)

Subprogramme	Project year					Totals
	1	2	3	4	5	
1. MICROELECTRONICS	186	258	360	410	456	1 670
2. SOFTWARE	177	317	343	318	285	1 440
3. AIP	140	281	392	441	441	1 695
4. OFFICE SYSTEMS	210	310	440	390	100	1 450
5. CIM	121	216	215	220	172	944

SUBPROGRAMME 1

ADVANCED MICROELECTRONICS

The major thrust of this subprogramme is aimed at major improvement of the most important strategic technological areas. Hence:

1. Most of the resources are concentrated into a limited number of projects in the areas of silicon MOS and bipolar for VLSI and very high performance circuits. 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 the 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, lower priority, work on two important areas which complement silicon VLSI, namely compound semiconductor integrated circuits and optoelectronics are provided for at a reasonable level.

In addition to the main thrust of the programme as outlined in 1, 3 and 4 above and expanded in section A below, provision is also made for a number of smaller projects. Suitable topics for these are identified in section B.

In section A the MOS and bipolar process programmes have been structured as large integral projects rather than separate 1 μm and submicron projects. This has been done in the interests 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 higher performance. This continuity of effort would be lost by having separate projects at 1 μm and submicron levels.

The other part of the process strategy is to include work on techniques common to MOS and bipolar in the MOS project, as MOS tends to lead in scale of integration and feature size, and hence does the pioneering work in areas like lithography.

The importance of CAD for VLSI to the overall success of ESPRIT cannot be overemphasized. 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) No 3744/81 and the ESPRIT pilot phase are already underway. 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. A careful analysis should be carried out during

the first semester of 1984 to analyze progress and objectives of such work, in order to help in identifying new projects to be launched as from 1985.

There are far more organizations with a direct interest and competence in this field than is the case with VLSI technology. The project 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 places 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.

SECTION A

TYPE A PROJECTS

R & D area 1.1:

Submicron MOS

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.

Prerequisites

— experience with state-of-the-art processing;

— activities on advanced process steps;

— availability of functioning CAD/CAT tools;

— critical mass at least 200 man-years over five years.

Programme

Year 1:

— choice of process (CMOS or mixed C- and NMOS) and of design methodology;

— choice of optical lithography equipment;

— establishment of activity on process steps and modelling.

Year 2:

— optimization of individual process steps;

— establishment of preliminary design rules;

— characterization of process steps.

Year 3:

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

Year 4:

— evaluation of novel process steps for submicron technology (gate material, isolation, multilayer three-dimensional active structures, etc.);

— choice of submicron lithography equipment;

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

Year 5:

— evaluation of the 0,7 μm process;

— demonstration of the process feasibility;

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

Intermediate objectives

18th month

— design and evaluation of test chip of more than 1 000 transistors based on 1 μm design rules with a pitch (metal plus spacing) of 3 μm;

36th month

— first samples of circuits with 0,5 million transistors, 1 μm design rules, with data on figure of merit and delay time;

48th month

— statistical data on homogeneity on a slice and yield for 1 μm design rules; and test circuits with more than 1 000 transistors with 0,7 μm design rules and pitch of 2 μm;

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.

R & D area 1.2:

Submicron bipolar (single project)

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 necessary:

— overall circuit concepts which must evolve together with the technology;

— a vertical device structure appropriate to submicron lithography;

— a convenient multilayer interconnection technology,

— good optimization between device parameters and specific logic form uses;

— appropriate high dissipation, high pin count, electrically matched leads, packages;

— process and device modelling.

Prerequisites

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

— critical mass of at least 200 man-years over five years.

Activities dependent on 1.2

Fast VLSI microelectronics for information technology.

Programme

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.

Year 2:

— preliminary optimization of process steps;

— establish design rules 1 μm;

— start design of demonstrator chips;

— start research on novel processes and structures for submicron technology;

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.

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.

Year 5:

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

Intermediate objectives

12th month

— evaluate and choose critical equipment;

24th month

— establish design rules at 1 μm;

36th month

— demonstrate 1 μm process feasibility for 10/20 Kgates, 100 ps gate delay chips;

42nd month

— establish preliminary design rules for 0,7 μm structures;

48th month

— design demonstrator chip at 0,7 μm.

R & D area 1.3:

CAD (projects to be defined)

Description:

GLOBAL OBJECTIVES

(a) to encourage research into novel and advanced CAD techniques to manage the ever increasing circuit complexities involved;

(b) to provide a capability for complex VLSI design that is widely accessible.

CAD/CAT OBJECTIVES

The overall aim is an integrated design system capable of handling submicron VLSI circuits containing several million components.

The system should:

— provide a user friendly facility that is readily adaptable to changes in technology;

— allow systems designers to achieve a rapid turnround of valid and testable designs and associated test information;

— provide facilities for the optimization of circuits for high-volume applications;

— include libraries of primitive and complex cells;

— incorporate relevant results of CAD projects under Regulation (EEC) No 3744/81.

POLICY

(a) 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 1.1 and 1.2);

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

(c) after the first five years considered here, there will be another five years further development of this project to support specific technology advances and incorporate worldwide CAD improvements;

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

BALANCE AND PRIORITIES

(a) the assigned projects will have to ensure optimum balance between work to develop novel and advanced CAD techniques and work to consolidate European capability;

(b) one emphasis will be to provide a general framework and data interchange basis to make existing and new techniques generally available to a wide range of industry. A key factor is to promote cooperative development between university and industrial groups;

(c) a second emphasis will be to concentrate on those CAD facilities that are specifically required by the demands of a 1 μm and submicron process capability in order to enable the designs of very large and complex chips containing up to 10 million transistors.

Main topics

1.3.1. *CAD management*

Provide coordination and intelligence.

1.3.2. *High level design and layout*

— high level (behavioural) design aids,

— cell library and techniques for large, parameterized cells,

— layout design and testing techniques,

— analogue and switch level verification,

— design management.

With a target to achieve full custom design at the 0,5 million transistor level in year 4.

1.3.3. *Research: advanced/innovative CAD*

— use of AIP and expert systems,

— use of special hardware,

— novel algorithms.

Complete development of second generation system in year 5.

1.3.4. *Establishment of CAD centres*

— implement first generation system in year 4.

R & D area 1.4:

Compound semiconductor materials and integrated circuits (single project)

Description

Integrated circuits in III-V compound semiconductor materials offer potential speed 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 the problems need to be tackled.

The technology encompasses GaAs homojunction structures based on the FET as well as GaAs/GaAlAs heterojunction structures using the high electron mobility transistor (HEMT) or the heterojunction bipolar. Basic research is required in

materials preparation, ion implantation, and IC process technologies.

Prerequisites

— source of pure materials;

— CAD facilities;

— suitable laboratory and experienced team.

Programme

Year 1:

— initiate materials research in GaAs including ion implantation to produce GaAs FET-based ICs;

— initiate work on molecular beam epitaxy (MBE) and metallo-organic chemical vapour deposition (MOCVD) for the growth of suitable heterojunction structures in GaAlAs.

Year 2:

— continue materials research;

— develop GaAs IC fabrication process on 2-inch wafers at 1 μm feature size using multilayer metallization, etc.;

— fabricate experimental discrete HEMTs and bipolars in GaAs/GaAlAs.

Year 3:

— continue materials research in GaAs and GaAlAs;

— initiate research on new materials, e.g. GaInAs;

— extend GaAs technology to 3-inch wafers and submicron features;

— continue research into optimization of HEMT and bipolar discretes;

— demonstrate 1 000 gate array in GaAs FET-based logic.

Year 4:

— continue materials research including new materials;

— carry out yield improvement exercise on basic GaAs IC process;

— establish basic process steps for a GaAs/GaAlAs IC process based on the HEMT or bipolar.

Year 5:

— integrate process steps for heterojunction bipolar (or HEMT) IC technology;

— fabricate experimental ICs based in this technology;

— continue new materials research (e.g. GaInAs);

— fabricate experimental discrete devices in GaInAs.

Intermediate objectives

12th month

— single-gate demonstration circuit based on 0,5 μm design rules;

24th month

— 30-gate demonstration circuit based on 0,5 μm design rules;

36th month

— initiation of 0,3 μm design rules;

— 1 000-gate demonstration circuit based on 0,5 μm design rules;

48th month

— demonstration of 100-gate circuit based on 0,3 μm design rules;

60th month

— demonstration of 1 000-gate circuit based on 0,3 μm design rules.

R & D area 1.5:

Optoelectronics (single project)

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. This will allow processing, combining and routing at very high speeds. In semiconductor form they will also be compatible with III-V integrated circuits providing a fast electrical interface.

Prerequisites

— Source of pure materials;

— Suitable laboratory and experienced team.

Programme

Year 1:

— initiate materials research on optical structures and improved methods of materials preparation such as metallo-organic chemical vapour deposition and molecular beam epitaxy;

— extend materials research to organics including fast response photochromic materials;

— fabricate basic discrete devices, e.g. lasers, LEDs, detectors, switches, etc.

Year 2:

— continue materials research;

— fabricate narrow line lasers and investigate detection techniques for coherent systems;

— develop bistable optical devices, high-speed modulators and optical couplers;

— research into monolithic optoelectronics.

Year 3:

— investigate integration in optical materials using thin film waveguides for interconnection;

— continue materials research;

— fabricate multi-component structures, e.g. laser arrays for wavelength multiplexing, switch matrices as basic switching elements.

Year 4:

— combine waveguide integration with monolithic integration technology to produce experimental optical systems on a single chip;

— continue technology development in $LiNbO_3$, photochromics for optical interconnections, and new materials.

Year 5:

— develop high-speed optical switching system and study application of optical techniques to computers.

Intermediate objectives

12th month

— GaAlAs metal organic chemical vapour deposition (MOCVD) established for discrete device fabrication;

— optimum Ti-lithium niobate technology established and 10 GHz modulation demonstrated.

24th month

— GaInAs MOCVD established for discrete devices;

— basic electro-optic switch technology optimized;

— proton exchange and organic overlay waveguide technology established for switches and modulators.

36th month

— GaAlInAs MOCVD established for discrete devices;

— 100 elements GaAlAs MOCVD optoelectronic integrated circuit demonstrated;

— 100 element electro-optic switch demonstrated;

— hybrid integrated electro-optic technology established;

48th month

— lithium niobate/oxide epitaxial growth established;

— 100 GHz electro-optic modulation demonstrated;

— molecular beam epitaxy (MBE) demonstrated for discrete and integrated components;

60th month

— 'optical system on a chip' demonstrated, using MBE and MOCVD material;

— ultrafast hybrid electro-optic processor demonstrated.

SECTION B

SUGGESTED THEMES FOR TYPE B PROJECTS

In addition to the topic areas already identified in section A (where type B projects may usefully complement the work programmes by providing the requisite technology and tools and/or anticipate next generation requirements), the following are specific examples of topics which would be eligible:

(a) *VLSI-related*

— Lithography (E-beam, X-ray, UV),

— Ion implantation,

— Semiconductor materials,

— Resist technology,

— Rapid anneal techniques,

— Layer processing techniques,

— Conductors (metals, silicides, contacts),

— Insulators (thin, thick, organic),

— Device reliability,

— CAD for GaAs,

— Computer-aided manufacturing methods.

(b) *Others*

— Interconnection (off-chip),

— Advanced physical analysis techniques,

— Flat screen display technology,

— Sensors and transducers,

— New technologies for advanced information storage,

— New inorganic and organic materials.

SUBPROGRAMME 2

SOFTWARE TECHNOLOGY

The objective of this subprogramme is to reach a stage where the production of information systems (i.e. products including hardware and software solutions) would have the characteristics of an industrial process, and, to a large extent, would be computer assisted. This implies bringing to the consciousness of every industrial organization the fact that software production is a true engineering discipline, subject to technical, organizational and economic factors.

The progress to be made in software technology has been divided into three general categories. As with any classification, such a division is arbitrary, and the categories are not independent. The first category of work to be performed is to contribute to the *understanding* of the process of software production and maintenance, taking as a departure point the best of current practices. The second category concerns itself with *implementing* the support (including tools) that will make the results of the understanding usable in practice. The third category is concerned with medium- and long-term R & D aimed at *evolving* new software production methods.

For further structuring of the work, a simple software life-cycle model is introduced. It is not intended that this model should limit the scope of projects; indeed there will be

projects specifically concerned with the development of such models. In this simple model, software production and maintenance consists of a sequence of intermediate levels of representation with transformations between them, proceeding from initial concept to operational system. In practice, such development must be iterative, and almost never follows a simple linear course. Such iterative operations are indicated in Figure 2-1 which shows them embedded in a broad project context. Thus, the work to be done can be subdivided into three major areas (see Figure 2-1): the (technical) *process* itself; *management* and control; and the support *environment*.

Combining the general categories with each of the life-cycle areas, a 3 × 3 matrix results, giving a total of nine subdivisions. On the basis of the strategic projects that have been identified, these subdivisions more or less naturally group into four R & D areas.

A fifth area is formed by demonstration projects, which would not be artificial projects but rather real projects used as evaluation and demonstration vehicles.

The five R & D areas are described on the following sheets.

R & D area 2.1:

Process — understanding and implementing

Description

The activities in this area address the transition to an engineering approach to systems and software engineering within the framework of the current life-cycle view. A scenario is envisaged in which well-founded scientifically-based methods are gradually adopted to replace *ad hoc* techniques currently in use. Such methods 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. The research and development programme in this area should continue for about five years, so more speculative and radical approaches to system development, for which considerable fundamental research is required, are not considered here (see 2.4).

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 programs rather than by completely new development.

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.

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.

R & D TOPICS

The work in this area will address:

— reference models of systematic approaches to system development;

— practical and disciplined system development methods;

— effective methods of software production and maintenance;

— study of application area needs;

— representation and transformation tools;

— verification and validation tools;

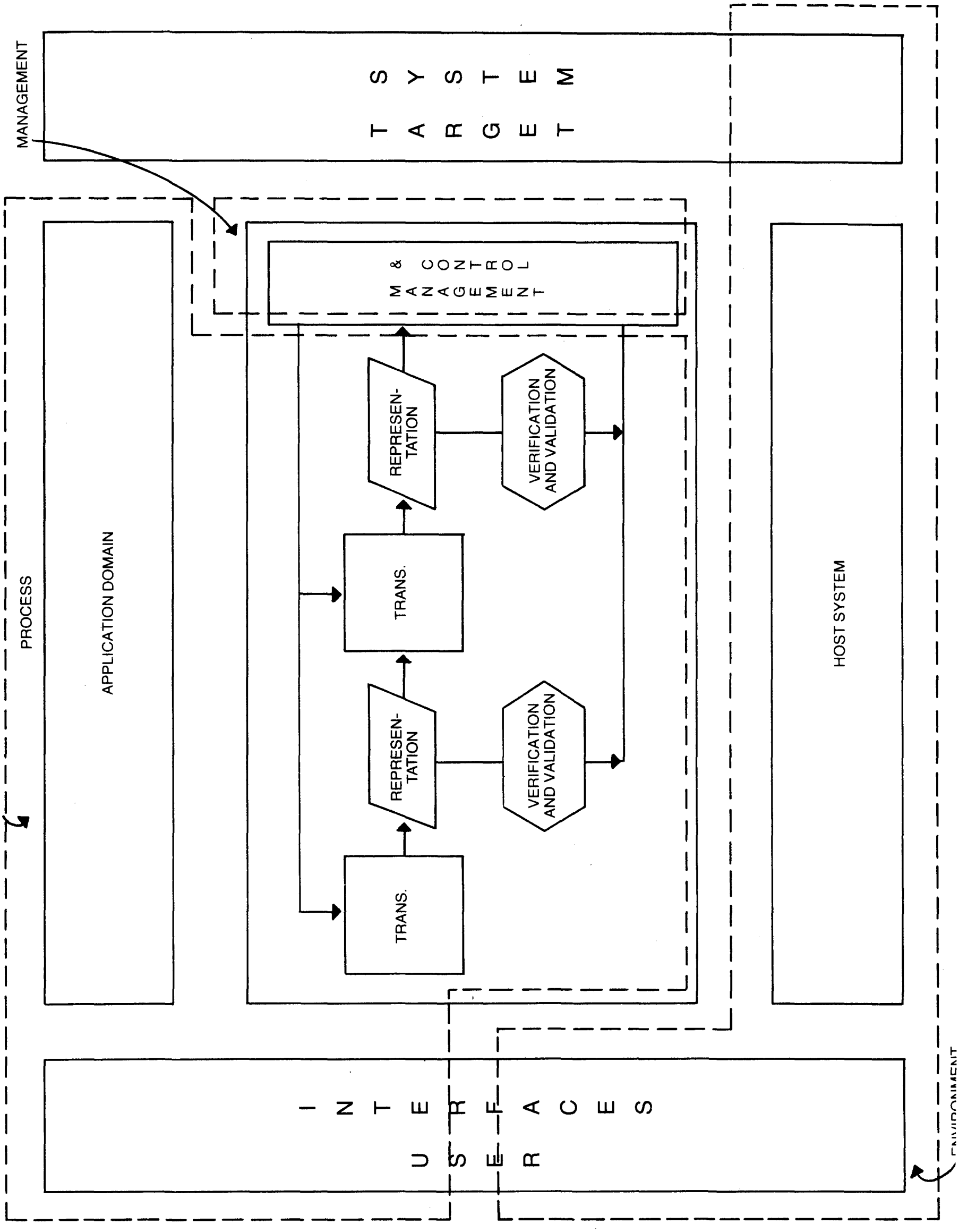

MANAGEMENT
SYSTEM TARGET
M & CONTROL MANAGEMENT
PROCESS
APPLICATION DOMAIN
REPRESEN-TATION
VERIFICATION AND VALIDATION
TRANS.
REPRESEN-TATION
VERIFICATION AND VALIDATION
TRANS.
HOST SYSTEM
USER INTERFACES
ENVIRONMENT

Figure 2 - 1

— support tools:

  — component library support tools,

  — documentation tools,

  — performance prediction and measurement tools,

  — reliability specification and measurement tools,

  — process support tools.

The programme includes continuation of work started by the pilot projects in Year 0.

TYPE A PROJECTS

2.1.1. *Methods, techniques and tools*

This topic should be covered by up to two projects to be started in Year 1, both answering to the description given below. The differentiation between these projects will be on the basis of the main approach adopted by them, or on the application area they address.

The objectives are:

— to identify an adequate range of effective methods of software production and maintenance,

— to provide tool support for these methods, assuming multiple levels of representation with incremental verification and validation.

The methods must achieve complete coverage of the entire spectrum from requirements definition through to the maintenance phase, including necessary iterations; methods must aim to minimize total life-cycle cost, and compatibility between various methods and notations used in successive life-cycle phases is a prime requirement.

To establish the overall context in which software development takes place, reference models of systematic approaches to *system* development must be addressed, and special attention be paid to the crucial requirements analysis task.

One especially important task is to investigate the issues relating to the use and re-use of software components.

Intermediate objectives

12th month

— prototype version of tools;

18th month

— reference model of system development;

24th month

— initial tool set;

36th month

— system and software development methods;

60th month

— final tool set.

2.1.2. *Integration of management and technical aspects*

This project addresses those management issues which are strongly affected by the technical properties of the solution expected from project 2.1.1.

The objectives are:

— to develop together, in one project, both management and technical approaches to software production and maintenance,

— to explore problems related to management and control of the software product, especially configuration management and version/variant control,

— to develop or abstract those standards that will be effective also from a management point of view.

Special attention will have to be paid to the use of families of 'prefabricated' components in integration and production management.

Intermediate objectives

24th month

— Methods and techniques for product management and control;

48th to 60th month

— Support tools for configuration management, integration and production management.

2.1.3. *Software methodology*

This project will investigate the suitability of methods and techniques for various application areas, and develop the criteria for selecting, from among existing or envisaged methods and techniques, those that are most appropriate for the project in hand on the basis of:

— the particular application area,

— the overall development situation (team size, other personnel and management constraints, capabilities of the technical environment, etc.),

— the envisaged product life (frequency of changes, number of variants, etc.).

Where possible the criteria should be quantitative, and to this end global numerical data will be collected and analyzed from a number of development projects over a long period of time. The utility of the criteria will require verification in application to real projects and adjusted in the light of practical experience.

Intermediate objectives

18th month

— study of application area needs;

36th month

— (qualitative) criteria;

48th month

— quantitative analysis of data collected from development projects;

60th month

— Full set of criteria.

TYPE B PROJECTS

The following themes at least will have to be addressed in this R & D area:

— system development models;

— system/software development methods, including:

  — use of existing components in new developments,

  — formal semantics of interfaces,

  — fault tolerance,

  — validation and verification,

  — capturing of requirements,

  — development of notations (including graphical ones) which have well-founded semantics,

  — reliability of specifications,

  — specification of both sequential and concurrent systems,

  — decomposition, integration and retaining of compatibility between evolving hardware and software subsystems both during development and during operational life,

  — hardware/software migration,

  — system optimization;

— representation and transformation tools, including the use of semi-formal as well as graphical languages;

— verification and validation tools;

— component library support tools;

— performance prediction and measurement tools;

— reliability specification and measurement tools.

R & D area 2.2:

Management — understanding and implementing

Description

Projects in this area are intended to consolidate understanding of, and effective means of support for, the management of software projects. The management approach which is developed must be consistent with the technical approach developed in the 'Process — understanding and implementing' area (2.1). This can best be achieved if the management

and technical approaches are developed together (see 2.1.2). It is also important that the projects in this area address both technical management issues, such as configuration control, and project management issues, such as effort estimation. Another important topic is the establishment of techniques for the collection of data which allow managers to evaluate and select methods and tools.

R & D TOPICS

Work in this area will address:

— management models of software production and maintenance;

— project planning and control tools and techniques;

— configuration management tools and techniques;

— production management, integration and control tools and techniques;

— maintenance management methods and tools;

— quality and reliability assurance tools and techniques;

— management database support;

— data collection and analysis.

The programme includes continuation of work started under the pilot projects in year 0.

TYPE A PROJECTS

2.2.1. *Software production and maintenance management support*

The objectives are:

— to develop quantitative management models of software production and maintenance;

— to provide support for the major functions of software production and maintenance management:

  — planning and control of software projects,

  — planning and control of software products,

  — maintenance management;

— to develop database support for management tools (e.g. by exploiting the database facilities of the common environment).

It is important that a wide variety of management practices be accommodated with a limited set of common facilities (e.g. through exploitation of generic properties).

Intermediate objectives

12th month

— cost estimating models;

18th month

— full quantitative models;

36th month

— initial tool set;

42nd month

— management database;

54th month

— complete tool set.

2.2.2. *Quality and reliability assurance*

The objectives are:

— to investigate in detail the effectiveness of two contrasting approaches to quality and reliability assurance, namely that of close control over the development process, and that of measurement and corrective action,

— to provide techniques and tools that will assist the assurance controls both pre- and post-production.

The properties by which a product's quality may be characterized and quantified should be identified and means by which a product's quality and reliability may be estimated and predicted should be determined.

Particular attention should be given to the verification and validation activity at each of the transformations in the life-cycle.

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

projects). The long-term aspect (assessment and evaluation of methods themselves on the basis or larger statistics) is addressed in project 2.1.3.

Intermediate objectives

24th month

— criteria for quality and reliability assurance;

36th month

— data collection and analysis techniques;

60th month

— tool set available.

TYPE B PROJECTS

The following themes at least will have to be addressed in this R & D area:

— monitoring techniques and progress parameters;

— maintenance management, e.g.:

  — fault and error reporting,

  — change control,

  — release control,

  — handling of enhancement requests;

— failure mode effects and criticality analysis.

R & D area 2.3:

Environment — understanding and implementing

Description

The 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.

Since multi-national development of software will be a central feature of ESPRIT as a whole, this environment is an important building block for all ESPRIT programmes. Hence it is imperative that there is general publication of all interfaces, thus providing for general exploitation and interception of the environment.

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, thus promoting extension to the complete integrated environment.

The environment developed must allow a range of implementations, on hardware of different capabilities, and with different aims (e.g. ease of installation v. efficiency). Therefore it is important that a spectrum of interfaces is defined through which tools operate on 'objects' such as programs, files, devices and other tools in order to accommodate these needs.

R & D TOPICS

Work in this area will address:

— environment infrastructure;

— common environment tools and components;

— common environment general services.

The programme includes continuation of work started under pilot projects in Year 0.

TYPE A PROJECT

2.3.1. *Common tool environment*

The objectives are:

— to develop a common environment to be used as primitive software development environment, and as the basis of a complete integrated software engineering environment,

— to develop an object-based approach to the provision of a tool-rich environment, where 'object' includes programs, files, devices and

other tools; the emphasis will be on meta-tools, which can be used to assist in the construction of specific environment tools and facilities; common tools and components will promote a homogeneous interface across all instances of the environment and reduce the cost of new tool development,

— to provide an appropriate infrastructure (basic framework) with standards and conventions for environment work-stations, with support from common user interfacing mechanisms, with basic mechanisms for program execution, communication and object management (environment database) and with local area network protocols and interface standards appropriate for environment functions,

— to provide a range of general services of interest to all users (e.g. mail, bulletin board, document preparation, etc.).

Intermediate objectives

12th month

— first prototype environment;

24th month

— initial common tool set;

36th month

— initial environment, and full common tool set and general services.

R & D area 2.4:

Process, management and environment — evolving

Description

Projects in this area should address the total activity of software development from the emergence or statement of a computer application concept or of a problem to be solved, through the installation and operation of the appropriate software or software based system, and throughout its subsequent lifetime in which continuing adaptation to changing environments and changing user perceptions is inevitable.

The programme provides both for a totally coherent process approach and for exploring fundamentally new approaches. The emphasis is therefore on longer-term research.

It is anticipated that overall structural changes in software management will result from improved understanding of the whole software process. In addition detailed evolution will follow improvements in such areas as measurements, quality assurance and software tools support. Part of the work in this area is therefore directed at significant improvement in software management techniques.

Another part intends to provide the basis for the more advanced environments of the future. This will involve the application of AIP techniques (see subprogramme 3) to the problems of software environments. Such environments might be expected to be extensible and play an active rather than a passive role. On the other hand, requirements coming from the AIP domain must be taken into account to provide environments suited to their needs. Moreover, it is desirable that appropriate interfaces between these and the initial common environment (see 2.3) be provided.

R & D TOPICS

The topics described here are of long-term and speculative nature. Details of the grouping of all topics into packages cannot be given at this stage and only one type A project has been defined. However, it is expected that proposals will provide other such groupings, and up to three type A projects could be accommodated. They will initially have a predominantly research orientation, but industrial take-up must be ensured from the beginning, both by the combination of research topics and by the structure of the participation.

Work in this area will address:

— improved models for software production and maintenance (with special reference to the coherence of the processes modelled); both the technical and the management aspects need to be addressed;

— construction and transformation of representations (including automatic and interactive program synthesis, with special attention for generic and re-usable software and for validation and verification);

— general methods and tools for application domain analysis with special reference to capturing of requirements;

— hardware/software synergy and new architectures;

— non-imperative languages;

— convergence of technologies in program specification, program implementation and database design;

— measurement and modelling;

— quality and reliability;

— expert system approaches to software production and maintenance, involving active databases, management expert systems;

— advanced support environments and human interfacing for the development of highly demanding applications such as advanced information processing applications.

TYPE A PROJECT

2.4.1. *Advanced interactive software development*

The objectives are:

— to investigate the possibility of developing an approach which begins to integrate the rigour of the 'software engineering' approach and the flexibility of the experimental and 'throwaway' style of software development exemplified by knowledge processing work;

— to provide an environment supporting this formal interactive style of program development. This environment should provide integrated support for existing languages and methods of several classes (functional, logic, object-oriented . . .);

— to provide appropriate interfaces to ensure effective interworking between this environment and the initial common tool environment (see 2.3.1 above);

— to provide facilities for rapid incorporation of future developments in different classes of languages.

Intermediate objectives

12th month

— common approach characteristics description;

24th month

— experimental interactive environment;

48th month

— advanced interactive environment;

60th month

— interfacing with common tool environment.

TYPE B PROJECTS

These can address any of the topics mentioned above.

R & D area 2.5:

Demonstration projects

There is a significant barrier to the introduction of new methods and tools into industry — no project manager wants to be the first to attempt practical usage of a new approach. This barrier can be addressed by providing financial support for demonstration projects. The intention is not to create an artificial project solely to demonstrate some new approach, but rather to use a real project as an evaluation and demonstration vehicle. The financial support should then cover the additional costs that are incurred in performing this evaluation and demonstration role. In particular, the funding must 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 community as a whole. The funding of demonstration projects should be conditional upon the production of such reports and critiques.

It is important that the results of such demonstration projects should be seen to be valid and conclusive; this requires, among other things, that the design and planning of such demonstrations should be evaluated from the perspective of the statistical theory of 'design of experiments'.

Projects of this type are expected to start in Years 2 and 3 (i.e. 1985/86 and 1986/87), and cannot be planned in any detail at this stage.

SUBPROGRAMME 3

ADVANCED INFORMATION PROCESSING (AIP)

The main theme is machine intelligence. This embraces the process of extracting knowledge, storing that knowledge for easy access and use and to enhance the knowledge base through usage. A major aim is to bridge the gap between the computer and the non-technical user by using computer-based intelligence to assist the user and present an easy, friendly interface.

Initial theoretical work will be on the process of reasoning from which to base the design of advanced expert or knowledge-based systems. While the main emphasis in the early years will be knowledge engineering and knowledge storage and usage, the emphasis later will be on the exploration of new architectures and the implementation of systems. In parallel, research will be undertaken on external interfaces, the interaction of man and the machine. An important feature of this work will be signal analysis and processing, particularly for handling visual data. Work will also be carried out on the specification and design facets of AIP systems.

Early in the programme a number of demonstrator AIP systems will be built using conventional equipment. These will be built as quickly as possible to accelerate the core of knowledge and experience in AIP systems and through accessible demonstrators obtain contributions from the wider research community. In addition, provision is made for a number of integrated, interdisciplinary 'focus' projects, that span not only the five main aspects of AIP but also the other areas of the ESPRIT programme.

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 realize 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:

— business 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,

— realization of the KBS applications on the most appropriate delivery vehicle in terms of MMI, engine capability, data/knowledge base capabilities, and storage capabilities as well as communication facilities,

— customization of the system for users by providing an adaptive interface which minimizes 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 application.

R & D TOPICS

Work will research, specify, classify and provision the tools and techniques of knowledge engineering, and will cover:

3.1.1. (*) Knowledge-based systems and their metrication

3.1.2. (*) Dialogue and natural language

3.1.3. (*) Knowledge representation and inference techniques

3.1.4. Preparatory work towards advanced KBS

3.1.4.1. Implementation languages and Environments (*)

3.1.4.2. Compilers and interpreters

3.1.4.3. Knowledge acquisition and manipulation

3.1.4.4. Advanced generation KBS applications

3.1.4.5. Learning techniques (*)

TYPE A PROJECTS

3.1.1. *Knowledge-based systems and their metrication*

The objective is an on-going programme, over at least five 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 at resources from the fifth year into project 3.1.4 for the second phase of the demonstrator programme.

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 3.1.1 and 3.1.4.4 jointly represent a rolling programme of demonstrators for early and advanced KBS. Also research topics 3.1.3 and 3.1.4.1 are expected to be very closely related, with a prime output into the advanced phase of demonstrators. However, it is expected demonstrators during the first five 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 two to three year duration.

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.

(*) *Note:* Work planned to start in Year 1 (1984/85).

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 of key importance 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 organized as a continously rolling programme.

Programme and intermediate objectives

Year 1:

— select application domain;

— choose appropriate tools and methods;

— establish implementation environment;

— identify metrication aspects for evaluation; develop concepts and methods for solutions.

Year 2:

— choose metrication tools and methods to be developed;

— define what measures are to be made and analyzed;

— define the applications to be instrumented and measured.

Years 1 to 3:

— assemble KBS demonstrator;

— record construction methods and results;

— record new domain characteristics.

Year 3:

— measurement and analysis of productivity and performance for the target applications.

Years 2 to 4:

— carry out experiments on demonstrators to determine acceptability and impact on 'client' productivity;

— report on construction productivity and recommend new tools and methods.

Year 4:

— publish productivity and performance recommendations, and guidelines for knowledge engineers;

— propose new metrication methods, especially those which are more automated.

3.1.2. *Dialogue and natural language*

Description

A major work 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 systems and client users.

The dialogue itself should enhance the quality of system behaviour by offering cooperation, understanding 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 use of high bandwidth graphics, explanatory pictures and films, and to the use of audio support.

Programme and intermediate objectives

Year 1:

— study of required language styles and capabilities;

— specify framework for exploitation of high bandwidth MMI.

Years 1 and 2:

— understand dialogue requirements classified by domain of application.

Years 2 to 4:

— create generators and parsers for a variety of dialogue languages.

Years 3 and 4:

— specify knowledge-based language processing tools.

Years 4 to 7:

— implement knowledge-based language processing/dialogue tools for integration into KBS applications.

3.1.3. *Knowledge representation and inference techniques*

Description

Knowledge representation is a key factor analogous to data modelling in conventional processing. Because of its complexity, it requires engineering, modelling and transformation tools of high sophistication. It is not expected that any one language will merge — 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 cooperating, knowledge domains, and thus research on interworking KRS and inference models will be essential.

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:

— natural deduction technique not requiring special implicative form;

— non-classical logic such as temporal and fuzzy logic, which are closer to real-world time related and qualitative behaviour, but which lack practical proof algorithms;

— knowledge-based control of the inference process itself;

— constraint propagation and truth maintenance;

— exploitation of contextual knowledge;

— cost/quality directed paradigms;

— classification of inference tools and methods against domains, KRS and paradigms;

— recognition of the need for real time transition of system state (and thus implicated knowledge) as a result of real-world change.

Programme and intermediate objectives:

Knowledge representations:

Years 1 and 2:

— compile all existing KRS proposals;

— cross-check and fertilize so as to differentiate and classify KRS;

— determine what is specifically and generally needed;

— impact of psychology on KRS.

Years 2 and 3:

— extend and consolidate — referring to models such as data dictionaries, databases and programming languages.

Years 3 to 5:

— propose new KRS tool kits and methods, and introduce these into project 3.1.1 for 'rolling' exploitation.

Years 4 to 6:

— publish European guidelines for components of KRS tool kits;

— reference 'production' implementation of new KRS.

Inference techniques:

Years 1 and 2:

— determine state-of-art in tools and methods, and classify against domains, KRS and paradigms;

— set up subprojects for research.

Years 3 and 4:

— undertake basic research on natural deduction, temporal logic, fuzzy logic, inference primitives, and knowledge based meta-level control of inference.

Years 5 and 6:

— construct inference models for output to the demonstrator and metrics programmes;

— continue research on approximate reasoning and meta-level control.

3.1.4. *Preparatory work towards advanced KBS*

Although this is categorized as an A-project, work in the first few years will be at a comparatively low level and then build up as advanced generation KBS become feasible. The preparatory work will include:

3.1.4.1. Implementation languages and environments;

3.1.4.2. Compilers and interpreters;

3.1.4.3. Knowledge acquisition and manipulation;

3.1.4.4. Advanced generation KBS applications;

3.1.4.5. learning techniques,

though it is possible that other topics in this area will become identified as work proceeds.

All five of the above topic areas are briefly described below, but only the two which are planned to start in Year 1 (namely 3.1.4.1 and 3.1.4.5) have programme outlines included.

3.1.4.1. *Implementation languages and environments*

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 common tools programme will address portability.

Programme and intermediate objectives

Years 1 to 3:

— identify and evaluate candidate languages (for example, Smalltalk, LISP, Prolog, Poplog) environments and architectures.

Years 4 and 5:

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

— procure extensions/changes.

Years 5 and 6:

— issue guidelines to ESPRIT;

— make reference language systems available.

3.1.4.2. *Compilers and interpreters*

The objective is the software implementation of interpreters/compilers for the various knowledge representations and manipulation methods developed from 3.1.3 and 3.1.4.1.

3.1.4.3. *Knowledge acquisition and manipulation*

Following early work on knowledge representation (3.1.3), experience from early applications and studies of knowledge engineering measures (3.1.1), and studies of dialogue (3.1.2), the needs for methods and tools associated with the practice of the knowledge engineering skill will become clear. The environment for knowledge acquisition and manipulation will of course be completely interactive, and be aided with graphics. Work in this area will include:

— knowledge editing, updating and retrieval,

— KRS proof checkers,

— knowledge dictionary 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,

— MMI tool kits.

This developing set of capabilities should be integrated into recommended 'European' tool kits for handling knowledge.

3.1.4.4. *Advanced generation KBS applications*

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 characterize most learned human experience.

Many times a problem has no simple solution at a given reasoning level; abstracting from that level allows one to argue about the reasoning process itself and gives rise to so-called meta-reasoning. Meta-reasoning deals with two types of problems: extending inference techniques for finding conceptual solutions to problems, and reasoning about inference techniques or rules for more efficient exploitation of these inference rules.

The advanced generation of KBS applications will be expected to exploit the lessons of first generation attempts (3.1.1), the fruits of KRS and inference research (3.1.3), the tools of knowledge and acquisition manipulation (3.1.4.3), the latest languages and engines (3.1.4.1 and 3.1.4.2), the fruits of natural language processing research (3.1.2), and the fruits of the external interfaces programme (3.2) for handling sound and images.

3.1.4.5. *Learning techniques*

Description

The knowledge acquisition process is complex and therefore it is mandatory to develop concepts, algorithms and techniques to support the development of programs and machines which learn. This task covers the identification of appropriate models of learning and the investigation of learning techniques appropriate for AIP systems.

Learning techniques might be based on the capability of the artificial system to measure its performance and to develop an evolutionary process which might improve such performance.

Programme and intermediate objectives

Years 1 and 2:

— identification of models;

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

Years 3 and 4:

— investigation of learning techniques such as writing code of programs which learn;

— preliminary testing.

Years 5 and 6:

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

TYPE B RESEARCH THEMES

Related to 3.1.1:

— 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.

Related to 3.1.2:

— dialogue specification and analysis tools,

— natural language systems architecture,

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

— semantics and the role of context.

Related to 3.1.3:

— 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,

— the relationships between knowledge representation and inference techniques, problems of self-reference and system 'self-awareness',

— real-time inference techniques,

— the role of meta-knowledge in inference processes,

— techniques for planning and program synthesis,

— structuring of reference techniques,

— automatic adaptation and enhancement,

— inference under conditions of conflicting and uncertain knowledge,

— the impact of knowledge representation on inference techniques.

Related to 3.1.4.1:

— 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.

Related to 3.1.4.5:

— 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,

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

R & D area 3.2:

External interfaces

Description

In the past, facts about the real world have largely been represented to a computer system at second-hand by people. The data fed in had to possess a formal structure that needed to be carefully specified to the system. This situation will change.

Two types of external interface will occur. Those that extract their information by direct communication with humans, and those that acquire knowledge by means of their sensors. In either case the system will need to process the signals and interpret their significance. Other important aspects concern the

presentation of the results by the system to a human, and the user-friendliness of the system from a human users point of view.

R & D TOPICS

Work in this area falls under two main headings:

3.2.1.: *Basic signal analysis and recognition*

— advanced algorithms and architectures for signal processing,

— study of pattern analysis techniques,

— optical signal processing,

— multi-sensor signal processing.

3.2.2.: *Recognition of specific signals*

— signal understanding,

— handwriting,

— speech,

— text-to-speech systems with natural quality,

— object and movement analysis,

— human perception,

— picture synthesis.

TYPE A PROJECTS

3.2.1. *Basic signal analysis and recognition*

The first layers of a signal understanding system will consist of preprocessing and feature extraction (e.g. filtering, identification, etc.). In many cases this will have to be carried out in real-time. In order to achieve this, new algorithmic structures and hardware will need to be developed. Such applications as image processing will require large bandwidths and highly parallel architectures, and hence VLSI plays an important part in the programme.

Pattern analysis is the basis of signal recognition following feature extraction and therefore is a vital part of a signal understanding system. There is a need to improve and extend the techniques for pattern analysis. Work is proposed in three topics:

— clustering and template formation,

— dynamic programming,

— relaxation — an interactive procedure to assist in the provision of optimal decisions when one has a set of cooperative phenomena.

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 nonlinear process known as degenerate four wave mixing (DFWM) also has considerable potential. Also research into optical processing architectures and system design is needed.

The final aspect of the project 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.

Programme and intermediate objectives

(a) **Advanced algorithms**

Year 0:

— choose target application, e.g. earth resource analysis, medical imaging, speech recognition;

— develop algorithms and through analysis and simulation provide a system package for architectural analysis.

Year 1:

— select among different parallel architectures using simulation and extensive modelling.

— Initiate design of VLSI package implementation of chosen algorithms.

Year 2:

— continue analysis and simulation;

— continue design of VLSI package of chips.

Year 3:

— develop a programming environment adapted to the proposed architectures;

— complete VLSI design and fabricate chips;

— construct partial breadboard of proposed architecture with limited number of processors.

Year 4:

— complete programming environment;

— construct demonstrator model and evaluate.

(b) **Pattern analysis techniques**

Year 1:

— survey state-of-the-art;

— plan programme of research and select target applications;

— initiate research on clustering and template formation;

— initiate research on dynamic programming.

Year 2:

— consider method of implementation such as systolic arrays;

— initiate work on relaxation in relation to edge detection.

Year 3:

— continue research;

— demonstrate clustering and template techniques;

— construct systolic array model for dynamic programming demonstrators.

Year 4:

— evaluate performance of demonstrators;

— demonstrate relaxation techniques.

(c) **Optical signal processing**

Year 1:

— identify applications. Initiate, design studies;

— specify performance requirements for spatial light modulator (SLM) and DFWM.

Year 2:

— evaluate and implement into system:

  — SLM,

  — DFWM materials and architectures.

Year 3:

— extend systems e.g. include Mellin-Fourier transforms. Implement improved SLM and DFWM materials/architectures.

Year 4:

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

(d) **Multi-sensor signal processing**

Year 2:

— study requirements and plan programme.

Year 3:

— simulate system and construction of model.

Year 4:

— construct demonstrator.

Year 5:

— complete and evaluate demonstrator.

TYPE B RESEARCH THEMES

Related to (b) above:

— sector quantization and marker modelling,

— techniques for description of time varying patterns,

— learning techniques in pattern analysis.

Related to (d) above:

— sensor tasking; modification of sensor operation after processing.

3.2.2. *Recognition of specific signals*

Description

To understand the meaning and content of real-world signals such as speech and images is a stage beyond mere recognition of individual items such as words. The project will investigate methods of handling the information content of the signals, and hence use of knowledge and inference techniques is essential. Use of non-number-crunching processor structures will be necessary. In addition, attention must be directed towards description languages for external domains (e.g. 2-D and 3-D scenes).

Direct input of manually written information would enhance man-machine communication. To achieve this, appropriate scanning techniques must be selected and developed, the output from which is subjected to suitable feature extraction and preprocessing techniques. Different methods of classification must be investigated. The project will look initially at hand-written characters, and subsequently at cursive script.

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 recognize only isolated spoken commands. Speaker independence and insensitivity to noise are other important requirements. The first phase will consider connected speech from limited but large vocabularies. Algorithms are required for feature extraction and preprocessing. Account must be taken of the conditions of speech input such as the noise environment, number of users and vocabulary. The classification technique should be economical in hardware. Phase 2 (after Year 5) will extend the work to continuous speech recognition from general vocabularies. This will necessitate research into recognition techniques based upon speech and linguistic knowledge.

The most convenient medium for the output of information from computers for humans is by speech symbols. The quality of such a speech signal must be as natural and intelligible as the normal speech signal. The different research topics must cover the linguistic and phonetic aspect as well as the production of naturally sounding speech signals by electronic means. The resulting system will depend on the language chosen, hence more than one project is needed to cover the different languages.

The object and movement analysis part of the project will start by looking at stereo and optic flow techniques for developing depth maps from 2-D images. Subsequent studies will concern the interpretation and symbolic description of 3-D objects and their deformation and movements. The project bridges the gap between image analysis/feature extraction and scene understanding. As such it contributes to the goal of providing a computer or machine with eyes.

Work on perception to obtain a better understanding of natural systems such as the eye/brain and ear/brain will be of great assistance in the design of signal processing systems. Speech analysis, based on a model of the human speech production process, is an example where lessons from natural systems have been successfully applied. The objective of phase 1 is to study low-level image and speech processing. Edge extraction is known to be a fundamental part of the early visual processing in humans, and cells have been identified in the visual cortex that are sensitive to edge segments of specific duration. The study should lead to new algorithms for image and speech analysis. The objective of phase 2 is to study higher level processes involved in human signal understanding; this phase begins after Year 5.

Picture synthesis is especially important in a scenario where computers simulate parts of the real world

e.g. in CAE or training applications. Very fast graphics processing techniques are as important as flexible storage techniques for images. Also important in this project is the development of systems with a resolution of more than 1 000 × 1 000 pixels.

Programme and intermediate objectives

(a) **Signal understanding**

Year 1:

— choose a simple application with very restricted signal variations.

Year 2:

— define grammar of the example, build the basic experimental system.

Year 3:

— evaluate the chosen example.

Year 4:

— include a second and more complex signal domain to test the adoption of signal understanding to new problems.

Year 5:

— evaluate the total system.

(b) **Handwriting**

Year 1:

— survey scanning techniques to initiate development;

— select algorithms for feature extraction for characters.

Year 2:

— specify a demonstrator for character recognition;

— choose method of classification.

Year 3:

— complete design of demonstrator and commence construction;

— initiate contextual analysis survey;

— initiate study of techniques for cursive script recognition.

Year 4:

— complete character recognition demonstrator;

— define research programme for cursive script recognition.

Year 5:

— evaluate character recognition demonstrator;

— start design of cursive script recognizer.

(c) **Speech**

Years 2 and 3:

— review algorithms for feature extraction and preprocessing. Relate to noise dynamics. Identify the information content of the feature to optimize choice. Study classification techniques.

Year 4:

— simulate recognition process on fast array processor.

Year 5:

— design and build demonstrator.

(d) **Text-to-speech**

Year 1:

— basic analysis of spoken speech, design of flexibly controllable speech synthesizer, identify the parameters necessary for natural sound.

Year 2:

— evaluate linguistic rules for speech production including prosodic parameters, phonetics of speech production.

Year 3:

— further evaluation of phonetic and linguistic rules, simulations of synthetic speech including articulatory rules.

Year 4:

— realization of flexible speech synthesizer;

— further evaluation of prosodic parameters;

— design of a letter cruncher machine for the linguistic and phonetic processes.

Year 5:

— realizing the total text-to-speech system.

(e) **Movement analysis**

Years 1 and 2:

— research into binocular stereo;

— research into optic flow.

Year 3:

— generation of 2½-D sketch;

— generation of depth maps from optic flow;

— symbolic descriptions of objects.

Year 4:

— study descriptions of movement, analysis techniques;

— study of transformation of 3-D objects.

Year 5:

— investigate amorphic changes of objects.

(f) **Human perception**

Year 2:

— study of speech perception in the ear, including simulation of different models;

— evaluation of human edge detection model.

Year 3:

— extend work to more general feature extraction.

Year 4:

— extend model to depth perception.

Year 5:

— study role of relaxation in human visual processing;

— study perception of texture.

(g) **Picture synthesis**

Year 1:

— design new possibilities for sequential memories, picture transactions in the memory.

Year 2:

— design of a high-speed processor for fast access to memory.

Year 3:

— interpretation of memory and processor.

Year 4:

— revised version of processor, especially concentrating on the cooperation with fast memory structures.

Year 5:

— interpretation of the picture systems into the display system.

TYPE B RESEARCH THEMES

Related to (a) above:

— computational linguistics,

— high-level visual perception,

— scene description languages,

— application of relevant techniques from cognitive psychology to signal understanding.

Related to (b) above:

— automatic dictionary generation,

— machine learning processes.

Related to (c) above:

— phonetics,

— syntax and grammar,

— psycho-acoustics.

Related to (d) above:

— linguistics,

— phonetics,

— linguistic rule compilers,

— text comprehension,

— study of more realistic speech models.

Related to (e) above:

— geometric reasoning,

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

Related to (f) above:

— relevant results and techniques from cognitive psychology,

— physiology of eyes and ears,

— models of human information processing.

Related to (g) above:

— picture description languages.

R & D area 3.3:

Information and knowledge storage

Description

Knowledge-based systems are designed to derive information from their knowledge base 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 its deduction mechanism.

This R & D area investigates the new forms of organization 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 organizations including machine aspects.

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

— the development of new storage structures,

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

— the realization of adequate dialogue 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 base studies for AIP,

— distributed data bases and knowledge bases,

— advanced KBMS.

3.3.3. Storage structures and architectures:

— database oriented architectures,

— performance models for storage structures,

— storage architecture

3.3.4. New generation knowledge machine

3.3.5. Medium-term research on storage media

3.3.6. Long-term research on optical discs

(*) *Note:* Work planned to start in Year 1 (1984/85).

3.3.7. Long-term research on biological storage.

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

Topic 3.3.1 incorporates continuation of work on interactive query systems started under the pilot projects in Year 0 (1983/84).

TYPE A PROJECT

3.3.2. *Data and knowledge bases*

Description

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 DB and KB, including formulation of inference and data query access at levels ranging from human visible to those internal to the new generation of systems. The focus of this work is to investigate commonalities and specifics in the architectural models of database and knowledge management systems.

There will be a parallel study 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.

The last part of the project emphasizes some advanced topics of knowledge base management systems which are not realized in present system and which are useful in knowledge-based systems and AIP in general. These include the representation and manipulation of complex objects, exploitation of inference mechanisms, realization of view mechanisms, semantic control and validation of queries.

Programme and intermediate objectives

(a) **Studies**

Years 1 and 2:

— Study fundamental requirements for including real-time constraints for knowledge-based information systems. Investigate the relevance of database technology to knowledge-based information systems.

Year 3:

— Develop specifications and model on a computer.

Year 4:

— Define system standards and structure and supporting specialized hardware.

Years 5 and 6:

— Study high-level interfaces, conceptual models, etc.

(b) **Distributed DM and KB**

Years 2 and 3:

— Study KB mechanisms with particular reference to inference and distribution;

— Develop methodology and model chosen structures.

Year 4:

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

Year 5:

— Study very large knowledge-based systems.

(c) **Advanced KBMS**

Year 1:

— Assess state-of-the-art for selected topics and relevance to AIP;

— Select KBMS as a vehicle of study.

Year 2:

— Develop model for selected KBMS features.

Years 3 and 4:

— Develop performance model and implement into an enhanced KBMS.

Later projects

Although not planned to start in Year 1, projects 3.3.3 to 3.3.7 are described briefly here to give an overall picture of the R & D area.

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 element of the project will develop the potential for an advanced generation database towards the end of the programme.

The aim of the 'performance models for storage structures' element of the project is to specify and target a system of metrics for, and quantification measurement of, the effectiveness of storage system structures.

The third element of the project will fully define the storage architecture for the evolving semantic models of computation, inference, knowledge base and operational environment arising from project 3.3.2.

3.3.4. *New generation knowledge machine*

The aim is to design and build a prototype of the knowledge management machine, test and demonstrate it together with intelligent interface and inference machines.

3.3.5. *Medium-term research on storage media*

Current candidates are identified below, the selection criterion being those devices underpinning the requirements of KBS best:

— *Discs with thin film head technologies.* Concentration on physical access techniques to achieve random access inclusive of latency in the range 2 to 3 ms and latency in the range of 1 to 2 ms. Capacity should be from 1 to 10 Gbytes and storage must be 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* Develop a very large capacity/fuzzy/non-deterministic/probabilistic matching content addressed memory of capacity greater than 200 Mb.

— *Mixed logic high density RAM.* To design 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.

3.3.6. and 3.3.7. *Long-term research on optical discs 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. Research is required to provide write and read facilities using such techniques as photochromism. 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 ångström 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 ångström and in 3-D structures using biological and genetic engineering construction techniques.

TYPE B RESEARCH THEMES

Related to 3.3.1.

— Security and associated issues in group usage of common knowledge bases.

— Behavioural and cognitive studies.

Related to 3.3.2.

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

— Investigate relevance of formalisms utilized in knowledge representation, including issues of co-existence and conversion of different representations.

— investigate fundamental architectural issues, i.e. logical inter-realtionships 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 utilization of bulk data through hybrid interfacing of DB and KB systems.

R & D area 3.4:

Computer architectures

Description

This R & D area investigates the potential for new forms of computer architecture. The traditional von Neumann architecture has a number of serious disadvantages as it precludes genuine parallel processing because of the bottleneck created by the processor/main-storage relationship. 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 new architectures on actual programming environment should be carefully studied. Basic software must be developed with the corresponding hardware.

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.

Both of these substantial projects are planned to start in Year 1 (1984/85).

TYPE A PROJECTS

3.4.1. *Ultracomputer, multiprocessor machines*

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, for numerical processing. 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), but this approach only attacks a small part of the overall programme.

Programme and intermediate objectives

Years 1 and 2:

— feasibility study of design strategies.

Years 2 and 3:

— study and selection of interconnection strategies.

Years 3 to 5:

— design and implementation of prototype.

3.4.2. *Non-von Neumann architectures*

Description

The availability of VLSI has provided a means of constructing machines with very large numbers (e.g. 1 000) of interconnected computing elements capable of concurrent operations. It is required to study interconnection architectures and special components for realistic and cheap solutions. The application targets are signal recognition and understanding 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 in order 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 characterized 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 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 realized through software on conventional computers. Parallel execution of these languages is required. Appropriate hardware mechanisms will be proposed after study of related algorithms. This part of the project will be in three phases; phase 1 and the start of phase 2 fall inside the five-year planning horizon.

Programme and intermediate objectives

(a) **Highly-parallel architecture**

Year 1:

— feasibility study and selection of interconnection strategies.

Year 2:

— simulations and definitions of basic VLSI components.

Years 3 and 4:

— VLSI component development and simulation.

Year 5:

— produce mock-ups.

(b) **Data-flow machines**

Year 1:

— search literature, generate set of alternative architectures. Identify applications suitable for data-flow machines. Select applications and alternative architectures for detailed study.

Year 2:

— study applications and alternative architectures;

— select application(s) and architecture for demonstrator.

Years 2 and 3:

— specify and design data-flow computer demonstrator. Commence implementation. Continue application studies.

Year 4:

— complete implementation of demonstrator, continue application studies.

Years 5 and 6:

— test demonstrator, make initial assessment of attributes, utility and performance. Relate results to application studies, publish results.

(c) **Reduction machines**

Year 1:

— search literature, generate set of alternative architectures;

— identify applications.

Year 2:

— select application(s) and architecture.

Year 3:

— design reduction mechanism;

— continue application studies.

Years 4 and 5:

— implementation, continue application studies.

Years 5 and 6:

— demonstrator, relate results to application studies, publish results.

(d) **Inference machines**

Phase 1

Year 1:

— search literature, study basic mechanisms, assess potential applications. Specify parallel inference machine as research tool.

Years 2 to 4:

— implement parallel research tool. Select applications for detailed study. Select approach to design of experimental parallel inference machine.

Phase 2

Year 5:

— specify and design experimental parallel inference machine using results of 3.4.1 and 3.4.2. Start implementation. Continue studies of mechanisms using research tool.

TYPE B RESEARCH THEMES

Related to 3.4.1:

— interconnection strategies for interworking of different architectures;

— development of symbolic processing machines;

— development of a machine architecture to support ACTOR-based languages.

Related to 3.4.2:

— connection machine designs.

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 within the AIP subprogramme.

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 trustworthy 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 coordinated

with 2.1; 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, indeterminacy, adaptability and self-monitoring potential for AIP systems.

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 interconnected, so that the formalisms for either cannot be laid down without continued reference to the limitations imposed by the other.

R & D TOPICS

The R & D topics to be addressed in this area are:

— Standards for AIP projects;

— Requirements specifications for AIP systems;

— Design specification methods for AIP systems;

— Design methodologies for AIP systems;

— Security/Confidentiality of knowledge and data in AIP systems;

— Reliability, credibility and integrity of AIP systems and their outputs;

— Testing and validation of AIP systems;

— State-of-the-art intelligence unit in critical basic areas;

— Monitoring and coordination of developments within the AIP programme;

— Updates of earlier tasks;

— Reverse engineering on classical information processing systems.

Due to their supportive nature, these topics can be characterized 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 optimize overall synergy within ESPRIT.

R & D area 3.6:

Focusing projects

Concepts

The other 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 felt essential to include a number of integrated inter-disciplinary projects that span not only the five identified aspects of AIP but also the other areas of the ESPRIT programme. Thus, where appropriate, these should be merged with other subprogrammes to achieve the size required consistent with the interdisciplinary nature of the focusing project. This section is concerned with these 'focusing' projects.

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 focusing projects are given in outline below. It should be stressed that these are merely examples chosen to illustrate the concept of focusing project and are in no way intended to restrict the final choice — what is important is that the ESPRIT programme include resources and effort to cover such projects. These projects should form part of the overall ESPRIT programme rather than the AIP subprogramme. Equally the final choice of projects will need to be flexibly determined in the context of the overall 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 utilizes 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 emphasizes 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 realizable (feasible, realistic, achievable) within the proposed time frame, and have a clearly identifiable end point within 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) The project 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 demonstratable prototype.

Examples

A number of topics have been identified, with a cluster of specific examples of focusing projects within each topic. The titles are given below in a structured form as illustrations only.

(i) Decision support:

- an agro-chemical adviser,
- planning systems for office automation.

(ii) Natural languages:

- interactive spelling correction and management.

(iii) Complex control systems:

- integrated vehicle, processor and physical environment.

(iv) Office systems:

- HELP-system for OS users.

(v) Programming assistance:

- automatic programming system.

(vi) Tools for information systems users:

- development of an atlas for IT.

(vii) General:

- computer aided system maintenance,
- water quality monitoring by satellite images.

Whatever is selected as focus projects, these will be of the type A.

SUBPROGRAMME 4

OFFICE SYSTEMS

Importance of the subprogramme office systems

The success of ESPRIT is eventually measured by the increased competitiveness of the European information technology industry, which can only be obtained by better products and not by results in the research field alone.

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 (see Figure 4-1).

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 stage 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.

Research areas of the subprogramme office systems

Taking into account the abovementioned integrated approach, the subprogramme has been divided into five research areas (see Figure 4-1):

— *Office systems science and human factors*

A joint study is imperative in order to address equally both the human factors and the rationalization aspects. The best systems from a purely technical point of view are of no use when they are not accepted by the users.

— *Advanced workstations*

The kernel of the future office will consist of workstations with new man-machine interfaces (data, text, images, speech). Thus, high priority should be given to this development.

— *Communication systems*

Networks and integrated information systems require a new system design using very wide band networks that use alternative basic technologies in order to process and to transmit vast quantities of multi-mode data all over the world.

— *Advanced filing and retrieval systems*

In order to progress towards a paperless office, it is necessary to overcome the present obstacles to processing of vast quantities of information and to fast retrieval of the stored information by new solutions.

— *Integrated office system design and evaluation*

The research for optimal and advanced designs for elements of the integrated office systems should lead to the development of prototypes for such systems; adequate methods and facilities have to be found that can serve as test environments.

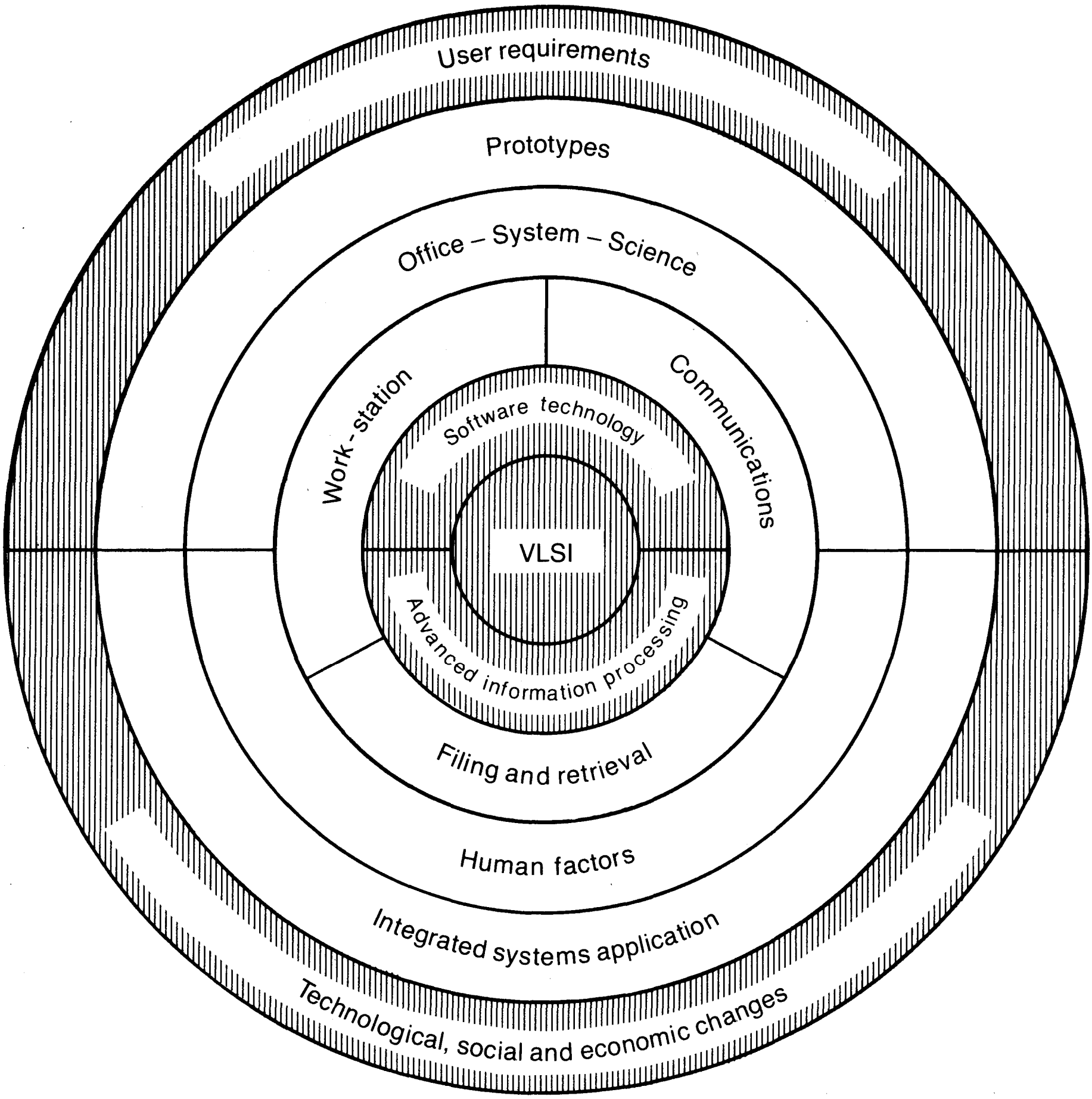


Figure 4-1

Relations of office systems to other ESPRIT subprogrammes and office environments

Research aims of the office systems subprogramme

1. (a) To analyze current and predicted office activities and to determine how new information technology might be applied to improve the effectiveness of office work and organization. Besides automation of various functions, this means better technical support particularly for clerks, professional and managerial staff in executing their non-deterministic 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 organizational and individual acceptance.

2. To establish major new man-machine interface technologies, peripheral technologies and document representation technologies relevant to the subsequent development of high-level office workstations for use in advanced office systems.

3. To create the basic technologies required for advanced office communication systems including technical fundamentals in communication systems architecture, optical technologies as a particularly significant technology and system aspects of value added services.

4. To acquire the systems and applications expertise related to filing and retrieval of all forms of office information in electronic storage systems in a user organization in an adequate way.

5. To create the possibility to check the validity of the total information concepts that are advocated, in environments that are realistic and allow quantitative evaluation.

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, that have to be organized, staffed and equipped for effective and efficient operation, and that have to interface with other branches of the enterprise, such as research laboratories and manufacturing.

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 a coherent attack on the problems, ranging from empirical studies to consistent operational classifications and computer-based analysis and design tools.

Consistent with this approach, the main areas identified are (a) office systems analysis, (b) office systems design and (c) human factors. 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. Independent human factors laboratories are also seen as important, offering the possibility of an unbiased judgment on commercial products.

R & D TOPICS

The topics to be studied in this area include:

4.1.1. *Office systems analysis:*

— functional analysis of office requirements (*);

— implementation of functions;

— performance measurements (*);

4.1.2. *Office systems design:*

— office system design methodology (*);

— a language for the specification of offices (*);

— office simulator;

— transaction monitor;

4.1.3. *Human factors:*

— independent human factors laboratories (*);

— human/machine cognitive compatibility (*);

— qualification and work (*);

— user service interface in a multi-service environment.

Work is already under way in the functional analysis and performance measurements topics of 4.1.1, started by the pilot projects in Year 0 (1983/84).

TYPE A PROJECT

One type A project is identified in the human factors area. The project may embrace R & D topics listed as type B projects.

4.1.3.1. *Independent human factors laboratories*

This project 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 project aims at the creation of managerial, organizational and legal structures to formalize the cooperation, and the elaboration of a well-selected set of research topics by the laboratories cooperating.

Programme

Year 1:

— elaboration of managerial, organizational and legal structures that consolidate the cooperation;

— start of cooperation work in selected research areas.

Years 2 to 5:

— elaboration of training programmes, setting up and (re)allocation of specific research facilities among the partners, the elaboration of procedures for internal and external consultation, the execution of selected research.

Intermediate objectives

12th month

— establishment of managerial, organizational and legal structures;

24th month

— establishment of the first training programme in human factors;

48th month

— results of specific human factors research available.

TYPE B PROJECTS

All the above topics are suitable for type B projects. Those described below are planned to be started in 1984/85.

Office systems analysis

4.1.1.1. *Functional analysis of office requirements*

The standard functions in an office are identified to reduce the requirements for customization. Investi-

(*) *Note:* Work on these topics is planned to start in Year 1 (1984/85).

gation of the benefits of computer-based office systems to organization and office worker. A glossary of agreed terminology will be included.

4.1.1.3. *Performance measurement*

Traditional profitability studies have limited boundaries and neglect important influences such as flexibility, value of information, etc. This project includes these non-quantifiable factors besides the quantifiable factors.

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.

4.1.2.2. *A language for the specification of offices*

A language for the specification of offices will be developed from functional models.

Human factors

4.1.3.1. *Independent human factors laboratories*

To catalyze the further development, the use and the cooperation of human factors laboratories to act as European centres for guideline generation, performance measurement, human factors product evaluation, and in general to increase the awareness of the human factors in design.

The laboratories may provide post-graduate training facilities. Projects in this area will have concrete functional objectives, that can only be achieved through the collaboration of a number of industry-oriented laboratories.

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.

4.1.3.3. *Qualification and work*

Study of the evolution of office work due to the introduction of office information technology and other factors. Development and evaluation of system-based training facilities that help the user to adapt.

R & D area 4.2:

Advanced workstations

Description

The workstation is the user's gateway to the office system. User acceptance and user performance depend on the design of the corresponding man-machine interface.

The most important channel for information input to the user is the visual channel. This channel, as well as the other sensory channels, have evolved to provide information for motoric activities which should not be suppressed but adequately integrated in operating the interface. In consequence, VDUs and touch keyboards will emerge to form an integrated input/output device suitable to manipulate text and images by direct manual access. 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.

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 acoustic channel cannot handle as much information as the optical channel but is our most effi-

cient means of information transmission. Acoustical 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 developments of specific workstation components should lead to a general architecture which will allow the integration of the subsystems in an architecturally homogeneous workstation.

R & D TOPICS

The following R & D topics are identified:

4.2.1. System aspects of workstation design (*)

4.2.2. Vision interface

— flat panel displays,

— high resolution video scanner,

— image coding (*);

4.2.3. Paper interface

— advanced scanner (*),

— advanced printer (*),

— graphics coding (*),

— graphics recognition (*);

4.2.4. Speech interface

— speech coding (*),

— speech recognition (*),

— speech synthesis (*);

4.2.5. Office languages

— office document language (*),

— office interface language (*).

(*) *Note:* Work is planned to start on these topics in Year 1 (1984/85).

Pilot projects are underway in the vision interface, paper interface, speech interface and office language R & D areas.

TYPE A PROJECTS

Projects on the topics listed below are planned to be started in 1984/85. The support of more than one project on R & D topic 4.2.1 is considered.

4.2.1. *System aspects of workstation design*

Description

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 subsystem and the network interfaces in an architecturally homogeneous workstation both from the hardware, the software and the human factors point of view.

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.

Programme

Year 1:

— definition of a model of man/machine interaction;

— definition of computer performance, storage requirements;

— definition of the requirements of advanced interfaces;

— definition of workstation architecture.

Year 2:

— assembly of subsystems and start software development for experimental workstation.

Year 3:

— completion of software experimental workstation;

— test of workstation; evaluation of results.

Year 4:

— continued evaluation of experimental workstation in a number of environments (links with network and servers required);

— definition and construction of advanced workstation interfaces to multimedia input/output, filing system, network, etc.;

— completion of language interface.

Year 5:

— assembly of advanced workstation;

— identification of test-sites, requirements.

Intermediate objectives

12th month

— specification of experimental workstation architecture;

24th month

— experimental workstation operational;

36th month

— experimental workstation evaluation;

48th month

— specification of advanced workstation interfaces (multimedia network);

60th month

— advanced workstation operational.

4.2.3. *Paper interface*

Description

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 redundance, reduction, etc.).

Projects in this area may contain topics listed under type B projects.

Programme

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.

Year 3:

— development of coding algorithms;

— development of a multicolour scanner.

Year 4:

— development of a graphics coder;

— development of multifont character recognition;

— development of experimental multicolour printer.

Year 5:

— development of a handwriting recognizer;

— development of a multicolour printer-scanner.

Intermediate objectives:

24th months

— optical character recognizers;

36th months

— demonstration of scanner;

48th months

— demonstration of multicolour printer;

60th months

— demonstration of handwriting recognition;

— demonstration of multicolour printer-scanner.

4.2.4. *Speech interface*

Description

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 algorithms and high-quality speech output, guaranteeing user acceptance of the speech interface. Projects in this area may contain a number of research topics listed for type B projects.

Programme

Year 1:

— specification of software for speech synthesis.

Year 2:

— specification of speaker independent recognition of isolated words.

Year 3:

— demonstration of feasibility of speech synthesis;

— implementation of 16 kb/s codec;

— specification of speaker independent recognition of connected speech.

Year 4:

— implementation of 8-4 kb/s codec;

— demonstration of feasibility of speech synthesis in all EC languages, Spanish and Japanese;

— specification of speech recognition in all EC languages, Spanish and Japanese.

Year 5:

— 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.

Intermediate objectives

36th month

— speaker independent isolated word recognizer for limited vocabularies;

— hardware implemented speech synthesis for one language;

— 16 kb/s codec;

48th month

— speaker independent isolated word recognizer for limited vocabularies in at least three languages;

60th month

— speaker independent connected speech recognizer for restricted syntax speech;

— hardware implemented speech synthesis for at least three languages;

— 2,4 kb/s codec.

TYPE B PROJECTS

Projects in this category are planned to start in 1984/85, separately or as part of relevant type A projects. In exceptional cases, type B projects sharing a common methodology, or closely related objectives, may be combined to form one type B project.

Vision interface:

4.2.2. *Vision interface*

The project aims at the development of devices which allow the pick-up and display of image information with a definition at 1 000 lines and the handling of image information at different levels of understanding. The high-definition display will also allow the easy introduction of data and commands.

4.2.2.3. *Image coding.* Devices for bit-rate reduction of video signals due to 64 kb/s and 256 kb/s respectively.

Paper interface:

4.2.3.1. *Advanced scanner.* Scanner for at least 1 000 pixel resolution multicolour and grey scale.

4.2.3.2. *Advanced printer*. Printer for at least 1 000 pixel resolution multicolour and grey scale.

4.2.3.3. *Graphics coding*. Hardware implemented intelligent coding algorithm with very high compression ratio.

4.2.3.4. *Graphics recognition*. Algorithms for omnifont and multifont character recognition respectively, and for handwriting recognition.

Speech interface:

4.2.4.1. *Speech coding*. Hardware implemented algorithm for speech bit rate compression to 16, 8, 4 and 2,4 kb/s respectively.

4.2.4.2. *Speech recognition*. Algorithms for recognition of speaker independent isolated words (limited vocabularies), speaker dependent and speaker independent connected speech (restricted syntax).

4.2.4.3. *Speech synthesis*. Devices for text-to-speech synthesis of satisfactory naturalness and resolution quality.

Office languages:

4.2.5.1. *Office document language*. Definition and implementation of a family of formal languages to represent documents, as well as translators between such languages.

4.2.5.2. *Office interface language*. Definition and implementation of languages for easy multi-mode document description and natural user interaction, implemented for the official EC natural language environments.

R & D area 4.3:

Communication systems

Description

Office communication presents a number of possible long lead time research projects. 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 interconnnection of LANs, and the gateway facilities for multimode functionality. R & D should lead to new systems and to standards. 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 systems 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 networks.

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.

The third and fourth topics intend to advance the standardization of value added communication services in the form of mail box messaging for text, image and voice, and for public information systems using interactive multi-mode Videotex.

R & D TOPICS

4.3.1. Communication system architecture (*)

4.3.2. Optical wideband LAN (*)

4.3.3. Multi-mode messaging

4.3.4. ISDN-based advanced Videotex (*)

Pilot projects are underway in LAN standardization, wideband transmission and communication system interfaces.

(*) *Note:* Work is planned to start on these topics in Year 1 (1984/85).

TYPE A PROJECTS

Projects in this category planned to be started in 1984/85 are described below. In communication systems architecture, support of more than one project is considered when different aspects need to be emphasized.

4.3.1 *Communication system architecture*

Description

Determine the topologies most appropriate for typical office situations including local, distributed and long-haul linked offices, given by traffic requirements and distance. Define network management strategy including appropriate 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

Year 1:

— study alternatives of architectures, 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.

Years 2 to 5:

— design basic architectures (e.g. LAN-based, PBX-based) on the knowledge acquired above;

— first statements on economics, performance, standards;

— 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.

Intermediate objectives

12th month

— network architecture requirements analysis;

18th month

— specification of network architecture for implementation;

42th month

— tools and methodology specification;

48th month

— pilot network implementation(s);

60th month

— evaluation report pilot network(s);

— report on tool specification methodology.

4.3.2 *Optical wideband LAN*

Description

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

Years 1 to 5

— architectures and protocols for optical wideband LANs defined;

— examine and design transmission and interface equipment for fibre optic techniques;

— define the design requirements of VLSI chips to implement the protocols for network interfacing, guaranteeing good levels of reliability and security;

— evaluate demonstrator designs, carry out necessary developments for demonstrator;

— implement demonstrator to show functional and economic feasibility in an operational in-house environment.

Intermediate objectives

3rd month

— specification of achitectures and protocols for optical wideband LANs;

12th month

— specifications for optical LAN transmission techniques;

18th month

— specification for VLSI chips for network interfaces;

36th month

— specification for demonstrator;

48th month

— implementation of pilot demonstrator;

60th month

— evaluation report of demonstrator.

TYPE B PROJECT

One B type project in this area is planned to start in 1984/85.

4.3.4 *ISDN-based advanced Videotex*

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.

R & D area 4.4:

Advanced filing 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.

The proposed research is oriented towards 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 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. Work on the filing interface-related aspects of query languages and declarative content languages is identified.

Usage and needs 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 addresses 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.

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.

Pilot projects are underway on information server design and information models.

TYPE A PROJECT

One type A project in this area starts in 1984/85. It may contain topics listed under type B projects.

4.4.1. *Office information server design and evaluation*

Description

This project 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.

Programme

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.

Year 3:

— definition of a work programme to validate system concepts;

— desk assessment of designs based on available devices.

Year 4:

— implement designs, including optical disc and first phase file filters.

R & D TOPICS

The topics covered by this R & D area include:

4.4.1. Office information server design and evaluation (*);

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 (*),

— very high integrity systems;

4.4.4. Components:

— file filters (*),

— optical storage systems concepts (*).

(*) *Note:* Work is planned to start on these topics in Year 1 (1984/85).

Year 5:

— operate, evaluate and improve initial implementations.

Intermediate objectives

18th month

— Specification of information server(s);

24th month

— Performance evaluation by simulation;

48th month

— Prototype(s) of information server(s);

60th month

— Evaluation of server(s).

TYPE B PROJECTS

Type B projects are planned to start in 1984/85 according to the following subject list. In exceptional cases, type B subjects may be combined to form another type B project. Some type B subjects may be included in type A projects.

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 methodologies and experience.

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.

User file:

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, standard user interface.

Components:

4.4.4.1. *File filters.* Study of the implications of searching large files with special searching aids, e.g. hardware, microcode, software, etc. Identify needs and develop extensions to existing file filter technology to satisfy predicted office requirements.

4.4.4.2. *Optical storage systems 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.

R & D area 4.5:

Integrated office system design and evaluation

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, and based upon the results of structured analyses in the office systems science and human factors areas.

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.

R & D TOPICS

4.5.1. *Advanced integrated office system prototypes*

4.5.2. *Office system test and evaluation environments*

No work on these topics is planned for start in Year 1 (1984/85).

SUBPROGRAMME 5

COMPUTER INTEGRATED MANUFACTURE

The long-term aim of the research programme is to increase the productivity and competitiveness of the Community CIM vendors in particular, and industry in general, especially the 'discrete part' manufacturing industries, who ultimately utilize this technology.

The specific main objectives of the subprogramme are to:

— generate the necessary basic groundwork for creating, developing and formulating the principles and rules for future design of competitive components or total systems for computer integrated manufacturing,

— generate total systems architectures that allow users to adapt to computer integrated manufacturing systems in a progressive manner, at their own pace and fulfilling their own specific needs

— to ensure that the development programme applies equally well to small, medium-sized and large companies manufacturing in small-batch as well as large scale mass-production modes.

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 three or more pilot advanced CIM systems should be established as part of the ESPRIT programme within designated centres of excellence. Such systems will 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. The lack of such focus may well mean that the effort and money devoted to the R & D programme is needlessly dissipated.

R & D area 5.1:

Integrated system architecture

Description

A wide variety of CIM systems will be implemented within manufacturing industry. Each system has to serve its specific application in an optimum manner. In order to be competitive and preserve flexibility by taking advantage of new technologies as they become available, effective design methods for CIM must be developed. At present there are no guidelines or international standards available for the design of system architecture 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 enable the development of integrated system structures it is necessary to include the requirements, specification, and possibly the development of data management techniques. The efficient structuring and manipulation of the stored data is critical to both storage needs and execution speed.

CIM systems require a high degree of fault tolerance; therefore methods for error detection, prediction, recovery and system maintenance must be developed. Communications systems will be required to operate efficiently within the CIM environment. There is also a need for effective man-

machine interfaces with graphics capability and a requirement for a command language to facilitate interaction with the system at all levels.

To encourage the wider use of CIM systems by reducing the risk of failure, formal methods should be developed to allow the representation, specification and testing of proposed systems prior to installation.

R & D TOPICS

To fulfill these objectives, work is planned in two area:

5.1.1. System architectures:

— design rules,

— system structure,

— command languages and data management strategies,

— factory local area network;

5.1.2. Graphics subsystems

Work on both these topics is planned to start in Year 1 (1984/85). Work on design rules has already started under a Year 0 pilot project.

TYPE A PROJECT

5.1.1. System architectures

Description:

Design rules.

Prepare detailed recommendation for a set of design rules covering hardware and software of CIM systems;

System structure

Develop elemental components and subsystems, consistent with the design rules, with which to implement CIM architectures;

Command languages and data management strategies

Develop a data management strategy (DMS) to serve all components of the CIM system. Develop a common command language to facilitate interaction with systems at all levels from CAD through CAM to control systems on the shop floor;

Factory Local Area Network

Identify requirements for factory LANs. Explore possibilities for exploiting current LAN developments. Define work needed to achieve requirements identified above. Carry out necessary developments.

Programme

Year 0 (pilot project):

— produce first draft of design rules for specific areas of manufacturing.

Year 1:

— finalize design rules;

— identify elemental components and subsystems which it is necessary to develop;

— specify common command language;

— identify requirements for DMS;

— identify requirements for robust data links;

— definition of formal methodology;

— investigate suitability of available LAN systems.

Years 2 and 3:

— develop components and subsystems;

— identify requirements for operating system, possibly in cooperation with software technology (2.2);

— develop common command language, DMS and protocol for robust data link;

— develop formal methods;

— investigate problems specific to factory LANS and prepare design specification.

Years 4 and 5:

— interface with AIP. Apply knowledge based systems to CIM;

— apply formal methods to CIM systems;

— develop prototype factory LAN system.

Intermediate objectives

12th month

— issue preliminary set of design rules;

— definition of requirements for robust data links;

— definition of formal methods.

24th month

— finalize and issue design rules;

— phase 1 components/system prototypes available for testing.

36th month

— develop data management strategy and issue first draft;

— first draft of command language;

— define design specification for LAN;

— phase 2 component/subsystem prototypes available for testing;

— formal methods for simulating CIM systems available for testing.

48th month

— definition of interfaces between CIM architectures and AIP;

— formal methods available;

— interface command language with various activities in CIM;

— LAN prototype system available for testing.

60th month

— industrial evaluation of LAN system.

TYPE B PROJECT

5.1.2. *Graphics subsystems*

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 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).

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,

— forms the basis of an integrated data base for the whole manufacturing process.

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.

Modular structures for CAD/CAE subsystems (which include 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 subsequent enineering and production activities, as well as good display quality and capabilities.

This requires an integrated CAD/CAE system which can generate the information needed to select, define, verify (simulate) and optimize the production process in terms of generalized manufacturing operations. Starting from this, the CAM systems will produce the detailed production data for actual manufacturing.

The role of AI techniques in product and production system design must be analyzed in order to verify feasibility.

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,

— production 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).

(The list is not exhaustive.)

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.

Work on both topics is planned for start in Year 1 (1984/85).

TYPE A PROJECT

5.2.1. *CAD/CAE facilities for product and process design*

— 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 and integrate into overall system structure(s);

— based on CAD/CAE general tools, adapt or

Programme and intermediate objectives

12th month

— identify requirements for product design methodologies;

— complete survey of available systems and hardware.

24th month

— 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

— initiate development of application software for product design system, CAD/CAM tool integration and coding and classification system.

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.

60th month

— finalize integration of general tools with other CAD/CAE activities.

TYPE B RESEARCH THEME

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.

R & D area 5.3:

Computer-aided manufacturing (CAM)

TYPE A PROJECT

Description

A computer-aided manufacturing system in this context addresses the management of factory operations. 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) minimum amount of human supervision and intervention for individual process tasks;

(ii) processes to be individually programmable;

(iii) interfaces to all other production activities;

(iv) possibility for introducing modifications and extensions without violating total system 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 in this project.

A clear rationalization effect can be expected if design data prepared with computer assistance is 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 definiton and design phases.

Programme

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 project 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 and costing;

— the primary activity for year 1 is the full definition of subsequent stages of the CIM R & D workplan;

— identify suitable test-bed environment.

Years 2 to 4:

— develop selected CAM subsystems with an emphasis on high-integrity real-time operation, and integration in test-bed environment.

Year 5:

— conduct comprehensive tests of the overall integrated CIM system(s) using software developed in years 2 to 4.

Intermediate objectives

12th month

— definition of CAM subsystems;

— recommendations for subsystem tool development (with emphasis on real-time operation);

— definition of development and implementation plan.

24th month

— phase 1 subsystem/tools ready for integration and testing.

48th month

— phase 2 subsystem/tools ready for integration and testing.

60th month

— prototype CAM system demonstrable in test-bed application.

R & D area 5.4:

Machine control systems

Description

The major problem confronting the manufacturing industry specializing in manufacturing a great variety of parts in low and medium volumes is the development of a highly flexible, high productivity system. The major task of the suppliers of CIM equipment is that of enhancing the technologies required for automation, flexibility and systemization. All these technologies are essential factors in developing the flexible and versatile manufacturing system.

Machine centres for automatic machining of metal parts plus a system for automatic loading and unloading and a conveyor system for automatically transferring workpieces from one machining process to another, are available from many sources. A problem which still has to be attacked is the integration of machine centres into overall CIM systems.

Further development is required to apply CNC machines to other than metal parts, to develop automated assembly systems and enhance the capability of robots beyond the simple operations at present carried out.

Research and development are 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 machining systems

— numerical control of machines,

— definition of general structure of flexible manufacturing systems (FMS).

5.4.2. Automated assembly and robotics

— automated assembly systems,

— robot systems.

5.4.3. Plant availability and quality optimization

— basic plant diagnosis technology,

— diagnosis formulation,

— action planning.

Work on all these topics is planned to start in Year 1 (1984/85).

TYPE A PROJECTS

5.4.1. *Flexible machining systems*

Description

— design and implementation of communication and data transfer among NC, FMS and CIM;

— definition of specific microelectronic subsystems and components to be integrated into special IC's;

— extension of numerical control to other processes and machines;

— define a general FMS structure; identify, design and implement major subsystems, such as production line operating system; command language, tool ordering scheme.

Programme

Year 1:

— definition and specification of communication and interfaces among NC equipment and other subsystems;

— definition of general architecture and subsystems of FMS.

Years 2 and 3:

— definition and functional specification of dedicated microelectronic circuits for NC, PC and FMS;

— design of major subsystems for FMS.

Years 4 and 5:

— analyses of manufacturing processes and machines where NC can be applied and implementation of new applications;

— implementation of major subsystems for FMS.

Intermediate objectives

12th month

— define specification for interfaces between NC equipment;

— define FMS system architecture and subsystems.

24th month

— specification of dedicated microelectronic circuits for machine control systems;

— initiate major subsystems for FMS.

36th month

— analysis of the application of NC to a variety of processes;

— develop major subsystems in FMS.

48th month

— develop NC equipment for processes previously identified;

— complete development of major subsystems in FMS.

60th month

— develop NC equipment with integrated process optimization;

— implement major subsystems in FMS.

5.4.2. *Automated assembly and robotics*

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. There is a clear linkage here to that part of project 5.1.1 which deals with command languages only;

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;

(c) a set of requirements for the design of components/products for robot-based production.

Programme

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.

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.

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.

Year 4:

— continuation of work for Year 3 and realization of priority subsystems.

Year 5:

— realize the generalized robot planning/integration system.

Intermediate objectives

12th month

— evaluate AI strategies for robot systems.

24th month

— establish rules for interfacing automated assembly systems with CAM;

— application of AI strategies to robot systems.

36th month

— incorporate AI strategies into automated assembly systems;

— develop generalized robot language.

48th month

— develop algorithmic structure for supervision of automated assembly systems.

60th month

— develop integrated automated assembly system using real-time sensor-driven control.

TYPE B PROJECT

5.4.3. *Plant availability and quality optimization*

Research, develop and finally integrate the group of diagnostic/decision-making technologies essential for the principal, and often conflicting, goals of (i) maintenance of consistently high *product quality* and (ii) maximum *plant availability*.

R & D will be carried out under three headings:

1. *Basic plant diagnostic 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.

R & D area 5.5:

Subsystems and components

Description

A number of subsystems and components will be required to implement CIM systems. It is not considered that many of these require collaborative research on a European scale. Such items as intelligent sensors, transducers, etc., are considered within the competence of individual companies, providing the basic microelectronic technology is developed, and requirement specifications are disseminated from the CIM programme.

R & D TOPICS

However, three topics that have been identified as requiring collaborative effort are:

5.5.1. Image processing

5.5.2. Microelectronic subsystems

5.5.3. Sensor programming and standards.

Work on 5.5.3 is planned to start in Year 1 (1984/85). Work on 5.5.1 and 5.5.2 has already been started under a pilot project in Year 0.

TYPE A PROJECTS

5.5.1. *Image processing*

Real-time capture of images and their interpretation is going to present many difficult problems to solve, both as regards hardware and software.

A prime application of imaging is going to be in the use of complex images as 'sensory input' for a large range of applications with respect to CIM, such as:

— automatic assembly,

— monitoring in CNC machinery — 3D measurement,

— manipulator control,

— testing and inspection,

— tool use detection and measurement,

— automatic diagnosis and repair,

— global monitoring.

The requirement is for the real-time capture and processing of 3D images, the development of methods of understanding of complex images at speeds which make off-line and real-time control, testing and inspection possible.

Programme and intermediate objectives

12th month

— specification of high-speed algorithms which can be implemented in VSLI;

— 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 2½-D demonstrator model;

— investigate AI techniques for image processing;

— specify hybrid coherent optical and electronic architecture.

24th month

— development of image processors;

— development of the 2½-D demonstrator.

36th month

— investigation of 3D image processing;

— incorporation of VLSI processors;

— continue development of image processors;

— incorporation of hybrid optoelectronic processing.

48th month

— implementation of AI techniques and 3D demonstrator.

60th month

— continue development and evaluation;

— undertake exploratory work on holographic methods for inspection and image processing;

— implementation of some selected pilot operations on the factory floor.

5.5.2. *Microelectronic subsystems*

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 many of the subsystems required for machine control, picture processing, graphics, etc., on single chips. This will require close collaboration between automation specialists and semiconductor designers.

Programme and intermediate objectives

12th month

— Design specification for:

(a) 3-axis continuous path interpolators;

(b) CNC axis controller;

(c) Servo interface and degree of freedom controllers for robotic manipulators.

24th month

— incorporation of chips in machine tools and robot control systems and evaluation.

36th month

— complete testing, finalize design and issue design information to SC manufacturers;

— start definition and specification for graphics primitives in VLSI.

48th month

— test commercial products and issue any modifications required;

— develop graphics primitives in VLSI.

60th month

— finalize/review/refine graphics primitives in VLSI.

TYPE B PROJECT

5.5.3. *Sensor programming and standards*

Sensors and sensor configurations will be used in many of the CIM subsystems. Each sensor system must be individually programmable and re-programmable for a specific task. In particular, attention should be given to the standardization possibilities offered by integrated VLSI combinations of image sensors and measurement pre-processors.

Similar to graphics, a functional interface to sensors and sensor configurations is needed which allows the development of sensor application systems independent of the particular sensor system used. The functionality should also be independent of a particular application.

Such a functional level sensor standard could have a tremendous impact on application range, and

compatibility of sensor systems. In connection with the standards to be developed, sensor programming tools must be developed which recognize the functional classification.

NB: This approach is orthogonal to the 5.5.1 area where emphasis is on individual, high- or low-quality (expensive or cheap) sensor development.

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 CIM application and development centres. To fulfil the needs for education, research and development, and demonstration, at least two such sites must be identified, one with an academic infrastructure but with a proven record of technology transfer, and one in a real manufacturing environment.

In order to achieve this objective, the following projects and themes have been identified:

5.6.1. CIM application and development centres

5.6.2. General topics for CIM support

— product design guidelines for automatic production;

— economic methodologies for evaluating investment in CIM systems;

— interaction of CIM systems with management information systems.

TYPE A PROJECT

5.6.1. *CIM application and development centres*

Description

Establish centres of expertise, continuing education and research where CIM-technology and tools can be tested, demonstrated and developed.

Programme

Year 1:

— Preparatory study for CIM application and development centres.

Years 2 and 3:

— Formulate plans and select sites for CIM application and development centres.

Years 4 and 5:

— Establish CIM application and development centres.

Intermediate objectives

12th month

— Complete preparatory study for establishment of centres.

24th month

— Formulate plans for development of centres.

36th month

— Select suitable sites for development centres.

48th month

— Complete detailed plans for development centres;

— Undertake preparatory work in establishing centres.

60th month

— Complete the establishment of centres.

TYPE B PROJECTS

5.6.2. *Miscellaneous support for CIM*

The following areas are considered of interest:

— *Product design guideline for automatic production*

Create an understanding and ability to design mechanical products for automatic manufacturing.

— *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 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.