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(Acts whose publication is not obligatory)

COUNCIL

COUNCIL DECISION

of 10 December 1985

adopting the 1986 work programme for the European Strategic Programme for Research and Development in Information Technologies (ESPRIT)

(85/558/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

HAS DECIDED AS FOLLOWS:

Having regard to the Treaty establishing the European Economic Community,

Article 1

The ESPRIT work programme set out in the Annex is hereby adopted for 1986.

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,

Article 2

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

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

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

Article 3

This Decision shall take effect on 1 January 1986.

Whereas the projects identified fall within the areas described in the Annex to that Decision;

Done at Brussels, 10 December 1985.

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

For the Council

The President

F. BODEN

⁽¹⁾ OJ No L 67, 9. 3. 1984, p. 54.

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INTRODUCTION

This section is an integral part of the ESPRIT 1986 Workprogramme and is necessary for its proper interpretation.

0.1. BACKGROUND

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

This is the third such workprogramme and it covers the period 1986-1990.

0.2. PURPOSE

The purposes of the ESPRIT 1986 Workprogramme are:

- to serve as a guideline to potential proposers by indicating the intended scope of the total ESPRIT workprogramme;
- to describe project areas and their interrelationships, and include descriptions of current work commenced as a result of Calls for Proposals in 1984 and 1985;
- to provide a framework for assessment and review of projects under way, in order to appraise their progress individually and in relationship with each other;
- to act as a reference document for considerations relating to coordinating activities under ESPRIT and under other Community and national programmes, and to serve as a basis

to relate ESPRIT to technological programmes outside the Community.

0.3. LAYOUT

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

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

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

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

0.4. THE ESPRIT APPROACH

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

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

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

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

- (i) to have sufficient command of basic technologies;
- (ii) to have systems capabilities which are adaptable to changing market needs thereby permitting the knowledge of markets to have further influence on technology development.

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

SUBPROGRAMME 1 — ADVANCED MICROELECTRONICS

Advanced Microelectronics in the context of this subprogramme encompasses all research and development aspects concerning the provision of the physical elements for the acquisition, processing, storage, transmission and display of data required by modern informatics products. It is thus the hardware foundation of the information technology industry.

This subprogramme concentrates on the priority areas needed to ensure that Europe maintains a competitive position regarding the supply of these essential ingredients for her IT manufacturing industry with the required capability, in sufficient quantity and at competitive prices.

SUBPROGRAMME 2 — SOFTWARE TECHNOLOGY

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

Work in the subprogramme addresses theories, methods and tools to put software production on a sound engineering basis, project management and

industrial aspects to put these into the business and industrial context, a common integrated software engineering environment and the demonstration of the effectiveness of new software production methods.

SUBPROGRAMME 3 — ADVANCED INFORMATION PROCESSING

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

SUBPROGRAMME 4 — OFFICE SYSTEMS

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

The subprogramme has been divided into five areas:

Office system science and human factors

Advanced workstations

Communication systems

Advanced filing and retrieval systems

Integrated office systems.

SUBPROGRAMME 5 — COMPUTER INTEGRATED MANUFACTURE

The two main objectives of the CIM subprogramme are: one, the creation, in the Community,

of an environment in which multi-vendor automated manufacturing systems can be implemented with the resulting integrated system having minimum functional overlaps and maximum connectivity, and two, to support individual work on selected subsystems, interfaces and tools whose development or refinement is seen to be of strategic value to Community industry, and whose design aims are consistent with the general architecture of the environment.

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

0.5. PROGRAMME EXECUTION AND INFRASTRUCTURE

The Commission manages and monitors the execution of the programme.

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

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

In the IES area there are development projects for instance developing OSI conformant software for the interconnection of computing systems and development facilities, service projects providing e.g. computer based mail and conferencing facilities, and support projects studying key issues such as security.

A number of the research and development projects in ESPRIT will lay the scientific and technical foundations on which standardization activities will be based later. Conversely, some demonstrations of the interworking of standards may require additional work; this work will be considered as part of the infrastructure. The work

towards standardisation will be guided by the general IT standardisation policy established and not duplicate any of the existing organisations or actions.

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

0.6. TELECOMMUNICATIONS

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

In September 1983, the Commission prepared a communication to Council, demonstrating the increasing economic importance of telecommunications for the economic development of the Community, and proposing six action lines in this field.

The second line of action calls for cooperative R & D and worksharing at the pre-competitive stage. In 1984, the Commission initiated a Planning Exercise in Telecommunications (PET) in conjunction with major European companies and the national PTT laboratories. The aim was to assess the advantages that might stem from a Community approach for identifying the technological development needs which have to be satisfied to make available in the Community the capacity of establishing integrated broadband communication (IBC) in 1995 and onwards.

As a result of this planning exercise, the Commission has submitted to the Council a proposal in two parts:

- Definition of an IBC reference model, which will be used to identify precisely the subsequent action of an envisaged R & D programme in Telecommunications, aiming at enabling the realization of the IBC;
- A set of technology assessment activities, primarily to support the development of the reference model.

The Council has approved this proposal in July 1985 and the Definition Phase of a programme for

'Research in Advanced Communications in Europe (RACE)' is now in the launching phase and will draw on the results of the relevant ESPRIT projects; proper coordination between the two programmes will be assured.

0.7. TYPES OF PROJECT

In the ESPRIT 1986 Workprogramme, a distinction is drawn between Type A and Type B projects.

These are defined as follows:

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

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

0.8. CURRENT STATE OF THE PROGRAMME

This workprogramme describes work in progress as a result of the 1984 call for proposals or about to start as a result of the 1985 call for proposals. The steps leading to this work were as follows:

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

A first call for proposals for the main programme was issued on 21 March 1984. Nearly 450 proposals were received in response and were evaluated during May and June 1984. A shortlist was selected in July 1984 for detailed negotiations and final approval. In addition, much of the work carried out under the earlier Pilot Phase was combined with the main programme.

A second call for proposals led to a similar sequence of events in 1985, with 400 responses being received, evaluated and a shortlist for negotiations agreed in July 85. To strengthen the Software Technology effort, a supplementary call for propo-

sals was published in September 1985 to improve the coverage of the workprogramme.

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

0.9. WORKPROGRAMME COVERAGE AND INTERPRETATION

The 1986 Workprogramme covers the period 1986-1990. This is sufficiently long to cover the duration of the longer projects. However, information technology is rapidly evolving and therefore the R&D objectives may well have to be modified in the course of yearly revisions.

In the 1986 Workprogramme, less detail is included on intermediate objectives compared with 1985, since many of them are embedded in the ongoing projects.

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

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

To aid the presentation, the descriptions of current work are typographically distinguished in *bold* face. These descriptions are located under the most appropriate heading, but it should be realized that in some cases projects formulated in response to previous workprogrammes overlap the subject boundaries currently used.

In the 1986 Workprogramme, project descriptions for proposals received in 1983/84 have been updated compared with the description in workprogramme 1985. The updates cover changes between proposals for work and finally negotiated contracts. Also, results of on-going work are reported where appropriate.

The best information on the 1985 projects available at the time of writing (October 1985) has been incorporated in the 1986 Workprogramme. However, it should be noted that at the time this workprogramme was drafted the Commission had not yet concluded final negotiations on all this work and some modifications may prove necessary in some cases.

The 1986 workprogramme, shows that, while the technical areas selected for the first phase of ESPRIT have been covered to a significant extent, some important areas still remain. They are identified in the workprogramme, chapter by chapter, under the subheading 'Scope for further work'.

Call(s) for proposals to be published in 1986 will be either for a selection of work still not covered,

or for work allocated to projects that have terminated prematurely, provided the topic continues to have priority for the attainment of the ESPRIT goals. It is intended that the projects retained after these calls should strengthen particularly the coherence of the work in ESPRIT and bring it closer to reaching the strategic objectives.

Such call(s) will be focussed and involve smaller resources than the larger calls for proposals made in previous years. Only a selection of the areas mentioned in this workprogramme as potentially suitable will be included in such calls.

Intending proposers should therefore await the publication of the more detailed call(s). They will specify the necessary information.

0.10. RESOURCES BREAKDOWN

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

The resulting approximate distribution of Community contribution to the five technical areas (in MECU) allocated so far for support of projects assuming that they run to their planned completion, is as follows:

Subprogramme	Year of call for proposals		Total	Percentage of total
	1983/84	1985		
1. Microelectronics	85.5	76.5	162.0	24.2
2. Software technology	72.9	56.6	129.5	19.3
3. AIP	89.8	65.0	154.8	23.0
4. Office system	82.6	54.6	137.2	20.5
5. CIM	45.2	41.2	86.4	13.0
Total	376.0	293.9	669.9	100.0

These allocations show some changes compared to the previous periods due to earlier work being resubmitted subsequently in modified form under a later year's call.

They have the status of planning figures and are derived on the basis of the actual set of projects currently under way or under negotiation. They will need to be updated as changes are reported in the project and contract status of the technical areas. However the intention is to maintain the approximate distribution between the five areas.

Notes :

- (1) The figures for 1983/1984 combine the contributions to 1983 Pilot Projects and to projects started as a result of the first call for proposals on the main programme in 1984.
- (2) The figures for 1985 are target figures and may need adjustment in the light of final contract negotiations.
- (3) The Software Technology figure for 1985 includes an allowance to cover the supplementary call for proposals.
- (4) The figures exclude any expenditure on management and infrastructure.

SUBPROGRAMME 1:**ADVANCED MICROELECTRONICS****1.0. Introduction**

Advanced Microelectronics in the context of this subprogramme, encompasses all research and development aspects concerning the provision of the physical elements for the acquisition, processing, storage, transmission and display of data required by modern informatics products; it is thus the hardware foundation of the Information Technology industry.

This subprogramme concentrates on the priority areas needed to ensure that Europe maintains a competitive position regarding the supply of these essential ingredients for her IT manufacturing industry with the required capability, in sufficient quantity and at competitive prices.

Overview of the subprogramme areas

The major thrust of the research and development programmes within Microelectronics is to push the silicon based technologies of MOS and Bipolar towards their limits of capabilities (areas 1.1 and 1.2) whilst pursuing the possibilities afforded by the compound semiconductor materials, such as Gallium Arsenide (area 1.4), which have potential capabilities in key areas beyond those possible using silicon. In areas 1.1 and 1.2, four new B projects are under negotiation, two in each area. In area 1.4, one new A project and two new B projects are under negotiation.

Apart from a capability to produce high function count chips, it is also necessary to deal with the problems posed by the complexity of their design. Managing this

design complexity effectively is the main goal of Computer Aided Design (CAD) of VLSI Systems, the subject of area 1.3. Five new A projects are currently under negotiation in this area.

Area 1.5 is concerned with the possibilities afforded by optoelectronics devices especially in the data transmission field. The ongoing A project in this area will be updated and improved by new concepts as a result of 2 proposals in the 1985 call. A new B project is also currently under negotiation.

Advanced display technologies is the subject of area 1.6. This offers the possibility of replacing the ubiquitous CRT, as the main vehicle for large scale display, by more compact solid state based counterparts. One new B project is currently under negotiation.

Areas 1.8 and 1.9 of the previous (85) workplan have been subsumed into a new area 1.7. Here research themes are brought together which are more innovative or longer term than those contained in the topic areas 1 to 6 as well as critical areas of technology and techniques with a common trunk. Topics here include packaging, device modelling and special processing materials and techniques.

Computer control of manufacturing VLSI is also needed to support the technology programmes. Here reduction in feature size and layer thickness places increasing demands on process control where the final

device parameters are dependent on a large number of variables. The minimization of human handling and an attack on the sources of yield limiting contamination are critical in this situation. For a given level of contamination, yield falls rapidly as feature size is reduced.

These problems could be addressed by appropriate type B projects in this area.

The above is also an example of where cross-subprogramme cooperation could be of great value. Cooperation with CIM projects addressing similar problems should be encouraged.

7 new projects are currently being negotiated in area 1.7.

R & D area 1.1: Submicron MOS

The requirement is to develop all the individual process steps to achieve submicron feature size in MOS (such as lithography, etching and doping). The target is a process capable of making several million components of logic and memory per chip. It is envisaged that below about 0.7 μm tools other than optical lithography will be used. Process and device modelling will be included. To achieve these goals the critical techniques common to R&D areas 1.1 and 1.2 need to be developed (see area 1.7).

1.1.1. Objectives:

The main objectives of the broad 5-year programme are:

- at 18 months: design and evaluation of test vehicle of more than 1 000 transistors based on 1 μm design rules with a pitch (metal plus spacing) of 3 μm .
- at 3 years: first samples of demonstration circuit with 0.5 million transistors, 1 μm design rules, with data on figure of merit and delay time.
- at 4 years: statistical data on homogeneity on a slice and yield for 1 μm design rules; and test vehicle with more than 1 000 transistors with 0.7 μm design rules and a pitch of 2 μm .
- at 5 years: 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.

1.1.2. Current projects and projects under negotiation

'SOI Materials and Processing towards 3D Integration'

Proj. Ref. 245: A/84

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

- a) the growth of SOI active layers having electronic properties needed for the realization of high quality devices and circuits*
- b) the stacking of two active levels in a way that avoids any degradation of already built devices*
- c) the single level SOI processing for the fabrication of individual components and for their connection; the development of a complete process incorporating two active layers.*

'Submicron CMOS Technology'

Proj. Ref. 554: A/84

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

Two workpackages of Project 554 above are likely to be expanded by the addition of the following two projects:

'Submicron Contact Technology and Reliability'

Proj. Ref. 810 : B/85

The work aims at developing suitable contact technologies compatible with CMOS and bipolar circuit fabrication with one micron or submicron design rules.

The contact properties are being investigated and life tests under various stresses, using extensive failure analysis, are being carried out, to assess quantitatively, the contact performance and reliability.

'Refractory Metal Gate Transistor'

Proj. Ref. 1125 : B/85

The work deals with the use of tungsten as gate material: sputtering or chemical vapour deposition will be investigated and compared; different gates structures such as pure W, W on polysilicon or other pad layers will be studied. Emphasis will be put on W-oxide — Si devices characterization and reliability. However, process changes required for W usage will also be addressed and set up on a submicronic demonstrator circuit.

'Physical-chemical Characterization of Silicon Oxynitrides in Relation to their Electronic Properties'

Proj. Ref. 369: B/84

The aim of the project is firstly to establish the relation between the physico-chemical and the electrical properties of silicon oxynitride film and secondly the relation between the physico-chemical properties and the growth parameters. This research will be carried out in view of the likely applications of silicon oxynitrides in IC technology, for instance in MNOS based non-volatile memories and in submicron MOS devices.

'Substrates for CMOS VLSI Technology'

Proj. Ref. 509 : B/84

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

- *a highly defective bulk region*
- *a defect-free denuded zone*

A thickness of this zone around 1-10 μm is identified as an optimum compromise for several factors (leakage current, insensitivity to latch up and soft error).

Part 2: To characterise epi wafers with diameter 4 and 6 inches. The thickness of the epilayer should be in the range 5-10 μm , both for p+ and n+ substrates. This thickness range is suitable for submicron CMOS. Finally,

IG and epi process should eventually match to have intrinsically-gettered, low leakage epiwafers for submicron CMOS devices insensitive to soft errors.

1.1.3. Scope for further work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 1.2: Submicron bipolar

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

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

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

Critical techniques needed to support areas 1.1 and 1.2 are covered in area 1.7.

1.2.1. Objectives:

The main objectives of the programme over 5 years are:

- at 1 year: initial process design; evaluation and choice of critical equipment.
- at 2 years: establish final design rules at 1 μm .
- at 3 years: demonstrate 1 μm 10/20K gates, 100 ps gate delay circuits.
- at 4 years: establish final design rules for 0,7 μm structures.
- at 5 years: Availability of first samples of 20/50K gate circuits in 0,7 μm process.

1.2.2. **Current projects and projects under negotiation***'Submicron Bipolar Technology — I'*

Proj. Ref. 243: A/84

The overall objective of this programme is to develop specific bipolar submicron process steps leading to complete processing sequences for the manufacture of very high performance integrated circuits. A common test mask and common test procedures have already been defined and agreed between the partners in order to provide suitable environment and comparison basis for effective collaborative work. Two main milestones are defined in the programme of work :

- a) end of 1987, intermediate 1 μm process; demonstration of a gate delay of about 100 pS at a complexity of 10 to 20K gates.
- b) end of 1989, submicron process; demonstration of a gate delay less than 100 pS at a complexity greater than 20K gates.

Two workpackages of project No. 243 above are likely to be expanded by the following two projects:

'Very High Performance Bipolar Structure'

Proj. Ref. 1018 : B/85

The aim of the work is to develop and optimize processing schemes for a sidewall base contact structure as a complement to the submicron bipolar structures developed in 'Submicron bipolar Technology — I'.

'High Performance Polymers for Multilayer Interconnection Insulation'

Proj. Ref. 1025: B 85

The work concerns the research and development of high performance polymers for intermetallic insulation layer with or without photocrosslinking potentiality. These high performance polymers would be polyimide based resins and would exhibit

- a) High thermal and chemical resistance;
- b) High mechanical and dielectric properties together with suitable etching resistance.

'Submicron Bipolar Technology — II'

Proj. Ref. 281: A/84

The project focusses on the development of a bipolar technology for high speed data and signal processing products. This technology will allow the realization of delay

times of less than 100 ps and the integration of 50K gates in an area of about 100 mm². Therefore it is necessary to reduce the structure dimensions to less than 1 μm to develop a suitable transistor structure and a multilayer metallization up to five layers. The feasibility of IC's with the indicated integration level by means of this process will be demonstrated at the end of the project by an adequate test vehicle (demonstration chip).

Previously the state of technology development will be demonstrated at appropriate stages by 2 more demonstration chips. The first demonstration chip will be a ECL-Gate Array with about 10K gates. It is characterized by the following features:

A self aligning emitter-base structure with poly-Si-emitter and -base will be used for the transistor. Performance advantages result from a reduction of the transistor area due to self aligning processing, from polySi-emitter and from lower base resistance. Typical delay and speed power product is 200 ps and 0,7 pJ, respectively. Three layers of metallization are provided for wiring and power distribution using an organic/inorganic sandwich for the isolation layer. The metal pitch will be 6 μm in the first layer (without vias). The chip area will be about 150 mm² and the power consumption will be typically 23 W. The planned packaging is based on a TAB process with a capton film in the standard 35 mm size.

At the time being, most of the activities carried out within the scope of the project concentrate on process development for realizing the first demonstration chip. An exact definition of the second demonstration chip will be provided at the end of the second year of development work.

'A High Performance CMOS Bipolar Process for VLSI Circuits'

Proj. Ref. 412: A/84

This project aims at the development of a VLSI technology which combines, on a single chip, MOS circuitry of the highest density presently obtainable, with bipolar circuitry of similar density, but better suited to specific tasks, in particular, the interfacing with external equipment. In the project the main effort will fall on the technological side: development of methods which allow both bipolar and MOS transistors to be made in compatible process steps, and this down to dimensions comparable to those presently obtained in MOS-only technology. In parallel with this technological work design methods have to be developed for the specific type of circuitry envisaged, along with a study to determine, for various types of application, the most appropriate division of subsystems between the two circuit technologies.

1.2.3. Scope for further work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D area 1.3.: CAD**1.3.1. Objectives**

The two primary objectives are:

- (a) to develop advanced CAD techniques to manage the ever increasing circuit complexities within microelectronics;
- (b) to provide a capability for complex VLSI design which is widely accessible to the EEC IT community.

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

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

Strategy

- (a) A positive attempt should be made to encourage the emergence of an overall CAD infrastructure such that the majority of tools developed under existing programmes together with future tools can be combined to provide an integrated widely accessible tool capability.
- (b) As far as possible, complex demonstrator chips will be used as a focus for each stage of the programme.
- (c) Device and process modelling is not considered as part of the CAD projects but is included in the pro-

jects concerned with the development of new VLSI processes (see areas 1.1, 1.2 and 1.7); however compatibility with CAD is required.

- (d) Care should be taken to promote cooperative development between universities, industrial groups and research institutions in order to transfer know-how and make CAD available to a broader community.
- (e) Care will be taken to interface with, support and employ the results of other ESPRIT activities.
- (f) the application of knowledge engineering techniques to CAD should be emphasised.
- (g) dedicated CAD hardware should be incorporated where appropriate.
- (h) there is a vital need to incorporate the results of current European projects which are in most cases difficult to quantify.

1.3.2. Current projects and projects under negotiation*'High Level CAD for Inter-active Layout and Design'*

Proj. Ref. 10: A/83

Following the completion of the pilot phase work has commenced on the main phase of the high level CAD project. The main topics under investigation include high level design methodology based on Petri nets, hierarchic floorplanning with a high degree of automation, analogue and general cell design, data modelling and data base management.

An introductory manual on high level design has been issued and contains most of the partners, ideas on the application of Petri nets to the design of concurrent systems. This will be updated at periods of about six months.

A review of placement algorithms has been made and proposals were made for the development of a hierarchic floorplanner. Automation will be provided by means of constructive placement and simulated annealing algorithms. The activities on the task of cell building have achieved as a first result, a design system for computer-aided nominal design of cells to be used within VLSI circuits. A new design method has been established for the task of designing integrated circuits at transistor level. Future work will concentrate more on the development of

the appropriate software tools and their integration around a common data base.

'Advanced Algorithms, Architecture and Layout Techniques for VLSI Dedicated Signal Processing Chips'

Proj. Ref. 97: A/83

The main goal of this project is to develop CAD systems for designing custom integrated signal processing chips based on four different target architecture types

- (a) hardwired bit-serial,
- (b) hardwired bit-parallel,
- (c) systolic arrays and
- (d) customized bus-oriented multiprocessors.

For each architecture type, industrial design experience is accumulated through the actual design of integrated circuits. From this experience a general methodology is derived, which specifies

- (1) how a given digital signal processing algorithm can be implemented with the target architecture,
- (2) how the architecture can be integrated in Silicon using a pre-defined circuit cell library. Once a design methodology has been defined, specifications are derived for CAD tools to perform various design tasks. The major effort is then invested to develop these tools and design the circuit cells.

The CAD tool AMA1, proving the feasibility of the above approach, was developed. It fits together with CAD tools developed on the pilot phase to form a complete design system for hardwired bit-serial architectures. This design system, can completely automate the design of complex integrated circuit digital filters with a design time of less than a week. This CAD system has been successfully applied to the design of a PCM-FDM Transmultiplexer with a complexity of 35 000 transistors.

In order to set up design methodologies for the other three architecture types (b)-(d) mentioned above, another milestone has been the successful organization of 5 technical workshops at various partner sites. These workshops have helped to further stimulate the partner interaction which had already started in the pilot phase. Active workgroups have been formed with technical personnel from different partner sites, which are carrying out joint research activities.

In the work forecasted to be ready by the time the workplan is published, the milestones which will be reached are summarized here.

Design methodologies for architecture types (b) and (d) will be developed. The beta-version of the filter synthesis program FALCON will be delivered. The alpha-version

of SAILPLANE (a new limit cycle analysis tool) and the final version of CANDI (coefficient optimization tool) will be delivered. The results of a design exercise for type (d) architectures will be compiled. To support silicon integration of type (b) and type (d) architectures the alpha-versions of a data-path compiler and a controller compiler will be delivered. Further progress on version V.II of the standard placement and routing tool CALMP will be made.

'High Yield High Reliability Ultra-large Scale Integration System Through Reconfigurability'

Proj. Ref. 244: B/84

Project 244 aims to produce ultra large scale integrated circuits of one million transistors with a standard 2 μ m CMOS technology, by using defect tolerant architecture, configured at the end of the manufacturing cycle. Redundancy introduces new constraints on the design, for instance, each of the elemental blocks of the design must be easily testable and repairable, whilst the increase in area of the silicon should not exceed 30 %. Specific CAD tools have to be developed to allow the efficient use of defect tolerant architectures. The tools should help with such topics as: yield estimation, test strategy and testability, floor planning, sizing and pin count, redundancy, language for circuit representation and formal verification.

'Improvement of Yield and Performance of ICs by Design Centering'

Proj. Ref. 456: B/84

During the first 6 months of the project, work has been done on the following tasks:

- 1. Development of a yield and performance optimization program.
- 2. Study of pre- and postprocessors for the schematic input of circuits.
- 3. Improvement of transistor models.
- 4. Determination of parameter deviations and correlations.

During that period the partners have achieved the following results:

- 1. Development of interfaces to transfer the data of the approximation and design centering programs to the program SPICE.
- 2. Linking of the approximation and design centering programs to the modified network analysis program.
- 3. Investigation of the schematic input of circuits (SDS and PCAD).
- 4. Development of a new MOS transistor model.

5. *Investigation of parameter deviations and correlations in the production of Bipolar and MOS ICs.*

During the following 6 months the project will have carried out the following tasks:

1. *Improvement of the link between design centering and network analysis programs.*
2. *Development of an interpreter for the calculation of circuit characteristics.*
3. *Definition of a preprocessor for schematic input of circuits in the optimization program.*
4. *Establishment of computer controlled parameter measuring systems.*
5. *Reduction of CPU time for the calculation of the new MOS transistor model equations.*

'CVS (CAD for VLSI Systems)'

Proj. Ref. 802: A/85

The aim of the CVS project is to implement an integrated CAD system capable of coping with the needs of the 1990s, when the improvements of the semiconductor technology will consent to produce chips of about 1 million transistor complexity. Such a CAD system must lead to a factor 10 improvement in design time, based on novel tools for architecture synthesis connected with parametrized digital/analogue cell implementations techniques. CVS draws heavily on results from the existing projects CVT (Microelectronics Programme 3744/81, MR-04-CVT) and SPECTRE (ESPRIT Project No 554)

'European CAD Integration Project (ECIP)'

Proj. Ref. 887: A/85

Complementary project with 1058

ECIP addresses the area of data exchange and infrastructure standards with the objective of defining and promoting standards within the European IT industry. The ability to readily interchange data and CAD tools between companies seems a key area for bringing into practical reality many of the benefits of collaborative tool development in Europe and for making available the results of ESPRIT to the wider European IT community. Effective liaison between the ECIP project and all other ESPRIT CAD projects will be established ensuring transfer of experience in both directions. In particular, the project 1058 which develops advanced tools will be complementary to the ECIP project. In this way it will be ensured that the standards developed in ECIP are based on a wide experience of requirements and should there-

fore be widely acceptable to developers of present and future CAD systems.

'Advanced Integrated Circuit Design Aids (AIDA)'

Proj. Ref. 888: A/85

AIDA intends to explore the application of modern programming techniques and knowledge base engineering to CAD tool development. It will constitute a design assistant that proposes solutions rather than record and validate the designer's ideas. This allows the designer to apply his creativity where it is most efficient leading to improved design quality.

Research and development work will be done, applying modern programming techniques (e.g. those developed for expert systems) to VLSI-CAD tools. The potential contribution of these techniques is twofold:

1. *The basic techniques may be used to make new tools, much more efficient than classical ones.*
2. *The basic integrated circuit design knowledge may be recorded into the machine, and used by "expert" modules, under the control of a system designer.*

AIDA project intend to explore these two domains, to develop experimental tools using these techniques, and to experiment on real industrial cases to demonstrate the benefit they could give.

'Cooperative Development of an Integrated, Hierarchical and Multiview VLSI-Design System with Distributed Management on Workstations'

Proj. Ref. 991: A/85

This project aims at the development of a complete, integrated, open and cost effective design system on a large variety of intelligent workstations. The work is an extension of project MR-09-DFT under the Microelectronics Programme 3744/81 and focusses on functional data models, distributed datamanagements, verification of submicron structures, advanced multilevel simulation as well as self-testing/fault tolerant synthesis techniques. Commercial exploitation is envisaged.

'Knowledge Based Design Assistant for Modular VLSI Design'

Proj. Ref. 1058: A/85

Complementary project with 887

The goal of the project is the development of an interactive knowledge based system for verification of electrical,

functional and timing correctness of flexible VLSI modules as generated by silicon compilers. The system is highly interactive during the module design phase.

During the call of a module by the floorplanning program, the system is driven by a rule based expert system of which both an engineering workstation version as well as an advanced LISP machine based version will be developed. A verification speed of 20 000 transistors/hr on a workstation is projected. The system also automatically calls a novel waveform relaxation switch-circuit level simulator implemented on a multiprocessor hardware accelerator. This will lead to 100...300 times SPICE performance and will allow for efficient and accurate simulation of up to 4000 transistor circuits. Moreover, a new interactive mode, based on the waveform analysis technique, will allow for 'real time' user interaction supported by an advanced multiwindow user interface. The adaptation of a register-transfer-functional switch level simulator to the hardware accelerator will be investigated. A knowledge based extractor will provide a link to symbolic/procedural module layout generators.

As a complementary project to 887 (ECIP), it will ensure that the standards promoted by ECIP will keep future developments in CAD for VLSI possible.

1.3.3. Scope for further work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D area 1.4: Compound semiconductor integrated circuits

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

The technology encompasses GaAs circuits based on Field Effect Transistors (FET's) as well as GaAs/GaAlAs heterojunction structures using high electron mobility transistors (HEMT) or the heterojunction bipolar transistors (HJBTs). Basic research is required

in materials preparation, ion — implantation, and IC process technologies.

1.4.1. Objectives

The specific objectives of this programme are:

- at 1 year: demonstrate feasibility of MESFET based circuits with 1000 gates and gate delay (tpd) of less than 100 ps. Also, demonstrate basic HJBT and/or HEMT circuits (other than ring oscillators).
- at 2 years: demonstrate at least 1K memory (less than 1 ns access time, less than 500 mW dissipation) and/or equivalent complexity circuits. Demonstrate feasibility of 100 gates HEMT and/or HJBT circuits.
- at 3 years: evaluate yield on a demonstrator circuit of 1K or equivalent complexity, on at least 10 wafers. Demonstrate feasibility of 1K HEMT memory and /or comparable HJBT circuit. Comparison of various technologies (if possible with the same circuit for each technology). Decision for selecting one out of them.
- at 4 years: demonstrate 16K memory (or equivalent) in the selected technology.
- at 5 years: Demonstrate large circuit of 10 to 20K gates complexity, gate delay of less than 50 ps with figure of merit less than 100 femtojoules. This demonstrator could be a 16K memory with an access time in the order of few nanoseconds or it could be defined during year 3 to fulfil needs of other ESPRIT areas (specially high speed data bus) or of telecommunication industry (signal processing circuits for instance).

1.4.2. Current projects and projects under negotiation

'Compound Semiconductor Materials and Integrated Circuits — I'

Proj. Ref. 232: A/84

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

'Compound Semiconductor Materials and Integrated Circuits — II'

Proj. Ref. 522: A/84

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

The following project is the result of a rearrangement of the two preceding ongoing contracts No 232 and 522, with some improvements required to meet the objectives of the workplan.

'Compound Semi-Conductor Integrated Circuits'

Proj. Ref. 843: A/85

This project is a collaborative programme involving six major European companies from three countries in an attempt to establish high speed GaAs VLSI circuits in the commercial market. The availability of state of the art circuits will serve European system and equipment manufacturers in the IT industry and help to provide them with the necessary worldwide competitive edge.

The programme will investigate in detail two active devices which are potential candidates for LSI/VLSI integration, namely MESFETs and HEMT. They are presently in different stages of maturity, but many key technologies are common, such as ion — implantation, advanced lithography (e-beam and DSW), dry processing and self-alignment techniques. They will be investigated in parallel in all their aspects, from device modelling to fabrication yield, by the participating members in close collaboration so rapid advances can be made with limited resources.

During the five years of this programme, various key demonstrators of increasing complexity, such as counter, multiplexers, multipliers, A to Ds, SRAMs and gate arrays will be produced. They will provide the necessary feedback to design and technology and will help to steer the programme towards its VLSI goal.

'Technology of GaAs-GaAlAs Bipolar Integrated Circuits'

Proj. Ref. 971: A/85

The general objective of the research programme is to develop advanced aspects of GaAs/GaAlAs bipolar

integrated circuit (MBTs) process technology and associated expertise.

The two bipolar logics that will be developed consist of emitter coupled logic (ECL) and integrated injection logic (I²L). Single heterojunction (wide gap emitter) — MBTs, and double heterojunction (wide gap emitter and collector) — DHBTs will be investigated and compared. At the same time, efficient analytic switching models for these devices will be developed. A combination of numerical simulation and experimental verification will be used to ensure the validity of the analytic models for discrete devices. The first two years will be spent on the development of high performance transistors (3 μ m emitter width HBTs with an f_T exceeding 17 GHz) with good yield and uniformity on 2" diameter substrates. Simple integrated circuits like divide by 2 and divide by 4 circuits, will be fabricated for operation with high input frequency (exceeding 4 GHz). One of the exciting tasks will be the realization of non-alloyed ohmic contacts, which with the programme on metallic-alloys, such as plasma deposited W-Si, enables the realization of advanced integrated circuits. In this respect, the state of the semiconductor surface chemistry is recognized to be an important factor.

During the two following years, simple front-end signal processing test circuits (3 bit Adder for instance) will be fabricated to determine applicability of HBTs for a fast 8 bit processor.

In the later stage of the project high speed demonstrator circuits will be developed such as digital analog converters or signal processing circuits.

'CAD Methods for Analog GaAs Monolithic ICs'

Proj. Ref. 255: B/84

The major emphasis of the research programme is the development of a full CAD library of theoretical models and experimental data for passive elements and active components required for the design of GaAs analog ICs. The work starts by deriving physical models and equivalent circuits for different types of MESFET and passive elements both for lumped and distributed approaches. The next step is the CAD of groups of passive and active devices for the integrated implementation of elementary functions. Here besides circuit analysis, coupling between adjacent elements and thermal distribution will also be simulated. In the successive phase, analog ICs defined as high level functional blocks have to be considered with special analysis programs. This final CAD program includes package effect evaluation and error sensitivity analysis. Interactive optimization will be organized in a user-oriented, transferable package. The project starts with C and X band investigation to be extended to 18 GHz. The CAD capability will be proven with different GaAs IC demonstrators, including submicron dimension devices.

'Large Diameter Semi-Insulating GaAs'

Proj. Ref. 1128: B/85

GaAs Integrated Circuits are using an n-type active layer prepared by ion implantation of donors directly in semi-insulating wafers, followed by an annealing to cure the implantation damages. In order to realize LSI circuits, one must control the properties of each individual micro-FET needed in this case and this can only be achieved if the active layer of each of them is perfectly under control.

This project is aimed at developing an industrial approach for the preparation of large diameter (2") semi-insulating GaAs substrates which can allow to prepare very homogeneous active layers by ion implantation and thus to control the properties of each individual micro-FET made on it.

Three different goals have to be reached:

- 1. Determine ways to define material homogeneity for ingots of diameter 2" and larger. This will be done by correlation between results of measurements made on bulk material and on processed wafers cut from it.*
- 2. Investigate possible ways to improve cristalline quality by using two parallel and complementary approaches, and end up with either a choice between the two techniques or a mixture of both.*
- 3. Grow larger (2") ingots of suitable quality using the recipes worked out in goals No 1 and 2.*

1.4.3. Scope for further work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 1.5: Optoelectronics

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

ble with III-V integrated circuits providing a fast electrical interface. This programme is not aimed at optics-based computers but rather at providing components and subsystems for large bit rate transmissions.

Remark: The achievement of the objectives of this programme needs very large resources which may not be available within the framework of ESPRIT. On the other hand these objectives represent a minimum target to remain competitive.

1.5.1. Objectives

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

- at 1 year: demonstrate a monolithic photodetector with internal amplification.
- at 2 years: demonstrate a monolithically integrated receiver with bandwidth greater than or equal to 2.5 GHz.
- at 3 years: demonstrate an integrated transmitter with a bandwidth greater than 2.5 GHz.

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

b) *Wavelength multiplexing (WDM) with integrated optics:*

- at 1 year: demonstrate of DFB laser with threshold current lower than 50 mA; demonstration of waveguide fed photodetector; low loss monolithic waveguide (smaller than 1dB/cm).
- at 2 years: demonstrate of 2.5 GHz bandwidth modulators in semiconductors.
- at 3 years: demonstrate an integrated transmitter with a bandwidth greater than 2.5 GHz.
- at 4 years: demonstrate integrated WDM transmitter and receiver modules.

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

1.5.2. Current projects and projects under negotiation

'InP Based Optoelectronic circuits'

Proj. Ref. 263: A/84

The general objective of the research programme is to significantly increase the data rate in information

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

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

In addition to this programme, one work package is to be added to investigate the possibility of fabricating an integrated optic source with independent control of both output power and wavelength using electro optic effect and current injection to tune distributed feedback (DFB) gratings lasers.

'Optical Interconnect for VLSI and High Bit Rate ICs'

Proj. Ref. 380: B/84

This speculative research programme is undertaken to investigate the application of optical interconnection to reduce the package pin count and electro magnetic interference in VLSI and high speed integrated circuits and in sub-assemblies containing these components. The current one year study to investigate in detail the role and capability of interconnection got underway in early 1985. Early work has included design studies of the performance, cost and implementations of optical sources and detectors and choice of optical fibre for optical interconnect. The limitations of optical interconnect have been assessed in terms of power budgets, bit rates, and technological compatibility and the application of the technology is currently being studied considering communication protocols, IC performance boundaries and the impact on processor architectures. Some experimental work has commenced on investigating low cost techniques for fibre

to chip interfaces and for the incorporation of optical fibres into printed circuit boards.

The next project is a continuation of the preceding on-going project No 380.

'Optical Interconnect for VLSI and High Bit Rate ICs'

Proj. Ref. 986: B/85

The inherent wide bandwidth and crosstalk immunity of optical transmission media permit very high bit rate signals to be readily distributed overcoming the transmission line and rf-interference problems encountered with very high bit rate ICs. Many lower bit rate signals, each of which would conventionally employ a package pin, can be time multiplexed together to form one easily transmitted, high bit rate optical signal which leaves the package via one optical pin so avoiding very high pin count packages for VLSI chips.

The following work packages form the proposed programme:

Design, manufacture and evaluate functional optical interconnect demonstrator working at up to 1 GBs^{-1} and demonstrating pin count reduction for VLSI chip. Investigation of optical interconnect up to 5 GBs^{-1} . Optimise physical aspects of optical interconnections. Undertake extended applications study.

'Molecular Engineering for Optoelectronics'

Proj. Ref. 443: B/84

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

'Basic Technological Studies for GaInAs MISFETs'

Proj. Ref. 927: B/85

In $0.53\text{Ga}0.47\text{As}$ epitaxially grown on semi-insulating InP substrates is a promising material for high speed logical devices as well as integrated micro-optoelectronic circuits for $1.3\text{ }\mu\text{m}$ applications. Insulated gate field effect transistors (MISFETs) can be realized on this material.

This programme has three aims:

- *first, to obtain a better understanding of the basic phenomena at the insulator/InGaAs interface,*
- *second, to explore the possibilities of ion implantation,*
- *third, to evaluate the influence of the InP substrate quality.*

Once these three aspects have been explored, technological processes for high speed logic devices and integrated optoelectronics will be optimized.

1.5.3. Scope for further work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D area 1.6: Advanced Display Technologies

1.6.1. Objectives

In many product areas, eg workstations, electronic office equipment etc. there is an urgent need in Europe for new advanced display systems to replace and supercede the conventional CRT. Such displays would need to be of large size (A4 and above) and of medium to high definition. Colour capability would also be desirable/necessary.

Many approaches are currently being investigated. A technology definition effort in which major existing community practitioners would combine their knowledge and experience is required to define within a short time period the most adequate way to tackle this problems.

1.6.2. Current projects and projects under negotiation

'Materials and Technologies for High Mobility TFTs for LC Display Bus Drivers'

Proj. Ref. 491: B/84

In current practice, the peripheral driver circuits for active matrix liquid crystal displays consist of external IC-chips. This project proposes to develop thin film materials and technologies for column- and line-bus drivers to replace the external IC-chips. The main task will be to develop a low temperature deposition process for the semiconductor thin film material compatible with the glass substrates used for the LC-display. The main material suggested is

polycrystal-line silicon, deposited in a high power glow discharge process. Furthermore elementary Thin Film Transistor (TFT) circuits suitable for bus driver shift registers will be developed and investigated and Driver prototypes of short length shall be combined with LC-matrix display and tested.

'Large Area Complex Liquid Crystal Displays Addressed by Thin Film Silicon Transistors'

Proj. Ref. 833: B/85

LCDs dominate the portable displays market. Thin-film transistor addressing of LCDs would allow an increase in display size and complexity to levels adequate for word processor and graphics displays. The aim of the present project is to investigate a viable technology for the fabrication of large area (A5 to A4) complex (up to 1000 addressable lines) LCDs based on polycrystalline and amorphous silicon transistor active matrices. Thin-film silicon devices show promise of higher yield and reliability than other approaches. Extensive investigation of the following areas is planned: optimisation of transistor characteristics, yield, and stability over large areas; special high throughput, large area semiconductor processing equipment; special LCDs fabrication techniques; colour systems; interactive displays; human factors.

1.6.3. Scope for further work

Further work in this area is dependent on the outcome of the technology definition efforts described in 1.6.2.

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R&D area 1.7: General Supporting Topics

1.7.1. Topics

This area covers:

- research themes not already identified in the microelectronics areas 1.1 to 1.6
- topics which support one or more of the areas 1.1 to 1.6
- research themes which look forward beyond the early stages of the microelectronics programme towards the submicron goals.

Since this is very wide-ranging in its scope, no specific programme of work is set out. Instead, on-going pro-

jects are briefly described (in numerical order) and indications given of other candidate topics.

1.7.2. Current projects and projects under negotiation

'Advanced Interconnect for VLSI'

Proj. Ref. 14: B/83

The overall objective of this programme is to develop high density interconnect compatible with one micron MOS and Bipolar VLSI technologies. This interconnect technology will feature four levels of low resistivity metal interconnect with high electromigration resistance and stable, low resistance contacts to the underlying silicon circuit.

The Pilot Phase of the project has demonstrated good progress and cooperation between the partners. A common process, common test mask and common test methods have been established in order to provide a practical environment for cooperative research.

In 1985 this core process has continued to be used with yield improving and the first milestone has been achieved: it has been decided to continue with polyimide as dielectric for the core process.

The following milestones of the programme are:

- | | |
|------------|--|
| Sept. 1985 | — Specification for Test Reticle for 5 μm and below.

Demonstration of metal dry etch capability adequate for 5 μm pitch |
| Dec. 1985 | — Test Reticle available |
| Sept. 1986 | — Select Optimum Process

Demonstration of 3-Layer Metal at 5 μm pitch |
| Dec. 1986 | — Yield and Reliability data on Optimum Process |
| Sept. 1987 | — Demonstration of 4-Layer Metal at 3 μm pitch. |

'Automatic Design Validation of Integrated Circuits Using E-beam'

Proj. Ref. 271: B/84

The project seeks to develop a methodology for the automatic design errors diagnosis of VLSI devices based on the observability facility given by an electron beam system, connection to the CAD environment, pattern recognition to automatically position the E-beam, global

methodology, possibly based on expert systems to define the diagnostic strategy, new hardware circuitry to enhance the EBT performance. The areas of computer control of the electron beam system, interfacing to CAD software, identification of circuit elements, methodology for design error diagnosis, test pattern generation for electron beam debugging, design for electron beam testability, and electron beam equipment development, will be addressed in order to achieve this overall objective.

'Assessment of Silicon MBE Layers'

Proj. Ref. 305: B/84

This project is divided into three parts:

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

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

'Plasma Deposition Technology for Magnetic Recording Thin Film Media'

Proj. Ref. 334: B/84

It is expected that in near future recording media and heads prepared by thin film technology will compete the conventional particulate media and conventional heads. Both longitudinal and vertical recording in thin films promise a significant increase of information density. In this project, appropriate deposition technologies will be studied which provide high deposition rates to produce such films in a industrial scale. This includes magnetron sputtering, electron beam evaporation and plasma enhanced metal-organic chemical vapor deposition.

'Silicon-on-insulator Systems Combined with Low Temperature'

Proj. Ref. 370: B/84

In the project a number of techniques will be used and combined in order to obtain good quality single crystal layers with thicknesses varying between 0.5 μm and 50

μm for a variety of applications. These relate to both silicon-on-insulator (SOI) and to SOS (silicon-on-sapphire) for high performance integrated circuits, and also for the provision of alternatives to the currently used cumbersome dielectric isolation (DI) processing.

'Dopant Profiling for Submicron Structures'

Proj. Ref. 519: B/84

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

'Investigation of all aspects of the Interconnection of High Pin Count Integrated Circuits'

Proj. Ref. 544: B/83-84

This project has the following aims:

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

It is the aim to realize all interconnect systems with just two layers, thereby achieving low cost through reduced handling and inexpensive materials.

'High Resolution Plasma Etching in Semiconductor Technology-Fundamentals, Processing and Equipment'

Proj. Ref. 574: B/84

It is widely recognised within the electronics industry that plasma etching will play a vital role in achieving sub-

micron technology both in silicon and III/V semiconductor systems. However, much remains to be done to understand the complex chemistry and physics involved by applying suitable diagnostic methods. Until this is accomplished the full potential of plasma etching will not be realized. The overall programme is necessarily interactive and brings together centres of expertise in plasma chemistry and physics, instrument manufacturers and a supplier of chemicals to the electronics industry. Collectively they possess a unique combination of knowledge and facilities which will assure success in this broadly based programme.

'Wafer Scale Integration'

Proj. Ref. 824: B/85

The design and demonstration of a 25 million transistors system on a single chip is to be performed by connecting the good cells of a wafer. The demonstrator chosen is a 4 Mbit static RAM in a $1.4\mu\text{m}$ CMOS technology using redundancy at the intracell and intercell levels, in order to tolerate end of manufacturing defects. Special interest will be given to test facilities and test strategy both at the cell and whole wafer levels. After test, reconfiguration techniques will be used to avoid faulty elements in the cell and to further increase cell yield. Decoding logic and externally controlled switches will be used to configure the good cells on the wafer.

Software will be produced to provide automatic selection of the switches to be programmed to give the necessary interconnect. The yield of aluminium interconnection lines will be increased by repair of short or open. A study of thermal and electrical characteristics of the package and bonding will be made and used to provide a suitable package for the demonstrator.

'Packages for High Speed Digital GaAs ICs'

Proj. Ref. 830: B/85

The various package design requirements being evolved to meet the requirements of the GaAs IC industry are being addressed. The project will result in the establishment of package standards together with clearly defined design principles and methods of fabrication.

The project will lead to the establishment of 4 package designs, an 8, 16, 24 and 40 I/O lead package having the necessary operational characteristics for mounting and hermetically encapsulating GaAs ICs for use in high speed digital applications. Extensive use will be made of sophisticated computer aided design and simulation modelling throughout the project, the success of which

has already been established in the case of the 8 I/O lead package. Three technical approaches to package construction will be investigated, the use of direct-sealing techniques, glass joining fired ceramic and co-firing glass-ceramic. Associated investigational topics will include materials, metallisations, heat dissipation etc.

Sample packages of the various designs will be made available for evaluation and qualification approval testing. This project is complementary to project 958.

'High Performance VLSI Packaging for Complex Electronic Systems'

Proj. Ref. 958: B/85

This project is directed towards demonstrating the feasibility and the evaluation of high density structure on which VLSI chips will be connected with very dense (100 to 125 μm pitch) TAB interconnect on a high performance multichip substrate.

Electrical and thermal performance shall be measured to evaluate the capability of such a structure which could be used as a basic building block of a very high performance system (1GHz clock or 20-50 ns system cycle time).

This project is complementary to project No 830.

'Algorithms for a Robust and Efficient Semiconductor Simulator'

Proj. Ref. 962: B/85

This work is providing fully tested general algorithms for simulating semi-conductor devices in three dimensions. These algorithms would solve for the steady on-state condition of a device, or for dynamic transient and small signal conditions, and to take into account the interaction of device operation with the temperature of the crystal lattice. The algorithms are to be tested in research computer codes developed as a result of the project, and this code will be validated against real devices.

Since the computational demands of these algorithms are very large there will be a strong interaction between suitable algorithms and the availability of computers with advanced architectures. A study will also be carried out to delimit the applicability of the assumed physical model, both with reference to materials and device dimensions.

'0.5 Micron X-Ray Lithography Masks Resists and Transferred Images'

Proj. Ref. 1007: B/85

The objective of this work is 0,5 μm X-Ray lithography up to the actual demonstration of the lithography process. In

particular, resist and mask technologies will be developed, appropriate to 0,5 μm resolution while compatible with higher resolution limits. Hence mask technology will utilize Si-based membranes which are appropriate for use with the softer (i.e. higher-resolution) wavelengths.

'Advanced Mask and Reticle Technology for VLSI Sub-Micron Microelectronics Devices'

Proj. Ref. 1043: B/85

This project addresses specific areas of the maskmaking process to develop new equipment, materials and processes and the aim is to combine such developments to create an enhanced mask and reticle technology to satisfy the wafer fabrication requirements for advanced and complex devices.

'Ultra Sensitive Impurity Analysis for Structures and Materials'

Proj. Ref. 1056: B/85

This project is developing an advanced physical analysis technique which is needed for the characterisation of microelectronics fabrication technologies. The technique which is based on sputtering and laser resonance ionization will be highly sensitive, free of matrix effects when multilayers are profiled and suitable to three-dimensional profiling with higher sensitivity as compared to standard Secondary Ion Mass Spectrometry.

1.7.3. Scope for further work

- a) Sub-micron processing research themes in support of ongoing project areas 1.1 and 1.2.

To achieve processing at feature sizes of 0.5 μm and below the following topics are identified:

- i) 0.5 μm lithography with production throughput and associated resist development which should be compatible with dry etching processes
 - ii) Modelling of processes and devices including experimental verification.
- b) B-type research themes
 - i) In support of areas 1.1 and 1.2
 - Semiconductor processing materials and equipments
 - Photo-assisted technology

- High Speed on-wafer testing
- Automated manufacturing and control.
- ii) in support of areas 1.4 and 1.5
 - Specific CAD for III-V-integrated circuits
 - Modelling optical elements
 - reliability
- iii) Other general research themes
 - Lithography (X-ray-, Ion-,)
 - Various active elements on high mobility semi-conducting materials

- advanced physical analysis techniques
- sensors and transducers
- new technologies and techniques for advanced information storage
- interconnect technologies

In call(s) for proposals to be published in 1986, priority would be given to modelling (with the main emphasis on GaAs), to equipment related to automated manufacturing and control, and to interconnect technologies.

SUBPROGRAMME 2:

SOFTWARE TECHNOLOGY

2.0. Introduction

In 1983 the need for a comprehensive software technology programme was justified on the basis of the high rate of increase in the complexity and amount of the software to be generated through to the end of the century. This need is even more evident today, 2 years after the start of the ESPRIT Pilot Phase. The objectives of the ESPRIT software technology sub-programme are being followed by a number of programmes across the world.

The recognition that the key issues relate primarily to the development of environments, methods and tools to support the design of ever more complex systems (which include hardware and software components) of high quality and reliability with higher levels of productivity has set the major directions being taken by the ST programme. After 2 years of ESPRIT Phase I, we now have underway a number of projects which are addressing the key issues listed above, and we are now in a position to identify the areas which require strengthening and indeed adding to the workplan for Software Technology.

The directions required for 1986 are identified in detail in the following sections, but the need for new projects to promote the rapid transfer of the results of the programme into the industrial environment is likely to be the main theme for 1986. Therefore the following themes will be given for new work called for in call(s) for proposals published in 1986:

- (i) reuse of software components
- (ii) commercial security of software
- (iii) demonstrators for evaluation of methods and tools in the industrial environment (see section 2.4.)

Review of the Software Technology sub-programme has identified the emphasis which needs to be given to the different topic areas, but it is not considered necessary for the 1986 workplan to significantly revise the key activities which need to be supported.

R & D Area 2.1: Theories, Methods and Tools

The need to support the system development process with more rigorous methods and tools is a major theme in the ST workplan. Measurement of productivity and of system quality and performance also is of great importance.

2.1.1. Topics

The topics within this area are:

System oriented approaches:

Formal methods for system development

Hardware/software synergy

Requirements engineering

Software security

Improving current software development approaches:

Reusability issues

Formal specification

Rigorous transformations and methods

Advanced software development approaches:

Methods for formal description and verification of concurrent, distributed, embedded real-time systems

Systematic study of the system development process
Application of AI techniques to development

Quality, Reliability, Conformity Testing and Demonstrating

Product and development process metrics

used in a well engineered merge for specification of large distributed systems, rapid prototyping is provided by the analysis of abstract implementations;

— *Modula, Ada-like languages are considered for the programming activity.*

Semi-formal transformations of system descriptions at different levels are supported by validation and documentation activities.

2.1.2. Current Projects and Projects under Negotiation

System Oriented Approaches

'Formal Methods for Asynchronous Systems'

Proj. Ref. 1033: B/85

The project aims to provide a formal framework and a suitable toolset for the development of asynchronous embedded micro and distributed systems.

The formal framework is based on:

- *Scott's domain-based state machine, for the mathematical model;*
- *Hoare's logic and temporal logic, for the correctness in analysis and design.*

The toolset includes presentation language and tools such as a design database, formal design provers based on theorem proving techniques, designer's assistants and simulators. The toolset will be linked to an asynchronous system development environment which is currently being implemented and will also be compatible with PCTE.

A set of tools supporting the GRASPIN methodology is designed on top of PCTE common tools, which makes a significant use of graphics and of concepts such as focussing techniques, multiple windowing concepts, and simultaneous handling of different contexts.

'Software development using concurrently executable modules (PEACOCK)'

Proj. Ref. 266: B/84

The objective of the project is the design and implementation of a unified family of languages covering the whole software life-cycle. All languages will use the concept of 'Concurrently Executable Module', and have a common signature (abstract syntax).

The family includes a semi formal language for requirements capture, algebraic languages for formal specification, and procedural languages for implementation.

The project will also provide education and training material, as well as evaluation reports on field trials.

Improving current Software development approaches

'Personal Workstation for Incremental Graphical Specification and Formal Implementation of Non-Sequential Systems (GRASPIN)'

Proj. Ref. 125: A/83

The project aims at a personal software development workstation for incremental Graphical Specification and stepwise formal Implementation of Nonsequential systems.

The methodological framework is characterized by an integration of formal and informal techniques in the development process:

- *structured analysis diagrams and entity relationship diagrams are used for requirement analysis;*
- *an extension of the 'initial semantics' approach to algebraic specification and high-level Petri-nets are*

'Program Development by Specification and Transformation (PROSPECTRA)'

Proj. Ref. 390: B/84

The objectives of this project are to develop a strict methodology for program development by transformations from formal specification.

A wide spectrum language from formal specifications to Ada programs will be defined with a semantics covering the concurrent aspects.

The transformation rules are proved correct 'once and for all', and their application, supported by software, would guarantee the development of programs correct in relation to specification. The use of Ada as a standard language, and specifications using annotations in Anna, or an Anna-like language, will ensure portabilities

between APSE's. In order to support the use of these tools in a workstation, a collection of additional tools would be developed.

The tools will be generated according to a uniform paradigm at each level: system development, transformation development, Anna/Ada and control.

'Software Environment for the Design of Open Distributed Systems (SEDOS)'

Proj. Ref. 410: B/84

The objective of the project is the definition of formal description techniques and support tools for development and implementation of OSI protocols and services and more generally, of open distributed systems.

Two formal languages will be defined: ESTELLE (based on a state-machine model), and LOTOS which combines the algebraic specification language ACT-ONE and the CCS calculus. Both languages will be submitted to the ISO standardization procedure.

Prototypes of syntax-directed editors, of verification and simulation tools will be produced for both languages. The project will also specify compilers and test sequence generators.

'Formal Description of Arbitrary Systems by Means of Functional Languages'

Proj. Ref. 881: B/85

The project aims at developing a prototype of a general purpose system description environment based on the so-called 'system semantics'.

System semantics is an extension of the denotational semantics of programming languages in the sense that it is applicable to arbitrary systems: various properties of a system are described by corresponding meaning functions.

A prototype general purpose system description environment based on functional languages and extended with primitives of system semantics will be developed.

Another goal of the project is the design of a prototype system description language for the following two areas: analog electronic circuits and digital systems (including VLSI).

'Rigorous Approach to Industrial Software Engineering (RAISE)'

Proj. Ref. 315: A/84

The project aims at building a complete systems development based on an enhanced version of the VDM method.

The development process described by 'project graphs' will be mathematically modelled in terms of logical systems (institutions) (e.g. equational logic, temporal logic), their transformations, system descriptions in various logical systems, transformations of descriptions. Operational models of the project graphs will be related to the activities of project managers, software engineers, programmers and project librarians.

A wide spectrum language supporting specification design will be defined. Extensions of the model-based VDM method, particularly for the specifications of concurrent systems, will be considered together with property-based methods and other model-based methods.

Tools supporting the RAISE methodology will be built (first in prototype form, then in production quality form), several industrial applications will be undertaken, and training and educational material will be produced.

'Formalisms, Methods and Tools (FOR-ME-TOO)'

Proj. Ref. 283: A/84

The main goal of the project is to define, implement and experiment a technology for the process of systematic development, verification and validation of software systems, based on the principle of reusability of software components.

The software development process, when conceived as a process with special attention given to the reuse of pre-fabricated components and to the structuring of the system to be developed into usable components as building blocks is characterized as a combination of the 'top down' and 'bottom up' approaches.

Reusability of descriptions and analysis of the sequential aspects of software systems is based on a specification language defined by using some of the primitives of ASL: a kernel specification language with 'loose' semantics.

Reusability of descriptions and analysis of the concurrent aspects of software systems is based on various classes of Petri nets: from condition-event nets to high level nets and stochastic Petri nets.

An environment of support tools will assist the developer in following a discipline for stepwise derivation and development of Sw components, for retrieval of components and for composition of Sw components.

Advanced Software Development Approaches*'An Integrated Formal Approach to Industrial Software Development (METEOR)'**Proj. Ref. 432: A/84**The basic goal of this project is the application of formal methods to the process of developing industrial software.**The development process will be studied and modelled by individualising building components for analysing existing methods and developing new methods of software development.**A language for requirement engineering will be defined with a semantics covering temporal aspects.**Algebraic methods are adopted for specifying passive and active objects (process algebras and the algebraic specification language, ASL), denotational models of concurrent systems provide a basis for defining a calculus in which various properties of such systems can be proved.**In particular, the project aims at integrating the object-based language paradigm, the algebraic approach to software specification, the relational approach and so-called formal heuristic.**The impact on management and metrics of the application of formal methods in software development will be considered.**Industrial take-up, especially in the area of constructing real-time distributed systems, is provided by the planned construction of prototype environments.**'Investigation of Performance Achievable with Highly Concurrent Interpretations of Functional Programs'**Proj. Ref. 302: B/84**The project investigates to use the functional approach for achieving thorough exploitation of the potentials of highly concurrent hardware architectures. This involves measurement of the complexity and parallelism of functional programs written in the FP, Lispkit and Me-Too languages.**The project will develop:*

- a tool for translating Lispkit and Me-Too to FP;*
- tools to measure dynamic complexity and parallelism of FP programs;*
- a virtual machine to simulate parallel execution of functional programs.*

*An evaluation report will be produced on the achievable performance of different functional approaches on parallel machines.**'An Advanced Support Environment for Method Driven Development and Evolution of Packaged Software (TOOL-USE)'**Proj. Ref. 510: B/84**This project will develop techniques for the formal definition of methods used in the development of software. The project focusses on one main idea, namely that the building of a support environment should be parameterised by methods expressed in a development language. It will seek to achieve understanding and formal modelling of:*

- the software construction process*
- the application domains*
- the target systems*

*and would continue with the definition, implementation and evolution of a prototype environment for software development based on formally defined methods.**'Application Software Prototype Implementation System (ASPIS)'**Proj. Ref. 401: A/84**The major aim of this project is the exploitation of state-of-the-art techniques in the fields of specification languages and artificial intelligence in order to construct tools, termed assistants, helping the partial automation of the first phases of the life cycle.**The main problems which will be tackled by the project are:*

- capturing the domain knowledge to be used by the assistant;*
- choosing an appropriate representation formalism for coding knowledge*
- defining the basic architecture of assistants;*
- defining an appropriate language for interaction between assistants and users.*

The final objective of the project is the creation of a set of advanced methods and tools which will permit a flexible approach to applications software production based on an interactive style including mainly:

- rapid prototyping by interpretation of the components specifications;*
- reusability of components through knowledge based assistants.*

'Advanced Interactive Development of Data-Intensive Applications (AIDA)'

Proj. Ref. 892: B/85

The project will define and develop methodologies, languages and tools to support specification, prototyping, design and implementation of information systems.

The prototype environment will allow specification in the developed System Modelling Language (SML), and prototyping by translation of SML to an executable combination of FLOP and NIAL.

Design and implementation will use semi-automatic transformations (supported by rule-based assistants) of SML to TAXIS, and of TAXIS to DBPL.

The integration of the various tools will be set on the integration of their underlying knowledge base.

'Proof-oriented Systems'

Proj. Ref. 1041 and 1158: A/85

The two complementary projects have combined to give the above named project. The two parts are:

'Syntax-directed Tool Generator'

Proj. Ref. 1041

The project aims at a meta-system generating syntax directed editing, transformation and proof tools, from descriptions of the syntax and semantics of the formalisms used in software development.

Meta-languages for the description of context conditions, transformation rules, proof rules and tactics will be defined.

A sequence of tool generators accepting those meta-languages will be designed and release versions of the generator system will be targeted to widely available environments.

'Advanced Techniques integration into Efficient Scientific application software (ATES)'

Proj. Ref. 1158

This project aims to integrate advanced techniques into an integrated Sw development environment within the

areas of scientific application programming, with particular emphasis on efficiency.

A programming language integrating three advanced techniques:

- abstraction of data types and operators
- relational database programming for scientific data
- formal specification and proof

will be defined by taking into account the specificity of scientific programming.

An efficient software development environment will include a proof subsystem which allows the user to validate an algorithm with respect to some specification, or to get error information if the algorithm is invalid.

The adequacy of the whole system will be evaluated by developing application libraries.

Project 1041 and 1158 are seen as complementary: project 1158 should provide a demonstrator project for the generation part of project 1041. Both projects will exchange information and deliverables to avoid duplication of work.

'Development of an Efficient Functional Programming system for the Support of Prototyping'

Proj. Ref. 891: B/85

This project will develop a functional programming system for the support of prototyping in an efficient manner.

Investigation and definition of capabilities and uses of a functional programming system will be carried on the following areas:

- rapid prototyping;
- efficient code generation for functional programs to be processed on conventional sequential hardware;
- programming in the large;
- persistent object management for long term storage.

A prototype system will be needed to demonstrate the approach.

'Debugging and Specification of Ada Real Time Embedded Systems (DESCARTES)'

Proj. Ref. 937 : B/85

The project intends to assist developers of real-time embedded systems in Ada by investigating formal methods and by designing software and hardware tools.

Formal semantics and proof systems for real-time languages, with emphasis on composability will be investigated.

A specification language including real-time constraints and correctness preserving transformation will be designed.

Traceability of transformation decisions in the context of real-time constraints and analysis tools will be developed.

Quality, Reliability, Conformity testing and demonstrating

'Reliability and Quality of European Software (REQUEST)'

Proj. Ref. 300: A/84

The project aims at progress in quantification of software quality and reliability, thus enabling their specification, prediction, measurement and assurance.

The areas of work include the following:

identification and validation of metrics for the 'quality' concept, and construction of a quantitative model for its prediction; particular emphasis will be put on robust regression methods;

- development of metrics and models for reliability prediction, both for software systems in general and for domains requiring ultra-high reliability (e.g. fault-tolerant systems);*
- investigation of the impact of using formal methods on reliability prediction and demonstration;*
- definition of a methodology for the certification of software products.*

To facilitate the development and validation of the metrics, the project has initiated a database for industrial data on software quality and reliability. The population is provided by various projects in Europe.

2.1.3. Scope of Further Work

Ongoing projects can be expected to produce a reasonable coverage of the theoretical basis for methods and prototype tools to support more formal approaches to the design of large sequential systems and concurrent systems. The two very important topics of component reusability (component specification, verification, validation) and system performance and planning metrics are poorly covered currently.

These two topics will be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 2.2: Management and Industrial Aspects

The theories, methods and tools developed under sub-area 2.1 will provide the raw material necessary for product development, build and maintenance, and for effective management of the development process itself, ie. development project management. The management methods and tools required to operate on this raw data are the main subject of this part of the Software Technology Workplan.

2.2.1. Topics

The topics within this area are:

Software production and maintenance support (short term solutions including those for special domains)

Management of advanced software production (project management, product management, commercial security)

2.2.2. Current Projects and Projects Under Negotiation

Software Production and Maintenance Support

'Software Production and Maintenance Management Support (SPMMS)'

Proj. Ref. 282: A/84

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

Two customizations should undergo field trials, followed by the corresponding evaluation reports.

Management of Advanced Software Production

'Integrated Project Management Systems'

Proj. Ref. 814 and 938: A/85

The two complementary projects have combined to give the above named project. The two parts are:

*'Project Integrated Management Systems (PIMS)'**Proj. Ref. 814*

The project aims at developing a rule-based management system to be used as a consultant or as a training system. The prototype management consultant and management instructor will be evaluated through field trials.

*'An Autonomous and Interactive Workbench to aid Software Project Management'**Proj. Ref. 938*

The objective of the project is the implementation of a prototype workbench with particular emphasis on planning, project control and decision support. The tools rely heavily on a common knowledge base. The system is intended to be UNIX V and PCTE portable.

Projects 814 and 938 are seen as complementary: both are concerned with the production of integrated management tools, project 814 puts emphasis on the rule based approach, project 938 on the coupling with software development tools. Both projects will exchange information and deliverables to avoid duplication of work.

2.2.3. Scope for Further Work

Previous calls for proposals have not resulted in a sufficient number of good projects in this subarea. However, work is in progress on simple management tools and rule-based management systems.

Work is required within this subarea to provide the methods and tools (eg. product control, commercial security issues) for the support of reusable software components, to complement the work identified in subarea 2.1.

It is likely that small projects addressing the above topics will be considered for inclusion in call(s) for proposals published in 1986.

R & D Area 2.3: Common Environment

In this subarea the work on environments can cover a wide spectrum of topics: from integrated toolsets to method driven system development support, from application oriented support systems to environment generators.

2.3.1. Topics

The topics within this area are:

Common Tool Environment
Evolution to more advanced environments
Host/target issues

2.3.2. Current Projects and Projects Under Negotiation**Common Tool Environment***'A Basis for a Portable Common Tool Environment (PCTE)'**Proj. Ref. 32: A/83*

The project develops a Layer of basic functionalities for a portable common tool environment. This environment will be upwards compatible with UNIX V.

The PCTE 'kernel' consists of:

- *basic mechanisms for process control, interprocess communication, as well as an Object Management System (OMS) based on an Entity-Relationship model, and supporting the subschema concept;*
- *user interface mechanisms providing the concepts of User Agent (supporting windows, menus and other bitmap facilities, and a command language) and of Application Agent (providing a syntax-directed editor and the interface to UNIX tools);*
- *distributed facilities (LAN interface and higher layer protocols).*

Two prototypes of the PCTE kernel are developed: a UNIX-Based version and an Ada-based one.

Specifications have been published and are widely circulated within the ESPRIT Community.

The kernel will be evaluated by developing a few significant tools, which include a Configuration Management System (CMS) and a Knowledge-Based Programmer's Assistant (KBPA).

*'Automated Support for Software Engineering Technology (ASSET—feasibility study)'**Proj. Ref. 267: B/84*

The objectives of this feasibility study are to demonstrate the technical feasibility of a proposal to develop advanced interactive graphics support for a range of methods covering each phase of the software lifecycle and based on the EPOS system.

The outcome of this feasibility study is summarized in a final report.

*'PCTE-Added Common Tools (PACT)'**Proj. Ref. 951: A/85*

The project objective is the development and documentation of an initial toolset for PCTE (Proj. 32) with focus on those basic tools that a potential user would expect to find with a 'basic operating system'. This implementation of a layer of functionalities above PCTE basic mechanisms will provide the tool developer with a higher level interface to PCTE. The project will be conducted in close collaboration with the PCTE project.

The prototype version may include among others:

- tools for data definition and data query*
- tools for environment administration*
- document preparation tools*
- communication facilities (user-user and gateways)*
- support for C, Pascal, Lisp and Prolog*
- configuration management tools*

Evolution to more advanced environments*'Generation of Interactive Programming Environments (GIPE)'**Proj. Ref. 348: B/84*

The main objective of the project is to investigate the possibilities of automatically generating interactive programming environments from language specifications.

Such an interactive environment will be generated from a complete syntactic and semantic characterization of the language to be used.

Such syntactical and semantical characterization will be formally expressed in a Language Definition Formalism (LDF): inference rules-based approach and an algebraic approach are considered as the starting point for the design of the LDF.

A prototype system will be designed and implemented, consisting basically of an LDF compiler, a file system and a user interface.

*'Development and integration of accurate operations in Numerical Data Processing (DIAMOND)'**Proj. Ref. 1072: B/85*

The project aims at developing methods and tools allowing accurate floating point arithmetic on computers, based on a mathematical theory of computer arithmetic in which all operations are defined by so-called semi-morphisms.

Such systematic theory of computer arithmetic aims at performing the basic arithmetic operations to maximum accuracy and providing sufficient control over the rounding process so as to ensure reliable error bounds.

This project will pursue different approaches: embedding of convenient arithmetic notations into ADA and Pascal; AI-techniques for formula transformation and symbolic manipulation; construction of methodological framework and knowledge based on numerical programming.

*'A Rule Based Approach to Information Systems Development'**Proj. Ref. 928: B/85*

The project aims to achieve information systems which more accurately match the business requirements of users. Individual end user requirements are collected using a rule-based approach. These views are integrated into a single model which is subsequently used for application generation.

A prototype system will be developed consisting of:

- a rule-based fact gathering and presentation system with different views for presentation and with validation tools;*
- a unified knowledge base (UKB) to store, aggregate and validate individual views;*
- an application generating system to realize applications from rule-based descriptions in the UKB, either by transformation or by interpretation of the rules.*

*'Concepts and Components Reuse in knowledge-rich Environments'**Proj. 974 and 1094: A/85*

The two complementary projects have combined to give the above named project. The two parts are:

*'A knowledge-base Environment for Software System Configuration reusing Components (KNOSOS)'**Proj. Ref. 974*

The objective of this project is an environment supporting a method for components reuse during software configuration.

The user requirements for such an environment will be captured through studies conducted by industries familiar with large applications development.

A KNOSOS prototype will be constructed by integration and adaptation of a relational DBMS, a knowledge representation and manipulation tool, a software configurator, an automated configuration management system, and a common user interface with graphic capabilities. This prototype will be evaluated through field trials.

'Support System for pragmatic reuse of software concepts (PRACTITIONER)'

Proj. Ref. 1094

This project aims at methods to identify, isolate, document, store and retrieve program concepts at the design level, i.e. design ideas, schemes for software subsystems and components.

The potential of a linguistic approach as a basis for methods to analyse existing programs will be investigated. A prototype system supporting these methods will be evaluated by performing extensive experiments.

Projects 974 and 1094 are seen as complementary: both projects aim at reusability, but with different emphasis: one project aims at new industrial practices allowing software configuration by reusing components; the other one tackles the design aspects of the problem, and looks for reusable concepts.

Both projects will exchange information and deliverables to avoid duplication of work.

Host/Target issues

At the moment there are no projects covering this area.

2.3.3. Scope for Further Work

The work started in 1983 on the Portable Common Tool Environment (PCTE) has provided the central core of the first generation environments work for the ESPRIT software technology programme. The interfaces defined by this project provide the necessary link for the integration of the tools being produced within the other subareas of the ST workplan.

As a result of the supplementary call for proposals in 1985 work on advanced environments and host/target issues is expected to be launched in 1986.

The work supported within the subarea must provide the framework for the adoption of the integrated support environments into industry. It is important therefore to ensure that the ongoing work includes:

- (i) support of wide spectrum languages and integrated mixed-mode environments (e.g. functional and logical programming techniques).
- (ii) development of environment generators for the more efficient support of advanced design methods.

The above two topics are likely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 2.4: Evaluation and Demonstration Projects

To support the urgent need for fast technology transfer into industry it is particularly important that the results of the ESPRIT programme include quantitative and qualitative assessment of the costs of introduction into and the use of the integrated development environments, methods and tools in a controlled industrial environment. This sub-area will become increasingly important as the programme matures.

2.4.1. Topics

The topics to be included in this area are:

Evaluation and demonstration projects for specific methods and/or techniques

Evaluation and demonstration projects for integration issues

2.4.2. Current Projects and Projects Under Negotiation

Evaluation and demonstration projects for specific methods and/or techniques

'Software Development Demonstrator through GRASPIN Methods and Tools'

Proj. Ref. 800: A/85

This project will evaluate and demonstrate the suitability of the state of the art in software development technology, for industrial purposes. The methodology and its basic set of support tools will be provided by the GRASPIN project (P125).

The evaluation and demonstrating of the GRASPIN methodology and tools will be done with respect to projects in two application fields: Computer Integrated Manufacturing and Office Automation.

'Demonstration of Prospectra Methodology and System'

Proj. Ref. 835: A/85

The PROSPECTRA project will provide a rigorous methodology for developing correct software and a

comprehensive support system. The method and the tools represent a significant departure from the current practice in the industry. The proposed project will demonstrate the feasibility of applying this methodology and its support tools to real-life industrial projects.

Evaluation and demonstration projects for integration issues

At the moment there are no projects covering this area.

2.4.3. Scope of Future Work

The work underway currently is reaching the stage at which early prototype models are becoming available

and it is now feasible to begin the experimentation and evaluation process.

This is a particularly important part of the ST workplan and it is likely that a number of small demonstrator projects together with a limited number of large demonstrator projects will be considered for inclusion in call(s) for proposals published in 1986.

The objective of the demonstrator projects is to evaluate the methods, tools and development support environments in an industrial environment. Funding for specific application developments will not be provided unless for evaluation purposes.

SUBPROGRAMME 3:

ADVANCED INFORMATION PROCESSING (AIP)

3.0. Introduction

The ESPRIT workprogramme for AIP was developed to ensure support of advanced techniques for the processing of information. It was recognized that the future requirements for information processing could not be met by the more traditional computational methods and hardware and software architectures, and therefore a programme was defined to cover:

- (i) knowledge engineering
- (ii) advanced signal processing including man-machine interfaces
- (iii) information and knowledge storage
- (iv) computer architectures

The AIP sub-programme is, by definition, addressing primarily advanced research topics and therefore it is to be expected that the major topics listed above will need continued support in 1986. However, some encouraging results have already been obtained, particularly in the early applications of knowledge engineering techniques, and the opportunities to use the AIP Technologies within the other sub-areas of the ESPRIT programme will become increasingly more evident. To assist in this technology transfer, greater emphasis will need to be given to the work on advanced system design methods and the focusing projects which will provide the qualitative and quantitative assessments necessary to support the movement of this technology into industry.

The following themes will be given priority for new work called for in call(s) for proposals published in 1986:

- (i) demonstrators (see section 3.1.3)
- (ii) multi-sensor systems (see section 3.2.3)
- (iii) integration of numeric and symbolic processing (see section 3.4.3)

R & D Area 3.1: Knowledge Engineering

This R & D area is concerned with the tools and technologies needed to develop Knowledge Based Systems.

3.1.1. Topics

The topic of knowledge engineering needs to be addressed by a balanced programme of theoretical studies and practical research and development projects, which will provide the methods and tools required to move this new engineering domain progressively into commercial and industrial environments.

The topics within this subarea are:

- Knowledge Processing
It comprises Knowledge acquisition, representation, manipulation including inference techniques and learning techniques.

- Dialogue and Natural Language including use of graphics
- Development and Application of Knowledge Based Systems into the operational environments

3.1.2. Current Projects and Projects Under Negotiation

Knowledge Processing

'Knowledge Integration & Management Systems'

Proj. Ref. 112: A/83

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

The wide potential applications are underpinned by an engineering approach where existing tools like OMEGA were taken apart to investigate the fundamental structure.

A development system for the combination of knowledge sources and for communities of cooperating agents is currently in the implementation phase. Finally, a manipulation system for large knowledge bases will be developed. As an example, an extended PROLOG Systems configurator had been built and is being used for systems assembly by some of the partners.

'An Architecture for Interactive Problem Solving by Cooperating Data and Knowledge Bases'

Proj. Ref. 316: A/84

The main goal of the project is the design and implementation of an expert system architecture for advice-giving. The original goal of a user seeking advice may be ill-defined and there may be a huge number of potential solutions for the user to choose from. The purpose of an automatic advisor is to help the user articulate his goals and then to generate candidate solutions for the user to accept or reject. The main computational problem to be solved is one of controlling the cooperative functioning of several sources of knowledge, which may use different

representational schemes interpreted by different inference engines. A promising architecture appears to be one which considers each knowledge source to be an independent agent, which only communicates with other such agents via a global data structure, under the supervision of a flexible scheduler capable of reasoning about control. In addition to architectural issues, the project emphasizes the importance of user modelling in man-machine dialogue and the use of large databases to provide an advisor with comprehensive information.

The concepts proposed have been validated in the early stages of the project, and work is underway on a financial investment adviser to be demonstrated in 1986.

'Advanced Logical Programming Environments'

Proj. Ref. 363 + 973: B/84

The objective is to produce a prototype Advanced Programming Environment for industrial use. A number of areas will be addressed; programme execution on either parallel or classical architectures; program creation from a specification language; abstract data type specification and theorem proving if appropriate.

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

'Integration of Symbolic and Numeric Learning Techniques'

Proj. Ref. 1063 : B/85

The objective of this work is to improve knowledge acquisition for KB Systems. The project will identify the best features from different approaches to knowledge acquisition, in order to improve the quality of 'noisy' data.

The project will be based around existing software: MAIN - based around Michalski's INDUCE and AQ11, a symbolic learner; AGAPE and AGAPE-C which use theorem proving techniques and taxonomies of

descriptors of example sets; and NEDDIE which is an extended version of Quinlan's ID3, which uses numerical manipulation to constrain its search space.

An example application will be demonstrated in 1987 showing integrated learning of symbolic and numerical methods.

See also Proj. Ref. 107 described under 3.3.

Dialogue and Natural Language

'ACORD: Construction and Interrogation of Knowledge Bases Using Natural Language Text and Graphics'

Proj. Ref. 393: A/84

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

The knowledge representation will be based on recent results in formal semantics and on logical theory of data bases.

To support dialogue, the system will select appropriate presentation of output, text or graphics, and identify relevant information for output. The system interface will feature a symbiotic interplay of graphics and natural language.

'Communication Failure in Dialogue : Techniques for Detection and Repair'

Proj. Ref. 527: B/84

The aim of this project is the development of a robust and portable natural-language interface to a relational database system.

The initial stages of the project involve the study of human dialogues in a simulated database-query environment, including recovery from various types of communication failure. From an analysis of these dialogues a formal model of the dialogue process will be developed. The formal model will serve as a basis for a computer implementation of an English and Italian natural-lan-

guage front-end to a students' records database. An important element of the implementation will be the use of non-verbal systems (e.g., graphics, pointing, icons) in roles analogous to the non-verbal components of human dialogues.

The robust dialogue component of the project has potential applications outside the database domain. Elements of it can be used in the development of a front-end to expert systems or for information retrieval in an office environment.

'Graphics and Knowledge Based Dialogue for Dynamic Systems'

Proj. Ref. 857: A/85

This project will develop improved user/system interfaces for dynamic large-scale industrial control systems, by the design of intelligent graphics and knowledge base dialogue systems.

Three cooperating knowledge processing expert systems will be built, that will give the operator of a supervision and control (S&C) system intelligent support in diagnosing and recovering from faults, and will provide an intelligent graphics interface.

A further aim of the project is to assemble different KBS Demonstrators for use in 'hard-tech' industrial environments and to identify appropriate metrication aspects and methods.

The project will develop expertise by building a set of dialogue design and specification tools for use in solving problems identified during a survey of users of S&C systems. These tools will then be used and tested throughout the project, to build these systems.

The project attempts to identify metrics which are of significance, and methods for their assessment.

See also Proj. Ref. 107, 311 described under 3.3 and Proj. Ref. 1015 described under 3.6.

Development and Application of Knowledge Based Systems

'Expert System Builder'

Proj. Ref. 96: A/83

The aim of the project is to provide a system enabling expert systems to be developed and tested by personnel inexperienced in artificial intelligence. A ring structured model has been identified for the system to allow progressive development and extension of the facilities within the individual layers, with the inner rings being completely independent of the domain. The test system provides the tool set for the upper layers, with the capability for later

extensions. A particular domain has been chosen, that of diagnosis of electronic systems, because of its increasing demand in equipment and manufacturing, and labour intensiveness of the methods presently employed.

Implementation of the tools on symbolic processors has commenced. Portability of the eventual software and the independance from domain specific characteristics are the main design factors. The first demonstrations ran successfully in September 1984.

*'Time Dependency and System Modelling in KBS's
Design for Industrial Process Applications'*

Proj. Ref. 256: B/84

The project addresses some of the research topics connected with the design of KBS's that have to closely interact with complex processes (e.g. industrial diagnosis, plant monitoring, process control, etc.), thus being able to deal with a type of reasoning where time dependency is crucial and where there is a specific need for representing and using qualitative models of physical systems.

A detailed study at the level of system design (midway between pure speculation and prototyping) is to assess the state of the art and to define of effective architectures and knowledge representation paradigms.

*'Knowledge Representation and Inference Techniques in
Industrial Control'*

Proj. Ref. 387: A/84

The aim of the project is to design and implement an Expert System to assist maintenance, fault diagnosis, optimization of data flows, and control in an industrial process-control environment of very high complexity.

Therefore the Expert Control System must take the time-dependency into account, and capturing of input data must be accomplished automatically and intelligently.

To overcome complexity barriers in such devices, a machine learning capability is included.

Advances over existing Control Systems lie in making process-control more secure by assisting the operator in his decisions and by reducing the drop-out rate of the controlling devices.

'Knowledge Based Assistant for Electromyography'

Proj. Ref. 599: B/84

The aim of the project is to develop a knowledge based assistant to support physicians in all stages of an electro-

myographic (EMG) examination of patients with neurological disease. In the short term expert assistance will be implemented on two separate, well-defined and important aspects of the EMG problem ; in the longer term a more ambitious system will be developed to provide more comprehensive assistance to the physician. The first system will be demonstrated in 1986 to exemplify the interconnect of signal acquisition, knowledge based systems and medical expertise.

*'Design, Experimentation of a KBS Architecture and
Tool Kit for Real Time Process Control Applications'*

Proj. Ref. 820 + 865 + 1096: A/85

This project deals with KBS tools for real time applications. The first phase concerns the study of the current state of the art in KBS for process applications. The second phase is a design and implementation of a prototype KBS toolkit. The toolkit developed will offer a concrete working environment for KBS designers in a complex domain.

The work will concentrate on one aspect such as CAD systems.

The project will investigate how the knowledge structure of multilevel hierarchical real-time industrial control systems may be partitioned through well-defined abstraction levels which will allow separation of control (procedural) knowledge from descriptive (declarative) knowledge. It will also define metrication techniques which will be evaluated in conjunction with the building of demonstrators.

3.1.3. Scope for Further Work

Current projects provide a reasonable coverage of the basic knowledge engineering techniques. The application of knowledge-based systems (KBS) into the operational environment is becoming increasingly important.

Small projects addressing the demonstration of KBS techniques and tools in the industrial environment are likely to be considered for inclusion in the call(s) for proposals published in 1986. The objective of the demonstrator projects is to evaluate the methods, tools and development support environments in an industrial environment. Funding for specific application developments will not be provided unless for evaluation purposes.

R & D Area 3.2: Advanced Signal Processing including Man-Machine Interfaces

Work under this part of the AIP sub-programme is concerned with the development of methods and techniques to enable the control of computer-based

systems, including through appropriate man-machine interfaces. The signal processing element needs to be able to accept a wide range of signals, and be capable of information extraction, interpretation for the support of decision making in real-time.

3.2.1. Topics

The topics within this area are:

- Image Processing (2-dimensional and 3-dimensional images, depth and motion analysis and picture synthesis)
- Speech recognition and understanding (in particular continuous speech input and speaker independence)
- Multi-sensor signal processing i.e. the combination of a number of separate input signals into a single interpretation of the current status of the operational environment where the signals are derived from vision, sound, touch, sensors, etc.

3.2.2. Current Projects and Projects under Negotiation

Image Processing

'Advanced Algorithms and Architectures for Signal processing'

Proj. Ref. 26: A/83

Main objective of the project is to develop a real time signal processing system that is designed to be compatible between first (i.e. feature extraction) and successive (i.e. recognition and understanding) levels of computing functions. The work has therefore been planned to run in three parallel areas : speech analysis, image analysis, signal recognition and understanding.

For image processing, the approach consists of extracting and manipulating the information that is contained within the image.

This information may be described either in terms of structures such as edges, shapes, degrees of movement and textures, or in term of statistical constructs. Early achievements include an edge detector based on texture changes and an optimal shape interpolation technique based on dynamic programming. The initial application target is the development of a set of tools, both algorithmic and hardware, for this level of processing. Applications involving medical imagery and industrial inspection will be used to test these tools and to study architectural and implementation issues.

'A Study of Real-time Perspective Synthesis'

Proj. Ref. 411: A/84

The purpose of this R&D work is to study picture synthesis based on a very compact 20 Gigabits sequential/random read only memory and high speed processors which can supply picture synthesis techniques in real time. The main work will be to study the feasibility of 35 mm film for data storage and to design the interface hardware and software techniques which are required for the completion of an experimental system. In order to identify desired design features, the picture synthesis will be used on a 3D display mix of computer graphics and terrain images for cockpit instrumentation.

Initial results of the study have been established for a variety of recording and coding schemes, reading techniques and film substrates.

This project has cross-references to ESPRIT area 3.3 'Information and Knowledge Storage'.

'Image and Movement Understanding'

Proj. Ref. 419: B/84

The proposed research is directed to understand the computational bases of vision and movement, with particular reference to scene understanding and cursive script understanding. With regard to scene understanding (based on stereo pairs or multiple views of pictorial images as input to the system) the project is focussed on the interface between the 'early stages' of computation, which provide rich but ambiguous descriptions in terms of low-level features, and the 'knowledge-based' processing, which generates descriptions of 3D organization of the visual world compatible with the properties of the physical world. With regard to cursive script, we think that recognition is still a far goal. Basic knowledge needs still to be acquired about the mapping from linguistic material to hand trajectories. The goal of the project is to understand the writing process more than recognize it. Furthermore, we address the cognitive modeling aspect with the hypothesis that interfacing it with a signal processing stage is essentially common to vision and movement.

'Real time generation and display of the 2.5 D sketch for moving scenes'

Proj. Ref. 532: B/84

The project will develop and implement a demonstrator prototype of an imaging system which is capable of producing a form of 2.5 D sketch directly. This sketch, in

which image intensity will be related to range, will be in one-to-one pixel correspondence with an illumination intensity representation generated simultaneously. Statistical operations performed on successive range estimates should permit a marked improvement over the single measure resolution.

'Integrated Optic Technologies for Real Time Wideband Optical Signal Processing'

Proj. Ref. 866: B/85

The scope of this project is to develop an integrated acousto-optical device including various optical elements as well as the radiation source and suitable detectors for one-dimensional signal processing in the 0.1-10 GHz range. Applications for such a device range from super-fast LAN connections to (1-D) correlation in radar processing systems (for dynamic clutter rejection). The device is to be rugged and compact.

'External Interface for Processing of 3-D Holographic Images for Analysis and Control'

Proj. Ref. 898: B/85

The aim of the project is the development of an external interface system, that links physically generated 3-D images to inspection and analysis procedures. While this has to be a general and flexible system, it is used in this project for holographic interferograms and X-ray radiographs for applications in areas such as real time testing and inspection and 3-D measurement. For this task, optical and electronic methods have to be combined in order to extract the relevant information from multiple 3-D images. A further aim of the project is the automation of the holographic interferometry and the X-ray radiography for on-line testing in the manufacturing process.

'Depth and Motion Analysis'

Proj. Ref. 940: A/85

The objective of this project is to solve a mathematical and theoretical problem underlying depth and motion analysis at the level of hardware implementation. Prototypes of a vision system will be constructed, which will be able to guide a mobile vehicle, or arms of industrial robots, during obstacle avoidance and arm manipulation.

The accomplishment of this project is relevant to robotics, factory automation and aerospace technology. The tasks

of this project consist not only of theoretical studies for the reconstruction of 3 D structure and determination of motion parameters, but also in the design and prototyping of a vision system as well as its implementation in VLSI.

'2-D Coherent Optical Dynamic Processor'

Proj. Ref. 1035: B/85

The purpose of the project is to develop and implement an optical correlator for pattern recognition based on the most recent technological developments. The feasibility of parallel optical signal processing is demonstrated by using a spatial light modulator (electrically and/or optically), a solid state laser, and non linear components based on the Four Wave Mixing (FWM) process, allowing real time modification of the correlation function. By improving the spatial light modulator and FWM components technology, a corresponding improvement in processor performance is demonstrated, leading ultimately to a resolution of $1\,200 \times 1\,200$ pixels in parallel at a standard TV frame rate.

Speech Recognition and Understanding

'Advanced Algorithms and Architectures for Signal Processing'

Proj. Ref. 26: A/83

With respect to speech the target will be to extend current state of the art techniques for recognition. This will be achieved by combining the complementary approaches of automatic classification techniques, Hidden Markov Models, and feature extraction. The resulting system will be tested using a vocabulary in the order of 1 000 words with constrained syntax and using continuous speech. Subsequent work will consist both of improvement to the system and its constituent techniques and of interfacing this system to higher levels of recognition and understanding. A front end for diphones recognition was demonstrated in 1984.

Multisensor Signal Processing

At present no project addresses this topic.

3.2.3. Scope for Further Work

Current projects provide a reasonable coverage of systems for feature extraction. The more complex

problems of multi-sensor systems need to be given a higher priority for future work.

It is likely that a large project in this area will be considered for inclusion in call(s) for proposals published in 1986.

R & D 3.3 Area: Information and Knowledge Storage

Effective knowledge based systems will need to be able to access information and knowledge in the most time-efficient manner, and this data will need to be stored in the most space-efficient manner.

3.3.1. Topics

The topics within this area are:

- Definition and Implementation of new Data/Knowledge base building mechanisms. They are required to achieve acceptable space-time trade-offs for the advanced knowledge-based systems.
- New Data/Knowledge base accesses
- New physical devices

3.3.2. Current Projects and Projects under Negotiation

Definition and Implementation of New Data / Knowledge Base Building Mechanisms.

'Advanced Data and Knowledge Management Systems'

Proj. Ref. 311: A/84

The project aims at the definition of an advanced system which allows an intelligent and efficient management of large amounts of information stored in it. The following topics will be addressed:

- 1. Information and knowledge storage organisation for deduction and retrieval of facts from a specific domain using possibly incomplete and inexact knowledge about the domain (and related meta-knowledge).*
- 2. Definition of optimisation techniques at the domain independent level as well as at the domain dependent level for efficient access.*
- 3. A natural language interpreter.*

The project will also address issues related to logic programming, with the goal of comparing the two

approaches and, eventually, of finding out criteria in favour of the adoption of one of them, in order to start the design of a system embodying the selected approach.

'Advanced Knowledge Base Management System'

Proj. Ref. 530 : A/84

The project studies and develops a prototype of KBMS, obtained by integrating the data base technology with an inference component, based on logic programming technology. Different integration mechanisms and different strategies for knowledge partitioning are evaluated with respect to performance and reusability of existing data bases. Options using distributed DBMS and/or defining the distributed architecture at the inference component level will be considered and a structure will be chosen for prototyping. The possibility of using the data base technology to store the deductive knowledge will also be studied as a possible solution for very large knowledge-based systems. The project will develop tools (typically concerned with various user interfaces) for building and using knowledge-based systems.

'Next Generation Integrated Data Base and Knowledge Base Management System'

Proj. Ref. 1005:

Proj. Ref. 1117: A/85

Proj. Ref. 1133:

The role of this composite project is to design and implement a simulator for an advanced Integrated DB and KBMS by considering results of earlier ESPRIT projects as well as new developments outside ESPRIT. This will include access to non-integrated and heterogeneous data and knowledge bases, various forms of knowledge representations and programming. The system will also provide a user-friendly interaction. Application areas will be studied and chosen for a simulation. Further features of this project are: study of parallel architecture for storage and processing, and the design of suitable inference machines.

The three individual projects are:

Proj. Ref. 1005: B/85. 'Next Generation Data Base Management System — MUST' which is concerned with preliminary phases in the development of the next generation databases management system.

Proj. Ref. 1133: B/85. 'Advanced Model for Integration of DB and KB Management Systems' which aims at the feasibility of integrating DB and KBMS.

Proj. Ref. 1117: B/85. 'Knowledge Based User Friendly System for the Utilisation of Information Bases' which is aimed at a KBS to provide support for the access and use of information from an information base.

New Data / Knowledge accesses

'A Logic-oriented Approach to Knowledge and Data Bases Supporting Natural User Interaction'

Proj. Ref. 107: A/83

A Logic Oriented Approach to Knowledge and Data Bases, supporting Natural User Interaction (LOKI) applies logic programming in a number of novel ways, to systems software and to knowledge-based applications.

The systems software work is all based on a new Prolog. Special tools allowing access to databases at source level by a variety of Prolog-type languages. These tools will form the implementation language for a high-level knowledge representation formalism. A conceptual modelling language (CML) will be developed for general real world application, based on frames definable within predicate calculus.

One use of CML will be to store the knowledge of project management required by one of the project's two application systems with a German and English front-end. Another application is the development of an expert system that models some of the knowledge used in aircraft design. This is called ADROIT, and a first prototype, restricted to wing design, is already complete.

'Intelligent Help for Information System Users'

Proj. Ref. 280: B/84

The project proposes to investigate approaches towards helping users of information systems learn optimally to exploit the functions of those information systems. These approaches will be operationally implemented in the form of a prototype HELP system to provide guidelines, instructions and explanations to user requests for information systems facilities. A set of UNIX utilities have been targeted, and based on this a demonstration of a structural help system was given in 1985.

'Knowledge Based User Friendly Interfaces for the utilisation of Information Bases'

Proj. Ref. 641: B/84

The project defines a knowledge-based system to provide user-friendly interfaces to existing and new databases

and knowledge bases. The schemata of existing databases will be described by semantic data models.

The work of the first year study consists of:

- Design of a standard interface to heterogeneous distributed databases based on a conceptual data model;*
- Development of an interaction methodology between the user and the system based on logical independence;*
- Design of an advanced application environment for end-users concerned with modelling some reality, handling existing data and knowledge and creating solutions to standard or unexpected problems.*

'High Densities Mass Storage Memories for Knowledge and Information Storage'

Proj. Ref. 957: A/85

This project is to develop further techniques associated with storage technology, covering perpendicular recording on floppy and rigid discs, and magneto-optical recording. In addition to the development of basic components to support these technologies, work will be carried out into defining the internal coding of the data, 'local intelligence' characteristics of the storage device and system requirements using the devices.

The three-year objectives of this project include prototypes for perpendicular magnetic recording on floppy and hard disks with densities of about 100 000 fci and the presentation of a thermomagnetic disc drive with at least 15 000 fci and 150 ms access time.

3.3.3. Scope for further work

Current projects provide a reasonable coverage of this subarea.

It is unlikely that this area will be considered for inclusion in call(s) for proposals published in 1986.

R & D 3.4 Area: Computer Architectures

This R & D area investigates the potential for new forms of computer architectures.

3.4.1. Topics

The topics within this subarea are:

- Development of new communication mechanisms
This will allow greater connectivity of machines supporting current architectures.
- Development of non-von-Neumann machine architectures
- Development of architectures for the integration of numeric and symbolic processing
- Advanced Machine Architectures for highly concurrent processing.

The topic of advanced machine architectures necessarily includes consideration of machine performance, reliability and availability (hardware and software aspects) and the development of appropriate development support environments. The work will promote advances in basic hardware and software technology by providing early indication of the requirements from work in the microelectronics and software areas with respect to advance components, and will also provide fruitful applications areas for these technologies, e.g. architectures for optical computing.

Advances in computer system design is a fundamental prerequisite of successful realization of many of the targets for the development of information technology.

3.4.2. Current projects and projects under negotiation

Development of new communication mechanisms.

'The Connection Machine: a Dependable Open Distributed System Architecture'

Proj. Ref. 818: B/85

This project will look at the basic problems of an OSI LAN architecture with fault tolerance as a primary requirement.

'Integrated Environment for Reliable Systems'

Proj. Ref. 874: B/85

The one year period will be used to clearly specify each part of their overall tem design (architecture, host software, interconnection) with reliability and fault tolerance functionality.

Development of non von-Neumann machines architectures

'Parallel Architectures and Languages for AIP — A VLSI Directed Approach'

Proj. Ref. 415 + 313: A/84

This project aims to investigate the different non-von-Neuman architectures previously described and

implement some of them in systems nearer to the commercial sphere. The prime objective is to reduce the execution times required by A.I. applications by a substantial factor. Concurrency will be achieved through a large number of identical processing elements implemented in VLSI. Ideally, a concurrent machine should support all three programming styles (object oriented, functional and logic) which will allow the full exploitation of concurrency, but the principles upon which such a machine could be based are not yet fully understood. All three styles will be explored through studies into machines which support each programming style separately, and through common working groups which will explore several areas of general relevance.

All subprojects are based on messages passing between identical units, here called PCMs, consisting of communication hardware, processing hardware and local memory. In addition to the subprojects and working groups, an application study group will be formed to select applications with which the various styles may be evaluated and their suitability for various fields of application established.

'Parallel Associative Development Machine as a Vehicle for A.I.'

Proj. Ref. 967 + 1106: A/85

Time critical applications, such as 'real time' speech and image understanding need suitable high-performance computer systems.

This project is intended to address this requirement by the construction of a common development machine (PADMAVATI). The proposed machine architecture will be based on an array of computational nodes each containing a high performance microprocessor, memory and communication interfaces. The programming environment will be based on standard Prolog and Lisp with extensions to support parallel execution. The resulting hardware architecture and software system will be tested by implementing experimental, computationally intensive tasks from the fields of natural language, speech and image understanding on the completed machine.

Development of architectures for integration of numeric and symbolic processing.

At present no project addresses this topic.

Advance Machine Architectures for highly concurrent processing.

'Message Passing Architectures and Description Systems'

Proj. Ref. 440: B/84

The project will build three levels of tools for the development of Expert systems:

- Message passing languages
- Description languages for knowledge representation
- Reasoning and strategy programming

The project will develop techniques for implementing message passing languages that will exploit new highly parallel architectures.

The techniques will cover issues of run-time support like allocation, migration, garbage-collection and persistency of actors. A description system will be developed to support the basic mechanisms of knowledge representation: conceptual hierarchies, inheritance, attributions.

To perform reasoning on the description system, rather than providing a fixed strategy, primitives and constructs will be developed that will allow to programme deductive strategies tailored to specific applications. Strategy execution will be performed concurrently by a large number of actors each exploring a small portion of the knowledge base.

At the end of the project, there will be:

- 1) *a solid implementation of message passing;*
- 2) *techniques for exploiting specialized concurrent hardware to implement actors efficiently;*
- 3) *a package of knowledge representation primitives, and*
- 4) *a description system and related interaction tools; with applications ranging across the KBS and MMI spheres.*

'Development and Application of a Low-Cost High Performance Multi-Processor Machines'

Proj. Ref. 1085: A/85

The goal of this project is to develop a prototype high performance flexible multiprocessor computer. A computation rate of 500 million floating point operations per second will be achieved by concurrent operation of a large number of specially developed VLSI floating point processors. The machine will be implemented as a regular array of 'super-nodes' with each node consisting of typically 20 processors. A configurable interconnection strategy in each node, using a switching network to be developed in this project, will provide a flexible architecture suitable for a wide range of scientific and engineering problems.

It is proposed to demonstrate the utility of the configurable architecture, both for use as a single-user work station (operating with a single super-node) and as the basis for a large, powerful array of super-nodes, by mounting a range of application software. These will range over CAD for VLSI, signal-processing, large-scale modelling and simulation. A prototype will be built by the end of 1987, and a machine will exist by the end of 1988.

3.4.3. Scope for Further Work

Current projects provide a reasonable coverage of all topics included in this except for the integration of symbolic and numeric processing.

It is likely that a large project in this area will be considered for inclusion in call(s) for proposals published in 1986.

R & D 3.5 Area: Design and System Aspects

3.5.1. Topics

The definition of lifecycle models for advanced information processing systems will be an evolving activity which will need to respond to the progress being made in the various sub-areas of this programme. It is important to ensure that this topic is fully integrated with the related work in the Software Technology programme so that a practical evolutionary strategy for both the inclusion of new development methods based on AIP techniques into development support environments and the production of development support environments for the production of advanced information processing systems.

3.5.2. Current Projects and Projects under Negotiation

'Design of Techniques and Tools to aid in the Analysis and Design of Knowledge Based Systems'

Proj. Ref. 12/304: A/83

This was a pilot project that investigated the types of tools and design techniques necessary for the analysis, design, implementation and testing of Knowledge Based Systems. The purpose was to specify the techniques which will aid in the building expert system. In particular valuable work was done, and a good insight was made into analysing the process of Knowledge Acquisition. The findings of the project were used as a basis for the proposal of project Ref. 1098.

'A Methodology for the Development of KBS'

Proj. Ref. 1098: A/85

The prime purpose of this project is to assist the transfer of Knowledge Based Systems technology into commercial

use by providing methodological guidance for the development process. It is believed that Knowledge Based Systems development can be treated as a particular case of software engineering and that the same requirements must be placed on the development of Knowledge Based Systems as on other types of software. In short KBS must be produced to specification and to acceptable standards by a controllable process.

3.5.3. Scope for Further Work

At the current time the single project underway in this area together with the work in subprogramme software technology is considered to be sufficient.

It is unlikely that this area will be considered for inclusion in call(s) for proposals published in 1986.

R & D 3.6 Area: Focussing Projects

3.6.1. Topics

The diverse but inter-related nature of the topics covered by advanced information processing requires that the basic R & D programme be supported by a mechanism for the integration of results from the various projects.

Future information technology systems will need the successful integration of the results from the basic technology R & D programmes and therefore the vehicle of focusing projects within the AIP programme will become increasingly more important as the programme matures.

3.6.2. Current Projects and Projects Under Negotiation

'A Case Study for Satellite Data — ARTS-IP'

Proj. Ref. 867: /85

This project is aimed at real-time image processing using Synthetic Aperture Radar (SAR) images for remote sensing as a test-bed.

'Integration of AI, Vocal I/O and NL Dialogue — Application to Directory Services (PALABRE)'

Proj. Ref. 1015: /85

This project aims to design and implement a question-answering system for easy access to, and modification of an information base, integrating systems of natural language, speech recognition, dialogue modelling and knowledge based techniques.

'Shipboard Installation of Knowledge-Based Systems Conceptual Design'

Proj. Ref. 1074: /85

This project is aimed at concepts for the utilisation of advanced KBS on ships, and will develop systems that allow ships complement to reach economic levels, allowing flagging of ships by Member States to continue, stopping the drift to flags of convenience and thus maintaining safety and performance standards.

3.6.3. Scope for Further Work

The definition phases of three focusing projects are currently in progress. The continued support of these projects will be reviewed in the autumn of 1986.

SUBPROGRAMME 4:

OFFICE SYSTEMS

4.0. Introduction

Information is an important instrument of competition. This concept is now widely recognised. Office Systems provide a major vehicle through which information can be applied as an aid to navigation through the present

turbulent changes in business, technology, commerce and government.

While the potential contribution of information technology to improve effectiveness can be easily recognised, the delivery of solutions to the information

problem areas is an entirely different matter. The problems are 'fuzzy' and frequently the solution processes appear to be artistic rather than scientific. The users of information frequently have little or no knowledge of the technological content and necessary technical processes that are involved in processing information.

The majority of users require solutions and not products. These solutions have to be reasonably complete and this implies that integrated systems must be provided, not only in the sense of the interrelationship of the technical components (both hardware and software) but also in terms of the functions that these components perform as a support to the day-to-day operations, planning and strategy development of organizations.

The challenges facing Office Systems development include:

- Providing integrated information system architectures and scenarios for their implementation, that will allow rapid, economic and reliable adaptation to the changing needs of a great variety of private and public enterprises.
- Understanding and supporting the non-deterministic tasks of a wide range of office workers and not just providing a technological update of traditional and limited office functions.
- Achieving major improvements in human-system interfaces that realistically allow effective use of office systems by a wide range of office workers.
- The development of solution oriented approaches to office problems. Delivering product elements and some services, and expecting the user to create the total own solution cannot continue.

The key European opportunity relates to the development of system solutions. The implications of European requirements must be that these solutions have an adaptability, flexibility and inbuilt interworking capability that will be a real strength outside Europe. This will only be true if the application of technology reflects a degree of user sensitivity in advance of our major competitors.

Research 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 knowledge representation and some other fields, integrated and applied system solutions are developed which take into consideration user requirements and foreseeable evolutions in the technical, social and economical field.

The Office Systems programme provides the key elements and concepts that mark 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 architectures, functional modules and communication networks with standardized interfaces are necessary.

In developing these systems, which are essential for the survival of our industrial companies, human and social factors have to be considered in the early stages of planning. Only in this way can we ensure that the systems will be accepted later on by the users and that economic expectation will also be met.

Taking into account the above mentioned integrated approach, the subprogramme has been divided into five research areas. The aims are:

Office system science and human factors (4.1)

- (a) To analyze current and predicted office activities to determine how information technology might be applied to improve the effectiveness of office work and organization and of the enterprise as a whole. Besides automation of various functions and the use of knowledge management methods, this means better support particularly for clerks, professional and managerial staff in executing their judgemental tasks.
- (b) To improve understanding of human, social and cultural factors in the office and to ensure high performance of users when interacting with the systems, whilst at the same time offering optimal working conditions and ensuring adequate organization and individual acceptance.

Advanced workstations and human-machine interfaces (4.2)

To establish major new human-machine interface technologies, peripheral technologies and document representation technologies and information manipulation relevant to the development of office workstations for use in advanced office systems.

Communication systems (4.3)

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, the management of resources connected by networks, and system aspects of value added services.

Advanced multi-media information storage and retrieval systems (4.4)

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

Integrated office information systems (4.5)

To create flexible, reliable and economical total information system architectures and implementation scenarios, and to check the validity of the total information concepts in environments that are realistic and allow quantitative evaluation.

Priority will be given to integration projects especially in area 4.5.

R & D area 4.1: Office Systems Science and Human Factors

This research programme has been devised to give a better understanding of the office environment. Offices are the 'nervous system' of any enterprise. These must be organized, staffed and equipped for effective and efficient operation, and interfaced with other branches of the enterprise (such as research laboratories and manufacturing) and the external environment.

At present the understanding of this field is patchy. There is no formal science of office automation as there is for production automation. This programme, however, makes possible coherent approaches to on the problems, ranging from empirical studies to consistent operational classifications and definition of computer-based analysis and design tools.

Consistent with this approach, the main topics identified are (a) office systems analysis, (b) office systems design, (c) human factors and (d) the possible application of knowledge based methods. The analysis part of the programme delivers useful input for the design oriented phases.

It is evident that the incorporation of human factors, especially into a technology-oriented programme is an essential prerequisite for effective use and a broad acceptance of the envisaged systems and thus for their final economic success. The research programme therefore includes specific research projects on human factors related to the office environment and this leads to programmes for cognitive aspects together with work structuring, qualification and training. Human factors laboratories are also seen as key competence centers and catalysers, offering the possibility of unbiased judgment regarding experimental systems and on commercial products.

4.1.1. Topics

The topics to be studied in this area include:

Office systems analysis

- (a) operational and functional analysis of office requirements
- (b) benefits analysis
- (c) a glossary of agreed terminology
- (d) analysis of human tasks within the office

Office systems design

- (a) office system design methodology
- (b) modelling and simulation of office information systems
- (c) transaction monitor
- (d) deterministic and judgemental functions
- (e) techniques for user interface design

Human factors

- (a) human factors laboratories
- (b) human-machine cognitive compatibility
- (c) qualification and work
- (d) user aids and learning tools
- (e) human-machine interface specification language
- (f) natural language interpretation and production

4.1.2. Current Projects and Projects Under Negotiation

'Functional Analysis of Office Requirements'

Proj. Ref. 56: B/83

The primary goal of this project is the investigation and analysis of office functions through the application of a new method being developed. The project will provide guidelines for the evaluation of available office systems, and it will support the manufacturers choice of facilities to be integrated into the system. The project includes development of methods to assess key qualitative and quantitative benefits to be gained through the use of computer-based office systems, and methods to assess individual and social resistance to the eventual introduction of information technology.

The method developed will be applied to the analysis of information system requirements and to information technology assessment for important OS application domains. Such domains explicitly dealt with in the project are at present: public administrations, large manufacturers, hospitals, the 'telework environment'.

This project and the projects 285 and 813 will fully exchange results and coordinate planning.

'Tools for Designing Office Systems (TODOS)'

Proj. Ref. 813 : B/85

The project objective is to develop tools to support office systems design. The five goals are:

- to investigate models for office systems design, from the level of detail of a feasibility analysis to the level of detail of an implementation specification;
- to provide a design support environment based on graphical interfaces and using expert techniques to guide the design and identify problems and incorrect specifications;
- to provide tools for the evaluation of the proposed office models at the different development phases;
- to provide tools for the choice of an architecture for the office system;
- to provide tools for office prototyping from specification of the conceptual model.

This project and the projects 56 and 285 will coordinate planning and fully exchange results.

'Office Support Systems Analysis and Design (OSSAD)'

Proj. Ref. 285: B/84

The project aims to create a model for an integrated office system, based on the most recent studies, but going as far as possible in a total integration. In particular the following subjects will be addressed: modelling office tasks and activities, developing a language (grammar and vocabulary), developing a method for the specification and measurement of performance, producing design procedures for office system, assessing requirements for user-oriented information management systems.

This project and the projects 56 and 813 will coordinate planning and fully exchange results.

'Human Factor Laboratories in Information Technologies'

Proj. Ref. 385: A/84

The project aims at providing a focussing point for human factors activities in Europe. Three major fields of activity can be distinguished:

1. The development of a methodology for the integration of Human Factors knowledge into IT products

as an essential contribution to all parts of the design process cycle.

The expertise required for this task will be gained in:

2. Investigation of interaction modes of the human/machine interface, and construction of a multi-modal HMI to achieve optimal interplay from the point of view of human factors.
3. The expertise gained in 1) and 2) will be made available to the European industry as a whole by a) developing a software package for an integrated decision support system and b) by organising a broad programme of publications, seminars, workshops and consultancy activities throughout European IT industry.

In the pursuance of these objectives, the primary subject for study will be how people use information and for what purposes. User reactions to existing equipment will provide essential evidence for such studies.

The output of the work is expected to be an understanding of intrinsic human requirements independent of equipment, that can be applied at every stage in product design from abstract conception to the resolution of concrete design issues. There will be explicit recognition that as a consequence of the open-ended nature of the human use of information, conscious attention must be given to the interface between an information system and its human designers as well as its users. Some emphasis is given to user learning processes and their support by means of IT systems.

An additional result of the project will be the development of a dynamic glossary (GLOT) in the field of information science and technology within 3 years. The glossary will be constructed on the basis of a large unified systematization providing not only terminological definitions but also inter- and intralingual interconnections between the lemmata and their parts. English and German terminology will be used in the start but in the end all languages of the European Communities will be included.

'Cognitive Simulator for User Interface Design'

Proj. Ref. 234: B/84

This two-year project is aimed at the development of a simulation tool to assist designers in assessing the human cognitive compatibility of particular interface designs for comparative purposes. Deliverables include the software package and user guide with a review of cognitive modelling and dialogue design guidelines derived from valida-

tion trials. The produced software must be compatible with the results of standardization of e.g. operating systems.

4.1.3. Scope for Further Work

This area is well covered by projects retained and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 4.2: Advanced Workstations and Human-Machine Interfaces

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

The most important channel for information input to the human user is the visual channel. This channel, as well as the bi-directional vocal channel, have evolved to provide information for motoric activities which should be adequately integrated in operating the interface. In consequence, VDU's and touch keyboards and speech receptors will emerge to form an integrated input/output device suitable to manipulate text and images by direct manual and vocal control. Preferably the screens should have the dimensions and portability of paper (electronic paper). Another approach to a more comfortable 'visual input' will be the large screen display. The need for multi-functional capabilities will require the development of devices which allow graphic input and editing, on-line handwriting and ideogrammatic conversation.

As long as there is no portable paperlike display, printing will be necessary and the need will be growing for faster, more versatile (text, graphic, colour) printers at low cost. The provision of human-machine interfaces which support the complete range of functions traditionally carried out by pen or paper is necessary.

A high proportion of telephone or face-to-face communication indicates that visual and spoken information will be preferred whenever it is applicable. Visual communication will require the development of high definition colour video scanning devices with the necessary processing capabilities for efficient storage and transmission and the use of the multifunction flat panel display.

The voice channel cannot handle as much information as the vision channel but is our most efficient carrier of natural language. Voice communication will require the development of sophisticated processing for improving the acoustic environment, and the development of

coding schemes. Voice communication between man and the office system will require the development of efficient speech recognition and of a natural speech synthesizer.

An important aspect of facilitating the standardization of the interface with the human world and the paper world is easy-to-use formalized languages. These are to be designed in a way which allows the user, rather than the computer professional, to specify his needs directly to the system.

The implementations and testing of user decision support functions are considered to be imbedded in the workstation. Availability of these functions is supposed to be a key-factor in the competition among office products.

The development of specific system interface components should lead to a general architecture which will allow the integration of the subsystems in an architecturally homogenous solution. Although the work items are phrased in terms of integration into a physical workstation, proposals should not necessarily be confined to those which assume that all the associated functionality is resident in the workstation. Solutions involving distributed functionality accessed over communication links are equally relevant.

Much of the software that supports the user will reside in the workstation. Any rules that are, or will be, agreed upon in order to improve portability of software, should be implemented. This applies also to rules and agreements with respect to other aspects of the system.

4.2.1. Topics

The following R & D topics are identified:

System aspects

- (a) System aspects of workstation design
- (b) Workstation security

Vision

- (a) vision interface
- (b) flat panel workstation design
- (c) high resolution video imager
- (d) image coding

Paper

- (a) paper interface
- (b) advanced scanner
- (c) advanced printer
- (d) microfilm interface
- (e) graphics coding

- (f) graphics recognition
- (g) intelligent graphics recognition

Speech

- (a) speech interface
- (b) speech coding
- (c) speech recognition
- (d) speech synthesis
- (e) intelligent speech recognition.

Office languages and procedures

- (a) office document architectures and languages
- (b) office interface languages
- (c) multi-media document manipulation
- (d) intelligent user function support
- (e) user to user multimedia communication

4.2.2. Current Projects and Projects Under Negotiation

'Secure Open Multimedia Integrated Workstation (SOMIW)'

Proj. Ref. 367: A/84

The project involves the design and implementation of an office workstation (WS) which is based on the 'open systems' concept allowing the generation of standard protocols for communication media. It is thus possible to link the WS with different types of networks and with ISDN. The WS will be capable of processing different types of information including: text, fixed and moving images, graphics, voice and hand drawings. The WS will use a network-oriented operating system to control multiwindows and a distributed database management system. Its main 'hardware' parts will involve: a 32-bit CPU, intermediate capacity of disk, high resolution screen, mouse, camera, digitizer and compressor of speech, loudspeaker, optical character scanner and appropriate networking circuits. These will be complemented by a device and procedures to control access.

'Integration of European Typewriters as Low Cost Office Workstation'

Proj. Ref. 855: B/85

The project is aimed at assessing the future role of typewriters connected to office networks comprising other workstations, file servers and data processors.

The project will implement and test a prototype integrating various office functions such as electronic mail

services to outside suppliers, transmitting and receiving graphic information and connecting the alphanumeric and data functions and the voice telephone system.

A second aim of the project is to stimulate harmonization on the human and network interface levels among European manufacturers.

'Components for Future Computing Systems'

Proj. Ref. 956: A/85

This project aims at the design and experimentation with a Reduced Instruction Set Computer (RISC) computer of European architecture, starting from the established state of the art. The computer is primarily oriented towards office workstations and file servers where it would perform highly sophisticated functions in a user friendly manner.

'An Office Systems Research Workstation for Europe (ERW)'

Proj. Ref. 1032: A/85

The overall objective of this project is a hardware configuration and software environments suitable for research and prototyping advanced integrated office systems. This will strengthen the European computer industry and reduce its dependence on costly foreign products.

Specific technical objectives include developing within 3 years an advanced prototype with:

- very high performance at a low cost;*
- hardware design to exploit VLSI manufacture and RISC architecture in the processor design;*
- open architecture so that resources elsewhere on the network can be substituted for local resources;*
- tools for language development for generating RISC code to interpret virtual-machine instruction set;*
- programming environments for several languages.*

A demonstrable prototype of the workstation will be available in the third quarter of the third year.

'Interactive Handling of Digitized Images at the User Interface'

Proj. Ref. 79: B/83

This project covers the different aspects of picture handling at the user interface in an office environment: processing, storage, presentation and manipulation. Among the aims of the project are the identification of

user needs for picture handling in a multi-media interface, and the development of uniform descriptors for the picture properties.

'Modelling and Simulation of the Visual Characteristics of Modern Display Technologies under Office Work Conditions'

Proj. Ref. 612: B/84

The project aims at designing, engineering and building a simulator in order to test properties of the displays based upon new technologies. Specific objectives are: comparison of displays simulated according to user acceptability criteria ; conducting a limited number of ergonomic experiments designed to simulate prolonged office work conditions to obtain more insight into architectural and technology factors related to quality and 'visual confort'.

'A High Compression Picture Coding Algorithm for Photographic Videotex'

Proj. Ref. 563: B/84

The purpose is to develop with a group that is representative but small enough to be effective, a high compression picture coding methodology that can be applied to television signals. The final goal of the work is the definition of a selected coding technique as a possible European standard for photographic videotex on ISDN.

'Video Coding at 256 KBits/S'

Proj. Ref. 925: B/85

The project consists of surveys and specifications, and harmonisation efforts among leading manufacturers. The Surveys to be carried out are of the technical requirements in Teleconferencing. The specifications are for moving picture CODECS in the range 384-64 Kbit/s.

'The Paper Interface'

Proj. Ref. 295: A/84

This project addresses the role of paper and paper-related processes in the context of advanced electronic office systems. Research will be conducted into techniques that efficiently handle information on paper, and that will promote the ultimate reduction of paper use.

Particular techniques considered are:

- the electronic reading of previously prepared paper documents to encode image, and encode and recognize text and graphics;*

- electronic representation of documents regardless of the original means of creation;*
- methods for optimizing the reproduction of documents containing pictorial coloured information. These include colour processing innovative compression algorithms and enhancement of colour rendition methods in order to finally reproduce on an appropriate output device true colour pictorial information;*
- the processing to reproduce an electronic document for different output media (soft copy, hard copy, and transmission);*
- the encoding and recognition in real time of textual and graphical information as typically produced by man.*

The results will be implemented in a research machine for the purposes of evaluation and demonstration.

This project is complementary to project 853.

'Acquisition, Compression and Reproduction of True Colour Image Documents'

Proj. Ref. 853: B/85

The project will deal with methods for optimizing the reproduction of documents containing pictorial coloured information. The reproduction of a colour document consists of a few essential steps, from the input of the original to the final print out of the copy. Further intermediate steps will be developed in order to optimize the full process: these include colour processing innovative compression algorithms to achieve high efficiency in storage and transmission functions and enhancement of colour pictorial information.

An integrated feasibility model will be developed to demonstrate the results of the research. Three modules will be produced:

- printer prototype*
- scanner prototype*
- coding/decoding module*

The techniques researched should lead to low-cost devices.

This project is complementary to project 295.

'Amorphous Silicon Contact Imager for Office and Graphic Applications'

Proj. Ref. 1051: B/85

The objective of this project is to develop a high resolution advanced contact imager for office and graphic applica-

tions, which will result in very compact systems. In this project new techniques, i.e. HOMOCVD and photodissociation to deposit amorphous Si will be investigated aiming at higher stability.

The project will:

- develop a linear contact type scanning image sensor with a-Si: resulting in a very compact system,
- Investigate new techniques to improve the properties of this contact imager.

In this first phase of a large range development programme, a linear contact type amorphous silicon imager with a matrix read-out in parallel blocks will be developed.

'Speech Interface at Office Workstations (SPIN)'

Proj. Ref. 64: A/83

The objective of this project is to develop the basic components of, and integrate these into, a comprehensive speech interface at the workstation. The components are: speech analysis, speech recognition, speaker verification, speech coding and decoding, and speech synthesis.

For the integration of the components it is important to have an understanding of the usage of the speech in human-machine communication, and the quality/functionality aspects that make that the interface is accepted by the human users. These two aspects will be studied extensively.

As concerns the coverage of different natural languages, these are at present: Italian, French, Dutch and German.

An extension of this project will then further investigate and implement a system to recognize and understand continuous speech using advanced techniques in the fields of natural language understanding, computational linguistics and artificial intelligence.

'Intelligence and Knowledge Aided Recognition of Speech (IKAROS)'

Proj. Ref. 954: B/85

Implementation of a system to recognize and understand continuous speech, speaker independent and in real time.

Restricted to a single application and a subset of natural language relevant for the application.

Models will be developed to perform an integration of prosodic, syntactic, semantic and pragmatic knowledge in the recognition system.

Methods will be investigated for the specification of applications including tools for generating applications and language specific knowledge sources.

Experiments will be done for English, French and German. The project is planned over a 5 year period.

The participants are independent and industrial research organizations from France and Germany with an industrial partner from the UK.

This project is complementary to project 64.

'Linguistic Analysis of the European Languages'

Proj. Ref. 291: B/84

The objective of this project is to provide, in the form of computer data files and associated methodology, the following concerning a number of European languages:

- dictionary lemmata, flexions, grammatical categories;
- algorithms and tables for converting the orthographic form into the phonetic one and vice-versa;
- algorithms and tables for the word stress assignment;
- statistics, ranking lemmata and flexions by frequency of use;
- texts, suitable for extracting further statistical information.

The project results are fundamental for a number of other projects, in particular those dealing with the natural speech and language.

A specification phase has started and will be followed by the development of a linguistic processor for high-quality multi-language text-to-speech conversion systems and for large vocabulary speech recognition systems. The cutter shall also provide for error detection and correction in string to be passed.

'Investigation into the Effective Use of Speech at the Human-Machine Interface'

Proj. Ref. 449: B/84

This project will identify the requirements for effective voice interfaces in particular for CAD/CAM/CAE workstations. The partners are user research associations, end users, and firms that are suppliers in the voice and computer fields.

The project results are fundamental for a number of other

projects, in particular those dealing with the natural speech and language.

*'Handling of Mixed Text/Image/Voice Documents
Based on a Standardized Office Document Architecture'*

Proj. Ref. 121: A/83

Basis for this work is a sophisticated object oriented document architecture being standardised up to the first basic level by ECMA, ISO and CCITT. By the project, concepts and architectures will be elaborated and verified that support the easy and natural processing of documents. The project will define and test bridges between the essentially paper-oriented office world and the electronic document world of tomorrow. (see also area 4.2.5.(c)).

The initial objective of this project, that will start with a specification phase, is to provide in the form of computer data files and of computer method fields coded in high level language, the following concerning a number of European languages:

dictionary lemmata, flections, grammatical categories;

algorithms and tables for converting the orthographic form into the phonetic one and vice-versa;

algorithms and tables for the word stress assignment;

statistics, ranking lemmata and flections by frequency of use;

texts, suitable for extracting further statistical information.

The project results are fundamental for a number of other projects, in particular those dealing with the natural speech and language and will be used in continuation phase where the aim will be to develop a linguistic processor for high-quality multi-language text-to-speech conversion systems and for large vocabulary speech recognition systems. The cutter shall also provide for error detection and correction in string to be passed.

This project is complementary to project 1024.

'Piloting of the Office Document Architecture (PODA)'

Proj. Ref. 1024: A/85

The project is to implement the new ODA standard for an office document architecture under UNIX in an essentially portable way. A pilot version of the software will be ported to one of the hardware products of each manufacturer in the consortium. The software to be used is partly implemented already in Project 121. Other parts (essentially a syntax driver, adaptable format checker and translator) will be written for this project. The language used

will be 'objective C', an object oriented preprocessor for C which is commercially available and, hence, renders no restriction to the portability of the software products delivered. The work includes a demonstration of document interchange between different vendor machines and installations, and the development of a common user interface.

Aspects of integrated systems are covered in a number of projects, although a fully integrated system approach is not addressed in a project yet.

This project is complementary to project 121.

'Intelligent Workstation (IWS)'

Proj. Ref. 82: B/83

The goal of this project is to provide the office worker with an integrated workstation software which can provide sophisticated services ranging from speech and graphics to expert level decision aids and automated report generation. The prototype workstation to be developed will be tested in Denvironments providing communication facilities and connected file servers. Much emphasis will be laid on the application of methods and software that aimed at representing knowledge of the office environment.

'Extended Office Process Migration with Interactive Panel Displays'

Proj. Ref. 878: B/85

In this project a prototype system is to be developed which combines the concept of extended process migration with a novel panel display device in order to assess and present office activities. Typical office activities consist of tasks which are performed in a parallel or sequential manner by persons in office roles. These activities are described formally in order to automate them, where the single tasks are to be performed. However where the involvement of human beings introduce non deterministic elements, these are to be included as exceptions.

Extended office process migration covers both the formally described flow of work and the handling of exceptions which occur frequently, especially in office work. On the basis of office process migration a prototype of an office system is to be developed as a tool for design, optimization and demonstration of office activities.

4.2.3. Scope for Further Work

In this area the following topics will be considered for inclusion in call(s) for proposals to be published in 1986.

- Vision and Display: In addition to existing projects, a project will be considered that deals with technology integration for the man-machine interface.
- Office languages and procedures: There are 4 projects in the office language and procedures subarea covering a broad spectrum already. Nonetheless this subarea is very wide and important; work with respect to intelligent user support and office interface languages emphasizing multi-linguism is particularly lacking.

R & D Area 4.3: Communication Systems

Office communication presents a number of possible long lead time research topics. Technological advances are needed in microelectronics and in fibre optics, and research is necessary on the principles of future communication systems such as wideband local area networks (LAN), the interconnection of LAN's and the gateway facilities for multimode functionality. R & D should lead to new systems and to standards consistent with the ISO reference model for open systems interconnection (OSI). Besides these technical problems, there are non-technical problem areas which have to be addressed in order to support the progress of office communication systems. The requirements of office communication have to be explored more systematically to get a more solid basis for future telecommunication system design. The special aspects of human interface with communication have to be studied, and the future relationship of the PTTs to new local communication systems has to be considered. New languages and operating system facilities are necessary in connection with distributed systems.

4.3.1. Topics

Within this scope of possible research activities, four main topics which cover some key issues have been determined.

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

The second topic addresses the wide band LAN, including the application of optical fibres, and all the technological problems related to this. It is also concerned with the role of switched communication in the office. It addresses the problems of advancing from current single service switching techniques towards multiservice variable bandwidth switching which will allow the interconnection of all office peripherals and resources.

The third topic deals with resource management in a distributed environment.

The fourth topic intends to advance the standardization of value added communication services in the office e.g. in the form of mail box messaging for text, image and voice, and for multi-media information systems such as advanced videotex.

Architecture

- (a) communication system architectures
- (b) security in communications
- (c) harmonization issues in communication

Technology

- (a) optical wideband LAN
- (b) advanced switching techniques

Resource management

- (a) distributed systems

Services

- (a) multi-mode messaging
- (b) ISDN-based advanced videotex
- (c) teleconferencing
- (d) advanced services

4.3.2. Current Projects and Projects Under Negotiation

'Broad Site Local Wideband Communication System'

Proj. Ref. 73: A/83

This project is concerned with the research and development of a local area wideband communication system for broad sites. The prototype system developed will meet the anticipated future communication requirements of large industrial, scientific and administrative organisations. The project will take into account data, text, voice and graphics communication needs, and it will provide backbone networks and gateways for heterogeneous LANs.

'Communications Systems Architectures'

Proj. Ref. 237: A/84

The emphasis of the project is on the development of new architectures for the interconnection of terminals and resources in an integrated multi-service environment. The network developed in this project will reflect the open

systems policy by providing interfaces following OSI standards.

A top down approach is proposed in three phases:

Phase one will identify the needs for communication by analysis of user requirements. A logical model of communication will be developed. A proposal will be made for the integration of a distributed operating system within the open system structure.

Phase two will develop the physical architecture by mapping the logical model from phase one onto actual communication technology.

Phase three will be the development of those system elements identified in phase two to achieve a pilot network demonstration. The pilot network will be benchmarked for performance to evaluate system design decisions in phase two.

'An Integrated Network Architecture for Office Communications'

Proj. Ref. 395: A/84

The project is to design and define an architecture for office communications, and to demonstrate a pilot implementation. The architecture will be capable of including all types of local and wide area networks, such as optical LANs, CATV broadband networks, PABXs, packet-switched networks and the emerging integrated services digital network (ISDN).

The integrated architecture will be demonstrated in a pilot integrated network including the broadband network and a variety of other available local and wide area networks, and linking the project partners' sites. The demonstrated applications will include an enhanced version of the document handling environment.

'Standardisation of Integrated LAN Services and Service Access Protocols'

Proj. Ref. 43: B/83

The aim of the project is to define the services to be provided by an integrated traffic LAN and to define a stable, LAN-technology independent interface between DTE and LAN access unit. This interface will comprise the physical interface and the service access protocols by means of which the services can be used.

'Parallel Architecture for Networking Gateways Linking OSI Systems (PANGLOSS)'

Proj. Ref. 890: B/85

This project is to build a prototype high-performance networking gateway using a highly-parallel architecture in order to meet the anticipated demand for linking OSI

systems and networks. To achieve this, the project is to study the following areas:

- overall architecture characteristics of a networking gateway;*
- the functional definition of a networking gateway (including performance and connectivity goals), and a formalized approach to design an architecture of such a gateway;*
- implementation-oriented issues (e.g. hardware/software split, suitable technologies), and a formalized approach to the transformation of specifications into implementations and on to parallel hardware;*
- performance analysis of proposed architectures, specifications and implementations;*
- Rapid prototyping of designs using hardware/software trade-offs as appropriate.*

'Local Integrated Optical Network (LION)'

Proj. Ref. 169: A/83

The LION project is implementing a wideband local area network based on optical fibre technology, with major application in the office environment, including such applications in industrial research laboratories, universities, hospitals and manufacturing plants. The LION will guarantee multiple access to a number of independent users with the requirements of distributed processing and distributed intelligence, and handle voice, data, text and video traffic. Very high bit rates are foreseen, requiring new technologies in integrated optics and very high speed electronic components.

'TALON — Testing and Analysis of Local Area Network Optical Networks'

Proj. Ref. 870: B/85

A special task (TALON) is aimed at providing solid technical and commercial philosophy for testing complex optical LANs. It supports and complements communications system design activities. Many of the currently established methods for testing point-to-point optical fibre links are ineffective when applied to complex optical topologies. The sub-project will build demonstrators and evaluate their effectiveness in different environments.

This project is complementary to project 169.

'Ultra Wideband Coherent Optical LAN'

Proj. Ref. 249: B/84

The project will investigate the feasibility of utilising coherent optical techniques in a local area network by

addressing both technical and system issues. It will consider new machine architectures to implement high bandwidth transmissions of order of several Gbits/sec for different types of information including voice, text and image.

'Dynamically Adaptable Multi-Service Switch'

Proj. Ref. 1059: B/85

This project intends to identify and exploit the relative advantages of a switch oriented communication architecture with respect to the wide variety of traffic and services necessary to the office. The project includes a requirement study, an advanced design and technology investigation, a partial prototype sufficient to illustrate the principle and also alternative architectural principles including the concept of bandwidth switching. Geographic location of terminals will be also considered and the traffic generated and the performance required by a future office communication system.

'Construction and Management of Distributed Office Systems (COMANDOS)'

Proj. Ref. 834: A/85

The main goal of this work is the creation of an efficient and easy to use environment of the development and management of distributed applications. To meet this objective combinations of advances and the state of the art of different technologies will be applied to innovative and general tools. The approach will allow for the specific characteristics of different distributed office information systems.

'Multipoint Interactive Audio-Visual Communication (MIAC)'

Proj. Ref. 1057: B/85

This project will develop and demonstrate a system for the simultaneous communication of speech, visual and data forms of information between persons at two, three or more, at widely separated locations, using ISDN and other 64 Kbit/s networks. The demonstration itself will be a multipoint international audioconference system with visual and office-system aids, but the signal and protocol infrastructure developed will be applicable to a wide range of other audiovisual services. This infrastructure developed will be applicable to a wide range of other audiovisual services.

4.3.3. Scope for Further Work

In this area multi-mode messaging services will be considered for inclusion in call(s) for proposals to be published in 1986.

R & D Area 4.4 : Advanced Multi-Media Storage and Retrieval Systems

Information technology and office automation are fundamentally concerned with the storage, accessing and movement of information, covering data, text, graphics, voice, images and other forms. Investigations leading to the definition of an advanced data-base model for office applications and studies of the security, privacy, authority of access and information distribution are fundamental to a wide range of office systems research.

The proposed research is oriented toward construction of a number of experimental prototype office information servers, and the operation of these in realistic conditions, alone and in association with each other, to gain practical experience in the systems implications of building these servers, loading them with practical information and using them in a realistic way.

The work is therefore divided into three general classes: systems issues, usage and needs, and components.

Systems issues: these cover the design and operation of office information servers, including high-performance filters and investigations of new information models and the development of metrics relating to these. Servers must be considered in relation to the other components of a comprehensive office system including other information servers and the distribution of information and functions between them. Work on the filing interface-related aspects of query languages and declarative content languages is identified.

Usage and needs: this topic addresses the nature of the information (data, text, graphics, images etc...) that will be held in office information servers in terms of quality, quantity and combination and the usage of that information. An internal adaptive interface is to be investigated, that responds to the needs and experience of users.

Components: the development of hardware, software and systems elements that will be incorporated into advanced filing systems, primarily in information servers, but also in advanced workstations. These include filters, the systems management issues relating to using optical discs in advanced office systems, the systems techniques required to achieve very high perceived reliability, and the application of advanced information

processing techniques to advanced filing and retrieval systems.

4.4.1. Topics

The topics covered by this R & D area include:

File server architectures i.e.

- (a) office information server design and evaluation
- (b) very high security systems

System issues i.e.

- (a) new information models
- (b) file query and declarative content languages

Usage and needs i.e.

- (a) nature and usage of filed information
- (b) user-file adaptive interface
- (c) performance of office information servers

Components i.e.

- (a) file filters
- (b) optical storage systems concepts

4.4.2. Current Projects and Projects Under Negotiation

'A Multimedia Filing System'

Proj. Ref. 28: A/83

The goal of this project is to develop a system that provides filing services for multimedia documents using magnetic and optical storage media. Particular attention will be paid to the needs of the office environment. The system will be implemented on a dedicated server that accepts requests from clients such as workstations or other devices. The units of communication between server and client will be multimedia documents rather than physical records or blocks.

The services provided by the server are those traditionally found in an information retrieval or database environment. However, the dual demands of a multimedia capability and application to offices introduce research issues. The server will be implemented by increments. The first prototype will deal with text and attribute data only, subsequent versions will add image and voice data.

The global design has now been completed and work is underway on the functional specifications of system components including the server subsystem and the user interface.

'Design and Operational Evaluation of Distributed Office Information Servers'

Proj. Ref. 231: A/84

The objective of the project is to design, demonstrate and then evaluate a family of working prototype office information servers capable of holding in digital electronic form representations of all office information currently committed to paper. A global model will be established both for the information held in the servers and the functions needed to manipulate and manage it. Key to the project is the consideration of the issues involved in distributed information, architecture and use in the office environment. Two major demonstrations of the capabilities of Office Information Servers are planned during the project. A pilot demonstration at the end of year 3 and a main demonstration at the end of year 4. A full year is then available for a full evaluation of the system.

An extension to the initial project will then investigate and report on the usability and performance issues deriving from the operation of a distributed set of information servers which collectively support a fully integrated service. It will also implement and evaluate two configurations:

- *'Logical server' — a set of 'unit servers' (one processor) on a single site, behaving as a single entity to the user.*
- *'Global service' — made up of several 'Logical servers', distributed geographically.*

'New information models for Office Filing and Retrieval'

Proj. Ref. 59: A/83

The project deals with research into new information models for office filing and retrieval. The emphasis will be on research of the theoretical issues of a model which characterises all forms of office information. A number of models will be developed and related to techniques of filing and retrieval of information.

Many key problems are being investigated, the majority of these dealing with aspects of human acceptability, or more precisely: speed and accurateness of the retrieval process for the skilled and unskilled user.

The models developed will be constructed and validated in a software environment which emulates the interaction of an office filing and retrieval system.

The schema architecture has been produced together with the sketch of the user interface. Work continues with work on querying, storage structure, and aspects of system security.

'A General Public Data, Voice and Picture Storage Retrieval System'

Proj. Ref. 901: B/85

This project is to create extremely large multi-media data and image base. It will be made widely available for use by the general public. It intends to demonstrate the feasibility of such a system, and includes : development of a new laser vision system combining analog and digitally coded information and a multi-media database retrieval system including a 'major walking' interface to geographical information. Design of the system will allow access by means of widely available, low cost workstations. Particular emphasis is given to a very easy to handle user interface that will make use of knowledge engineering techniques.

4.4.3. Scope for Further Work

In this area the following topic will be considered for inclusion in call(s) for proposals to be published in 1986: multi-media storage and retrieval system usage and needs.

R & D area 4.5: Integrated Office Information Systems

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.

The architecture for distributed systems is a major area of concern. Distribution of functional units networked together can be considered the fundamental concept not only for office systems, but for all future information systems. Elaboration and implementation of this concept is by no means trivial, and requires many new ideas and the development of reference models and standards. A particular aspect, system security, should be considered throughout the design process on the total system level as well as on component level.

Two topics are identified in the subarea Test and evaluation that are complementary but not necessarily mutually dependent.

First: the creation of test- and evaluation environments for office system components and integrated office sys-

tem prototypes, that allow qualitative and quantitative validation in a variety of simulated offices and enterprises. This work would also use the products of area 4.1 as well as other standards, performance and integration work.

Second: the design, development and evaluation of advanced office system prototypes, based upon state-of-the-art components developed in Europe, possibly under the ESPRIT programme (area 4.2 to 4.4), and based upon the results of structured analysis in the office systems science and human factors areas (area 4.1).

4.5.1. Topics

The topics to be studied in this area include:

Information system architecture

- (a) system architectures
- (b) systems security.

Test and evaluation

- (a) office system test and evaluation facilities
- (b) office systems application test beds.

4.5.2. Current Projects and Projects Under Negotiation

'Office Systems Security'

Proj. Ref. 998: B/85

The project deals with all security aspects of information systems in an integrated way. It is defined in three phases:

- *assessment of the state-of-the-art, including requirements and solutions in such highly sensitive areas as the military and process control.*
- *development of a security model for information systems.*
- *specification of security measures and elaboration of implementation guidelines.*

'Advanced Information System for Public Administrations (ASTRA)'

Proj. Ref. 831: A/85

ASTRA will provide facilities for testing and evaluating office information systems. The project consists of two phases : in the first phase an analysis of very large public administrations in four participating countries will be made with regard to information handling. The second

phase will provide two prototypes which are split on subjects of size, complexity, system architecture and costs into

- (i) a high level prototype, dealing with large amounts of data and*
- (ii) a low level prototype, dealing with the multifunctional aspects of office automation.*

These prototypes will make use of advanced storage and retrieval systems based on optical discs. Finally an evaluation of the second phase will result in test implementa-

tions of both prototypes in two different countries. The results of the project will be available for the PAs of European Member States.

4.5.3. Scope for Further Work

In this area the following topics will be considered for inclusion in call(s) for proposals to be published in 1986: Information systems architecture, Test and evaluation facilities and Application test beds.

SUBPROGRAMME 5:

COMPUTER INTEGRATED MANUFACTURE

5.0. Introduction

This area relates to the total range of manufacturing activities including computer aided design (CAD), computer aided engineering (CAE), computer aided manufacturing (CAM), flexible machining and assembly systems, robotics, testing and quality control. The area has been selected for its potential impact on the methods and economies of production, which are strongly geared to success for the IT industries, and for manufacturing industry in general.

The objectives in CIM are to create an environment in which multi-vendor systems can be implemented in a progressive manner, and in which Community IT suppliers can compete effectively. To achieve this, effort will be concentrated in two main streams. Firstly, work is needed on infrastructures, which concentrates on the development of design rules and architectures leading to a common reference frame. Relevant international standards activity must be continuously assessed, and areas identified in which European action could be supported. The second stream involves action on those sub-systems, interfaces and tools whose development or refinement is judged to be of strategic value for European Community industry (both users and vendors).

In order to stimulate and facilitate the transfer of new information technology concepts to the engineering industries within the Community, application centres will be encouraged to 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.

Six R&D areas are described:

5.1. Integrated Systems Architectures

5.2. CAD/CAE

5.3. Computer-Aided Manufacturing (CAM)

5.4. Flexible Manufacturing Systems

5.5. Subsystems and Components

5.6. CIM System Applications

R & D area 5.1: Integrated Systems Architectures

In the next decade, one can expect that a wide variety of CIM systems will be implemented within manufacturing industry. To be effective, each system must serve its specific application in an optimum manner. In order to remain competitive and to preserve flexibility, effective design methods for CIM must be developed so that new technologies can be exploited as they become available. At present, there are some guidelines but no international standards available for the design of systems architectures for CIM.

New and innovative conceptual approaches are required in order to fit appropriate systems architectures to the total manufacturing process from initial product development, product design, production planning and control, real time control of production equipment, materials handling, through to inventory control and sales. To support the total systems approach, it is necessary to develop strategies for data, communications, and processing, which address both physical and logical requirements. Systems architectures for CIM should be open, so as to avoid market domination by any one vendor, and to allow users maximum freedom of choice in their selection of sub-systems.

The resources needed to define open systems architectures, and the market strength necessary to gain acceptance of these, are beyond the reach of all but the largest and most influential organizations. However, the desirability of developing a reference model, which would allow users to develop multi-vendor CIM systems is readily apparent. This is an area where the potential for significant advances through a unified approach is high, and it is therefore particularly suitable for effort on a Community scale.

5.1.1. Topics

- the definition and development of open systems architectures that would be applicable in a range of manufacturing environments;
- implement these architectures in real manufacturing environments

5.1.2. Current Projects and Projects Under Negotiation

Preliminary work completed in pilot projects provides a useful basis for this and other areas of ESPRIT CIM. A book entitled 'Design Rules for a CIM System', editors: R.W. Yeomans, A. Choudry, P.J.W. ten Hagen, is already available. A further publication, covering design rules for the integration of robots into CIM, is scheduled for publication in 1986.

The current project in this area is:

'AMICE, A European Computer Integrated Manufacturing Architecture'

Proj. Ref. 688: B/84

It is intended to define and develop Open Systems Architectures for CIM, to support present and future needs. Design criteria for the architectures include:

- *openness, i.e. the creation of an environment in which multi-vendor systems can be supported. In this context, the architectures will be ISO-OSI compatible.*
- *protection of existing investment — i.e., migration paths will be identified from present to future implementations.*

- *capability for progressive implementation, with special attention to the needs of SMEs.*
- *applicability across a wide spectrum of industry.*

5.1.3. Scope for Further Work

This area is well-covered by existing work and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D area 5.2: Computer Aided Design/Computer Aided Engineering

The importance of CAD/CAE is that it :

- reduces the design time and facilitates optimization of the design, of products and processes,
- facilitates storage of all relevant aspects of design, and rapid update and retrieval of information,
- generates data which are used by the whole manufacturing process including robot and machine tool programmes.
- provides feedback from the manufacturing process to the design team which allows a more versatile and economic operation.

Modular structures for CAD/CAE subsystems (which include generalized 3D-modellers, geometrical design systems, engineering computational programs, simulation programs) are needed in order to give the designer access to different software packages and data bases. Such systems must be able to supply data that are readily usable for all interacting engineering and production activities, as well as good display quality and capabilities. Increasingly these systems have to support disparate and geographically dispersed organizations cooperating in the design process of a complex end product.

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

Unless very strong reasons can be shown, all projects in area 5.2 should be consistent with relevant architectures developed in area 5.1. The interaction of CAD/CAE with CAM (5.3) and FMS (5.4) systems must also be taken into account, and techniques under development in other areas of ESPRIT must be continuously reviewed.

5.2.1. Topics

CAD/CAE facilities for product and process design

Adaptation or development of tools and subsystems to support integrated CAD/CAE activities, e.g.:

- product design activities such as project management, concept design, preliminary design, analysis and simulation, final design, product documentation management, product configuration management.
- process design activities such as process selection, process modelling, process planning, process plan simulation, process plan optimization, process quality assurance planning,
- tools specific to different classes of products and processes, and to 'group technologies' concepts (geometry, dimensions, materials, tolerances, process operations type).

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.
- graphics tools to support management and supervisory activity in manufacturing environments.

Graphics systems

- to aid decision-making at management and supervisory levels.

5.2.2. Current Projects and Projects Under Negotiation

'Knowledge and Decision Support for Material Handling Systems'

Proj. Ref. 293: B/84

The project is investigating the applicability of expert systems for decision support and will develop a knowledge base for modelling material handling systems. The objectives are to analyse and define the knowledge necessary to achieve valid assessments for system designs and of system operation. The knowledge will be implemented in decision support systems and would be used by engineers planning a material handling system.

'CAD Interfaces'

Proj. Ref. 322: A/84

This project concentrates on important interfaces of CAD/CAM systems: the CAD data exchange interface, the CAD data base interface, the interface to finite element analysis and dynamic model optimization, and

the AI-based advanced high-level modelling interface. The first part of the work has been completed with an analysis of the existing CAD/CAM interface standards and the establishment of procedures for exchanging models between CAD systems. Testing has been carried out of high level data transfer between MEDUSA and BRAVO. The design and implementation of these interfaces will be closely coordinated with international standardization activity in this area.

'Development of an Integrated Process and Operations Planning System with the Use of Interactive 3D Modelling Technology'

Proj. Ref. 409: B/84

The objective is to develop an interactive graphics-based system for process and operation planning within a manufacturing environment. To reduce development costs, the overall system will be built from existing and proven system components of the project partners. The approach will be to achieve a uniform user interface for CAD and CAM-systems and secondly to provide a complete simulation of the manufacturing process.

'Design and specification of configurable graphics subsystem for CIM'

Proj. Ref. 496: B/84

The project has two primary goals:

- 1. The identification and classification of the differing requirements for graphics in the many areas of CIM.*
- 2. The development of software/hardware prototype graphics subsystems that meet the requirements of 1. above.*

The first goal has been achieved, the partners have carried out an exploratory survey covering hardware, software, and man-machine interface requirements for graphics of CIM systems and delivered the study report. To attain the second goal, the partners are currently preparing the design specifications of the prototype graphics subsystem and a set of design standards based on the use of the Graphics Kernel System (GKS) and the Ada programming language.

'VITAMIN: Visualisation Tools and Modelling Standards in Manufacturing Industry'

Proj. Ref. 1038: B/85

The project aims to produce a set of graphical visualization tools, based on modelling standards with the objective of improving decision-making in production management. A wide range of essential management information will be addressed, such as business, marketing, production management and production monitoring.

5.2.3. Scope for Further Work

The topics 'use of AI techniques' and 'graphics systems' will be considered in call(s) for proposals to be published in 1986.

R & D area 5.3: Computer-Aided Manufacturing (CAM)

A computer-aided manufacturing system in this context addresses the real-time management of factory operations. A CAM system acts as a high integrity information network that monitors a broad spectrum of interrelated activities in the manufacturing cycle and asserts consequent control on the basis of an overall management strategy.

Design aims of a CAM system should include:

- (i) maximizing assistance to human supervision in overall factory operations and in individual processes;
- (ii) processes to be individually programmable;
- (iii) compatibility with systems architectures defined in 5.1;
- (iv) possibility for introducing modifications and extensions without violating total systems concept.

5.3.1. Topics

- define and develop CAM systems in a range of industrial environments;
- apply innovative concepts as they become available.

5.3.2. Current Projects and Projects Under Negotiation

'Open CAM System allowing modular integration into factory management of a workshop structure in functional cells with various levels of automation'

Proj. Ref. 418: A/84

The purpose of the project is to develop a CAM System with an open architecture. This CAM system will be applicable to machine as well as assembly activities. Although the system is targetted at a specific manufacturing environment, the implementation methodologies and tools evolved in the course of the project are applicable to a diverse range of manufacturing environments. The system will be implemented in two pilot shops (machine shop and assembly shop), consisting of several cells

with various levels of automation. As implementation proceeds, a new flexible machining cell, consisting of a group of machine tools, measuring machines, materials buffering equipment and feeder robots will be incorporated into the system. The wider applications are relevant to the project 477. Liaison is being maintained between the two consortia for the mutual benefit of interchanging technical information.

'Control Systems for Integrated Manufacturing: the CAM Solution'

Proj. Ref. 477: A/84

The project is focused on production activity control (PAC), the role of which is to close the loop between production planning and execution. The results will be especially applicable to small batch manufacturing environments. The goal of the project is to design, develop and test the software modules required to close the control loop, reducing human intervention and reaction time as much as possible, and relying on data automatically captured from the plant.

The first phase is underway, with groups analyzing three related areas:

- *Process:* Analysis of manufacturing facilities and selection for the implementation of a suitable site.
- *Control:* Theoretical modelling for planning and scheduling the PAC system.
- *Software:* Investigation and analysis of suitable software tools and techniques required for the system.

Technical liaison is also being maintained with project 418.

'Knowledge Based Real Time Supervision in CIM'

Proj. Ref. 932: A/85

The project has 2 main objectives:

- The design and implementation of a knowledge-based real time development system oriented to a number of CIM application tasks.
- The installation and evaluation of the system at two dissimilar industrial plants.

The functionality of the system will be demonstrated by addressing the problems of real-time interpretation of plant data for fault diagnosis; action planning by

intelligent alarm handling and providing operator support data: optimization of throughput, economy and flexibility of operation.

5.3.3. Scope for Further Work

This area is well covered by existing work and is unlikely to be considered for inclusion in call(s) for proposals to be published in 1986.

R & D area 5.4: Flexible Manufacturing Systems

For industries specializing in the manufacture of a wide variety of parts in low and medium volumes, the development of highly flexible, high productivity systems is an important goal. The major task of the suppliers of CIM equipment is to enhance the technology required for flexible automation.

Machining centres for automatic machining of metal parts, systems for automatic loading and unloading of workpieces, and conveyor systems for automatically transferring workpieces from one machining process to another, are already available from many sources. A problem which still has to be attacked is the integration of machining centres into overall CIM systems, with proper acknowledgement of human factors.

Further development is required in the area of automated assembly systems, and to enhance the capability of robots beyond the simple operations at present carried out. Major benefits would be obtained if effective communication with the design process could be achieved. It is also necessary to take advantage of developments in Advanced Information Processing (AIP), and simulation systems.

Research and development 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.

5.4.1. Topics

Flexible manufacturing systems

- specification for interfaces between automatic equipment;
- definition of FMS systems architecture and subsystems;
- define and implement pilot FMS in testbed environment.

Automated assembly

- computer automated assembly systems;
- robot systems.

Plant availability and quality optimization

- basic plant diagnosis technology;
- diagnosis formulation;
- action planning;
- automated quality control and inspection.

Advanced control systems and concepts

- specification of computing requirements for subsystem control;
- incorporation of Advanced Information Processing (AIP) for work in system control packages.

5.4.2. Current Projects and Projects Under Negotiation

'The Integration of Welded Fabrication within CIM'

Proj. Ref 595: A/84

The project work is in the area of the development of sub-systems and control frameworks for the application of welded fabrication in CIM. A coordinated programme is being carried out in which methods will be developed for generating, structuring, storing, and manipulating control and output data at all stages of the fabrication process. To enable an integrated development approach, the project will concentrate on a specific industrial sector and limited product range and the area chosen is ship-building. However, results generated in this project will have a much wider application within fabrication industries, and the rules for integration developed in this project will be applicable to the automation of other fabrication processes, e.g. high energy electron beam welding, laser welding and friction welding.

Initially work concentrated in five main areas:

- *Design studies: the definition of product modularisation, standardization, code requirement and fitness for purpose.*
- *CIM Architecture/Software development: the development of simulation software for resource allocation and line scheduling. In addition inventory management, robot simulation software is being produced.*
- *Welding System Automation : procedural data handling and real time control of robot welding.*

- *Quality Assurance: aspects of data processing and shop floor monitoring.*
- *Production Cell Development: This will be the basis of an experimental system employing the hardware and software developed in the other areas.*

The project will continue to work towards these goals, ultimately in producing specifications for at least two advanced fabrication facilities incorporating CIM principles.

'Integrated Information Processing for Design, Planning and Control of Assembly'

Proj. Ref. 384: A/84

This project is aimed at demonstrating the principle of an integrated process for design, planning and control of small batch assemblies. The emphasis of the project is on defining and automatically assembling the product, rather than on the manufacture of the piece parts. The project also aims to demonstrate the concept of an integrated system for the complete assembly process including design planning, scheduling and control aspects, considering all interdependencies and feedbacks from related assembly objects and processes.

Current work has focussed on expert systems and simulation tools with attention to the existing systems for design, planning and scheduling an important precursor to the demonstrators in these areas.

'Development of a Flexible Automated Assembly Cell and associated Human Factors Study'

Proj. Ref. 534: A/84

The project is directed to the evaluation and the development of a programmable flexible automated assembly cell for mechanical objects of typically 0.5 m³ size. Although the concept is based upon the needs of an intended user, the project includes an assessment of the application of the system to industry generally. The project comprises five technological and two human factor sub-areas.

The technological areas are the use of robots with various other devices, including software development, the development of integrated sensors for robotic vision and optical data processing, the development of contactless inspection including integration, systems integration and

a study of the applicability of the technology to future manufacturing. The human factors are concerned with work organisation and job design within the cell, skill levels, supervision, quality assurance, maintenance and training issues and a study of the involvement of engineers and scientists in planning for human needs in the cell's operation.

'Operational Control for Robot System Integration into CIM'

Proj. Ref. 623: A/83-84

The project is directed to improving the integration of robots into computer integrated manufacturing (CIM) systems. Based on the design rules and the development paths derived in the pilot phase of ESPRIT (Ref. PP. 75) the project will establish automated integration facilities for the operational areas of planning and programming. A prototype of a computer aided planning system for a typical industrial application, and an improved CAD Robot linkage to be implemented. This will use an off-line programming system specially designed for robots. Graphical simulation requirements to aid robot planning and programming as a basic tool of the system will be analysed and implemented. A data management strategy will be derived to link the robot application into the CIM framework. The possibilities for using AI techniques for robotic applications, including implicit programming methods, will be investigated and methods for simulation identified.

'A Systems Technology for Optimising the Tradeoffs between Plant Availability, Product Quality and Safety'

Proj. Ref. 504: B/84

This project is directed to the development of a systems technology for automating the management of a discrete parts manufacturing plant. It will be based on maximizing their availability, product quality and safety. A high percentage of the proposed R & D effort relates to the on-line processing of plant machinery health, tool performance, product quality and safety data. The enabling technologies include signal processing, expert systems, system modelling, action planning, sensor network and computer system design.

Work has been carried out reviewing available technology in this field and the preparation of a suitable demonstrator which is now providing live data from machining operations to facilitate the development of process models to allow diagnosis, action planning and failure recovering routines to be developed.

'DASIQ: Distributed Automated System for Inspection and Quality Control'

Proj. Ref. 1136: B/85

The project is directed at the research and experimental application of a new distributed system, DASIQ, for inspection and quality control. The work is particularly aimed at the development and integration of optical inspection techniques for the assessment of surface finish and dimensional control. The DASIQ system will be integrated with the factory CAD/CAM systems for optimization of design-manufacturing processes.

'Advanced Control Real Time CIM Systems and Concepts for Flexible Automation'

Proj. Ref. 809: B/85

This project intends to develop and implement a real-time intelligent CIM system. Based on computing requirement specifications, the emphasis is on hierarchical control structures. Simulations of multiple manufacturing system configurations will be conducted in order to assess the adaptability of the system.

5.4.3. Scope for Further Work

In this area the following topics will be considered for inclusion in call(s) for proposals to be published in 1986:

- the integration into CIM of FMSs based on metal removal;
- development of advanced control systems.

R & D area 5.5: Subsystems and Components

A number of subsystems and components are required to enable the technologies in areas 5.3 and 5.4, thus facilitating the development and implementation of CIM. In particular, in order to compete successfully in world markets for plant automation systems, it is essential to make maximum use of microelectronics technology.

5.5.1. Topics

Two topics have been identified as requiring collaboration effort. These are:

- sensor systems for real time capture and interpretation of sensor data such as that required by sub-area 5.4.3

- microelectronic sub-systems for the control of machines, robots and assembly systems on specialized VLSI chips.

5.5.2. Current Projects and Projects under Negotiation

'Exploitation of Real-time Imaging for Arc Welding'

Proj. Ref. 9: A/83

In the first year of this project the following tasks were carried out:

- *an analysis of potential industrial arc welding tasks, which has resulted in the selection of candidate sensing applications in thin section/high production rate and thick section/high quality sectors.*
- *a survey of image analysis methods and applications.*
- *a study of image acquisition and processing approaches which would be applicable to the testbed sensing applications selected in the first phase.*
- *a definition of the possibilities for controlling metallurgical structures (and hence mechanical properties) of multipass welded components by precise placement of weldbeds. This represents a more severe control requirement than either production speed or weld soundness criteria.*
- *a specification of development approaches and hardware which will be used in subsequent phases of the project.*

The project is now focussing on two application areas, single and multipass welding. The development of image analysis and adaptive control algorithms for both welding techniques is underway with the construction of the hardware.

'General Purpose Sensory Controlled Systems for Parts Production'

Proj. Ref. 118: A/83

This project is directed to researching, developing and demonstrating the ability to obtain 2.5D and 3D images by means of visual, tactile and range sensing.

Initially seven tasks were defined in the workplan:

- i) User specification study*
- ii) System integration framework definition*
- iii) Gray scale sensor development*

- iv) *Tactile sensor development*
- v) *Range finder development*
- vi) *Direct 3D sensor development*
- vii) *Stereoscopic sensor development*

'Integrated Electronic Subsystems for Plant Automation'

Proj. Ref. 179: A/83

Within this project the functions performed by NC and Robot control systems are analysed and divided into sub-systems. These are being realised as general purpose sub-system integrated circuits which will be suitable for a broad range of applications in NC and Robot control. Test circuits have been specified as suitable for VLSI application. These are being developed for two specific applications while work is also being directed to specifying a co-processor which will support the design of control systems and the implementation of VLSI circuits.

'Integrated Sensor-based Robot System'

Proj. Ref. 278: A/84

The objective of this project is to develop a sensor-based system prototype (vision and tactile), for real time applications, in cooperation with industrial robots for intelligent handling and/or assembly. Test-bed applications are bin-picking, and workpiece handling on a moving conveyor belt.

'Computer-aided thermal Image Technique for Real-time Inspection of Composite Material'

Proj. Ref. 197: A/83

This project is directed to research into imaging and image processing techniques using thermal scanners for the development of a real time system for on-line inspection and monitoring of composite materials and products, in a mass production environment.

In the first phase of this work, image processing equipment has been developed to an operational state suitable for experimental purposes. In addition a prototype thermal impulse generator has been produced to support experimental aspects of this work.

5.5.3. Scope for Further Work

In this area the development of microelectronic subsystems will be considered for inclusion in call(s) for proposals to be published in 1986. However with less priority than 5.4 and 5.2.

R & D area 5.6: CIM Systems Applications

To maximise the coherence and strategic impact of the CIM sub-programme, swift action is needed to encourage application centres in which developments in ongoing projects could be demonstrated and refined within a framework of integration.

In addition to providing a focal point for community-based action in advanced manufacturing, benefits would include:

- promoting awareness of ESPRIT work by demonstrating ongoing R & D to a large European audience;
- highlighting needs, achievements and opportunities in the area of CIM integration;
- providing an environment to facilitate fast prototyping;
- catalysing subsequent developments including product realisation.

5.6.1. Topics

To achieve these objectives, the following projects and themes have been identified:

- CIM application and development centres.
- General topics for CIM support.

The following topics are given as examples, but the list is non-exhaustive:

- product design guidelines for automatic production;
- create an understanding and ability to design mechanical products for automatic manufacturing;
- methodologies for selection and configuration of CIM components;
- develop tools and methodologies for selecting CIM components and tailoring CIM systems to meet specific company needs;
- economic methodologies for evaluating investment in CIM systems;
- develop tools and methodologies for a correct economic evaluation of investment in CIM systems;
- interaction of CIM systems with organization, infrastructures and skill requirements;
- determination of the required changes in organization, infrastructure and skill requirements consequent upon the introduction of CIM systems;
- interaction of CIM systems with management information systems;
- definition of data interchange between CIM systems and management information systems (MIS).

The purpose of these activities is to develop tools and facilities to promote successful CIM applications.

5.6.2. Current Projects and Projects Under Negotiation

'Predesign of FMS for Small Batch Production of Electronic Cards'

Proj. Ref. 850: B/85

Preparatory study to explore the provision of facilities to support the development and system integration of various elements of CIM. The application area focusses on PCB (printed circuit boards) production. The intention is to provide the service primarily for small and medium sized companies.

'Communication Network for Manufacturing Applications'

Proj. Ref. 955: A/85

The objective of this project is to define, promote and provide a multi-vendor network environment for manufacturing applications. The work has been divided into four phases:

- Definition. This will consider the levels of the OSI structure relevant to CIM and a network architecture based on a hierarchical structure of networks.
- Demonstration of a network controlling existing machine tools.
- Demonstration of a multilayered network architecture.
- Examination of very broad band width networking technology.

'Product Design for Automated Manufacture and Assembly'

Proj. Ref. 338: B/84

The objectives of this project are two-fold. Firstly it is necessary to determine the range of manufacturing information which must be made available to the designer so that products are designed which are compatible with automated manufacturing and assembly techniques embodied in flexible machining and flexible assembly (including robotic assembly) systems. Secondly it is necessary to establish the basis on which this information is best made available to the designer using for example CAD systems.

Work has been done on meeting the first objective by the collection and collation of product information suitable for automated assembly. In parallel work progresses on developing a cohesive approach to establishing the requirements for product design for automated assembly.

'Data Transfer Between Computer Integrated Manufacturing Systems and Management Information Systems'

Proj. Ref. 319: B/84

The project addresses the linkage of CIM and MIS systems within the context in which they must operate, namely, the management, technological and operational infrastructure of the enterprise. This is related to the trends in information technology, the functional requirements of both hardware, software and operating systems, and the CIM vendor industry itself. Advances in computer technologies have created the opportunity for medium sized enterprises to apply sophisticated MIS-CIM techniques and hardware/software tools which were, up to very recently, only affordable by the largest enterprises. This project is therefore directed to actively test design concepts, techniques and prototype sub-systems in medium to small sized manufacturing environments.

'Development of Tools for Economic Evaluation of CIM in Smaller Manufacturing Companies'

Proj. Ref. 909: B/85

The objective of the work is to develop software tools to improve the ability of consultants, Chambers of Commerce and individual firms to carry out cost benefit analyses for investment in CIM. The tools are specifically aimed at small and medium-sized manufacturing companies and will be portable to a range of widely-available personal computers.

'Implementation of AI into Subjects for Advanced CIM'

Proj. Ref. 975: B/85

This deals with the integration of information about products being manufactured in CIM with the CAM system. This project is directed at improving the existing identification systems (Remote Programmable Transmitter/Responder and Interrogator with Artificial Intelligence) in order to meet CIM requirements, and to develop of remotely programmable transponders. An initial test bed for the technology will be motor car manufacture and wider applications within CIM are anticipated.

5.6.3. Scope for Further Work

The topic on Application Centres will be considered for inclusion in call(s) for proposals to be published in 1986 in so far as necessary because of 1985 proposals not maturing to contract. The area of mechanical engineering is already well-covered by projects under negotiation.