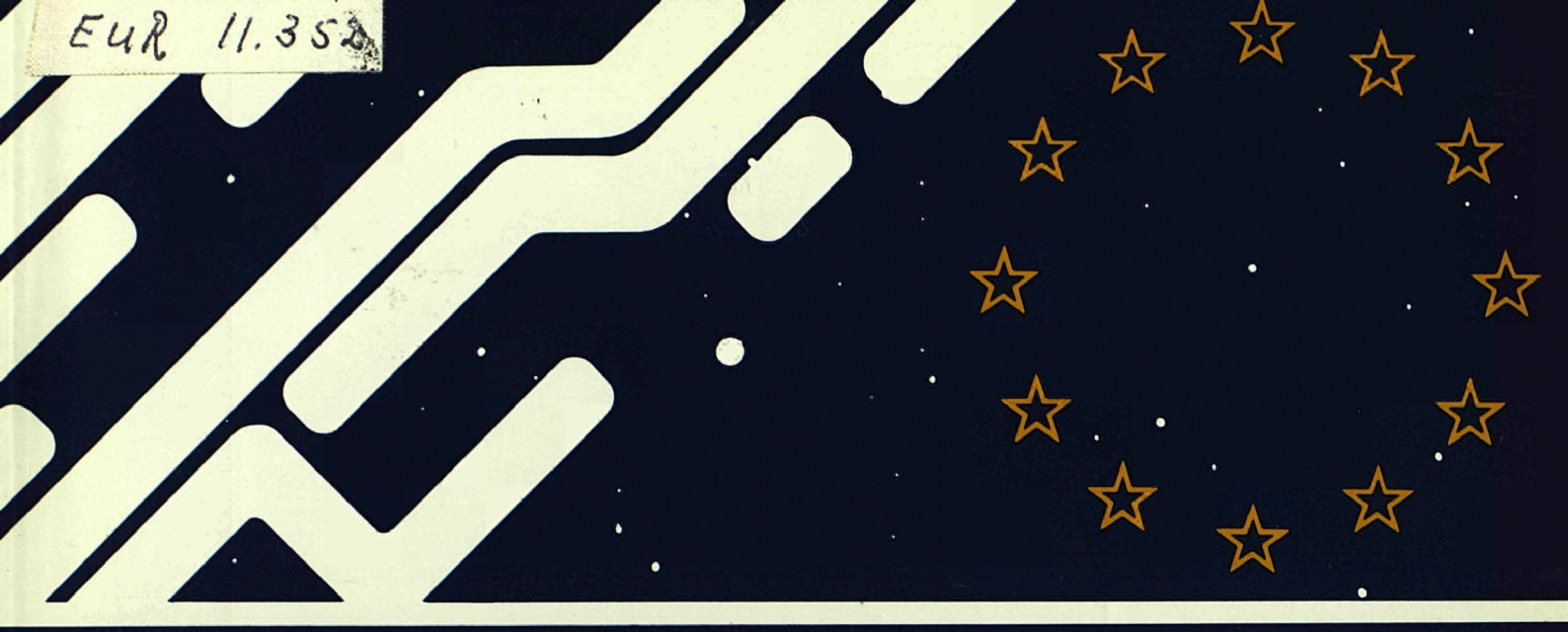

Esprit

European Strategic Programme for Research and Development in Information Technology

1987 Annual Report

Commission of the European Communities
D.G.XIII: Telecommunications, Information Industries and Innovation

PROLOGUE

In the "age of the computer", developments in Information Technology (IT) are not merely already affecting the day-to-day lives of most of the developed world; because of the key status of IT for all industries and for the emerging information society, these developments within IT are a critical element in shaping the future. Those who are involved in the development of the European Community are well aware of the benefits and of the dangers of this new age. For Europe the choice is simple: either we are at the forefront of developments in Information Technology, or we accept second-class status in the response to the single most important professional challenge and opportunity facing mankind.

ESPRIT is making an important contribution at Community level to the competitiveness of the European Information Technology industry and therefore to the strategic goal of the completion of the European internal market in 1992. The change in industrial and technological atmosphere since the start of ESPRIT in 1984 is profound. Not merely has there been widespread support for ESPRIT both in industry and in scientific circles, but the results from the programme are themselves starting to have an impact on European products.

In the long term, though, the most important result of ESPRIT and other Community programmes will be not only the individual industrial processes and products, but also the establishment of the habit of transborder collaboration of real European dimension, which will help to overcome national borders in a durable way. With 3,000 researchers and engineers working on more than 200 projects across Europe, we can see the start of a European Technological Community. This European Technological Community is one key to the future of Europe - I wish it every success.

Karl-Heinz Narjes

Vice-President,

Commission of the European Communities

Esprit

European Strategic Programme for Research and Development in Information Technology

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FOREWORD

by M. Carpentier, Director General,
DGXIII, Telecommunications, Information Industries and Innovation
Commission of the European Communities

Awareness of the European dimension in advanced technology has spread rapidly since the outline of a European Technology Community was first put to the EC Heads of State and Government by the Commission in June 1985. That Summit meeting marked recognition at the highest political level of the essential role to be played by technological cooperation in creating an economically competitive Europe for the 1990s.

It was not by chance that such a call for Community action in high technology should come a year after the full-scale launch of the ESPRIT programme. By providing a successful model for cooperation across frontiers - across industrial/academic frontiers as well as across national frontiers - ESPRIT has released a wave of innovative energy too long pent up in Europe.

In 1987, this new dynamism has been followed up on a broader scale. In July, the adoption of the Single European Act confirmed the Community's mandate for advanced industrial technology in the context of the single European market scheduled for 1992. In September, the Council of Ministers gave the go-ahead for the programme designed to give the Community the means to carry out that mandate: the 1987-91 Framework Programme for Research and Technological Development.

In several areas of high technology, 1987 has marked new initiatives, action and successes for European cooperation. These include an ambitious programme for the European Space Agency, following the resumption of Ariane launches, and the build-up of the Eureka initiative. Science and technology agreements between the Community and five EFTA countries marked the extension of European cooperation in 1987, while the Community has also pushed ahead with such key initiatives as ESPRIT II, the RACE programme and the Green Book in the field of Telecommunications, new action in standardization, technology transfer, training, information services, new technology application programmes and more. There has been intense activity in the area of European industrial restructuring, to meet a competitive challenge made the more urgent by the fall of the dollar.

This awakening of the technological Community is a very positive development. Nonetheless, the momentum of European cooperation must be increased - and nowhere more so than in the key areas of information and communications technology.

The action of the Commission's Directorate-General for telecommunications, information industries and innovation (DG XIII) is designed to provide the conditions of success across the whole range of the information and communication process made possible by electronic technology. Not only is this sector forecast to be the world's biggest business by the end of the century, but it also largely preconditions Europe's ability to take up new opportunities for economic and social progress. DG XIII strategy is therefore closely related to the overall objectives of the Community for the 1990s, particularly in providing the basis for the economic competitiveness and modern communications needed throughout the Community if Europe's economic and social actors are to make the most of the single market.

ESPRIT has already played an important role as a catalyst in the creation of the European Technology Community and this programme continues to have a central place in the overall information and communications strategy coordinated by DG XIII.

Its successes have been considerable. Through ESPRIT, for example, European industry developed the world's most powerful microchip in 1987. Yet only one European company figured that year in the list of the world's top ten semi-conductor manufacturers. While building on the successes of ESPRIT, therefore, DG XIII will continue to implement a closely-coordinated strategy which links trans-national precompetitive R and D in IT and telecommunications with measures to accelerate the take-up of results and open up a dynamic European market, for both equipment and services. In IT and telecommunications, as elsewhere, we need not only a European market and European technological development but a truly European industry, organised on a scale large enough to be internationally competitive. DG XIII strategy will continue to focus on the real needs of industry, while providing the necessary impetus for consensus and action across a very wide field of issues, on both the European and the international levels.

The fundamental objectives of ESPRIT remain essential to this strategy. Europe urgently needs the advanced technology and trans-frontier framework for collaboration this programme will continue to provide in its strengthened new phase beginning in 1988. The third key objective of ESPRIT, standardization, has a strategic importance that is not only central to the creation of a dynamic single European market but runs throughout the European response to the world-wide challenge of information and communications technology. Thanks to important initiatives taken by the Commission along with standardisation bodies and industry which led to new concepts, new procedures and new structures and in addition through the collaboration initiated by ESPRIT, Europe can now build a commanding position in the technological standardization required to ensure the transition from stand-alone information technology to integrated information systems.

1987 has been a turning-point: for ESPRIT, now entering its second phase; for the European Technology Community, now confirmed by the Single European Act. In 1988, the continued progress of ESPRIT will be a leading indicator of the Community's determination to secure the technological capacity on which its future largely depends.

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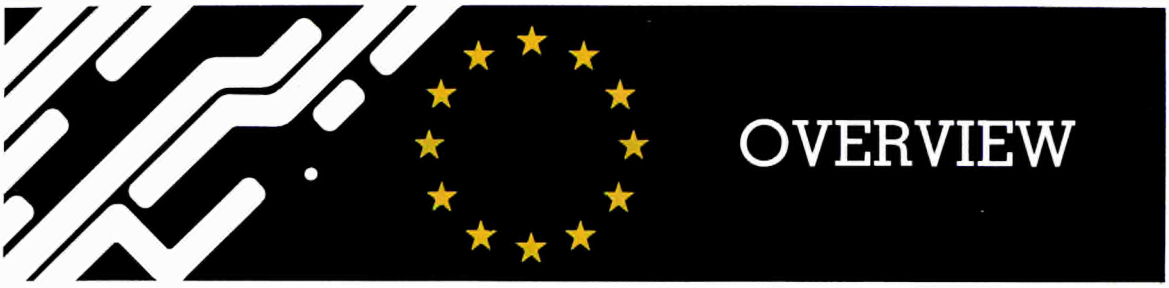


ESPRIT IN 1987: AN OVERVIEW
INTRODUCTION AND PROGRAMME HIGHLIGHTS

J.M. Cadiou,
Director, ESPRIT and Information Technology

OBJECTIVES AND STRUCTURE OF ESPRIT

ESPRIT, the European Strategic Programme for Research and Development in Information Technology, has three objectives:

- to promote European transnational cooperation in Information Technology;
- to provide the European Information Technology industry with the technologies it needs to meet the competitive requirements of the 1990s;
- to contribute towards the development and implementation of international standards.

The overall financial envelope of the first phase of ESPRIT (1984-1988) is 1.5 billion ECU. Of this one half is contributed from the budget of the European Communities, and the other half comes from the participating organisations.

Participation in ESPRIT is open to any organisation established and carrying out research and development in Information Technology within the Community. ESPRIT projects are carried out by consortia which must include at least two industrial partners from two different Member States of the Community.

The ESPRIT programme is implemented through precompetitive R&D projects based on the ESPRIT Work Programme, which describes the strategy, objectives, and technical aspects of the

programme work. Approximately once a year, the Work Programme is revised and published to serve as the basis for a Call for Proposals for projects in the five technology areas of the programme. This report describes the results obtained since the last Progress and Results report (1986) and up to December 1987, grouped according to these five areas:

1)Advanced Microelectronics

2)Software Technology

3)Advanced Information Processing

4)Office Systems

5)Computer Integrated Manufacturing

In addition to the projects in these five areas, ESPRIT includes a certain number of communications infrastructure and information dissemination activities. These are described in chapter 6 of this report.

1983 - 1986 PERIOD

The first phase of ESPRIT was adopted by the Community in 1984, after a pilot phase initiated in 1983. Industry responded enthusiastically to the two principal calls for ESPRIT I proposals, of 1984 and 1985, so much so that the budget available allowed only one proposal in five to be accepted. These two calls for proposals resulted in the start of 90 per cent of all ESPRIT I projects. A smaller, more focused, call for proposals in 1986 added another 20 projects bringing to 227 the total number of ESPRIT I projects.

By 1985 it was already clear, from the response to the initial calls for proposals, that the IT community and especially industry was responding massively to the transnational cooperation concept proposed in ESPRIT. By the way this was not to be taken for granted at the outset, since cooperation in high technology between competing companies really constitutes something of a paradox. The reason why it worked at all comes from the necessity to share resources and from the pre-competitive nature of the work itself.

The next major question was whether these cooperations would bear fruit, that is whether these cooperative set-ups would work effectively to achieve the technology objectives set out. The first elements of an answer to this question appeared in 1986 when the first results started to emerge from the projects; these were described in the document EUR 10940 "ESPRIT - Progress and Results".

However, in order for ESPRIT to fully achieve its objectives, it is not enough to produce technology results; these must have an impact on the industrial scene, that is they must be transferred from the R&D project which produced them into the industrial process. During 1987 we have seen the first elements of that process taking place.

1987: INDUSTRIAL IMPACT - DIRECT RESULTS

ESPRIT projects typically run for five years, and in 1987 only half of the ESPRIT 1 projects completed their third year. Therefore it is too early to make a full industrial impact assessment at this stage. Nevertheless, as of December 1987, 108 out of the 227 projects had produced a total of 143 results of industrial significance. These 143 results can be broken down as follows:

- 27 have contributed directly to products or services currently available on the market;
- 44 have contributed directly to products or services being developed for the market but not yet commercially available;
- 44 are being used outside the ESPRIT project, either within the company concerned or in another company (technology transfer);
- 28 have contributed to standardisation, either adopted as an international standard or being elaborated by an international standards organisation working party;

These results are discussed in detail in the relevant area chapters, and some of the most important ones are summarised below in the "Programme Highlights" section.

What can be said at this stage is that the indications are very encouraging, particularly the cases where an ESPRIT project has led to substantial downstream investment, either by one of the partners or by a third party; however, ensuring the appropriate exploitation of ESPRIT results will continue to be a major challenge for the European IT industry.

SPINOFFS BEYOND R&D

In the field of international cooperation, it is clear that there has been a fundamental change in the attitude of European IT companies. When ESPRIT was being prepared, one of the main structural problems identified in Europe was the lack of alliances between European IT companies. They seemed to seek US partners much more than European ones. In the course of four years, this situation has completely changed. Between 1983 and 1986 the number of international agreements between European IT companies increased seven-fold, bringing it to the same level as US-European partnerships. I am not referring here to cooperation in the area of pre-competitive research, but to commercial agreements in product development, marketing, and joint ventures. One of the

ESPRIT Programme Statistics - Projects and Participants, December 1987

Number of projects:	**227**		
Companies of less than 50 employees:	62	Companies of 50-500 employees:	84
Other companies:	181	Universities and Research Institutes:	199

Total number of participating organisations: 536

(which represents approx. 420 independent organisations, plus subsidiaries, joint ventures &c.)

most important alliances which took place in 1987 was the merger between SGS and Thomson Semiconductors, making the new company, STM, the second largest European semiconductor manufacturer.

Of course ESPRIT is not the sole reason for this change of attitude, and perhaps not even the major factor, but it has certainly played a role. As evidence of this, allow me to quote two prominent industrialists, speaking at this year's ESPRIT Conference Week:

> "The ESPRIT model for cooperation has changed attitudes about working together."
>
> (C.J. Van der Klugt, Chairman of the Board, Philips)

> "The ECRC (the joint research laboratory of BULL, ICL, and Siemens) was a purely company initiative, but one which would have been inconceivable without ESPRIT."
>
> (J. Stern, Président Directeur Général, Bull)

ESPRIT II

In July 1987, once the Council of Ministers had reached agreement on the Community Framework Programme for Research and Technological Development, the Commission submitted, under the aegis of this Framework Programme, plans for ESPRIT II, the second phase of ESPRIT. On 21st December 1987 the Council of Ministers took the first step towards adoption of ESPRIT II, the "common position" reached unanimously by the Ministers of the 12 Member States.

To ensure a rapid start, the Commission announced the first ESPRIT II Call for Proposals on 29th December 1987. As this report goes to press, preliminary responses suggest that there is massive interest in this Call for Proposals, from throughout the Community.

ESPRIT II will continue to focus on pre-competitive collaborative research and development; however, there will be yet stronger emphasis on the industrial nature of the programme. The programme will aim to

- provide a sustainable European capability in advanced components, especially Application Specific Integrated Circuits;
- provide the technologies needed for the next generation of information processing systems;
- enhance the capability of European industry to integrate IT into complete application systems, in a broad range of different environments.

ESPRIT II will benefit from a full European dimension, with the participation of organisations based in EFTA countries. There will also be a cooperative action in basic research, aiming at developing and maintaining a sound foundation for the European IT industry of the future.

The overall financial envelope of this second phase of ESPRIT is 3.2 billion ECU; as before, half of this is contributed by the participants, and the other half comes from the Community budget. A

new feature of ESPRIT II is a limited number of Technology Integration Projects. These projects will aim at ambitious, well-defined, industrial targets, and will require large-scale industrial effort of a Community dimension. They will demand tight management and major commitment from the project partners.

ESPRIT II is thus intended to build on, extend, and profit from the success of ESPRIT I.

PROGRAMME HIGHLIGHTS

In the following six sections, the overall strategy of each ESPRIT I area is outlined, and a selection of the most important industrial achievements of ESPRIT during 1987 is presented. For a wider discussion, and a full list of significant achievements, the reader is referred to the chapters concerned in this report.

1) Advanced Microelectronics

The aim of ESPRIT work in this area has been to ensure a continuing ability within the European industry to design and produce competitive semiconductor components. On the design side this has meant a continuing emphasis on integration of individual design tools, combined with increasing attention to issues of flexibility and reconfigurability; on the process side, efforts are directed towards achievement of specific medium-term technology goals in silicon and towards demonstrator projects in other technologies, such as Gallium Arsenide circuits and on-chip integration of optical and electronic functions.

As far as design work is concerned, 1987 has seen the arrival on the market of SPIRIT, a CAD system based on ESPRIT project 991, as well as the preparation of the Cathedral system (project 97) for use in a production environment, and the publication of the first set of standardisation recommendations from the ECIP project. The process activities are on schedule to meet their targets. For example, Matra Harris (F) has incorporated 1 micron CMOS technology from the SPECTRE project into its production lines, and Siemens (D) have started the commercial development of a new family of bipolar gate arrays; the BICMOS project has successfully implemented the full on-chip integration of 1.2 micron CMOS with bipolar technology, enabling microprocessor-controlled audio stereo source selection and volume control to be carried out by a single microchip.

In other technologies, demonstrators already produced include a 4K GaAs SRAM with 1 nanosecond access time, and a photodiode integrated with an electronic amplifier on one chip, which can receive information from fibre-optic cables at 560 Mbaud: this establishes an important enabling technology for broadband network communications.

2) Software Technology

The Software Technology subprogramme has three main thrusts. The first is a standard software development support environment; the PCTE is a basis not only for a substantial part of the Software Technology activities in ESPRIT but also for a growing number of national and other international activities. The second objective is a more rigorous approach to software system development, focusing on design methods and associated tools. The third thrust concerns the industrial management of software projects, and the methods, mechanisms, and tools to control sophisti-

cated system development projects.

The PCTE - Portable Common Tool Environment - is now available to all participants in Community research programmes, and to European universities. To date, more than 100 licences have been released. Also a number of national programmes and EUREKA projects are working with the PCTE results, a complementary "PCTE+" programme has been launched, and the European Space Agency has adopted the interface specifications for the Columbus project. The PCTE interface specifications are now managed by an independent management board (the PCTE-Interface Management Board), which is made up of representatives from the computer industry, the software industry, academia, and major development agencies, and which has entered the ECMA standardisation process.

In the elaboration of design methods, the emphasis has been on mathematically-based formal methods. In particular, the Vienna Development Method (VDM) for system design has figured prominently in ESPRIT activities. 1987 saw the start of the first industrial trial in ESPRIT of system development tools based on VDM. Formal methods have also been developed for the specification of ISO OSI protocols, with two languages developed for this purpose achieving the status of Draft International Standards in 1987. The GRASPIN project, based on net theory, has demonstrated an integrated tool set to support software system development from requirements analysis, through formal specification, incremental development and design validation to documentation.

Other work in the Software Technology subprogramme looking further into the future concerns the use of knowledge engineering techniques for software development, particularly in the transition from requirements capture to system design, and for management purposes.

3) Advanced Information Processing

The main goals in this area are to ensure the development and lay the foundations for the industrial application of knowledge engineering techniques as an important method for the production of sophisticated software systems; to develop new computer architectures, for symbolic and numeric processing at very high speeds, and for fault-tolerant systems; and to develop advanced system interfaces for effective communication between computing systems, between the computer and its environment, and between the computer and the user.

In 1987, emphasis was on the consolidation of the project work and the acceleration of the industrialisation of the results emerging from the projects.

In the area of knowledge engineering, the OMEGA expert system shell, based on the results of project 440, is being marketed by a small Italian company, Delphi SA, in the USA, Japan and Europe. Another system, the Expert System Builder (ESB), which provides a complete environment, compares very favourably with the current market leaders, US systems such as KEE and ART. PROLOG III, which extends PROLOG by the addition of powerful numeric capabilities, has been fully specified by A. Colmerauer, the designer of PROLOG, and a complete implementation of the language is being used in a diagnosis system for car engine components, developed by Daimler Benz (D) and Bosch (D).

In the area of computer architecture, work focuses on highly parallel architecture machines, and

the appropriate software, to achieve the performance levels required for advanced systems. The Supernode parallel computing system project has achieved significant results during 1987. The T800 transputer developed by INMOS, with a capacity of 1.5 million floating point operations (MFLOPS) or 10 million instructions per second, is now available for industrial use. Prototype machines of Supernode were shown at the 1987 ESPRIT conference. It is forecast that, based on this project, machines with a performance of 380 MFLOPS will be available in the near future at a cost much lower than current US machines. Telmat (F) and Thorn-EMI (UK) will launch commercial versions of Supernode in 1988.

In project 415 on parallel architectures for advanced information processing, the different approaches to symbolic processing have been analysed; the project has now designed an object-oriented architecture, and the necessary operating system and basic language are available, as is the first prototype of a logic machine.

The work in system interfaces has produced interesting results in image processing, natural language understanding, and speech processing, which are now being evaluated prior to application.

4) Office Systems

The Office Systems subprogramme of ESPRIT aims to ensure that European office information systems offer the capabilities of easy interworking in distributed multi-vendor environments, flexible system design, and ease of use for unskilled users. This overall aim has led to concentration on four issues:

- communication - the progressive implementation of the OSI reference model in wideband networks, gateways, and bridges;

- document structure - the definition and industrial implementation of the Office Document Architecture standard for multi-media documents;

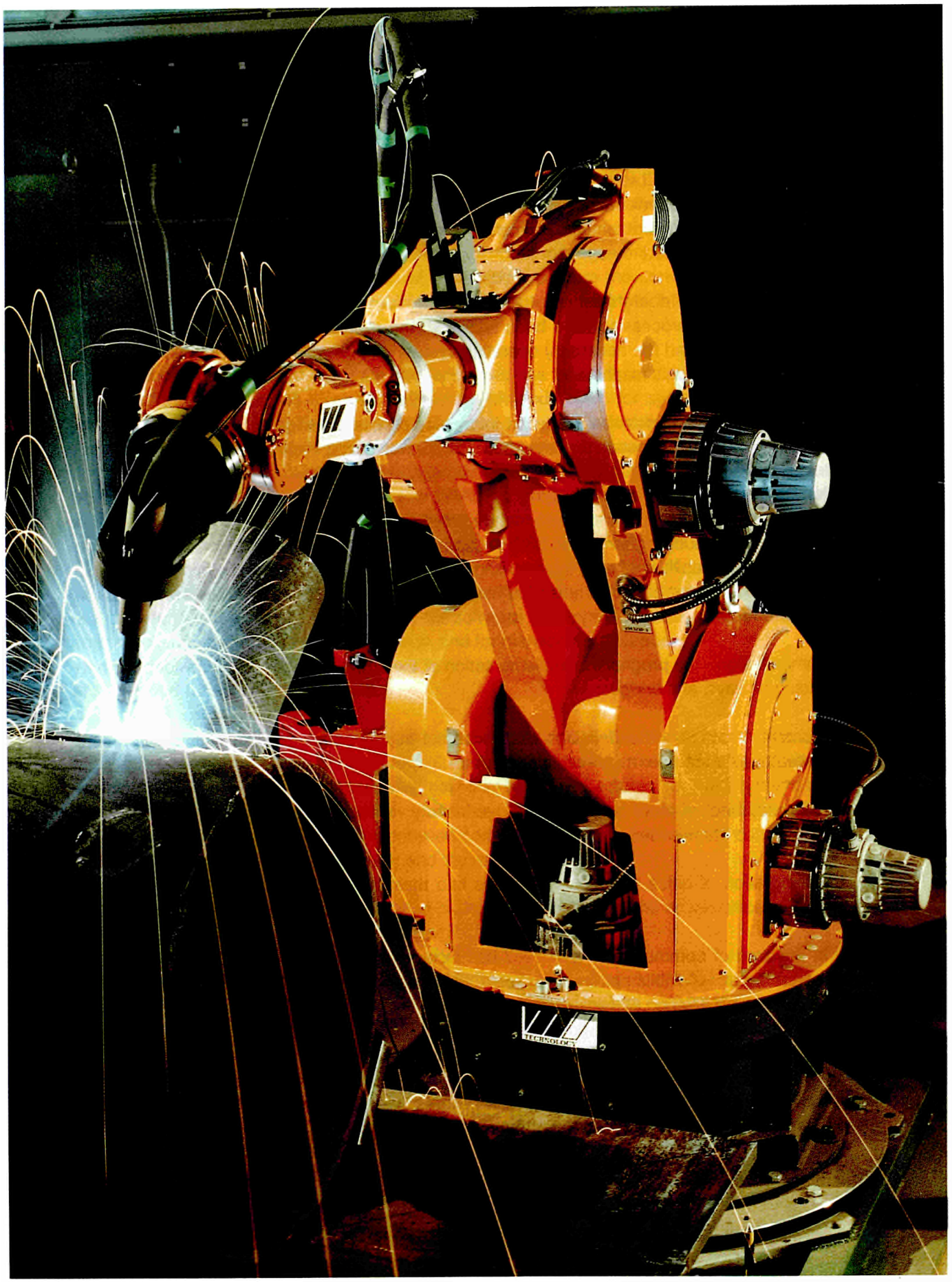
- the development of more powerful and user-friendly workstations and human-machine interfaces;

- the integration of office information systems into their environment, and their adaptation to user needs.

Work in the area of communications in 1987 has included the implementation of prototype networks operating at 140 Mbits per second, both local and wide area, as well as high-performance gateways for linking differing OSI systems.

1987 also saw the Office Document Architecture (ODA) standard prepared by the HERODE project adopted as an ISO standard, while six other ESPRIT projects have already implemented systems based on ODA. The PODA project demonstrated interworking of workstations from Siemens, Bull, Olivetti, and ICL, and is promoting further extension of the standard.

Over 1000 workstations running the BBC (UK) Domesday system, developed in project 901, were sold in 1987, while at the top of the workstation market the IWS project demonstrated in Hannover



at CeBIT 1987 an advanced desktop workstation with graphics and voice interfaces. Visual interface work includes advanced compression techniques for both still and moving images; results in both these fields have been sufficiently impressive that the techniques developed have been submitted to international standardisation bodies.

In the area of system design and integration, a design environment implementing the method developed and published by the FAOR project was demonstrated at the Politecnico of Milano in 1987. 1987 also saw the publication of a manual describing the formal approach to the implementation of office systems developed by the OSSAD project, while a new consultancy company "IT-Uptake" was set up in Ireland to exploit the results of the ESPRIT project of the same name.

5) Computer Integrated Manufacturing (CIM)

The strategy for CIM in ESPRIT has emphasised the development of standards and technology for multi-vendor systems. The technical goal has been to create architectures, design rules, and interfaces conforming to the Open Systems Interconnection model. At the same time, CIM subsystems have been developed in areas where strong market opportunities exist; these subsystems have included tools for real-time manufacturing control, shop-floor systems including robot controllers, sensors for assembly and inspection, and various simulation tools. In the implementation of the CIM projects, the joint involvement of vendors and users encourages a pragmatic approach with rapid application of results, and therefore substantial industrial impact.

1987 saw significant results and achievements from all these activities. Intermediate results of the AMICE project, developing a generic open architecture for CIM systems, have provided inputs to the relevant international standardisation work. Project 322 (CAD Interfaces - CAD-I) is developing vendor-independent interfaces for multi-vendor CAD and CAE systems. Some results have already been incorporated into commercial products, and inputs have been provided for the proposed International Standards Organisation STEP standard.

The CNMA (Communications Network for Manufacturing Applications) project, which links six major European computer manufacturers, gave a live demonstration at the 1987 Hanover Fair, showing computer-controlled manufacturing equipment from different suppliers working together; pilot applications of the network have been implemented at British Aerospace (UK) and BMW (D), and a further implementation is planned for Aeritalia (I).

In the field of real-time manufacturing and control, ESPRIT is supporting research and development work in production planning, dynamic scheduling, and maintenance. Some early results have already been applied in factories of several companies including COMAU (I), Philips (D), Renault (F), Tulip (DK), and Pirelli (I).

Many CIM projects are dealing with advances in techniques and equipment for CIM; for example tactile sensor systems have been developed by MARI (UK) in a new dedicated manufacturing plant, while a machining cell in Mondragon (E) is used as a testbed and demonstrator for application and integration of multi-sensor systems in manufacturing.

6) Infrastructure

Two areas of ESPRIT activity fall under this heading. The Information Exchange System (IES) is concerned with ensuring that communications mechanisms and services are available to support ESPRIT activities, while efforts are also made through various channels to make the results of the programme widely known.

The services currently provided by the IES include:

- Eurokom, an electronic mail and computer conferencing system based in Dublin, now serving over 1200 users;

- Eurocontact, a database to help potential project participants to find partners, which now holds details of 1600 organisations;

- IES Newsletter, a bimonthly publication on computer networking with a readership of 5000;

- 3 public databases held on the European Community Host in Luxemburg, covering research activities and electronic mail systems.

The IES is also involved in developing OSI conformant services, including support for the EUREKA COSINE project and the Message Handling project of the Résaux Associés pour la Recherche Européene (RARE); support was also given for the establishment of RARE. OSI conformant communications software for UNIX systems (developed in the ROSE project) is now in use across a pilot network of 20 sites, and in 1987 the THORN project completed a prototype international distributed directory service. The CARLOS project has developed modules to permit interworking with OSI conformant applications, and is in the course of establishing a network management centre for the Danish Library Service.

The prime forum for disseminating the results of the programme is the ESPRIT Conference Week. This year's event was the largest ever with nearly 4000 participants. The Conference has established its place as a major international event in its own right. It has a unique double viewpoint; not merely do ESPRIT projects report on their progress and results during the last year, but the conference also looks to the future. On the "IT Forum Day", major actors on the European political and economic scene discussed the political and industrial environment surrounding ESPRIT, and experts in various domains of IT discussed the strategic aims of ESPRIT II; later in the week the workshops and the proposers' day offered ESPRIT participants the chance to discuss the detailed implementation of the programme.

1987 also saw the establishment of five new Technical Interest Groups in various subjects; these groups constitute a valuable means of dissemination of results, as well as providing a forum for discussion of new ideas and projects. The CIM-Europe initiative, which covers eight such Technical Interest Groups, held a successful European CIM conference in 1987.

ADVANCED MICROELECTRONICS (MEL)

1. Introduction

Advanced microelectronics products are, by now, effectively determining the direction of development and the rate of innovation not only of the traditional electronics sector (Information Technology in general, telecommunications and consumer goods) but also of more mature industrial sectors such as the automotive industry. Moreover, since the main sources of microelectronic components today are controlled by our stronger industrial competitors world-wide (US and Japan), it cannot be assumed that Europe will continue in the future to be able to draw on these sources to meet its needs in a timely and adequate fashion. Mastering VLSI design and production capability is thus of immense importance, and Europe's overall strategic objective must be to establish and consolidate an economically viable supply capability of advanced state-of-the-art semiconductor components, especially Integrated Circuits (ICs).

The contribution of ESPRIT to the achievement of this strategic objective addresses both the "design" and the "technology" aspects of semiconductor ICs. This is achieved through a careful selection of projects and infrastructural activities directed to achieving maximum multiplier effect.

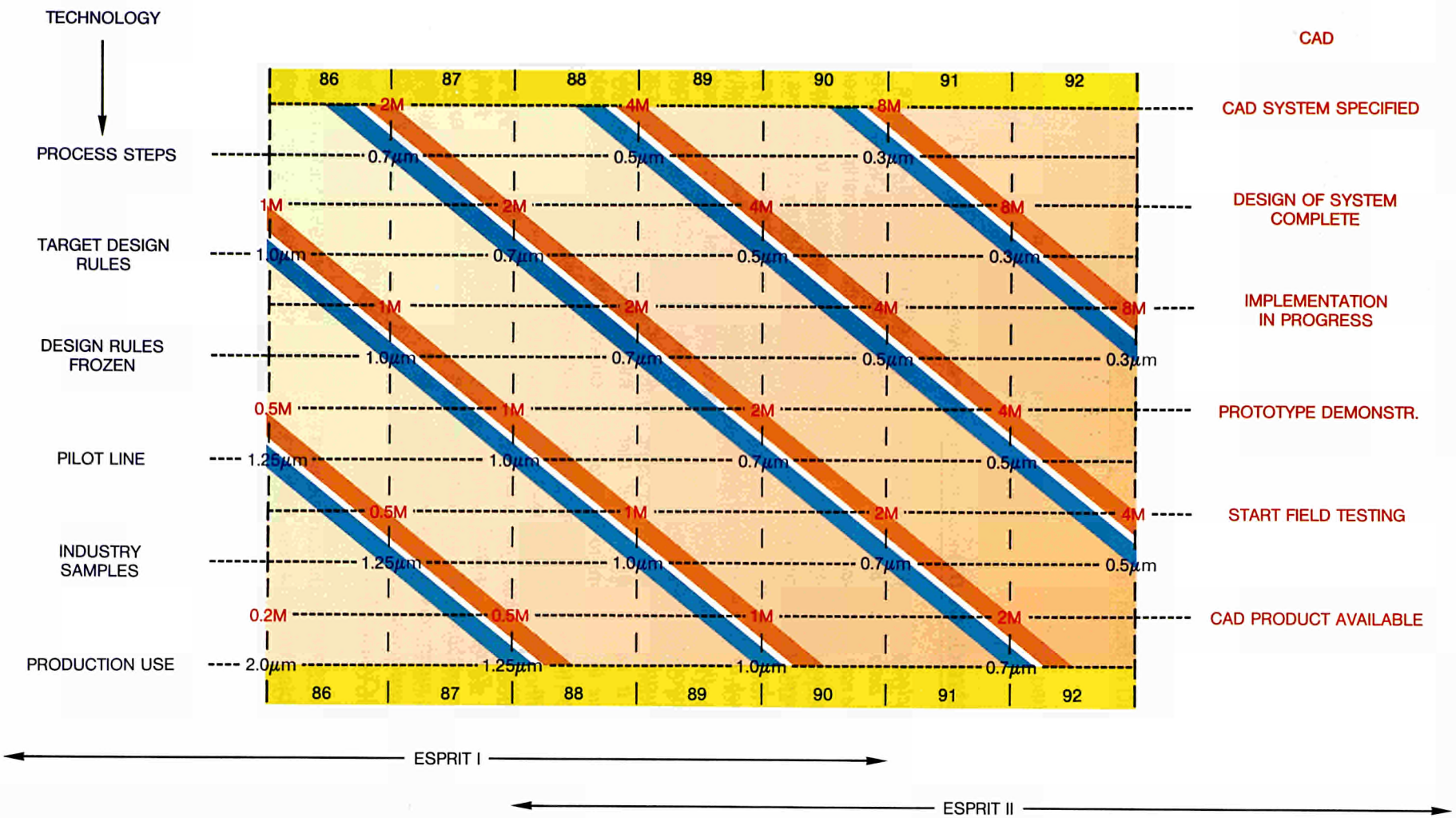
An example of how these two aspects relate to each other is shown in Figure 1. This illustrates, for the most widely used technology (CMOS), the relationship between the physical dimensions of devices to be fabricated and the complexity, in terms of numbers of transistors. The physical dimensions are dependent on the technology, while the complexity dictates the capabilities that a corresponding Computer Aided Design (CAD) system needs; thus, for example, to exploit fully the capabilities of 1 micron CMOS technology, a CAD system is required which can handle a design with 1 Million transistors.

The values given in the figure represent world-wide industry practice for past and present achievements, and broad expectations of future development. The objectives and intermediate milestones of ESPRIT CMOS projects are in line with these.

At the end of 1987 MEL had 43 projects running, 12 representing the main thrust and covering the crucial strategic aspects of the work programme and 31 addressing more specific topics, as a rule in support of mainstream project activities or exploring promising alternative routes. Compound semiconductors, optoelectronics and display technologies are therefore also being addressed as well as

FIGURE 1

PARALLEL EVOLUTION OF CMOS TECHNOLOGY AND CAD IN ESPRIT



TECHNOLOGY SPECIFIED BY DRAWN GATE LENGTH IN MICRONS.

CAD SYSTEMS SPECIFIED BY MATCHING MAXIMUM COMPLEXITY IN MILLION TRANSISTORS.

more strictly VLSI-related work on silicon. Although progress has been achieved on the whole front of activities, only those milestones achieved during 1987 will be singled out here. Furthermore, since the earliest ESPRIT projects have been running for 3 years, intermediate results have started to be transferred and used outside the research projects. Selective reference will be made to such transfer and spin-off effects.

"Design" and "Technology" will be the main sub-headings under which work in hand and the main achievements during 1987 will be reported.

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2. DESIGN

In the earlier work on Computer Aided Design for silicon based integrated circuits, the main emphasis was placed on developing individual tools to assist, in an effective and efficient fashion, throughout the various phases of the design of relatively simple circuits. By the mid 70s increasing circuit complexity led to the need to work on minimizing the overall design time and simplifying the use of the tools. The emphasis therefore shifted to integrating single tools into complete CAD systems covering the whole design process in a coherent and self-consistent manner; many such systems exist today and are in industrial use.

Current research and development (R&D) in CAD for VLSI still places strong emphasis on taking this approach further in terms of levels of integration and breadth of applicability, but R&D is also starting to address the problem of ensuring that systems are flexible and reconfigurable, so that particular design methodologies can be ported on to different CAD systems without the need to duplicate the complete infrastructure. In this way the turnaround time of the whole design process can be minimized by tailoring the design system to the particular requirements of the end product.

As the science of constructing such modular and flexible CAD systems is still in its infancy, an important goal in this research is the design and validation of "standard interfaces" to allow design data and design tools to be exchanged.

These trends are reflected in the presence within ESPRIT of four major projects tackling

CAD Systems integration projects

CVS - CAD for VLSI Systems (project 802)
A system to meet the requirements of the telecommunications sector. Broadly technology independent and including both analog and digital circuits.

AIDA - Advanced IC Design Aids (project 888)
More of a set of tools addressing the issues of portability and interconnectability, aiming to meet the needs of the major systems manufacturers' requirements for standard chips such as microcontrollers.

Advanced Algorithms, Architecture and Layout Techniques for VLSI dedicated DSP Chips (project 97)
Oriented towards CMOS and digital signal processing, to meet the needs for highly optimised chips, mainly for the consumer electronics sector.

Multiview VLSI-Design System ICD (project 991)
A distributed design environment with common library facilities to meet the needs of designers who are not tied to particular silicon foundries.

CAD Inter-system integration project

ECIP - European CAD Integration Project (project 887)

Looks at the needs of the system level projects for common standards to allow for interchangeability of design data and tools.

the system level within defined sectors and of a more "horizontal" one addressing the interoperability of systems and tools.

This last project involves the major European actors in the field, and shares partners with the four previous projects. This sort of matrix structure of partnerships amongst the main projects is designed to create effective liaison across the whole area, and to ensure timely interaction between decisions on standardisation and advanced research.

ECIP, which has a projected life span of 5 years, announced its preliminary recommendations after only 18 months, at the ESPRIT Conference in September 1987. A set of documents is now available giving details of the preliminary recommendations and the relevant background.

An important initiative towards the achievement of flexible exchange of tools is the "ESPRIT Microelectronics CAD Catalogue", launched in October 1987. This aims to provide a central reference point for information on advanced CAD tools and systems which exist in the Community, with priority given to software stemming from ESPRIT projects or other relevant Community research programmes. Besides being a service to the researchers in the Community, it may also provide an indicator of the relevance of ESPRIT results on the overall European scene. Already over 65 entries have been received from 19 organisations.

Excellent results are being achieved in the domain of digital signal processing (DSP), in terms of the level of integration. Following the successful development during 1986 of Cathedral-1, a fully operational silicon compiler for bit-serial architectures, project 97 developed during 1987 a second silicon compiler called Cathedral-2, and a further iteration in silicon compilation techniques, Cathedral-3, has reached the stage of a first prototype. Cathedral-2 provides an environment for the efficient synthesis of complex DSP circuits by translating a description of a behavioural flowgraph-type algorithm (expressed in the SILAGE language) into a dedicated multi-processor architecture; this allows the system designer to investigate and compare interactively different silicon implementations of a given DSP algorithm. Cathedral-3 is to be applied in the area of hard wired bit-parallel datapaths, leading to the design of fully customised applications, while the applications area of Cathedral-2 is digital audio equipment, lower end video, telecommunications, speech processing and linear algebra.

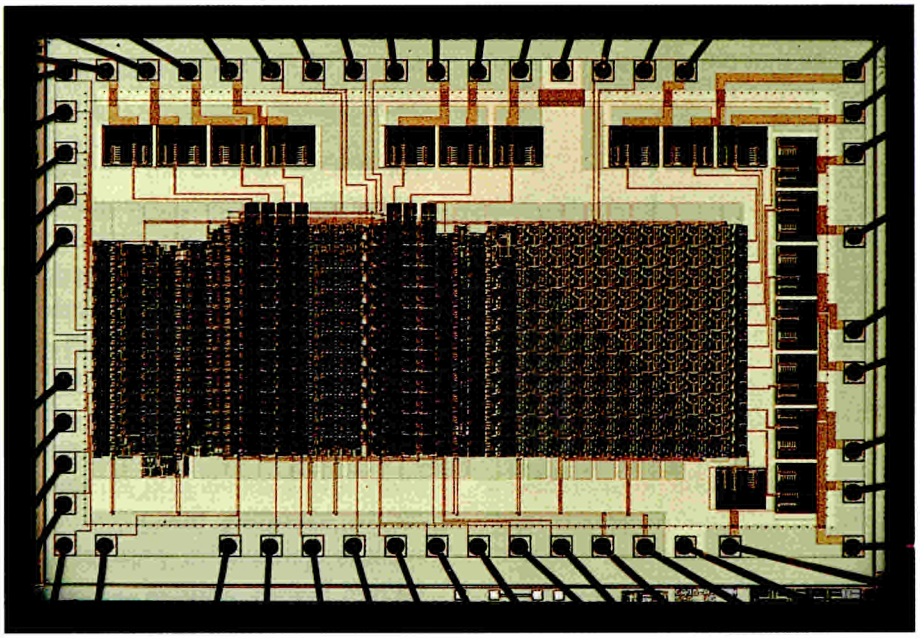
In order to test the validity of the approach and the quality of the results to date, Philips has used these newly developed prototype tools to re-design a Compact Disc signal processing chip. This test showed a reduction of the design time by a factor of ten, with an increase in the area of silicon of only a few percentage points. These results are so encouraging that the system is now being prepared for full integration in a production environment.

The results of project 991 in distributed design environments have more directly contributed to a commercial CAD product. A recently established small company, ICD of Enschede in the Netherlands, is marketing a CAD system based largely on the work of the project, under the tradename SPIRIT. The promotional literature describing the product acknowledges fully the continuing contribution made by ESPRIT.

Further developments, using innovative ideas on silicon compilation, are being implemented in the generation of tools now being developed.

Specifically in 1987 the following results were obtained:

- the incorporation of the ASTRA "System



Third order 35 MHz sampling frequency bit serial wave digital filter microchip designed by Cathederal-1 direct from a performance specification - "specification-to-silicon" (ESPRIT Project 97)

description capture language" from British Telecom into the ICD system;

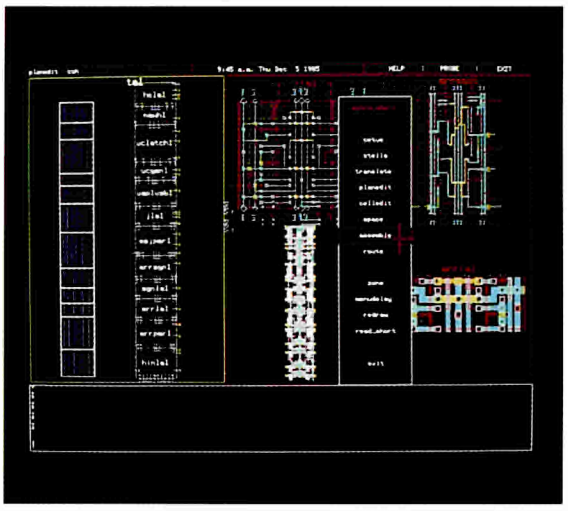
- the development of a new gridless channel router floor-planning tool;

- the development of SPIDER, a tool for taking into account global effects in VLSI (such as interconnect capacities).

These tools have already been used internally by the partners to design their newest chips and will subsequently find their way to the wider market in the next version of SPIRIT.

The results of European R&D projects are acknowledged and followed with interest by the CAD community worldwide. This was shown by the presence, in the IEEE International Conference on Computer Design held in Rye Brook, New York, in October 1987, of an entire session devoted to the results of the ESPRIT projects 97 and 1058.(1)

Another example of international acknowledgement was seen in an independent survey carried out by Queens University of Kingston (Canada) on software frameworks for CAD systems. This survey recommended the use



Screen of an ICD workstation running the system description capture language 'ASTRA' developed by British Telecom (ESPRIT Project 991).

(1) These two projects are closely linked: project 1058 (Knowledge Based Design Assistant for Modular VLSI Design) is developing a new fast extractor for use with the module generator under development in project 97, while the Structural Procedural Interface (SPI) which project 1058 is developing could become a platform housing Cathedral silicon compilers.

The topics addressed during the IEEE special session, which was called "Synthesis of DSP Systems at Leuven", were:
- Computer Aided Design of Digital Signal Processing Systems the IMEC view;
- Interactive Module Generator Design Based on Symbolic Layout;
- Electrical Timing on Behavioural Verification of CATHEDRAL-2.

of a system such as that developed by project 991, in preference to competitors such as Berkeley University's "OCT" and "VEM".

As a complement and support to the project-based R&D activities, close interaction and cross fertilization between the main CAD actors is being fostered via a series of technical workshops known as CAVE (CAD for VLSI in Europe). CAVE acts as a focus for the community researchers to gather twice a year to discuss their work. In addition to the normal sessions reporting on results in projects, a growing trend is the inclusion of special sessions which aim to discuss strategic issues of interest to the community. For example, in May 1987 a panel session discussed the problem of "Commercialisation of Results of CAD Research". Among issues discussed were:

- how to accelerate the use in an industrial environment of the latest CAD methodologies and tools;

- how to minimize the costs of reworking results when transferring them from the research environment to commercial use.

The actions under way and planned in ESPRIT which will provide some answers to these questions are:

- a new initiative, currently under discussion, aimed at reinforcing VLSI design skills in the Community;

- the publication of the ESPRIT Microelectronics CAD Catalogue (see above), which will increase the awareness in industry of new developments in CAD.

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3. TECHNOLOGY

Technology strives to move further the limits of the main physical constraints which IC design engineers have to face: packing density, speed of operation, and power consumption/dissipation.

The ICs themselves are the final product of an extremely complex manufacturing process which begins with the production of raw wafers and ends with fully tested and packaged ICs. The intervening processes include substrate production, deposition or growing of material layers (insulating and conducting layers), lithography and the patterning of devices, and doping of the active areas. All these steps are essential and all have to be carried out to extremely fine tolerances in order to achieve competitive production yields. The current feature sizes of advanced devices, of the order of one micron, require volume production machines capable of working to tolerances of a few tenths of a micron.

Technology work in Esprit encompasses such "process" work on different substrate materials, interconnection techniques, and selective application of these technologies to domains other than ICs, such as flat panel displays or magnetic recording.

These technology activities are here subdivided into "Silicon", "Compound Semiconductors", "Optoelectronics" and "Peripherals".

3.1 Silicon

Silicon semiconductor-based ICs constitute the vast majority of ICs used in data handling, signal processing, and consumer, industrial, and telecommunication applications.

For these ICs the goals are summarized in the stated objectives of ESPRIT MEL, to achieve by 1990:

- packing density - ICs containing the equivalent of one million transistors;

- speed - complex ICs with gate delays less than 100 picoseconds (ps);

- power dissipation - remaining below a maximum of 1 Watt/chip under current operating conditions.

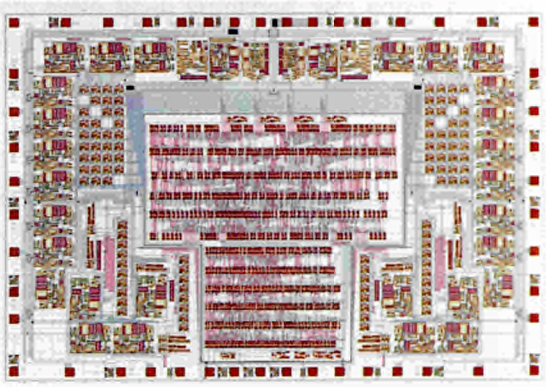
In pursuit of these goals, two mainstream developments of complete silicon processing techniques are being pursued:

- submicron CMOS technology (project 554 - SPECTRE), which represents the main thrust towards increased complexity and packing density, with the objective of developing the necessary building blocks for a 0.7 micron process, primarily dedicated to the production of fast digital circuits with 300 ps gate delay;

- submicron bipolar technology (projects 243 and 281), aiming at reaching a minimum feature size of 1 micron and a self-aligning transistor structure for very high speed digital circuits (delay times below 100 ps). Multilayer metalisation technique with up to four layers should allow an integration level of about 50 thousand gates per chip.

Besides these two major established directions, it was felt that the combination of bipolar elements with a core of CMOS logic could fill a gap between very fast but power hungry bipolar ICs and very large, speed limited, CMOS ones.

A major project (project 412 - BICMOS) was therefore launched to address this mixed technology. The primary target was to meet the needs of general purpose computing (where low power dissipation could avoid liquid cooling) and consumer electronics (where analog signal handling is an essential feature).



Layout of the first BICMOS demonstrator microchip; a high-performance, microprocessor controlled audio stereo source selector and volume controller. This chip features both analogue and digital functions and has a 70dB signal to noise ratio (ESPRIT Project 412).

This is now proving to have been a particularly farsighted decision, since the value of this mixed technology approach is now recognised everywhere in the world, especially in Japan, and the processes of bipolar and CMOS production have evolved to become quite similar.

After two and a half years work on these various projects is on schedule.

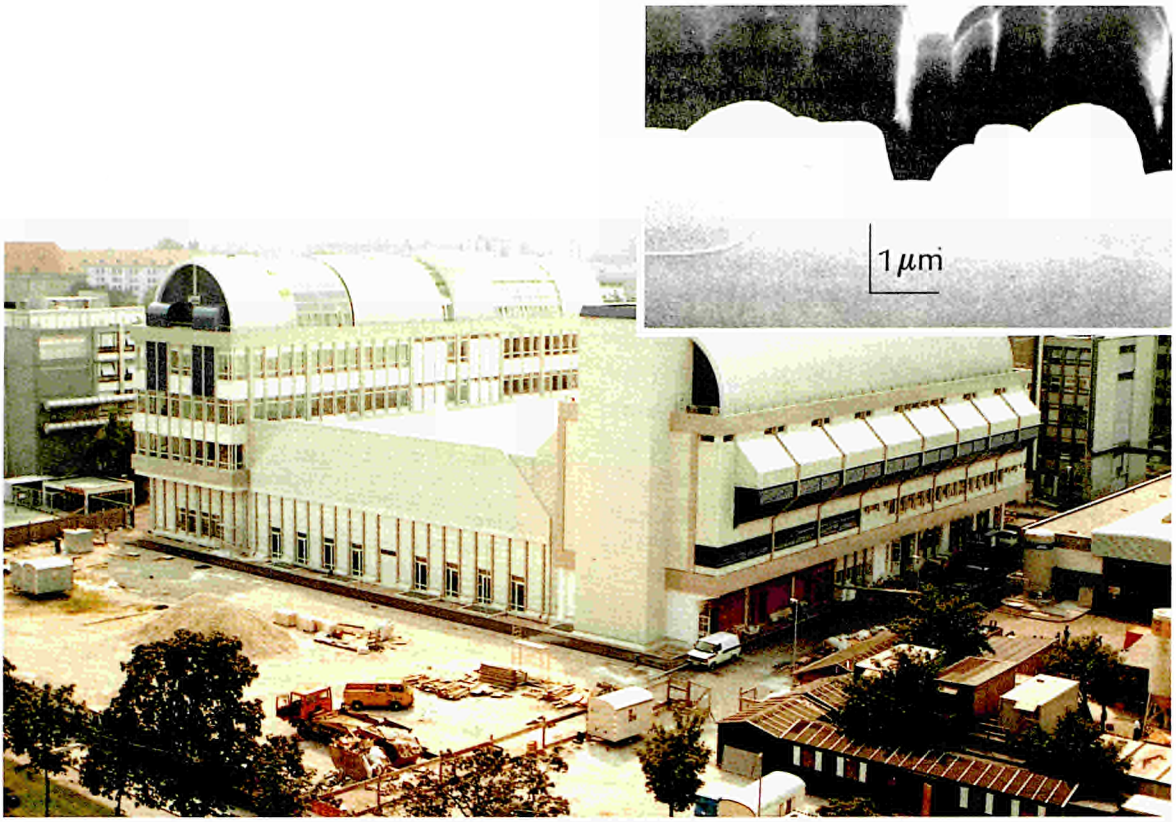
During 1986 intermediate achievements concerned work on individual process steps, simulation and choice of the demonstrator , joint definition of process flow, the issuing of design rules, and the realisation of common process evaluation and test masks.(2)

By the end of 1987 the SPECTRE project had demonstrated a 1 micron CMOS process by delivering a chip containing more than 100,000 transistors, grouped in building blocks featuring a systolic image processor and two 4K SRAMs (SPECTRE). This has enabled Matra Harris to transfer the technology into their fab-

(2) Technological evolution in microelectronics is characterised by the appearance and adoption in practice of "technology generations" (e.g. 1.5 micron, 1.2 micron). These are discrete evolutionary steps and tend to occur at intervals of 2 to 3 years.

The above projects are typically of 5 years duration and thus encompass two such technology generations.

Twice in the life of such a project, at the halfway point and at the end, a major milestone is represented by the realization of prototype circuits demonstrating the feasibility of the relevant technology generation. Such demonstrators can be of very varied nature, as their selection has to take into account, as well as purely technological requirements, the main industrial interests and product orientations of the industrial partners.



Cross section of a 1 micron bipolar transistor, the elementary building block for very fast integrated circuits, as seen through a scanning electron microscope. With 400,000 such elements in a single chip, a 9K array with a 200ps per gate delay is being produced by Siemens in a special new building in the Federal Republic of Germany (ESPRIT Project 281)

rication lines for 64K fast SRAMs and microprocessors, and STM to start the integration of selected process steps into the fabrication process of a 1 Mbyte EPROM.

Project 281 has built a 4K ECL RAM on-chip latch with 5 nanosecond access time, designed for cache memories and control store in computer applications (project 281) - one of the fastest semiconductor memories in existence today.

The results of project 281 have enabled Siemens to start the development of a new family of gate arrays. The design of these gate arrays uses improved design rules based on those used in the project to produce bipolar gate arrays of 10,000 gates.

The new process, called OXIS III H, which uses these design rules, enables a 40 per cent reduction of the power/delay product, and a 30 per cent increase in the packing density. This new gate array family, whose preliminary specifications have already been announced, provides a programmable power/delay product with 3 steps, which reduces power dissipation to an average of 1 Watt per 1000 gates. The complexity of these arrays will vary from 1,500 to 10,000 gates. First silicon is expected in the second quarter of 1988.

The Mixed Technology approach (project 412 - BICMOS) has achieved full integration of complex digital circuits (20,000 transistors in 1.2 micron CMOS) with analog devices meeting HiFi requirements. The project has produced a prototype chip, one sq. cm. in size, featuring a fully integrated audio control unit that can replace 7 electromagnetic switches and 3 poten-

tiometers. This not only reduces the dimensions and the weight (by a factor of 100) of the unit concerned, but also gives greatly improved reliability and longer maintenance free life to the end product.

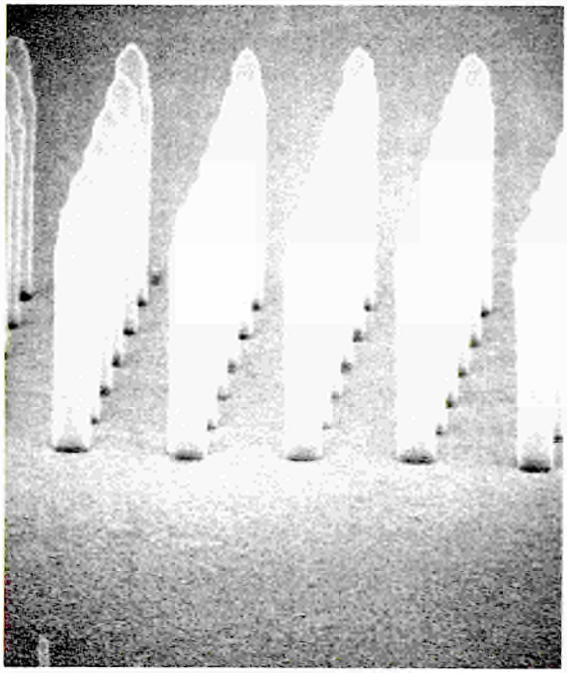
The processes needed for these achievements depend for their implementation on advanced equipment and systems for manufacturing and testing VLSI circuits. Progress on a given process step often goes hand in hand with the evolution of the machine necessary to perform it. Advanced process equipment, corresponding advanced techniques in process automation, and ultra-clean room facilities, are therefore key elements in the efficient and economic production of state-of-the-art ICs, whether custom or commodity.

Particularly from 1986 onwards, industry has shown considerable interest in this area. Although the resources initially allocated to this area in ESPRIT were rather limited (substantially more is now planned in ESPRIT II), 7 projects have been launched and some notable results are already emerging :

- the core of an advanced system using E-beam for the design validation of ICs has been demonstrated, reducing considerably the time required for the operation (project 271 - ADVICE) - negotiations are under way for full development and commercialisation;

- a novel reactive ion etching equipment capable of processing 200 mm wafers with 0.5 micron feature size has been developed (project 574); a prototype was recently shown at the Produktronika 87 Fair in Munich, with commercialisation expected during 1988.

In order to stimulate new activities, disseminate information on existing projects, and help the establishment of cooperating communities in specialized important subjects within the ESPRIT programme, two Technical Interest



The Leybold MPE 3003 - a 3 chamber reactive ion etching system developed by ESPRIT project 574 for cassette-to-cassette multistep processing of 200mm wafers.
Inset: a submicron structure (photoresists 0.15 micron) realised with this equipment.

The new R&D facilities of SGS-Thomson Microelectronics has just been completed in Italy. This lab is equipped with a 2500m^2 class-1 clean room, where full automation of process islands is being implemented (ESPRIT Project 1551). On this line STM is developing a CMOS technology devoted to ASICs manufacturing (ESPRIT Project 554). The inset illustrates a few cells of memory, designed for fine tuning of the process

Groups (TIGs) with corresponding series of workshops have been established. One TIG (to which project 1551 is pivotal) is on VLSI manufacturing automation and the other is on lithography. For more details see appendix 1.

3.2 Compound Semiconductors

Higher processing speed is one of the major goals for system designers. Gallium Arsenide (GaAs) technology is important in this respect because of its inherent potential for increasing the speed of memories and other major building blocks of computer-based systems.

In the last decade, the level of integration of GaAs ICs has increased rapidly. For the last couple of years the interest in applying GaAs ICs has been growing. This is evidenced by the number of new companies entering this business, especially in the USA and Japan, and by the commercial availability of MSI to LSI integrated circuits. A major application of these will be the new generation Cray III supercomputer, which is to include more than 40,000 GaAs ICs in its core.

However, compared with silicon, which is a very mature technology, where complex processing methods are resulting in good yields, GaAs IC processes are just taking their first steps towards maturity, and hence considerable further progress in materials and processing is necessary.

The specific objective of Esprit in this field is the demonstration, by the end of 1989, of ICs with 10,000 to 20,000 gates, a gate delay of less than 50 picoseconds, and a power/delay product of less than 100 femtojoules. This is being tackled by project 843 (Compound Semiconductor Integrated Circuits), which has chosen as demonstrator a 4K SRAM and various ICs for high bit-rate optical links and fast analog-digital converters. The first design of the 1K SRAM was demonstrated in 1986. This design is now being developed to be included in the Cray III supercomputer. A second de-

On characterisation techniques, ESPRIT is addressing notably the development of a laser assisted SIMS (Secondary Ion Mass Spectrometer) in project 1056 (Ultrasensitive Impurity Analysis for Semiconductor Structures and Materials). This equipment will allow better measurements to be made of shallow-doped regions of semiconductor chips, improving quality control, and will be used for contamination control in the ultra-clean semiconductor production steps.

Selected aspects of lithography (a critical step in the process of manufacturing I.C.s) addressed are 0.5 micron X-ray lithography, sources, masks, resists and transferred images (project 1007) and advanced mask and reticle technology for VLSI sub-micron microelectronic devices (project 1043).

The VLSI manufacturing automation area is addressed by project 1551 (Advanced Manufacturing System) aiming at establishing and implementing a long term strategy for a fully automated and integrated wafer fabrication facility. The emphasis is on techniques for increased yield and fast product turnaround.

Similar goals are being pursued by project 1563 (Automatic control of an ASIC Fabrication Sequence as demonstrated in the Plasma Etch Area) which is concentrating its efforts on the Plasma Etch Area.

sign of this memory, with improved access time (about 1 ns) and reduced area, was demonstrated in 1987. A set of multiplexer-demultiplexer ICs have been produced which operate at 4 Gigabits per second, the highest bit rate currently envisaged for optical fibre transmission systems.

Fabrication yield remains a limiting factor in GaAs manufacturing. Project No 1128 was set up to provide a supply of large diameter semi-insulating GaAs substrates suitable for LSI circuits. It has succeeded in growing 3" Indium-doped or undoped ingots, with low dislocation density, by decreasing thermal gradients during the growth. This has been achieved by using an original simulation code developed at the "Université Catholique de Louvain" to improve the pulling machines at Wacker.

The quality of the material so produced is second to none today, and can represent a solid base on which to build a strong commercial presence worldwide.

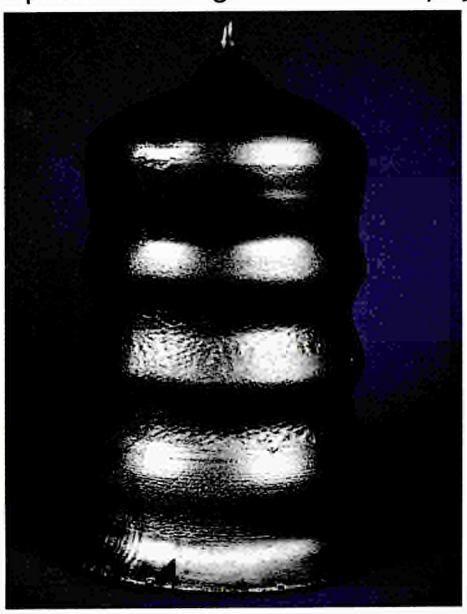
3.3 Optoelectronics

The associating of electrical functions and optical emitter/receivers on the same chip offers the possibility of a new generation of integrated optoelectronics devices (OEICs), with a large potential for optical communications. III-V compounds with a "direct band gap" structure also offer a whole set of optoelectronics capabilities.

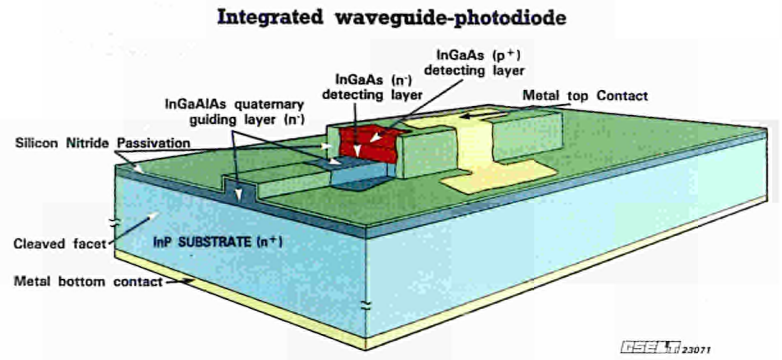
Project 263 was set to explore the various ways towards integration of electronic and optical devices. It succeeded during 1987 in demonstrating two integrated receivers:

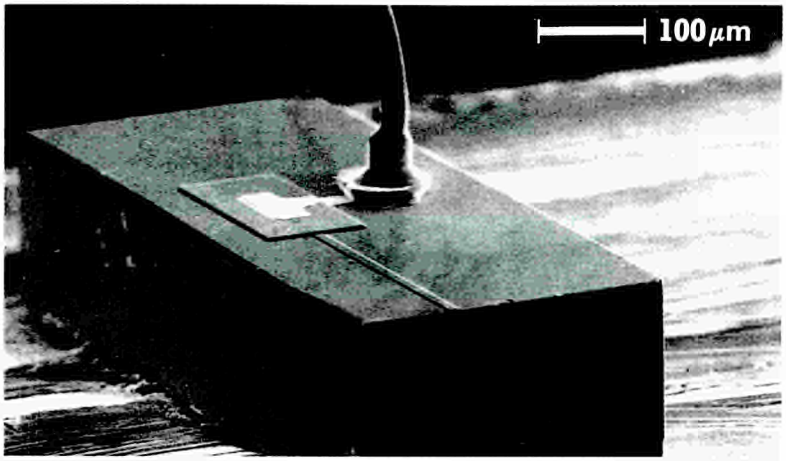
- a light guide ended by a photodiode, for easy connecting of an optical fibre to electronic equipment;

- a photodiode integrated with an amplifying



3" diameter undoped semi-insulating GaAs ingot with low dislocation density. Wafers sliced from such an ingot will permit the manufacture of GaAs integrated circuits at lower cost than is currently possible (ESPRIT Project 1128).





Waveguide integrated photodiode made using molecular beam epitaxial technology. This component will be integrated into a wavelength division multiplexer receiver for optical fibre communications (ESPRIT Project 263).

element, either a JFET transistor or a heterojunction bipolar transistor, operating at 565 Megabits per second, well adapted to telecommunication links.

These results and the new possibilities they offer are the basis for several projects in the RACE programme.

3.4 Peripherals

In addition to the activity directly or indirectly concerned with the production of ICs, other essential elements of informatics products are also being developed, based on techniques very similar to those used in the production of semiconductors. They include most notably non-volatile mass storage and input/output (I/O) devices.

Project 833 (completed in May 1987) and the complementary project 491 demonstrated interesting results at ECW87 in the form of prototype display and touch-sensitive input components.

These components are based on the use of liquid crystals directly addressed by thin film transistors fabricated in either a-Si or poly-Si material. The results point to the possibility of the eventual replacement of CRTs and conventional keyboards by solid state screens with touch sensitive areas. Ultimately these could become the principal means of I/O for future informatics products.

A single video frame (10cm x 13cm) from a prototype flat screen display, which uses active matrix LCDs with a resolution of 320 x 320 pixels.
Inset: scanning electron microscope view of a single pixel, showing the thin film transistor and part of the liquid crystal cell. (ESPRIT Projects 833 and 491).

SOFTWARE TECHNOLOGY (ST)

1. Introduction

The Software Technology programme has been designed to ensure that the European software industry will be equipped with the most appropriate methods and tools for the effective and efficient development of software systems.

To achieve this objective, three key needs have been identified:

- The requirement for a "standard" software development support environment which will provide a common basis for a family of integrated tool sets for software product development which is method, language and host machine independent. The standard development support environment will provide the basic utilities for object management, tools and user interfaces. This will enable full integration of the tools to ensure complete coverage of the software development process.

- A more rigorous approach to software system development. This will require a definition of design methods and the development of the tools to support these methods. Underlying this requirement is the need to provide a scientific basis for the future development of software engineering in Europe, and also the capability to move towards the goal of automatic transformations from specification to code.

- The above two requirements are concerned with achieving high quality software by the provision of the appropriate design methods, tools, etc. In many instances, the development of the software is carried-out within a very complex project structure. The effective project management mechanisms needed to control these projects must be defined and the appropriate tools developed if the ability to meet project development plans and to remain within allocated budgets is to be achieved.

Meeting these three needs would ensure a greater understanding and better control of the software development process, and provide the capability for the development of ever more complex systems efficiently and to plan. In addition, and to provide the capability to effectively monitor progress made towards the achievement of these objectives, the definition of appropriate metrics for software product development, and the performance of the software product itself, is included as an integral part of the programme.

The main directions taken for 1987 were to consolidate the standardisation actions launched in 1986, and to further encourage the industrial take-up of the results emerging from the projects. Currently there are 40 projects in

progress - 7 projects having been completed. Through these projects there are 165 organisations working in the Software Technology area.

2. SOFTWARE DEVELOPMENT SUPPORT ENVIRONMENTS

The aim of the work in this subarea is to provide the basic utilities for effective computer support to the software development process. To ensure maximum usage the basic utilities, which form the development support environment itself, should be independent of design method, high level language and host computer. The interfaces supported by the environment, especially the tool interface and the user interface, are particularly important.

These interfaces provide the opportunity for industrial standardisation and, therefore, have the potential of achieving an important degree of commonality in the development and use of tools produced for software development. The provision of appropriate development support environments allows the integration of management and design techniques which is a pre-requisite to achieving a tight control of the software development process. In ESPRIT, the Portable Common Tool Environment (PCTE) project (32) has produced the necessary interface specifications, the basic utilities and working prototypes of a development support environment which is at the core of the software technology programme.

The importance of this project has led to a number of complementary actions being launched to widen the use and the availability of the PCTE.

- The production of a set of general tools (syntax directed editors, desk-top managers, data manipulation languages, etc.) which run on top of PCTE - the PACT project (951).
- Porting of the PCTE onto non-UNIX operating systems - the PAVE project (1282).
- The production of formal specifications of the PCTE interfaces - the VIP project (1283).
- Evaluation of PCTE-based environments in controlled industrial experiments.
- The development of a full "software factory" based on PCTE - the SFINX project (1262).

The PCTE provides a development support environment for projects working within ESPRIT, and is now available to all participants in EEC funded R&D programmes and to European universities. To date, more than 60 licences have been released. Also a number of national programmes and EUREKA projects are working with the PCTE results, a complementary "PCTE+" programme has been launched and the European Space Agency has adopted the interface specifications for the Columbus project.

The PCTE interface specifications are now managed by an independent management board (the PCTE-Interface Management Board) which is made up of representatives from the computer industry, software industry, academia, and major development agencies. To supplement the C-version of the tool interface, the Board has released the Ada-version into the public domain. This will significantly ease the process of evaluating the PCTE as a basis for a full Ada Project Support Environment (APSE). Such a capability has been recognised as a major requirement for companies developing products for real-time applications. To further encourage the adoption of the PCTE interface specifications by industry, the specifications are currently being considered for ECMA standardisation. ECMA Technical Committee 33 has been formed for this purpose.

Following adoption by ECMA the interface specifications will be submitted to ISO.

The PCTE project has provided a clear lead for Europe in the development of state-of-the-art support mechanisms for software product development. To ensure faster use of the PCTE-based environment in industry, action has been taken to widen the availability of PCTE-based systems. One such action has been the launch of the SAPPHIRE project (1277) which is providing PCTE-based systems on a range of widely used workstations. A version of the PCTE running on a SUN workstation together with tools supporting the MASCOT development system and the Ada language have been successfully demonstrated by Software Sciences Ltd. of the UK. This SUN-based system, together with the Bull SPS 7-based system developed by GIE-Emeraude from France, are now available.

To take advantage of knowledge engineering techniques and other technological advances in, for example, the development of formal methods, action has been taken to develop the next generation of development support environments within the programme. This is a key issue since, to ensure that the industrial investment in the first generation PCTE-based environments is adequately protected, it is necessary that upwards compatibility with the PCTE is maintained. Full coordination of this work (both within the ESPRIT programme and other related programmes, e.g. EUREKA) is underway. Within ESPRIT, work is in progress on the development of environments which use knowledge engineering techniques embedded within their basic utilities to actively support program development and project management (project 1520 - ALF). Automatic environment generation for the support of specific methods is being addressed by the GIPE project (348).

Together, the PCTE and next generation environment projects, provide a good basis for industrialisation of software engineering practices. This is being achieved through the development of the technology itself, and the support of the standards necessary to ensure wide usage and protection of industrial investments.

3. DESIGN METHODS AND TOOLS

The application of an engineering approach to software development requires the adoption of a greater discipline in the development process, and depends on the provision of a scientific basis to software engineering, generally.

Problems stem from two causes: the inability to adequately describe the system as the design proceeds (in a way which allows the results to be fully verified and validated at each step), and the inadequate control of the development process as the design matures through to code production and system testing. In the short term methods have been, and are being, developed which provide mechanisms which allow a firmer control of the development process. By and large, these mechanisms involve manual procedures for verification and validation. These mechanisms, although rigorous in their approach, rely on the introduction of greater discipline rather than providing a stronger scientific basis to software engineering. In the longer term, it will be necessary to provide an underlying, more formal, basis in a similar way to that now available for more traditional engineering disciplines (eg. electronics, civil engineering, mechanical engineering). Within the ESPRIT programme the development and support of mathematically formal methods is being followed to provide this stronger base for the development of software systems.

From an industrial usage point of view, it is clearly necessary to ensure that we can properly bridge the gap between the informal and formal approaches. One project which is addressing this particular issue of integration

of formal and informal techniques is the GRASPIN project (125). The project has produced and demonstrated an integrated tool set which supports all aspects of software system development - requirements analysis, formal specification, incremental program development, design validation, documentation, etc. The original prototype was demonstrated on a personal workstation in 1986, and during 1987 has been transferred onto SUN-based systems and onto a distributed network of desk-top computers. The initial prototypes were developed on LISP and PCTE-based machines.

Although the application of rigorous, less formal, techniques is important in the short term, the main emphasis has been given to the development of formal design methods and the application of knowledge based techniques to software system design. These approaches are expected to provide the real industrial advantage and to do so within the lifetime of the programme.

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4. MATHEMATICALLY FORMAL METHODS

The need for validation and verification of the system design at each phase of the development process, i.e. from specification of requirements through system specification, high-level and low-level design to coding, has led to the definition of a number of methods based on formal mathematical theory. Applying these methods to the design of software systems is likely to provide the opportunity to give a basic engineering discipline to software production.

The definition and support of these formal methods has constituted a major part of the ESPRIT Software Technology programme. One method in particular, the so-called Vienna Development Method (VDM), has played an important role in the development of formal methods in Europe generally and has figured prominently in the ESPRIT projects. VDM is still undergoing further enhancement, but the central issue now is to accelerate the industrialisation of the method to ensure that the benefits to be gained from application of VDM are realised as quickly as possible. The RAISE project (315), has produced a preliminary systems development tool set based on the Vienna Development Method. The first industrial trial of the RAISE specification language, methodology and tool set commenced in 1987, and further trials are being planned in 1988.

A further advantage foreseen from the use of formal methods is the gradual movement towards automatic transformation from high-level design descriptions to code. The PROSPECTRA project (390) has produced a design support system which guides the user through a series of successive refinements by a set of rules which ensure correctness is preserved as the design proceeds. The PROSPECTRA system has been designed to address a large class of methodological problems with Ada as a final implementation target language. The choice of Ada as the standard language will ensure portability between different programming environments. The project is complemented by a PROSPECTRA demonstrator project (835) which will evaluate the system and provide cost/benefit information, training and other tool support for users.

Formal methods should also provide an important mechanism for the unambiguous specification of system interfaces. This would be particularly important for the process of international standardisation of interface specifications and for the subsequent conformance testing. The formal specification of the PCTE interfaces was mentioned in section 1. above. A further application included within the programme covers the development of formal specification languages for the definition of the ISO/OSI protocols. This was the objective of the SEDOS project (410) in which the ESTELLE and LOTOS languages were defined. These languages have already achieved draft

international standards status through CCITT and ISO. The SEDOS project was completed in October 1987. A complementary demonstrator project (1265)is underway which aims to demonstrate the SEDOS "technology" in a number of different fields where protocol validation is necessary.

5. APPLICATION OF KNOWLEDGE-BASED TECHNIQUES TO SOFTWARE SYSTEM DESIGN

A completely formal approach to software system design is unlikely to provide, by itself, a complete solution to the problems associated with the effective industrial development of software systems. Many aspects of the software development process cannot be described in mathematical terms and therefore other techniques are necessary to capture this additional information. The approach taken within the ESPRIT programme has included the integration of formal and informal methods (see the description of the GRASPIN project (125) above) and the integration of formal methods with knowledge engineering techniques.

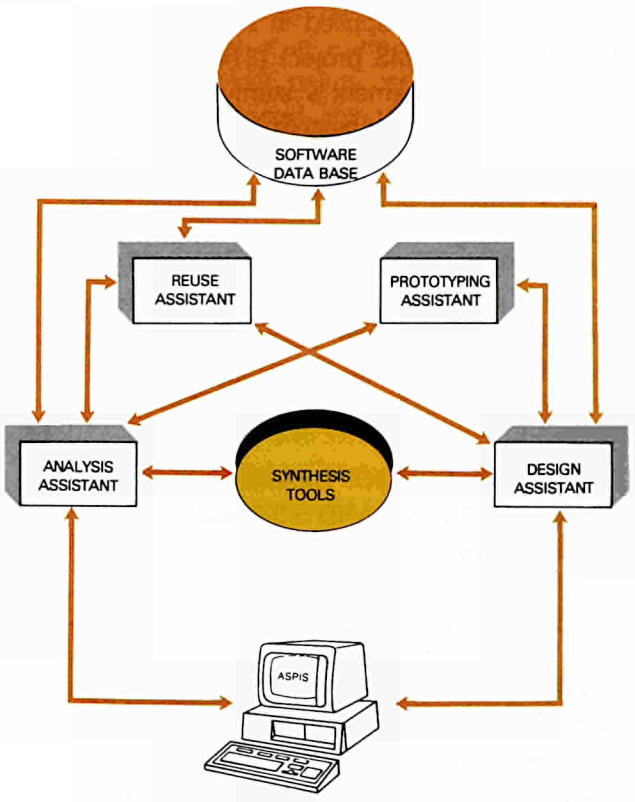
This work is carried out in close association with the activities underway within the Knowledge Engineering part of the Advanced Information Processing area (see chapter 3). Close technical and managerial coordination between the two areas has been ensured throughout 1987.

Knowledge engineering approaches show promise in several software development areas but the main results to date have been in the application of fast prototyping techniques to software system design - particularly in the area of the capture of user requirements. A prototype system for the analysis and design stages has been developed and demonstrated within the ASPIS project (401), and project KNOSOS (974) is incorporating knowledge engineering techniques within a mixed approach to rapid prototyping in the development of reusable software components. Results from both projects are close to industrialisation.

6. MANAGEMENT OF SOFTWARE DEVELOPMENT PROJECTS

Software development projects have been characterised in the past by cost and timescale overruns. The problems encountered in

ASPIS ARCHITECTURE



The APSIS project (ESPRIT Project 401) provides an intelligent interface to a software database. The system consists of four knowledge-based modules providing assistance for analysis, reuse, prototyping and design.

these projects have been partly due to the lack of adequate design methods, but the software development projects have often required complex support infrastructures of their own for which the appropriate management techniques have not been available. Once again, approaches are being followed which are based on both traditional methods of project management and on methods incorporating the techniques emerging from the knowledge engineering activities.

In the more traditional project management method style, the SPMMS project (282) has produced a prototype of the kernel of a project management support system. This includes a semantic data model for software development projects in order to provide a conceptual schema of the project process.

Knowledge engineering or rule-based techniques have been applied in two projects in this area. The PIMS project (814) employs a rule-based management system for use as a consultant or training system for the management of software projects. In the IMPW project (938), a project manager workbench has been defined for project planning, project control and general decision support. To date, the most significant progress has been in the definition of a generic cost estimation tool which forms part of the workbench.

7. METRICS FOR SOFTWARE DEVELOPMENT AND SOFTWARE SYSTEMS

The definition of metrics for software development productivity and software product characterisation (in terms of quality, reliability, performance, etc.) has proven extremely difficult. A major problem has been to achieve broad agreement as to the identification and definition of the metrics to be adopted. In an attempt to identify and define the key metrics, a working group was formed, consisting of many of the experts in the field in Europe, but to date, this has achieved very little success. Another attempt to resolve the problem will be made in 1988 by which time further experimental data should be available.

The main project in the area of metrics, the REQUEST project (300), has begun to produce some good results after a rather slow start and a rationalisation of the sub-tasks of the project. During 1987 the project has successfully coordinated its activities on the definition of a data model with a number of member state programmes. Hopefully, this will provide a basis for future progress in the definition and adoption of standard metrics for reliability and quality. The data model is implemented within a data library into which results from a number of projects across Europe are being entered. REQUEST has also produced models for quality and reliability control and prediction together with the associated support tools for data collection and analysis.

Other complementary projects, of recent origin, concentrate on the specific application domains of fault-tolerant systems (project 1609 - SMART), real-time embedded systems (project 1257 - MUSE) and systems reliability and testing (project 1258 - TRUST).

8. ADDITIONAL TOPICS

Other facilities and tools to support software development and software applications are being developed in ESPRIT. Two of the more significant results achieved in 1987 have been:

- the production, in the ATES project (1158), of tools for proving the correctness of scientific algorithms;
- the implementation, in the DIAMOND project (1072), of algorithms in PASCAL SC and ADA, for high accuracy floating point operations.

ADVANCED INFORMATION PROCESSING (AIP)

1. Introduction

The next generation of information processing systems will require:

- *The development and application of knowledge engineering techniques.*
- *The development of new computer architectures for symbolic and numeric processing, and fault tolerant systems.*
- *The development of advanced system interfaces for effective communication between computing systems, the computer and its environment, and the computer and the user.*

In 1987 priority was given to consolidation and acceleration of the industrialisation of the results emerging from the projects.

Results have been achieved particularly in the knowledge engineering and architecture projects where a firm base is now being built for the future enhancement and exploitation of these technologies and techniques by European industry.

- In the knowledge engineering area the OMEGA shell developed by Delphi SA (in project 440) has proven to be a significant advance on the early systems on the market and OMEGA is now in use by organisations in Europe, US and Japan. The PCE, an object oriented programming system, developed by the University of Amsterdam, has been released onto the market. PCE is also an example of the results of one project being used successfully by other projects within the programme.
- In the architecture area the Supernode project (1085) has achieved significant progress during the year. The T800 transputer developed within the project by INMOS is now available for industrial use. Within the same project APSIS has developed the "Lucky Log" simulator for computer aided design which runs on the Supernode machine. Lucky Log is currently undergoing field trial prior to release. In the field of fault-tolerant distributed systems the DELTA-4 team has developed a technique to give system protection against a local station failure. This technique involves the addition of a plug-in module to an existing machine, which is fully compatible with ISO/OSI specifications.

40 projects are in progress in the Advanced Information Processing programme. To date a

total of 9 projects have been completed successfully, and two projects terminated earlier than planned. 193 organisations are participating in this part of the programme.

2. THE DEVELOPMENT AND APPLICATION OF KNOWLEDGE ENGINEERING

The objective of the work in this domain is to accelerate the successful introduction of knowledge-based systems to a wide variety of application domains within industry. This ensures that maximum benefit is gained from the use of the fast maturing knowledge engineering techniques both in end-products and in the design, manufacture and maintenance phases of the product lifecycle.

The approach adopted was to:

(i)develop the methods and techniques for knowledge acquisition and knowledge representation;

(ii)develop domain-specific systems;

(iii)develop application independent knowledge-based system "shells", supporting languages, and user interfaces;

(iv)evaluate knowledge-based systems in the industrial environment.

The main target set for 1987 was to encourage wider industrial use of the knowledge-based system shells developed within the programme. This was tackled through a number of actions aimed at evaluating the use of the systems in specific application domains. The domains chosen included disease diagnosis of agricultural crops (project 1063 - INSTIL), financial investment advice (project 316 - ESTEAM), the control and diagnosis of faults in advanced telecommunication switching systems, and the control of electrical power distribution networks (project 387 KRITIC).

2.1 Knowledge Acquisition and Knowledge Representation

Of the two main approaches to knowledge acquisition, the more established is based on interviews with experts. The second is to derive principles from an analysis of case studies and examples.

ESPRIT projects cover both of these approaches. A system for knowledge acquisition by interview was developed by a partnership between SCS, STC, University of Amsterdam and the Polytechnic of the South Bank, in an early ESPRIT project (304). The system, named Knowledge Acquisition and Structuring or KADS, helps the KBS designer to structure the interview process, and, by using protocols of expert consultation, to elicit the requisite expertise. The original organisations, together with SCICON, have incorporated the KADS system into the PCE KBS tool kit which was first demonstrated in late '87. KADS is being used within a BMFT funded programme, and has supported the analysis phase of KBS development in several commercial projects undertaken by the partners.

The second approach to knowledge acquisition develops a set of rules from an analysis of relevant examples. GEC, Cognitech and the University of Paris Sud, the three partners of project 1063, are currently making an industrial evaluation of tools they have developed to support this process. The integrated learning system which forms the kernel of the system is being strengthened by the inclusion of methods for dealing with incomplete problem descriptors and noise. The ability to generate a knowledge base is being tested by a trial application to disease diagnosis in agriculture. The rules that are emerging are being evaluated by experts in this domain.

The target of the knowledge representation work is to bring computer representation of knowledge closer to conceptualisation and ex-

pression by systems designers.

The problem is one of representing concepts (and their defining characteristics) and the relationships between them, in a form that allows the application of reasoning processes. Semantic networks, and logic combined with an object-oriented approach, are two knowledge representation formalisms being examined as the basis of possible solutions to the problem of knowledge representation.

Several variants of semantic networks are explored in ESPRIT projects. Project 280 has developed a type of semantic network called a generic graph to represent user and information system modules; such models evolve as they adjust to growing expertise on the part of the user, reflecting the systems experience of the interaction and the current usage of the system. A prototype system to provide both instruction and help to users of the UNIX mail system has been demonstrated. The first prototype of a generic help system will be available in the Spring of 1988.

Another form of semantic network representation to cope with a more dynamic modification of knowledge, has been studied by DELPHI and the Free University of Brussels in project 440. This has been partially implemented in the OMEGA expert systems shell now on the market. During 1987 the Knowledge Representation System (KRS) also developed in P440 was taken to the market by Knowledge Technologies, a small company associated with the Free University of Brussels.

The results gained by CISE and FRAMENTEC in project 256 on the representation of qualitative or functional models of complex physical systems, such as power plants, are now the basis of an application-oriented project. This project (820) was launched to design a KBS architecture and tool kit for real-time process control applications. Prototype applications are in the course of development for three areas: a thermal power plant, a cement manufacturing plant and operator support in the control room of a geostationary satellite.

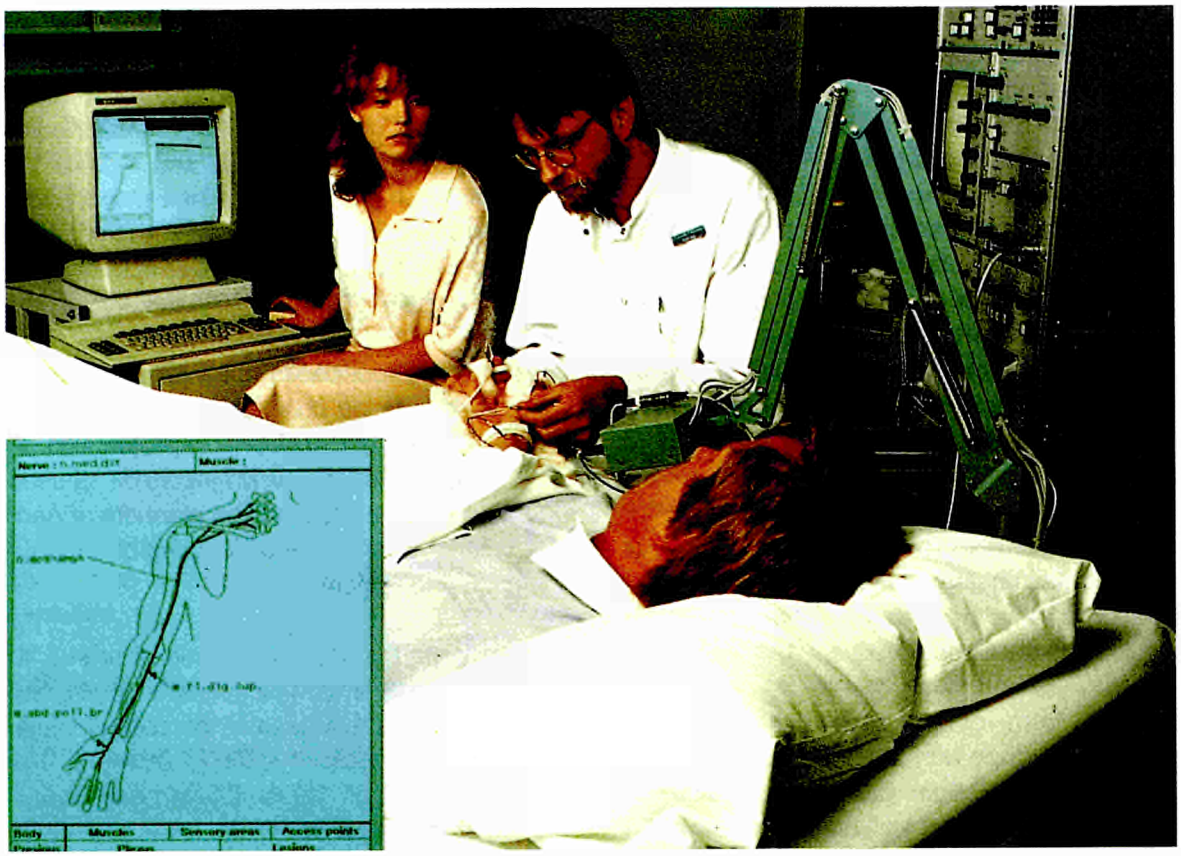
2.2 The Development of Domain-specific Systems

Here we are concerned with systems for specific types of application, viz. manufacturing scheduling, real-time control, and medical diagnosis. Each project combines the application of domain-specific systems with the development of new tools, some examples are as follows :

- A flexible tool package for job shop scheduling is being created by Battelle, Aeritalia, ELSAG, and ITALCAD in project 865. A demonstrator for this project is being used by the aircraft production planners of Aeritalia for operational scheduling of a manufacturing system.

- An expert system shell with features to handle the stream of real-time input and output data that arise in the control cycle, has been built by BBC, CRI and the Universities of Kassel, Leuven and Strathclyde in project 857.

- In project 599, a prototype system has been constructed to assist the consultant in electromyographical diagnosis from the analysis of bioelectrical signals from muscle and nerve tissue. It also advises on the test procedures to be performed. The novel approach adopted combines both causal and probabilistic models for diagnostic purposes, in a single network. Furthermore, it is well-integrated with the equipment and other aspects of the diagnostic system. The team of medical and software partners has successfully taken into account such aspects as user considerations and professional acceptance in the design of the knowledge-based expert



A knowledge engineer working with a doctor to perform an electromyography test on a patients arm (ESPRIT Project 599)

system. This system was successfully demonstrated in the Autumn. One of the partners, Dansk Medico Elektronik (Judex) a computer engineering company working on real-time systems, are incorporating the design of the user interface and the knowledge-based system into their range of medical equipment.

2.3 Evaluation of Knowledge-based Systems

Industrial use will not necessarily readily follow the availability of the systems emerging from the programme. Much needs to be done to ensure the acceptability of a product or of a technology after its development. Consequently, several projects are directed to obtaining information on the costs and benefits accruing from using these systems in an industrial context.

This information is being obtained through an evaluation of prototype applications within three of the smaller projects started in 1987. These evaluations will provide material to assist the management, selection, support and use of KBSs.

In one of these projects, an intelligent tutoring system shell for training is being evaluated. The project is identifying how to cut training costs and increase training effectiveness. Using an initial prototype, ITT, IET and DATAMAT are evaluating the results of commercial, scholastic and industrial field trials concerned with training in the use of office automation procedures.

2.4 The Development of Application Independent Knowledge-based System Shells, Support Languages, and User Interfaces

The majority of knowledge-based systems consist of an inference engine, a set of rules, and a database containing domain specific information. For any particular application it is necessary to develop the set of rules and provide the domain specific data. Clearly it would significantly reduce the cost of developing a particular knowledge-based system if a kernel system was available which could be tailored to any specific application domain simply by providing the necessary rules and domain specific information. Knowledge-based system "shells" provide such a kernel, and because of their potential regarding the reduction in development costs of knowledge-based systems they have been given major emphasis within the programme. Two particular systems developed within the programme are already available. The OMEGA shell from project 440 is being marketed by Delphi SA in Europe, the US and Japan and is being hosted onto the PCTE which will be a very useful facility for industrial users. A second system, the Expert System Builder (ESB) developed in project 96, which provides a complete environment, compares very favourably with the KEE and ART shells, produced in the US, which are the current market leaders.

The efficient implementation of knowledge-based systems has required the development of logic-based programming languages. In Europe the Prolog language has played a prominent role, and the enhancement of Prolog and its integration, into appropriate development support environments is of strategic importance to the effective development of knowledge-based systems.

Throughout 1987, steps have been taken to achieve a European-wide consensus on a common definition of Prolog and, in parallel with this action, an ISO working group is to be officially formed in March.

Prolog III which extends Prolog by the addition of powerful numerical capabilities, has been fully specified by Prof. Colmerauer, the inventor of Prolog, and his team, in project 1106 and a complete implementation is available. It is being used in the development of an expert system for the diagnosis of failures in an automobile engine component by Daimler Benz and Bosch.

A further enhancement of Prolog to provide an interface to the international graphics standard, GKS, has been completed in the ACORD project (393). The aim is to provide a Prolog graphics capability and natural language parsers are being implemented using the enhanced Prolog.

The development of a new logic programming environment consisting of advanced tools (e.g. a rational debugger, a language-oriented editor and a graphics interface) is being undertaken in project 973 - ALPES. Prototype versions have been demonstrated, and their integration is now in progress. Exploitation prospects are being evaluated by the prime contractor, CRIL.

Because of the very large amounts of data required in many industrial applications of knowledge engineering techniques it is very important that efficient interfaces are developed which will support effective interaction between the inference engines and the data-

bases. Three projects are addressing this particular issue and useful results have emerged. The exploitation of the BIM Prolog compiler was described in "ESPRIT - Progress and Results". For the other two projects:

- Within the ADKMS project, Bull, Nixdorf, Olivetti, and four universities have implemented an interface representation of two natural language parsers with a hybrid knowledge representation system called BACK. One parser is rule-based. The other is based on a linguistic theory which is being implemented in a computer system for the first time.

- Techniques that combine rules and relational algebraic expressions are being developed in the EPSILON project (530). A prototype workstation has been produced which demonstrates the feasibility of using commercially available software tools, in this case UNIX-based Prolog, and a commercially available relational database. In a second work package, a prototype has been developed that connects the DBMS workstations into an integrated KBMS.

3. THE DEVELOPMENT OF NEW COMPUTER ARCHITECTURES

The need of high performance computers capable of processing symbolic and numerical information will increase significantly over the next few years as the results of the knowledge engineering work and the advanced man-machine interfaces become embedded into a wide range of applications, eg CAD, office systems. The decision was taken at the outset of the ESPRIT programme to concentrate on the development of highly parallel architecture machines, and the appropriate software, to achieve the performance levels required. The use of parallelism also gives the additional potential benefit of providing flexible architectures suitable for a large range of system performance. To ensure that a sound basis was provided for the development of these machines one of the first ESPRIT projects (415) was launched to study the performance of the different approaches to symbolic processing on parallel architecture computers.

The results to date include :

- The design of the architecture for parallel object-oriented systems has been completed, and the operating system, the POOL 2 language and its compiler are now available.

- The first prototype of a logic machine, based on a Virtual Inference Machine, is now available.

- A data flow system has been designed.

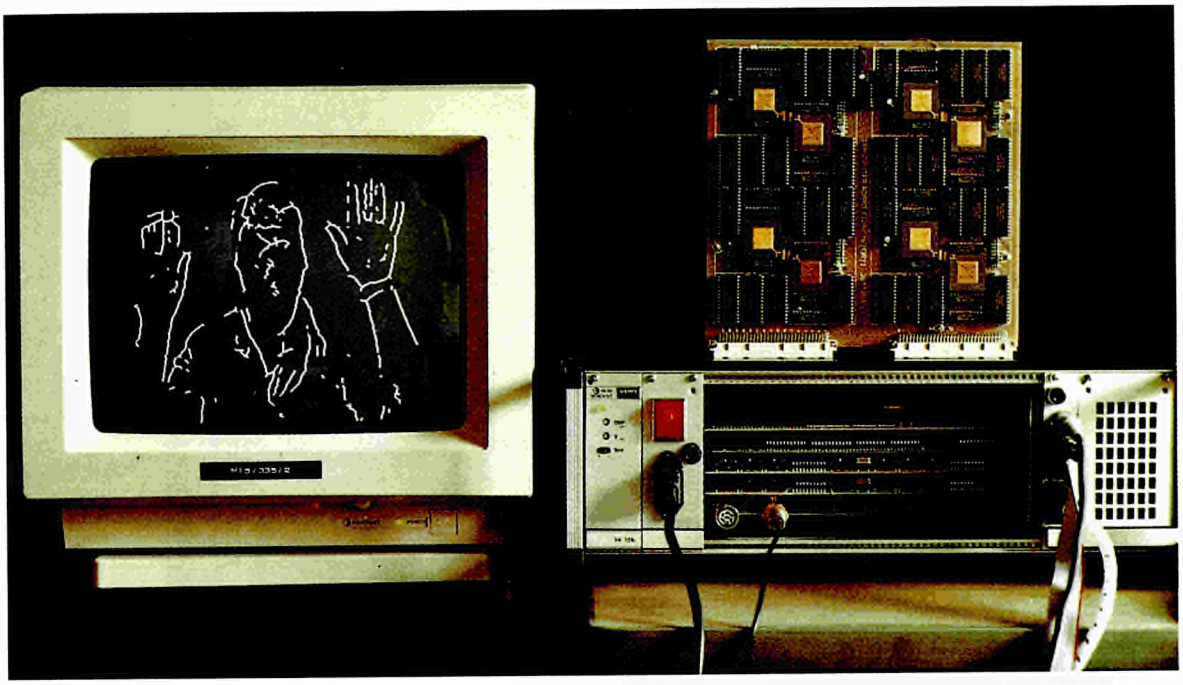
- An implementation of a functional parallel programming language (FP 2) is now running, and has been used as a programming language for a parallel inference machine based upon the connection method.

- A wide European forum on parallel computing has been established through the organisation of an international conference on parallel architectures and languages.

A particularly important objective in the computer architecture area was to develop a low cost, high performance parallel computing capability. The Supernode project (1085) has achieved spectacular results towards this objective, making substantial progress in four key areas:

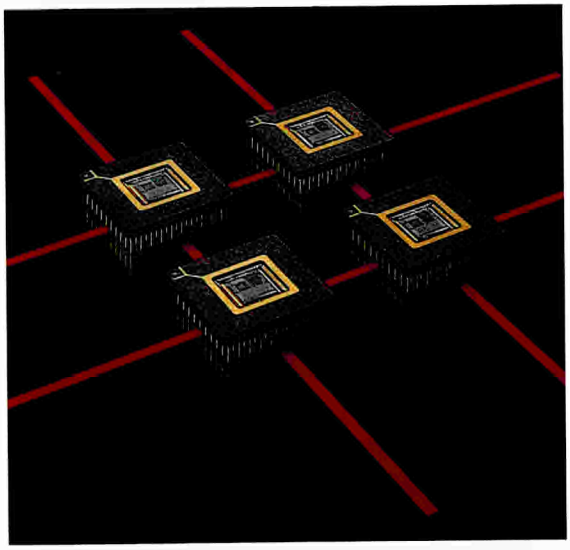
- The basic processing element. A floating point version of the transputer - the T800 with 350,000 transistors, and capable of 1.5 MFLOPs or 10 MIPs - is available and is already being exploited by INMOS.

- The interconnection architecture and a



Edge detection by the analysis of information intensive camera pictures, as a step in image processing (ESPRIT Project 1085)

non-blocking switch element. A highly modular architecture interconnecting nodes of 20 transputers each, has been designed. The architecture is fully reconfigurable with a project target of up to 64 nodes through the use of software controlled VLSI switches.



The T800 transputer, developed in ESPRIT Project 1085, which is the basic building block of the Supernode minisupercomputer.

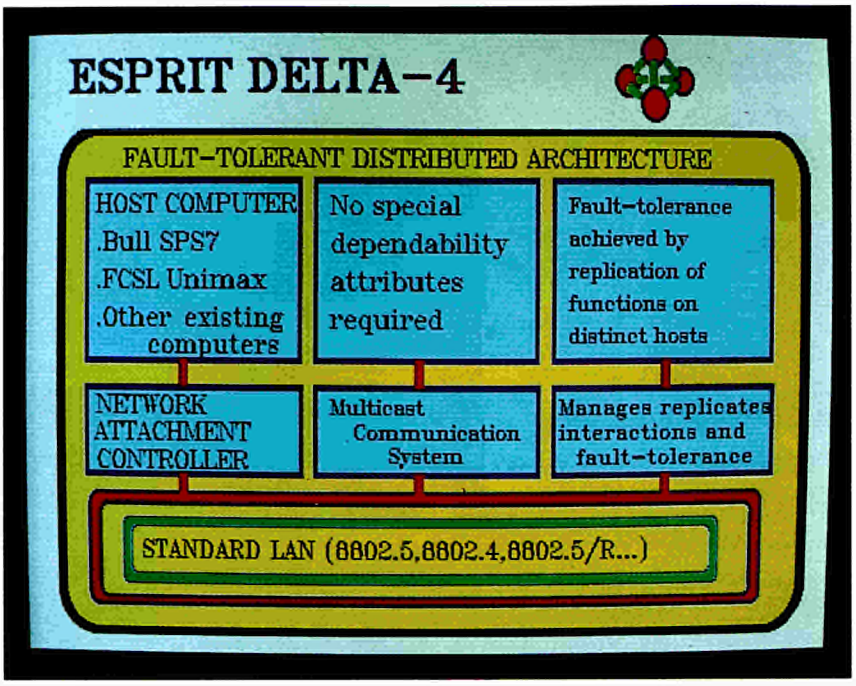
- Input/output interface components. Components are being designed capable of handling data at a rate of 100 Mbytes/sec through a number of 20MHz channels. This will allow on-line, real-time handling of high resolution image information, and many other data intensive applications.

- System software. Supernode is currently programmed using OCCAM and versions of the OCCAM support system, TDS.

Early single node prototype machines are available, and have been publicly demonstrated. The project partners forecast that the work will result in the delivery of machines employing 320 transputers with a performance of 380 MFLOPs.

The industrial exploitation is well underway with TELMAT and Thorn-EMI, who are two of the partners, planning commercial versions of Supernode.

The Supernode project (1085) has demon-



By using a module developed in the Delta-4 project, distributed computer systems can be protected against local station failures. Automatic re-configuration overcomes individual node failures (ESPRIT Project 818)

strated, during 1987, its flexibility and wide applicability in domains such as CAD and image processing. The Lucky Log simulator for computer aided design developed in the project by APSIS is currently undergoing industrial field trials prior to general release.

A further important aspect of system architecture development is in the field of fault tolerant computing tackled in the DELTA-4 project (818). This project has developed a technique to give a distributed computer system protection against local station failures. The technique involves the addition of a plug-in module developed within the project, which can be added to any machine, whose I/O ports conform to the ISO/OSI specifications. A distributed system employing these modules can then automatically reconfigure to overcome individual node failures. A multicast communication system implemented on a LAN was demonstrated in early 1987. Demonstrators of an RT Unix prototype and a Remote Service Request prototype have been developed, and work is under way on a Delta-4 system architecture and computational model.

4. DEVELOPMENT OF ADVANCED SYSTEM INTERFACES

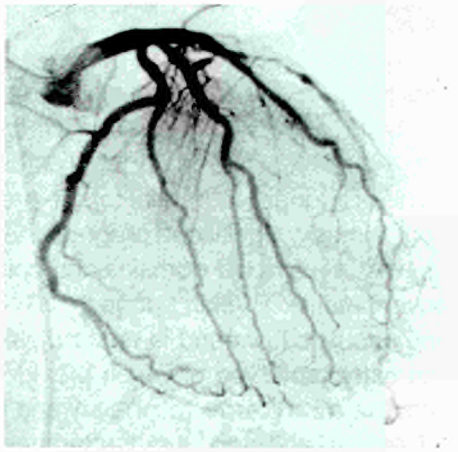
The prime objective of this part of the programme is to achieve computer understanding of the environment from external sensors. The work has concentrated primarily on image processing, natural language understanding and speech processing. Furthermore, the topic of multi-sensor operation has been added recently to complement the ongoing work, however it is too early to report significant progress from the projects in this field.

4.1 Image Processing

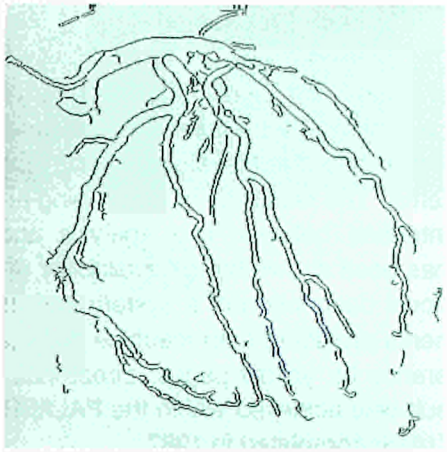
The initial aim is to develop systems capable of analysing and understanding 2-dimensional and 3-dimensional scenes and sequences of pictures (four-dimensional scenes).

The analysis by computer systems of static

Using Computer Vision to Identify Blood Vessels in an X-ray (ESPRIT Project 26)

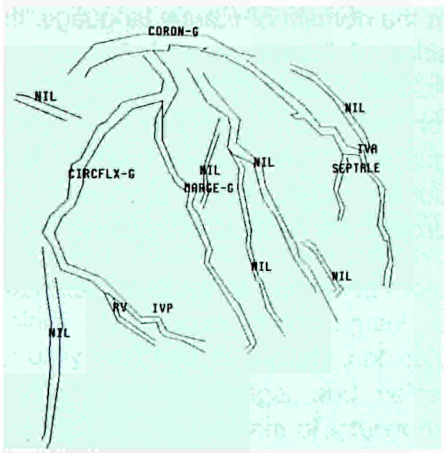


a) angiographic image of the coronary arteries



b) edge extraction using image processing

c) approximating the edges of b) using line segments



d) identification of the vessels on the angiographic image

2–dimensional and 3–dimensional scenes and of moving scenes is already finding application in domains such as stress analysis, robotics for computer controlled manufacturing systems and security systems. In the area of 2-dimensional image processing a set of algorithms for the processing of medical X-ray images has been produced in the SIP project (26). These algorithms are now being implemented in a prototype system which uses an explicit model of the scene (the organisation of the blood vessels) together with knowledge-based reasoning techniques to control the different processing levels. In the areas of 3-dimensional scene analysis and motion the following results are particularly interesting for industrial exploitation :

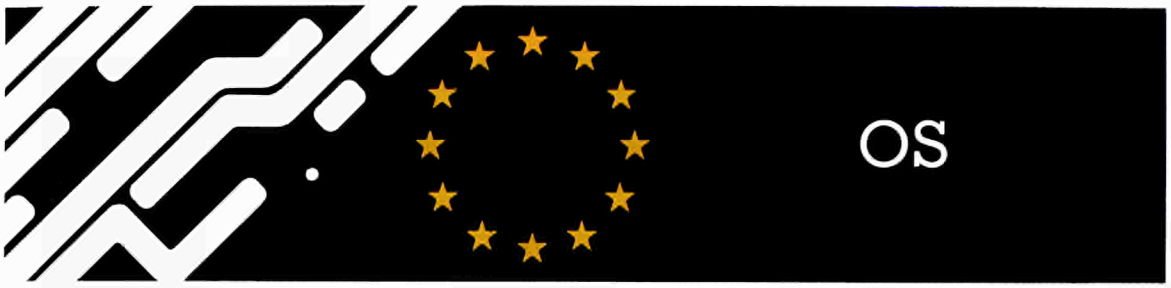
- A portable interactive software environment called VIS to generate or interrogate multiple representations of images or image sequences. The VIS system is currently being evaluated prior to full exploitation.
- A low-cost prototype system, using off the shelf components, for depth computation of objects in an industrial scene.
- A very fast stereo image processor which is currently being extended into an integrated depth and motion analysis system.

4.2 Natural Language Understanding and Speech Processing

The most significant results achieved to date have been in the areas of natural language dialogue and the development of speech systems. The feasibility of developing an effective interface between text analysis and speech has been shown by the availability of the functional description of a system and its components providing man-machine dialogue for reference to "yellow pages" directories. This result was achieved within the PALABRE project (1015) completed in 1987.

In the domain of natural language, the Universities of Edinburgh and Stuttgart within the ACORD project (393), have produced parsers for the French, English and German languages. These parsers together with the deduction component produced within the project are capable of handling complex sentences, e.g. sentences which require pronoun resolution.

The availability of systems capable of understanding continuous speech in noisy environments is a requirement for many application domains. This is a longer-term goal for the programme but already significant progress has been made within restricted domains and controlled environments. Within project 26 a stand-alone acoustic front-end is under development, an early prototype of which provides lexical access to a very large vocabulary and is capable of recognising continuous utterances under restricted conditions. Sentence recognition at a speed close to real-time is expected from the system by end 1988. This front-end sub-system is currently being connected to a sentence understanding sub-system which uses knowledge-based techniques. The understanding sub-system is being implemented on a parallel machine based on the transputer.



OFFICE SYSTEMS (OS)

1. Introduction

In Office Systems the solutions to information management problems are heuristic in nature, i.e. it is neither possible to predict all possible uses of a system, nor the intensity of its use nor its geographical extension, since the ways in which it will be used depend on the individual or group needs and on the experiences of the end-users.

R & D has to aim for systems that are generic in many respects and easily adaptable. This in turn requires a high degree of standardisation where standards are so defined that they do not limit flexibility but rather allow easy interworking and system reorganisation. The main elements of the ESPRIT office systems strategy are therefore "interoperability" and "adaptability".

The results of projects in Office Systems are presented according to four issues that have been addressed with priority worldwide, namely: communications, document structure, workstations and human-machine interfaces, and integration of information management.

Office systems can interoperate only if they are able to communicate. ESPRIT, upon adopting the Open Systems concept, has implemented the progressive definition of the Communication protocol layers of the OSI reference model in order to improve interworking capabilities. This sector has therefore been addressed under the heading of "Communications".

However, physical communication is necessary but not sufficient, since systems at each end must understand what they are sending each other, i.e. : "documents", which are the principal object used within an office and exchanged between offices to transfer information. "Document Structure" is becoming more complex since the concept of "document" is being gradually enriched to include not only text but also graphics, image, and voice. ESPRIT has tackled the problem of interworking with such multimedia documents and has developed a standard office document structure. ODA - the Office Document Architecture - is now an international ISO standard.

While office systems get more and more sophisticated, office workers need interfaces which enable them to exploit the full power of these systems in a highly efficient way and interact with them in a user-friendly manner. ESPRIT, therefore, has helped the development of more powerful and better performing "Workstations and Human-machine Interfaces".

The key to a smooth implementation of any office information system, and its ultimate goal, is complying with the needs of business and enabling office workers to carry out their tasks more effectively. To this end ESPRIT has

backed up systematic studies on "Integration" of technological solutions and user needs for user satisfaction.

Currently there are 44 projects in progress, with 172 organisations participating - 5 projects have been successfully completed, and 2 terminated earlier than planned.

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2. COMMUNICATIONS

Starting from the concept of Open Systems and the OSI reference model, the ESPRIT Programme recognised that further elaboration of OSI standards was needed and that the development of wide band communication technologies, complying with these standards, had to be pursued. Broadband communications for local and wide area networks together with the definition and implementation of distributed systems have thus been the main issues.

2.1 Network Technology

The distribution of processing power to workstations and servers required the development of networks that allow interoperation of these units. The variety of application environments suggests a range of options from which the network solutions will be selected with the optimal characteristics for the particular application.

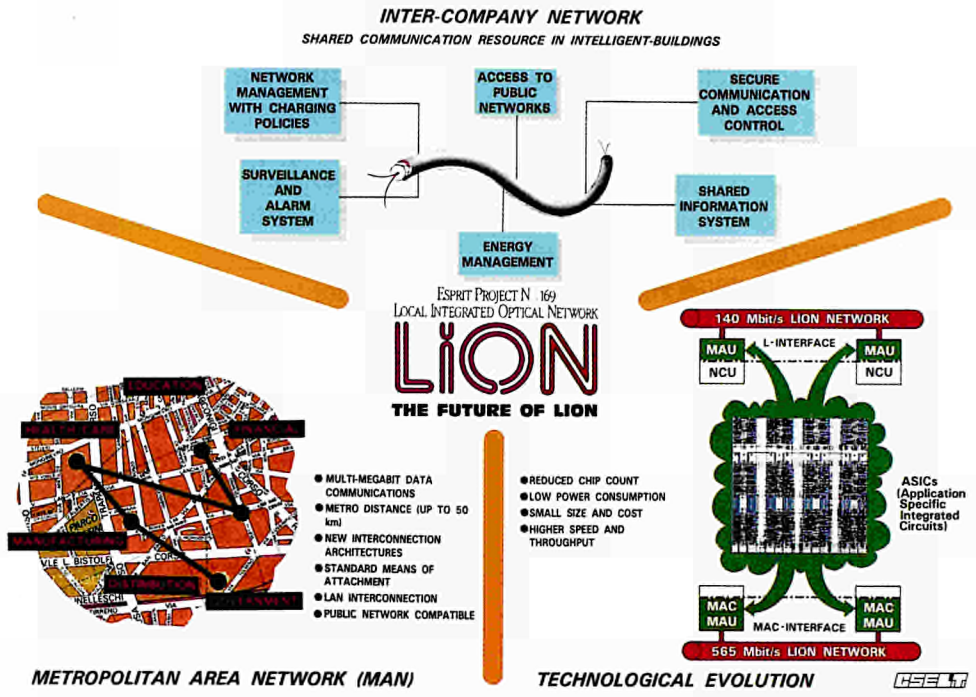
The increasing demand for multi-media high-volume traffic is compounded by the increasing number of units that have to interoperate. Bandwidth is therefore an important parameter to characterize a network.

Notwithstanding many other parameters that are important, timeliness is a characteristic that is crucial in real-time applications. Packet-switched networks allow efficient use of available bandwidth but will be less appropriate in demanding real-time environments. Project 73 (BWN) is in this category. Circuit-switched or hybrid-networks on the other hand allow application to real-time processes but do not fully utilize the available bandwidth.

The BWN project, run by ACEC, Bell Telephone, Stolmann and France Cable & Radio, has implemented a prototype at 140 Megabits per second, in operation at the University of Liège, with facilities giving access to ISDN, PSTN and satellite communication systems. The packet switched backbone network, connecting OSI compatible LANs of different manufacturers, uses a token ring protocol with duplex bridges operating at 1.7 Megabits per second, and is expected to foster the implementation of multivendor networks in high data rate communications environments.

The goal of the LION project (169) is to develop a LAN for laboratories, manufacturing and office environments, with an ultimate raw data rate of 565 Megabits per second. LION uses a hybrid protocol capable of handling packet switched traffic and of simulating circuit switched operation. A 140 Megabits per second prototype network has been implemented and was successfully operated at the 1987 ESPRIT Conference by CSELT, Alcatel-TITN, and NKT, with a variety of services connected, from phone sets to video cameras, computers, and measurement equipment. The implementation of the physical layer at 565 Megabits per second is under development now.

The UCOL project (249) is investigating the use of optical links, including those using coherent light, to give a bandwidth of 10 Gigabits per second. The research is aimed at applications requiring very fast response time, such as laboratory and industrial control systems, and bulk data and multiple TV transfers. So far, the project has defined in detail the architecture needed for such network and has developed protocols, which have been submitted to the "Metropolitan Area Networks" Group of ECMA for discussion about their potential adoption as standards. Novel hard-



Local Integrated Optical Network with a wideband capability. A multi-service network developed for global communication in different environments, for example, hospitals, universities, research laboratories and industrial organisations (ESPRIT Project 169).

ware components have been implemented and successfully tested by FACE Standard and GEC with the Politecnico of Milan. This project has identified appropriate and feasible choices for ultra high bandwidth networks for enterprise networks in the '90s.

2.2 Gateways and Bridges

The OSI framework permits several alternative implementations of LAN/PABX protocols. To allow full interoperability between OSI component systems, it is therefore necessary to provide a standard terminal/network interface to enable any terminal to be connected to any LAN or PABX, and high-performance gateways between networks using differing protocols. These problems are addressed by two projects. The "E-Interface" project (43), carried out by major companies, Philips, British Telecommunications, OCE, RCE/SESA, CSELT, GE-Marconi, Nixdorf, Plessey, TITN and the Universitiet van Twente, has implemented two alternative interfaces, based upon the formal specification of a serial link interface. This specification has been submitted in 1987 to ECMA for consideration as standard. The PANGLOSS project (890), grouping 7-Technologies, CAP, PCS and the Universities of Reading, Twente, and Liège, has implemented a gateway, with highly parallel architecture, offering the high performance needed for linking differing OSI systems. Such a gateway, fundamental for the operation of large networks linking major corporations, public administrations and hospital systems, and for supporting the expansion of VANs (Value Added Networks), has potential for industrial exploitation in 1988.

2.3 Distributed Systems

Operating System design, to fully exploit the resources available on networks, must have the components integrated in a coherent way to provide truly distributed operations, allowing optimal usage of resources and fault-tolerance, a standard interface to application pro-

grammes for these to run independently of configuration, and full manufacturer independence through OSI standards.

To achieve such goals two approaches have been adopted:

- Top-down approach - develop a general model for distributed systems in the framework of automata theory. Differentiate between closely coupled systems and global loosely coupled sub-domains ; derive required features from the modeling approach.

- Bottom-up approach - largely based on existing standard software and available experience on architecture, operating systems, programming languages, etc. Build bridging software between subsystems and develop operating systems largely based on existing products and standards.

The partners of the CSA project (237), Plessey, MARI, Philips and Synergie, have taken the "top-down" approach in the investigations of the requirements and desired functions for their distributed operating system. Starting with an abstract object-oriented modeling of business information systems, taking into account even sociological aspects, they developed a distributed automata theory. The strategic distributed architecture for ordering the tasks associated with an office environment, being developed in a prototype, provides all the attributes for the industrial implementation. The partners are active in the Open Distributed Processing Committee of ISO to see that CSA gets adequate exposure and verification.

The global distributed architecture investigation in the COMANDOS project 834 has been developed following the "bottom-up" approach, by putting together pre-existing heterogeneous hardware and software components using appropriate tools for integration. Olivetti, BULL, ICL and Nixdorf together with six research institutions have then specified and developed the distributed system kernel, systems services, interfaces and languages. They further defined and classified the tools according to the functions they are supporting in distributed systems.

3. DOCUMENT STRUCTURE

The aim of this area has been to develop and establish an industry Office Document Architecture (ODA) standard for multimedia documents comprising text, images, graphics, and voice annotations for manipulation, transfer and interchange between products and applications of different manufacturers for different users. The important actions concerning multimedia documents and the elaboration of the ODA standard have consisted of promoting document standards and implementing standards into industrial prototypes.

A first milestone was reached through the HERODE project (121), led by Siemens and Alcatel-TITN, when the ECMA 101 ODA standard was established very quickly in 1986. The subsequent elaboration of the ISO 8613 ODA standard was concluded in 1987. Voice editing is being investigated for inclusion into the ISO standard, as well as the extension to represent semantic content of documents. The ISO 8613 standard has received much attention also from companies outside Europe, and is being incorporated in the CCITT's T.400 and T.500 recommendations. These activities are undertaken by the PODA project (1024), the partners of which have supported the development of Document Application Profiles in SPAG, the Standard Promotion Application Group set up by a number of European IT companies that is providing a valuable complement to the ESPRIT work.

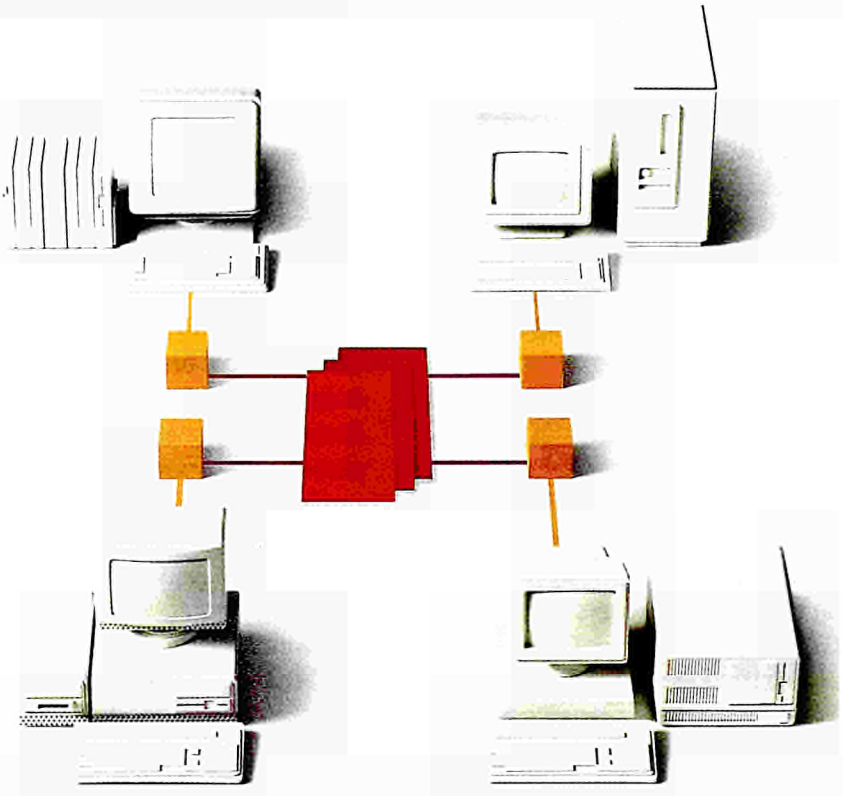
The ODA concept has already proven to be of great importance for structuring of multimedia

data in information systems. In the course of their evolution, six ESPRIT projects in the Office Systems area have adopted the flexible and powerful ODA framework for structuring, manipulating, and exchanging information. Five of these achieved results in 1987, which are presented below.

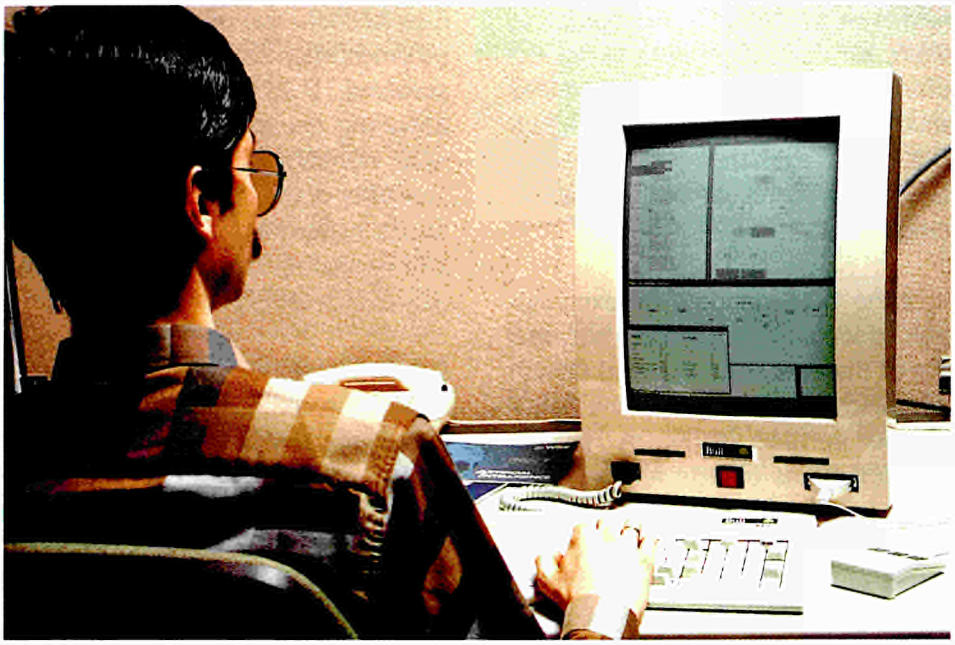
The power of the ODA standard for exchanging complex document structures between workstations of Siemens, ICL, Bull and Olivetti was demonstrated as a world first at the CeBIT fair in Hannover in 1987, by PODA project (1024). The capabilities of ODA are only fully exploited, if integrated in the document creation process itself. The PODA consortium has developed such a fully integrated editor based upon the ISO 8613. Further extensions of ODA are being planned and the partners in the consortium have submitted to ISO proposals for inclusion of voice annotation and geometrical elements in future additions to the standard. PODA has been most successful in achieving acceptance and recognition of the ODA standard by demonstrating the practical feasibility of the interchange of documents between equipment of different manufacturers and in proving its suitability as a basis for document handling in office systems.

Development of a multimedia document archive server has resulted in the document server, of the MULTOS project (28), which was presented at the 1987 Esprit Conference by Olivetti and its project partners. This server now comprises a powerful text query processor to match the query with the text content of the document base.

Furthermore, ODA enables the integration of



Office Document Architecture (ODA) aims at allowing the complete interchange of complex documents containing multimedia information (texts, pictures, etc.) in a multi-vendor distributed office system. The picture shows the schematic set-up of word-processors by Bull, Olivetti, ICL and Siemens for transferring ODA documents. As part of the Open System Interconnection Framework, the ODA standards have been supported and accepted by the International standardisation bodies ECMA and ISO (ESPRIT Projects 121 and 1024).



Screen layout from a demonstration of software tools for easy development of complex office applications on an advanced workstation developed by ESPRIT Project 82 (IWS) using the Bull Metaviseur hardware. Similar hardware is used by ESPRIT Projects 367 (SOMIW) and 956 (COCOS).

storage and retrieval of multimedia documents with that of data and rule bases pertaining to the office, thereby leading to complete office information servers. In the DOEOIS project (231), ICL, BULL, Fraunhofer Institute and Trinity College Dublin have developed the FACT storage and retrieval model, covering documents, data and procedures, the prototypes of which will be completed in 1988.

In the INCA project (395), GEC, Olivetti and Nixdorf have developed an ODA-SGML (Screen Graphic Mark-up Language) editor for handling multimedia documents for electronic publishing. The standard for the interchange of documents is based on ODA implementation exploiting the X.400 protocols.

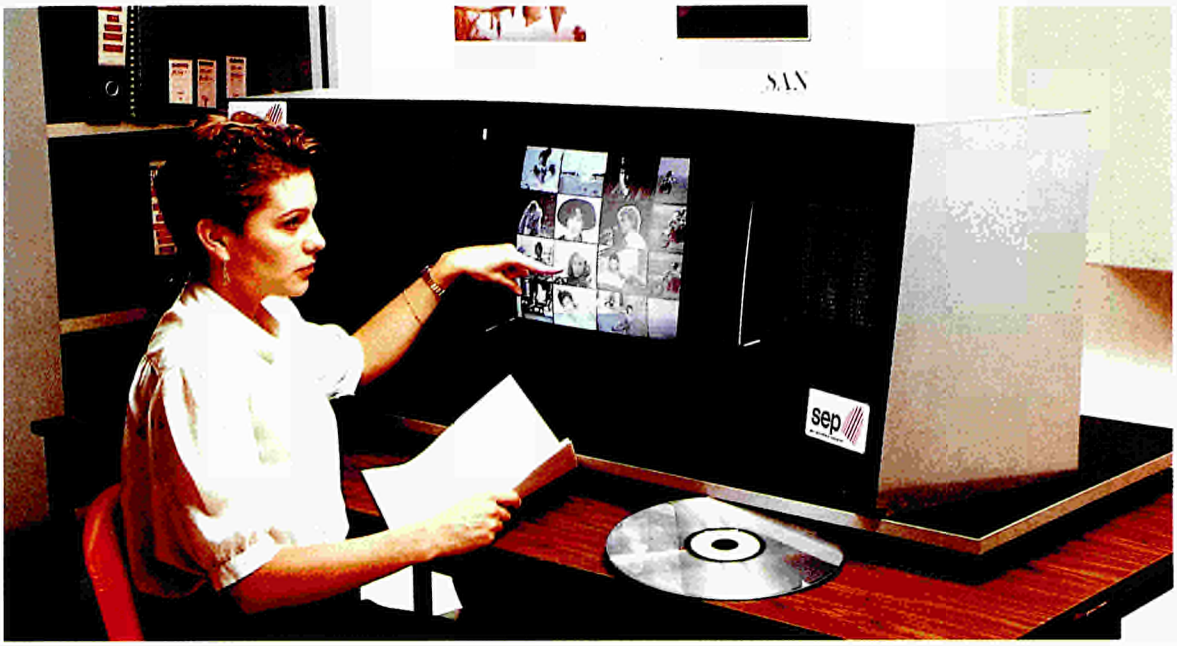
The ODA standard has also been adopted by the SOMIW project (367) for handling documents. BULL, AEG, CSELT and INRIA with four other partners have integrated the document handling applications into a common object oriented architecture implemented by the filing and retrieval modules within the workstation, integrating also the results of the "Paper Interface" project 295, that developed an editor for mapping A4 bitmap images into documents structured according to ODA.

4. WORKSTATIONS AND HUMAN-MACHINE INTERFACES

Workstations are the fastest moving system components, both in performance/cost ratio and market penetration. A few European companies have shown an impressive growth record in the low and medium ranges of this market, although the high end of the market is hardly addressed by European companies.

4.1 Advanced workstations

With the progress of the market requirement for systems handling coherently text, voice, and images, the multi-media information models and the related technologies are expected to develop very rapidly. Consequently, workstations capable of fully supporting such multi-



The 'Imageur Documentaire' is a system for the management of large image collections using the laservision ROM (Optical Disc) standard, as developed in ESPRIT Project 901. Possible applications of the system are for handling press images and for referencing illustrations of fine-art pictures.

media documents need to be developed.

There is a strong tendency towards standardization in the workstation area, but cost/performance considerations lead to a range of workstations with processing power and functionality as the main parameters.

Four different workstations have resulted from ESPRIT projects. They are presented here in the order of increasing processing power, although the sets of functions implemented differ widely and are not ordered in a particular way.

Philips, BBC and Logica have developed a truly multi-media (data, text graphics, speech still image and video) optical disk filing system with a human-machine interface that is outstanding for its ease of operation. The project concerned is project 901. The system is implemented on different microprocessors. The software allows a user to scan very easily extremely large multi-media data files, stored on the optical disks, LVROM (Laser Vision ROM). This technology has been patented and is a de-facto standard. The results have been used in the well known 'Domesday' project undertaken by the BBC. Over 1000 of these Domesday disc systems have been sold as a public source of information: in schools, colleges, universities, libraries, tourist information offices and government offices. Several other applications have been developed throughout Europe. This project resulted in a technological breakthrough, but even more important, it opened a market for new services that is expected to develop rapidly. Companies that were not in the project have already developed services that are very similar to those demonstrated by project 901.

Nixdorf, in the INCA project (395), has developed a medium range office workstation with A4 screen and powerful user tools and implemented the ODA-SGML editor for this workstation.

By adding in particular local storage, encryption modules, further I/O facilities and com-

munication interfaces to the Metaviseur, the SOMIW project (367) is concentrating on the provision of a workstation capable of handling multi-media data, taking advantage of the bandwidth afforded by ISDN and the distribution capabilities of the UNIX operating system. The development of both hardware and software involves the provision of various input/output devices for voice recognition and encoding, optical character recognition and video conferencing. The result of this work was successfully demonstrated at the CeBIT Fair in Hannover in 1987.

A high quality desktop technical workstation with graphics and voice interfaces has been developed in the IWS (Intelligent Workstation) project 82. The major achievement of the IWS project is the integration of different facilities in a single desktop workstation. The Operating System is UNIX-based. A User Interface Management System, consisting of tree editor, forms manager and visual programming facilities, enables the easy development of user interfaces. The Knowledge Representation System (KRS) developed by the Vrije Universiteit Brussel has been adapted to the office application environment by the project team formed by Bull, OCE and INRIA with three other research institutions. An authoring system developed by the University of Nijmegen has been added as an advanced application dealing with natural language input, utilising the basic IWS tools.

The development of flat panel displays for workstations is an area where improvements are expected to give significant competitive benefits. Project 612 is implementing a flat-panel display simulator. When realised, it will significantly reduce costs for the technology and application development industry. The architecture and all components of the simulator are available and assembly has begun by OCE, Cimsa-Sintra, GEC, Myfra, Universiteit van Twente and Barco. Barco has designed a CRT with novel characteristics, including shading correction, linearisation of the CRT transfer function, 180 MHz bandwidth video amplifier, and digital and analog input.

4.2 Human-machine interfaces

The development of basic algorithms and specialized signal processors for advanced systems interfaces for effective communication between the computer and the user, falls within the scope of the ESPRIT Advanced Information Processing area. The Office Systems area has been tackling the more specific application side by dealing with the integration of the specific research results into the workstation and application environment. Three interface areas are addressed in ESPRIT Office Systems:

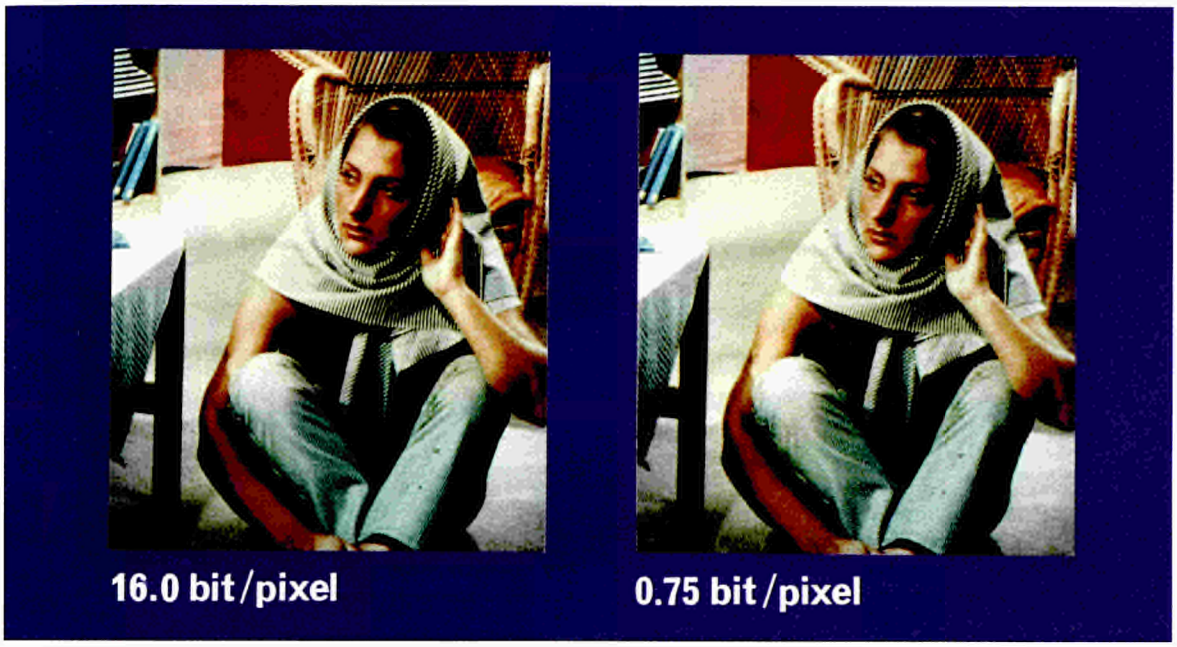
- vision: one of the important issues for human machine interfaces. Much work has been done to enhance the quality of the image. Image compression techniques, important for efficient communication and storage of pictorial information, have produced very encouraging results for both still and moving pictures.

- speech: while progress in speech technology overall has been slower than anticipated, there have been useful results in some areas.

- paper and "electronic paper": paper can be seen as an "indirect" man-machine interface, and one very important at the present stage of development of office automation.

4.2.1 Vision

In the field of still pictures advanced compression techniques have been developed by British Telecommunications, IBA , KTAS, Dr Neher Laboratories, CSELT, CCETT and Nixdorf in the PICA project (563). Two algorithms from this project, one 'Transform' type and one 'Predictive Coding' type, have been sub-



Photographic videotext image compression. The technology, developed by ESPRIT Project 563, provides a compression ratio of about 20 to 1 which still gives a good quality image afterwards. This technology provides the basis for the definition of an international standard for high quality image storage and transmission.

mitted to the joint ISO/CCITT committee for consideration as international standards. The first of the two algorithms, Adapted Discrete Cosine Transform, has been selected from 12 proposals submitted by Japanese, U.S. and European industrial groups as producing the best quality pictures after compressing a studio quality still picture from 800 kbytes down to 12 kbytes, and will now be developed into the world standard.

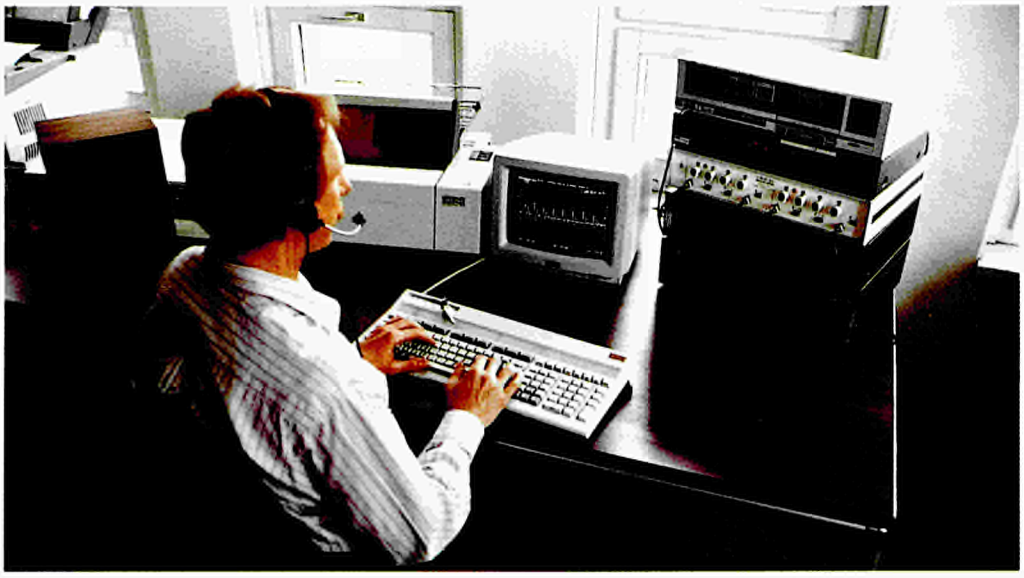
As for moving pictures, computer simulated results have confirmed the feasibility of real-time transmission of moving images over a 64 Kbit/s link with the technique developed by CIT-Alcatel, SAT, Philips, GEC, SEPA and Telefonica in project 925. When fully implemented this technique will allow the use of ISDN as a carrier for video conferences. The project has submitted their moving image compression algorithm as a candidate for the CCITT standard.

4.2.2 Speech

In the area of speech recognition, speaker independent recognizers for French and Italian, each with a vocabulary of 130 words, have been developed in the SPIN project (64). In addition, the consortium has produced synthesizers for French, Italian, and Greek and has demonstrated a "multipulse" coding algorithm for compressing speech to 9.6 Kilobits per second.

An essential condition for the development of multilingual interfaces utilizing linguistic knowledge is the ability to gather such knowledge in a way which is systematic, easily accessible, and language independent. The 'Linguistic Analysis of the European Languages' project (291), by a "multi-lingual" consortium lead by Olivetti, has accumulated basic linguistic data for 7 languages : Greek, Italian, Dutch, German, French, Spanish and English. The methodology used should enable the extension of the system to other languages. The data base is available for use by speech technology projects at cost.

The 'Multilingual Speech Input-Output Assess-



Demonstration of a dialogue with the workstation using "Speaker Independent" speech recognition and synthesis developed by ESPRIT Project 64 (SPIN) for use in office systems. There is a choice of two languages for the recognition (French or Italian) and a choice of three languages for the synthesis (French, Greek and Italian).

ment; Methodology and Standardization' project (1541) has in its first phase established a standard protocol on recording conditions for speech test material, enabling comparisons between recordings in different Community languages. Basic test sets in 5 languages have been produced according to this protocol, and a speech technology test workstation has been implemented. This project is closely linked to the SPIN project to define broadly acceptable cross language standards for office and other applications.

4.2.3 Paper

The 'Paper Interface' project (295), carried out by AEG, Olivetti, Philips and Plessey, deals with the techniques for the automatic transfer of information between paper based systems and electronic systems. An extremely advanced experimental multi-font character recognizer has been developed and demonstrated. The device is capable of distinguishing between textual, graphical and pictorial data. In parallel with this, an experimental handwriting analyzer based on dynamic pattern recognition techniques has demonstrated a first prototype, and high speed multi-colour high resolution scanners and printers are currently under test.

5. INTEGRATION OF INFORMATION MANAGEMENT

This is a domain requiring multi-disciplinary research teams, including psychologists, management scientists, and system engineers. For products to be successful in the marketplace, they must both be functional for end-users ("Human Factors" research) and answer the real needs of the user organisation (systems analysis, design and implementation aids). The integration of these requirements with the technology into products is the aim of ESPRIT work in this area.

5.1 Human Factors

The key project in this area is the HUFIT project (385), which has as its objective the rapid incorporation of Human Factors research results into the development of products. Some of the most significant HF labor-

atories and academic institutions throughout Europe cooperate in the project: Fraunhofer IAO, Husat, Bull, Philips, Siemens, ICL, Olivetti and the Universities of Cork, Münster, Minho, and Piraeus. The project is building a common "Human Factors for Information Technology" knowledge pool, and the momentum built by the project has already permeated the industrial development strategies and processes.

Many detailed results can be reported, particularly in the area of software ergonomy. As a test case, the Olivetti word processing product Oliwriter was evaluated by HUFIT before it was released. DIAMANT, a HUFIT-developed tool to develop graphical interfaces, has been adopted by Siemens for their software development. INTUIT, to assist in the design of human-friendly software, has been adopted by ICL software development.

The HUFIT project played a major role in the definition of the German standard DIN 66234 and in the preparation of the ISO standard ISO/DP 9241.

5.2 Systems Analysis and Design

To evaluate the extent to which an Office Information System meets the needs of users a complete methodology is required, covering the whole life cycle of OIS development from the specification of requirements to the design and implementation of an OIS architecture. A methodology for the first phase of the life cycle has been developed in the FAOR project (56) by STL, BIFOA, GMD and EAC Data; it was delivered in June 1987. The FAOR method uses an interactive - developer and user - phased approach in making explicit and formalising the system architecture and functions required. This approach guarantees user involvement and acceptance throughout the development life cycle. In addition the method provides benefit analysis techniques for determining the advantages and disadvantages of applying various office systems. By using this approach an organisation will be able to choose the system which best supports its business objectives.

The FAOR methodology has been published in a book and applied in other ESPRIT projects, such as the TODOS project (813) which is aimed at providing computer-assisted analysis and design tools oriented around the activities of an organisation. The initial prototype of C-TODOS (the architecture of the design environment) was demonstrated at the Polytechnic of Milano in October 1987.

A more formal approach in designing an office system has been taken by the OSSAD project (285). The approach adopted has three objectives :

- providing a structure covering the entire life cycle of a system from description of the requirements to implementation of the relevant facilities;
- providing means of analysing and designing the organisational structure and technical system in an integrated fashion;
- developing means of describing the functioning of a system to be understood by non-technical people.

The office language "OSSADIC" developed by IOT, CETMA, IPACRI, and the University of Milano can be used to specify technology/human behaviour interfaces. The results of the project are described in the OSSAD manual, published in 1987, which has been successfully applied in field trials in banking projects in Germany, Italy and France.

In general, the uptake of Information Technology into office environments has not matched the expectations of the IT industry, in part because of failure to understand and analyse the human, organisational, and economic factors

involved. The 'IT-Uptake' project (1030) (Memory Computers, Irish Medical Systems, Empirica, Work Research Centre) provided a set of guidelines enabling manufacturers, suppliers and end-user organisations to improve their understanding of these factors. The project created a model, completed by early 1987, providing a framework and detailed guidelines. The model has subsequently been applied in field trials in office, manufacturing, and remote work environments. This project explicitly explored the impact of technology on work organisation and the changes expected in the market place with the introduction of new technology. To exploit the project results, a new consultancy company, "IT-Uptake", has been set up in Ireland to provide services to the software industry.

COMPUTER INTEGRATED MANUFACTURING (CIM)

1. Introduction

For IT and factory automation vendors, CIM is a fast-growing yet relatively new market, where those who get established early can reap considerable advantage. It is an application area in which no single vendor can provide the complete solution and where interfacing costs form a substantial proportion of new investment. Within ESPRIT the CIM strategy has been to develop an environment in which multi-vendor systems can be implemented at reasonable cost, therefore priority has been given to projects that are designed to influence standards for open systems interconnection. Simultaneously, selected CIM subsystems have been developed. which have the potential to provide Community IT suppliers with significant market opportunities

Accordingly, ESPRIT CIM developments and progress are reported in two technology areas:

- Design Rules, Architectures, Communications and Interfaces aimed at creating a unified framework conforming to the ISO-OSI reference model.

- CIM subsystems in areas where strong market opportunities exist. This section covers methods and tools for real time manufacturing control, and shop-floor systems including robot controllers; sensors for welding, assembly and inspection; and various simulation tools.

2. DESIGN RULES, ARCHITECTURES, COMMUNICATIONS AND INTERFACES.

The objective in this area is to reduce the cost of designing, installing and maintaining manufacturing systems, by providing a unified framework based on the ISO model for Open Systems Interconnection.

Companies with existing investments in computer assisted design and manufacture are well aware of the difficulties in interconnecting the equipment of different suppliers. There are frequently incompatibilities of languages, data structures, data formats and communications protocols. These are the cause of much frustration, delay and expense (accounting for some 50-70% of CIM implementation costs). This greatly inhibits progress, especially in the smaller manufacturing companies.

This area is implemented through four key projects: open system architectures, communications, CAD interfaces, and robot integration. The joint involvement of users and vendors

encourages a pragmatic approach and the rapid application of results. The impact of this area on standards for CIM is already noticeable.

Project 688 (A European Computer Integrated Manufacturing Architecture - AMICE) is developing a generic architecture for CIM based on open systems concepts (CIM-OSA), together with implementation guidance for users. Intermediate results are being used as inputs by European representatives on ISO TC 184. Feedback on user requirements is provided by other CIM projects which also act as testbeds for emerging elements of the architecture. A set of CIM scenarios has been derived from the project partners (19 major vendors and users), and the first project outputs 'CIM-OSA - A primer on key concepts and purpose' and 'CIM-OSA: Strategic, management and design issues' were issued early in 1987.

Project 955 (Communication Network for Manufacturing Applications - CNMA) aims to promote, implement and validate emerging international standards for electronic communications in industry, addressing shop floor and office environments.

The CNMA demonstration cell at the 1987 Hannover Fair, incorporating a machining centre, automated tool management with a pick and place robot, and a manual job preparation area, all linked by an automated transportation system (ESPRIT Project 955).

The project is closely associated with the MAP and TOP initiatives in the US, and has had a significant influence on the development of internationally acceptable communication standards, in particular ISO DIS 9506 which covers Manufacturing Message Specification (MMS), which is a major application service to be included in MAP 3.0.. The CNMA team includes

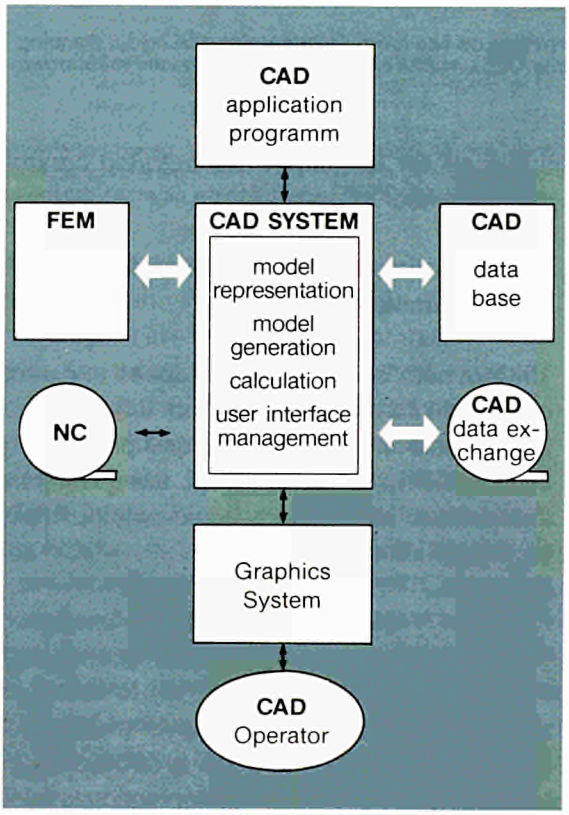
Robots on a car assembly line at BMW, Regensburg, using Manufacturing Message Specification (MMS) (ESPRIT Project 955).

six major IT vendors (Bull, GEC, ICL, Nixdorf, Olivetti, Siemens), five users (Aeritalia, BMW, British Aerospace, ELF, Peugot) and two systems houses, TITN and FHG-IITB.

A major pilot demonstration of the communications networks, including the first public demonstration of features of MAP version 3.0, took place at the 1987 Hannover Fair.

A pilot implementation in a new vehicle assembly plant at BMW has recently been commissioned, and another pilot in an airframe component manufacturing plants at British Aerospace is currently being implemented.

A wiring harness manufacturing plant at Aeritalia is the next target site. The BMW pilot at Regensburg is the first production facility in the world to use MMS



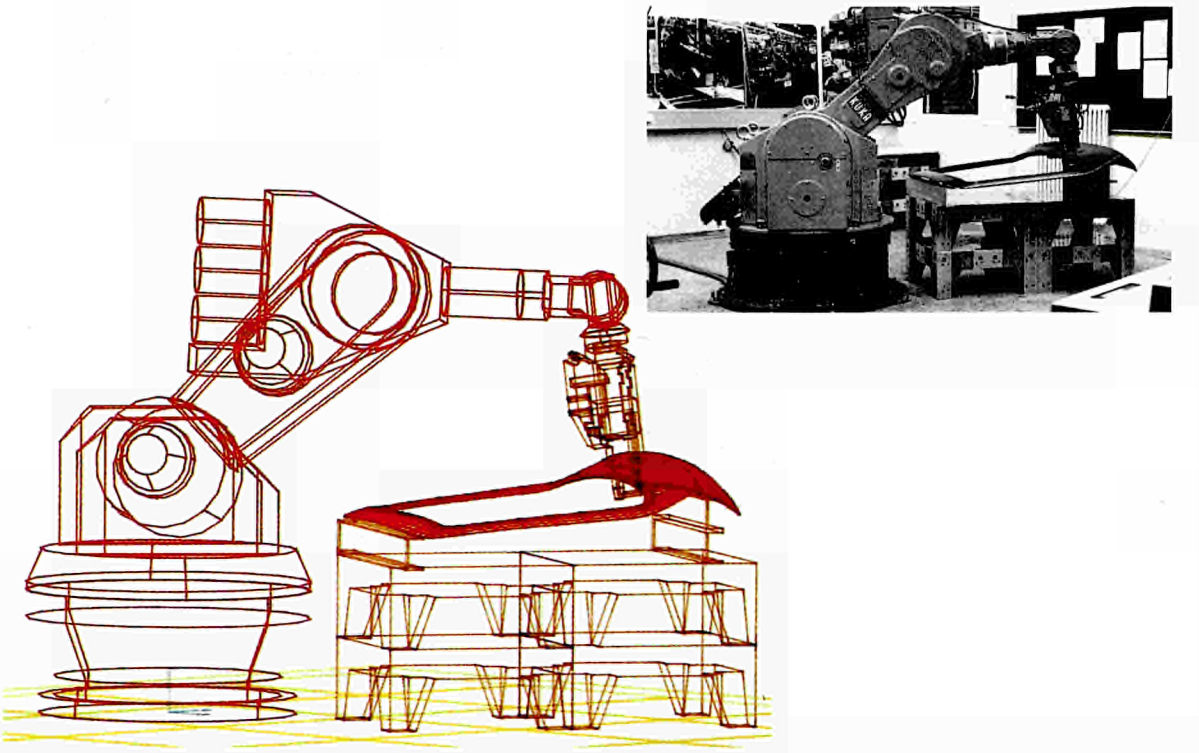
Vendor-independent interfaces developed by the CAD*I project enable the interchange of 2-D and 3-D models between a variety of CAD systems, CAD data bases and finite element analysis software (ESPRIT Project 322).

The project has issued two implementation guides detailing the profile of specifications adopted and advising on how these should be used to achieve interworking in a vendor-independent environment. It has also developed a suite of conformance testing tools to accelerate acceptance of emerging communications standards, the main actors here being ACERLI (F), FHG-IITB, TNC (UK) and SPAG (B). The CNMA project team will participate in the MAP/TOP/COS Enterprise Network Event at Baltimore, Maryland in June 1988, by way of a satellite link from the British Aerospace pilot plant at Salmesbury (UK), and will constitute the only real production environment involved in the event.

Project 322 (CAD Interfaces - CAD*I) - within the overall CIM architecture, this project defines standard interfaces to allow the data generated and held in different CAD systems to be exchanged. This enables the implementation of multi vendor CAD systems and facilitates the free flow of data without expensive conversion and restructuring, and the attendant errors that this involves. It also permits CAD data to be interfaced with Computer Aided Engineering systems, such as those used for the static and dynamic analysis of structures.

Vendor-independent interfaces developed by the project have been presented to ISO TC184 for incorporation into the proposed ISO STEP standard for data exchange which is due to be finalised by the end of 1988. Using these interfaces, data has been successfully exchanged between several CAD systems from different vendors. As a spin-off of this project, Leuven Measurement Systems (B) has incorporated the interface into a commercial product for the experimental testing and optimisation of the dynamic behaviour of machine tools, motor vehicles and aircraft. This product is being actively exploited in Japan and the US.

Project 623 (Operational Control for Robot



Computer simulation of a car door spot-welding operation permitting off-line robot programming and layout planning. The technique facilitates the functional integration of robots into CIM systems and considerably reduces robot down-time (ESPRIT Project 623).

System Integration into CIM) aims to provide methods and tools for the functional integration of robot systems into CIM. Subsystems for explicit robot programming, for planning of assembly operations and for optimising production layouts have already been developed. These are being used by KUKA (D) for the design and implementation of real production systems, where savings of up to 50 % are reported in tendering costs. Consortium members have played leading roles in the development of the IRDATA robot programming language, VDI 3863, which is now being prepared by ISO TC 184 as a draft proposal.

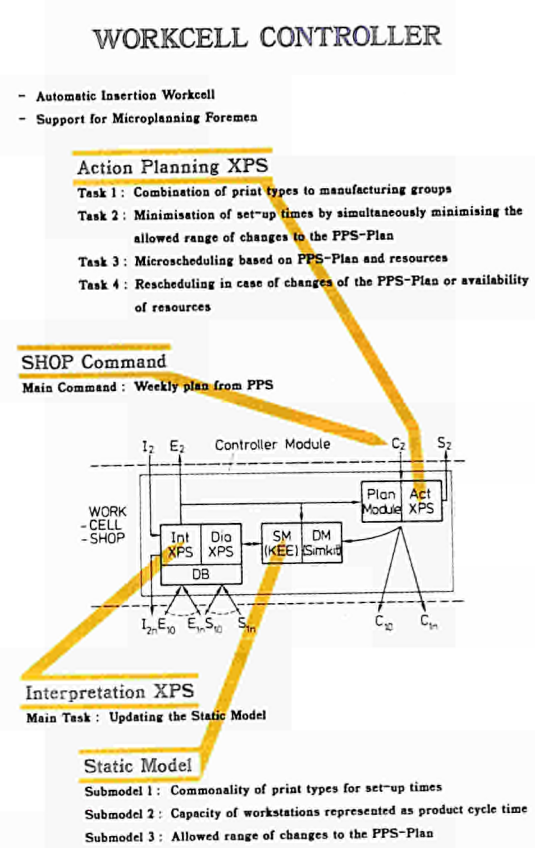
3. CIM SUBSYSTEMS

The objective is to support the development of CIM subsystems, especially in areas where there is high market potential. The subsystems fall roughly into two categories: methods and tools for real-time manufacturing control, and shop floor systems.

3.1 Methods and Tools for Real-time Manufacturing Control

The aim here is to improve the speed and ease of flow of information throughout the manufacturing cycle in order to increase productivity and flexibility. Three projects, using different approaches, have already achieved industrially applicable interim results.

Project 477 (Control Systems for Integrated Manufacturing) uses the top-down concept of Production Activity Control (PAC) to define an architecture and develop a novel method for modelling data flow through production systems. The need for human intervention is minimised and the reaction times of the manufacturing system reduced. Different sets of PAC user requirements have been used to prepare



Knowledge-based techniques are applied to the dynamic scheduling of a workcell for the insertion of surface mounted devices in car radio manufacture (ESPRIT Project 932).

three implementation sites for developing and demonstrating the project outputs and preliminary results are being applied for machine tool manufacture at Comau (I), electronics assembly at Digital (IRL) and automated engine assembly at Renault (F). Digital and Comau are also using the Application Network developed in the project. This constitutes an advanced application layer service for job shop type manufacturing and is in line with emerging communications standards. A novel methodology for modelling production system data flow is available as a spin-off from the project and negotiations are in hand with leading consultants to secure exploitation by mid-1988.

Project 418 (Open CAM System) is complementary with project 477. Here a more vertically structured or 'bottom-up' approach is adopted by establishing the information flow requirements in different functional manufacturing cells of varying complexity. Existing shop floor and planning systems have been analysed. As a result, a reference model and a skeleton architecture for CAM have been derived which take into account the increased complexity of planning as functions become more time-critical. PROCOS (DK), a key member of the consortium, has been able to exploit the early results of the project to design a sophisticated CIM system for the Danish meat-processing company, TULIP.

Project 932 (Knowledge-Based Real Time Supervision in CIM) is concerned with the real-time scheduling of products through manufacturing systems using knowledge based techniques. Detailed analyses have been completed of the decision-making networks for production planning and control, quality control, maintenance and process development, in a motor tyre manufacturing plant at Pirelli (I) and a car radio manufacturing plant at Philips (D). The results also allowed development of knowledge based simulation systems for modelling production flows through manufacturing plants in Philips, BICC (UK), and Pirelli, where the systems are being used to optimise production throughput and reliability. Working prototypes of several real-time production control subsystems have been developed.

In this group the linkage provided by common partners in these projects with AMICE (688) and CNMA (955) allows the work to conform with, and influence via implementation, major developments in factory communications and open systems architectures.

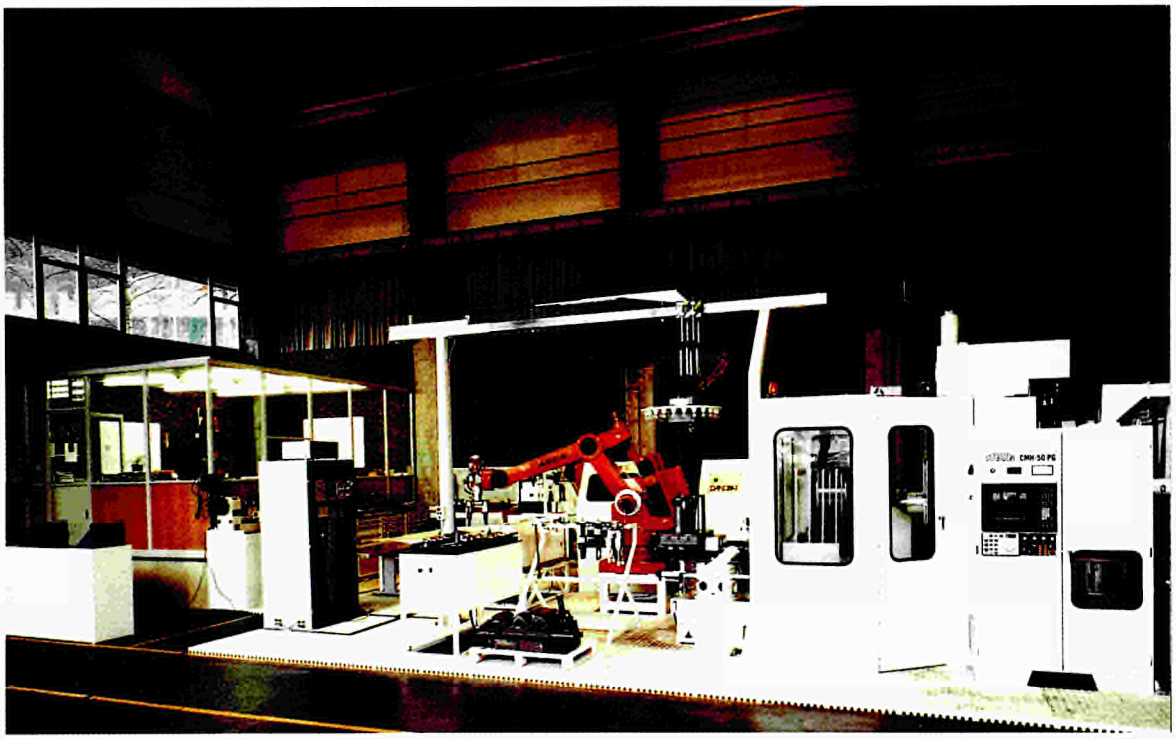
3.2 Shop floor systems

The implementation of information technologies in CIM requires advances in equipment and techniques used on the shop floor. To ensure maximum exploitation potential, priority has been given to developments which either

present strong market opportunities for European vendors or lie on the critical path of the successful implementation of CIM systems. These include systems for flexible machining and assembly, advanced robot and machine tool control, adaptive control of arc-welding and multi-media data capture and interpretation. Projects in this group contribute to improvements in product quality, plant availability and reliability, and faster throughput.

Project 118 (General Purpose Sensory Controlled Systems for Parts Production) is developing a sensor-controlled system for flexible assembly. The project partners include major vendors of control systems and complete manufacturing systems who are well placed to exploit the technology developed in the project. Prototype three-dimensional object recognition systems and force/torque sensing devices have been developed by Siemens (D), IPA (D) and SINCON (I). These are being integrated with robots and tested in a car wheel assembly station and on electro-mechanical subassembly stations by Comau (I) and Olivetti (I).

For successful dynamic control of manufacturing systems, timely availability of accurate and meaningful plant data is required. Project 504 (Plant Availability and Quality Optimisation) led by an SME, Stewart Hughes (UK), is developing the data capture and interpretation tools to provide the necessary information. In June 1986 process monitoring, using model based diagnostic techniques to interpret multi-sensor inputs, was successfully implemented in a flexible machine cell where complex metal cutting operations are performed. The prototype system can rapidly identify faults in the manufacturing process, establish their causes and instigate the necessary remedial actions. This is the first known application of these techniques to the discrete parts manufacturing environment and there is strong exploitation potential for the project results for both vendors of

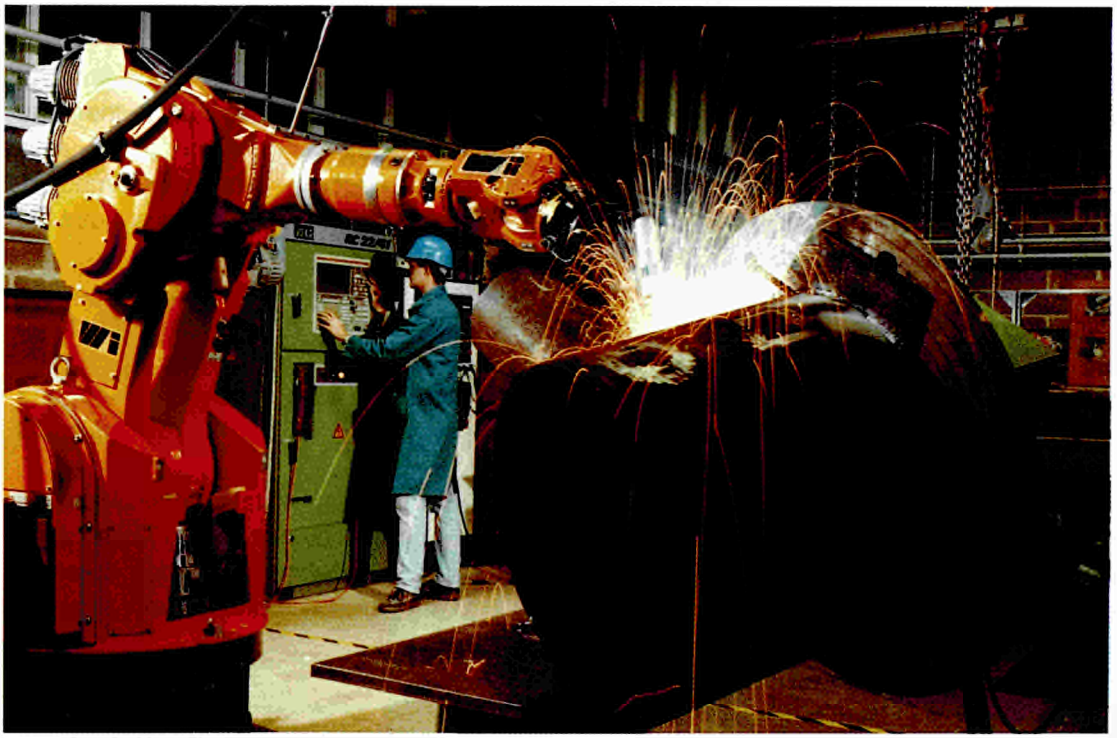


A fault tolerant flexible machining cell in Mondragon in Northern Spain using multi-sensor inputs, a modular universal monitoring computer, and model based diagnostic techniques (ESPRIT Project 504).

monitoring systems and industrial users. Following the successful demonstration on a single machine, the tools are now being implemented on a large scale demonstrator based on a Flexible Manufacturing System cell at the Ikerlan centre in Spain. Based on these early results, a prototype modular system (DAAS) has been developed for data acquisition and analysis and leading users, including British Aerospace, PSA and Ford Motor Company are showing strong interest in adopting the technology. These interim results are being exploited principally by ADERSA (F) and Stewart Hughes.

A major area where market potential for advanced CIM subsystems exists is welded fabrication. Project 9 (Exploitation of Real-time Imaging for Arc Welding) addresses the adaptive control of arc welding tasks to accelerate fabrication times and improve the quality of finished goods. An early result has been the development of a multi axis robot based welding system, equipped with a structured light vision sensor for automatic seam tracking. The system has been constructed and evaluated in an industrial environment by RWTH (D) and Messer Griesheim (D). The developments facilitate the automatic control of arc welding and will be applicable in a wide range of industries, including cars and shipbuilders.

Development of key technologies for flexible manufacturing and assembly systems is addressed by project 278 (Integrated Sensor-based Robot System). It is led by an SME, MARI (UK) and has industrial involvement from Bosch (D) and Joyce Loebl, a subsidiary of Vickers (UK). The project has developed new methods for the multi-media handling of sensory data by existing robot controllers. This has led to the development of multi-sensor systems for robots that combine vision and tactile sensing. Work on the vision system component has led to a high quality marketable product which is extremely competitive in terms of both price and performance with non Community sourced products. The main ap-



A test cell demonstrates off-line arc welding programming techniques for the heavy welded-fabrication industry. The robot-controlled welding head is following a complex curve in three dimensions formed by the intersection of two cylinders (ESPRIT Project 595).

plication areas are robot vision, inspection and metallurgy. Joyce Loebl has already taken orders for the UK, US and Japan. In view of the exploitation potential of the tactile sensor work MARI has set up a dedicated manufacturing plant.

Project 975 (Transponders for Real-time Activity Control of Manufacturing), also led by an SME, REDAR (D), is developing a system for monitoring the current location and status of single parts and assembled products in flexible manufacturing and assembly systems. Transponders capable of withstanding hostile environmental conditions, such as high temperatures and high levels of electrical noise, are commercially available as an early spin-off from the project. The prototype transponder has been tested in an industrial testbed at the Volkswagen plant at Wolfsburg.

INFORMATION AND RESULTS

1. INFORMATION EXCHANGE SYSTEM (IES)

1.1 Introduction

The IES is that part of the organisational infrastructure which is concerned with ensuring that the appropriate communications mechanisms and services are available to support the execution and management of the programme.

The general policy hinges around the gradual development and availability of OSI (Open Systems Interconnection) conformant computer communications products, and is divided into 3 areas:

- The provision of services to the ESPRIT community
- Support for developments conforming to OSI standards
- Harmonisation of standards implementations and other related Europe wide research networking activities, in order to allow for interworking.

1.2 IES Services

Due to the lack of availability of OSI conformant services when ESPRIT began, a set of ad-hoc services have been made available to users, accessed in principle via the X-25 public packet-switched network.

1.2.1 EuroKom

EuroKom is a centralized computer based electronic mail and conferencing service located in Dublin. Two way interconnections are provided with the international telex network and major research networks in Europe and the USA (Eunet, Arpanet, Bitnet, Csnet).

In 1987 a further gateway conforming to CCITT X400 recommendations for message handling systems was implemented. This is currently being tested in an operational environment.

The early users of the system tended to be particularly interested in electronic mail and the use of computers for communication, but as the user base has expanded - there are currently about 1200 registered users - the profile of the average user has changed; he is now less interested in the mechanism, and more interested in the ease of use, performance and reliability of the service.

Several steps were taken in 1987 to attempt to meet these user needs, in order to provide easier use. A "user-friendly" front end has been developed and will allow simple swapping between different services via menus. In order to improve the performance of the system, which was already detectably deteriorating owing to increased use, the existing host computer has recently been replaced by one of significantly higher performance. Benchmark tests indicate that this machine should be able to support up to 3,000 users, a figure which our current projections show should not be attained until 1990.

The reliability of the service is one of the major concerns, and a performance monitoring activity has been initiated. Investigations are currently taking place in order to identify improvements in areas where users report particular problems of connectivity.

1.2.2 Eurocontact

This service is intended to assist European Researchers in Information Technology to form partnerships for Community programmes. It is hosted on a GEC-UNIX machine and gives access to a database for those organisations wishing to co-operate on specific research and development activities.

1987 saw this service enter into real use by a significant user group, and after initial start-up problems were resolved, the service has been providing useful support to the potential ESPRIT II community. On-line searches for specific information take between 10 and 60 seconds, depending on the type of request, and details of approximately 1600 organisations are now included.

1.2.3 IES Data Collections

The European Communities Host (ECHO) in Luxembourg now contains three publicly available databases containing information concerning:

- a directory of people accessible through electronic mail systems (4976 entries);
- European publicly funded IT research projects (767 entries);
- European research sites and their facilities (995 entries).

The database on research projects also contains the Eureka projects. Average access to this database has been recorded at 19 hours per month.

1.2.4 COTEL

Cotel is a machine translation service sponsored by the IES for use by ESPRIT participants. Because the working language within ESPRIT is normally English, language pairs involving translation to or from English are provided. The language pairs currently available are English/French, French/English, English/German, German/English and English/Italian.

1987 saw this service brought into pilot operation. Six organisations are registered as users, and several demonstrations have been made, both in house and at public exhibitions.

1.2.5 IES Newsletter

This newsletter is distributed every two months to approximately 5000 readers. The twelfth issue was published in October 1987, and a separate section now incorporates news specific to COSINE, which is the EUREKA project aiming at providing a complete OSI conformant computer networking infrastructure for the European research community.

1.2.6 User Support

As well as the documentation which has been

produced to support the use of the services, telephone help lines have been put in place to answer queries and give additional explanations concerning problems of connectivity. In order to identify the quality of service that the IES is providing to the user, an in-house performance monitoring activity has been set up within the Commission. A user group has also been set up to provide a forum for Project Officers to express their opinions and explain problems.

As part of the 1987 ESPRIT Conference Week an IES workshop was held with representatives from industry, academia, and service providers. The workshop proved to be very useful and informative, and general support was expressed for IES policies. However it was pointed out that maximum benefit will only be gained from IES if the use of the services by the target population is almost total. The priorities were identified to be assuring user-friendly connectivity for existing services and providing additional support for project management. Plans for 1988 are being formulated in accordance with the views expressed at the Conference.

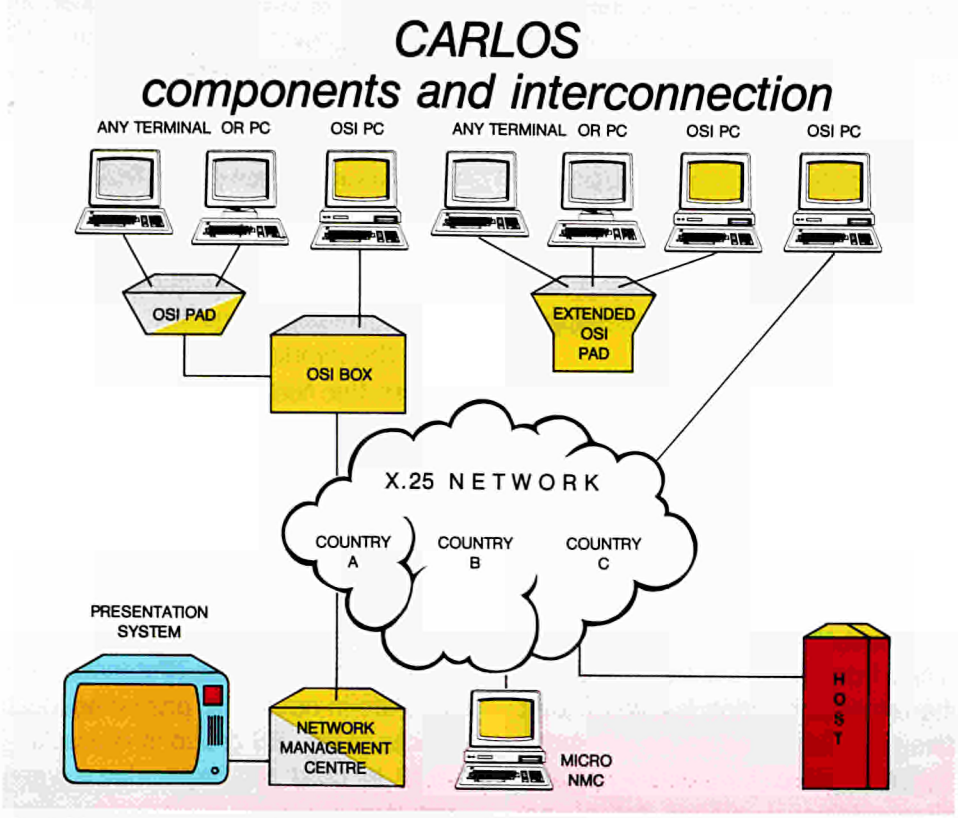
1.3 The IES Development Projects

As explained earlier, one of the activities undertaken by the IES is to encourage the development of OSI conformant products, and therefore several ESPRIT projects which are targeted towards OSI services have been initiated under this part of the programme. The original objective was that the final outputs from these projects would be directly used as a support for ESPRIT participants, although experience has shown that in some cases the companies involved in these projects have already gone one step further and are already introducing proprietary products, ruggedised to an industrial standard, which have the same or improved functionality.

A large section of the European R&D population have access to UNIX based machines, and so in order to enable them to communicate and interwork using OSI protocols, the ROSE project (33) aims to create OSI conformant communications software modules for the UNIX machines of 5 of the major European IT vendors, and to demonstrate interworking over a pilot network. This project has come to represent a test environment for prototyping OSI implementations on a European scale, and the work currently being carried out covers the Network Management aspects of OSI and the planning of a major demonstration to be carried out in 1988, when the project is scheduled for completion. The project provided major support from industry for the definition of the "Standards Promotion and Application Group" (SPAG) profiles, and inputs to the international standards definition process. In the current ROSE pilot network about 20 sites are in operation, one being located at the offices of the IES group in Brussels. This network is used for day-to-day communication between the project partners. The vendors participating in this project are now in the process of adding OSI conformant modules to their product catalogues.

Once OSI conformant services for messaging and file transfer are available on a pan-European basis, the supporting directory services will be required. The functionality provided by ROSE will be augmented by the THORN project (719), in order to provide an international distributed directory service for OSI communications users. The functions to be provided include "White Pages", "Yellow Pages", and aliasing. Prototype software conforming to ECMA standards was completed in 1987, and a large scale pilot exercise is now being set up in order to gain hands-on experience and generate feedback to the standardisation process.

The THORN project (719) is planned for completion in March 1989, when further ruggedisation will lead to a product being available



CARLOS components and interconnection (ESPRIT Project 718)

which, it is hoped, will be used not only for the IES but also for COSINE.

Another significant section of the IES user base is equipped with PCs and their requirement is to be able to communicate directly over the packet-switched networks. The CARLOS project (718) is intended to allow existing personal computers and terminals to communicate via OSI conformant protocols, even if their current communications packages are considered incompatible.

Depending on the customers' equipment, various modules have been developed to allow interworking with OSI conformant applications. The full "OSI-PC" conforms to all OSI layers protocols across the public X.25 packet-switched network. The "OSI-PAD" enables industry-standard terminal equipment to connect to the world of OSI communications. A sophisticated presentation system is already in operational use, comprising a set of tools for the presentation of network management information in graphical form.

The consortium has developed various hardware and software modules, which are being tested by Danish telephone administrations in an operational environment, and some of which have been incorporated in commercial products marketed by CASE (UK) and RC Computer (DK). A Network Management Centre is being supplied to Kommunedata (DK) to monitor and control the Danish Library Service's data communications.

An extension of the project was approved in 1987 and support for X-400 messaging will now also be provided.

The project development will be completed

over the coming months and will first be implemented and operated over the Danish packet-switched network during 1988.

1.3.1 Other Activities

During the period covered by this report a study, codenamed "Hermès", has been carried out to investigate the user requirements and planned market offerings for message handling systems conforming to the X-400 series of recommendations.

Further studies have been carried out in the area of security on existing mail and conferencing services, and a Requirements Catalogue for the development of a next generation Distributed Conferencing Facility has been produced.

1.4 Harmonisation Activities

OSI standards implementation is being promoted and supported in order to ensure that interworking of heterogeneous equipment is possible on a large scale, corresponding to the requirements of the ESPRIT model of Europe wide computer communications.

Having previously given encouragement and financial support to the formation of the RARE (Réseaux Associés pour la Recherche Européenne) association of users and providers of computer networks for researchers, support is now being given for the RARE Message Handling Project. The project links all participants, irrespective of where they are located, into one pilot "global" MHS service for the R&D community. There are approximately 180 operational nodes running in Europe, and support is also provided for the co-ordination needed to link together the different national services and to handle the aspects of distribution and configuration control.

Further activities are carried out in this area in support of the EUREKA COSINE project. As well as the previously mentioned inclusion of COSINE news in the IES newsletter, IES has also taken on the role of secretariat and project officer for COSINE. This entails organising meetings and conferences, representations at workshops and exhibitions including the annual COSINE workshop, and providing the administrative and management services backup required for:

- Obtaining consensus agreement on the terms and conditions of the contract between the participating bodies for the specification phase;
- Managing the project account;
- Providing programme management functions to ensure correct and satisfactory progress of the technical work is obtained.

As a result, IES provides major input to the COSINE Policy Group.

Through contacts with RARE, COSINE and the international computer-communications community, IES is also promoting harmonisation of networks for researchers world-wide, so as to ease their communications in general and to foster an outlet for Community industry products conforming to the standards.

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2. ACCESS TO THE PROGRAMME'S RESULTS

Special efforts are made in order to ensure that information judged to be of wide interest is made easily available. During 1987, in the various Member States:

- ESPRIT Projects gave demonstrations at 16 exhibitions and conferences.
- 28 ESPRIT Information Days and similar events were held.

A major demonstration at the 1987 Hannover Fair - ESPRIT Project 955 (CNMA)

- 7 ESPRIT books and 1 in the ADA publication series were published.

- Some 100,000 volumes of ESPRIT project synopses were distributed.

and numerous presentations at conferences, technical papers, press articles, and videos were prepared and published.

2.1 The 1987 ESPRIT Conference Week

ESPRIT participants and a selected set of invited specialists met in October 1987 at the ESPRIT Conference Week. Technical presentations were held during the first two days, giving an overview of progress in many of the projects. Workshops provided a more detailed review of progress and problems on each area of the programme. This was an essential step in the decision-making process leading to the definition of the work programme for 1988. One day was set aside for leading European decision makers in the IT field to talk about the industrial and political framework in which ESPRIT takes place.

The Conference was organised in a way that allowed projects to mount demonstrations displaying their achievements. A total of 50 working models and several hundred posters were exhibited. This Conference proved to be the largest and most successful held so far, with 130 papers and nearly 4,000 participants. It was encouraging to note that the attendees were not only from the strictly IT field, but that representatives of National Governments and the European Parliament were present, and the event was given coverage by the mass media as well as the specialist press.

2.2 Technical Interest Groups

The ESPRIT Technical Interest Groups (TIGs) are an important means of communication between projects with interests in common. Full information on these TIGs, including contact points, is given in the next chapter, "TIGs".

The ESPRIT Conference Week , Brussels

2.3 Facilities for forming consortia

In connection with each ESPRIT call for proposals, one or more proposers' days are organised. These events, held in Brussels, are structured so that not only do potential proposers have the chance to discuss the work programme and strategy with ESPRIT staff, but - equally important - they can talk to each other, and find potential partners for their research. In 1987 a Proposers' Day organised during the ESPRIT Conference Week was attended by some 800 people.

Another facility provided for the same purpose is Eurocontact (see the first section of this chapter).

TECHNICAL INTEREST GROUPS

The following ESPRIT Technical Interest Groups (TIGs) were active during 1987. Each of these TIGs has the objective of enabling communication between ESPRIT project partners with interests in the field concerned, and of providing a forum for discussion of approaches and problems; the more specific objectives are given below. For contact points within the CEC, the postal address, in addition to the two lines printed after "Contact Point" is:

Commission of the European Communities
Rue de la Loi 200
B - 1049 BRUXELLES
BELGIUM

TECHNICAL INTEREST GROUP ON LITHOGRAPHY

This group, formed on 2 December 1987, has the following objectives:

- exchanging views in the lithography field.
- promoting standardisation of metrology procedures.
- presenting specific activities by supporting projects studying optical and x-ray lithography.

The group meets twice yearly. Currently, only ESPRIT partners may participate, but it is envisaged that participation will be opened to other interested parties. The first workshop of the group was held in December 1987.

Contact Point: Paolo Malinverni - CEC
DGXIII/A3
Tel: +32.2.236.07.20

TECHNICAL INTEREST GROUP ON VLSI MANUFACTURING AUTOMATION

This group, formed in June 1987 has the following objectives:

- exchanging views and experience in the implementation of standards; recommending changes and additions to standards;
- promoting future industrial co-operative actions for solving problems;
- collecting semiconductor manufacturing requirements for automation in order to provide informal recommendations to manufacturers and users;
- promoting the use of, and disseminating information on, a uniform set of standards.

The group meets twice yearly. The core participants of the group are partners in ESPRIT

and EUREKA projects; others may participate by invitation only. The group held its first workshop in October 1987.

Contact Point: John Tsalas - CEC
DGXIII/A3
Tel: +32.2.235.50.24

CAVE WORKSHOPS (CAD FOR VLSI IN EUROPE)

The first CAVE workshop was held in May 1983. During 1987 workshops were held in May and in December. They have the following objectives:

- disseminating the results of ESPRIT CAD projects;
- ensuring rapid and consistent exploitation of new research ideas by means of selected tutorials;
- maintaining the strong sense of identity of the existing community of CAD researchers in Europe.

Contact Point: M J Newman - CEC
DGXIII/A3
Tel: +32 2 235 70.63

EFIT - EUROPEAN FORUM FOR INFORMATION TECHNOLOGY

This forum, initiated in 1987, is due to become operational in 1988. Its objective is to bring together IT providers and IT users in Europe to discuss and evaluate offers and requirements on a continuing basis. There will be a board with representatives from a wide spectrum of interested parties including the CEC. EFIT will liaise with area-specific associations in Europe.

ADA-EUROPE

This group, formed in 1980, has the following objectives:

- pooling resources and exchanging information on Ada within and outside the Community, to ensure that expertise in the Ada language and its environment is used most effectively;
- providing a link between the Commission and the United States (specifically the Ada Joint Program Office), and the International and National Standards Organisations within Europe;
- giving guidance to Europeans working on Ada and promoting the awareness, development, and use of Ada and Ada-related tools.

Principal Activities in 1987

- Ada-Europe Conference in Stockholm held in May.
- 25 Working Group meetings on Ada-related issues.

Contact Point: Karel De Vriendt - CEC
DGXIII/A2
Tel: +32.2.235.77.69

VDM-EUROPE

Formed in 1985 with the objective of increasing awareness, use, development, and standardisation of the Vienna Development Method (VDM).

Principal Activities in 1987

- VDM87 Symposium, Brussels, held in March;
- 3 meetings devoted to VDM standardisation and presentation of VDM-related projects.

The group is open to all European parties interested in the use, propagation, and further development of VDM. It plans to meet 3 or 4 times a year and to organise a major VDM-Europe Symposium annually.

Contact Point: Karel De Vriendt - CEC
DGXIII/A2
Tel: +32.2.235.77.69

SOFTWARE PRODUCT AND PROCESS METRICS (SPPM)

Formed in 1986, the objective of this group is the advancement of software metrics and quality. During 1987, workshops and meetings identified three main areas for action: software certification, software experimentation, and a European software laboratory.

Contact Point: N Abu El Ata, DATAID,
43 av Raymond Poincare
75116 Paris, France
Tel: +33.1.45.53.47.26

LISP

Formed in 1987, the objective of this group is to prepare an ISO Lisp standard.

Principal Activities in 1987

- completion of the first draft submission to ISO;
- establishment of the ISO working group.

Contact Point: Jerome Chailloux, ILOG
2 av Gallieni
94250 Gentilly, France
Tel: +33.1.46.63.66.66

PM2 (PROJECT MANAGEMENT PROJECT MEETINGS)

This group, formed in 1987, has the following objectives:

- collecting data models of member projects, comparing their expressiveness, and trying to reach a common model allowing the exchange of tools between the different systems;
- describing a minimal set of functionalities for the different project management tools;
- reaching a common definition of the User Interface functionality;
- comparing the different process models and investigate whether there is an underlying common model.

Contact Point: John van Zijl - CEC
DGXIII/A4
Tel: +32.2.236.03.22

CIM EUROPE

CIM-Europe, launched in September 1985, is an Information and Awareness activity of ESPRIT. Its function is to consolidate and enhance the effects of ESPRIT CIM by disseminating information on progress and achievements in the programme. It stimulates interaction between project teams in CIM and in other areas, encouraging the development and the application of CIM techniques to the benefit of European industry. CIM-Europe is based on the following Technical Interest Groups, which are open to all interested parties.

TIG	Subject	Date Formed
1	Cells, Architectures and Communications	Dec 1986
2	Advanced Information Processing in CIM	Sep 1985
3	Human Factors in CIM	Sep 1985
4	Design for Automated Manufacturing	Jan 1986
5	Control and Management for Production Systems	Jan 1986
6	Production Systems Design and Engineering	Jan 1986
7	Advanced Robotics and Intelligent Sensors	Sep 1986
8	Shipbuilding, Heavy Engineering and Large Structures	Oct 1986

Each TIG has a Working Group meeting two or three times a year, and also organises public workshops. Typically three workshops are organised each year in addition to an annual CIM-Europe conference.

Principal Events in 1987

Date	TIG	Place	Event
Jan 28-30	2	Athens	Workshop on Advanced Information Processing
Feb 2		Brussels	1st Workshop on Interfaces in the Automobile Industry (ODETTE)
May 18-21		Knutsford	CIM Europe Annual Conference
June 23-24	7 & 8	Bilbao	Joint Workshop on Automation and Robotics in Manufacture and CIM in Shipbuilding and Allied Industries.
Oct 20		Brussels	2nd Workshop on Interfaces in the Automobile Industry (ODETTE).

Contact Point: CIM-Europe Secretariat - CEC
DGXIII/A5
Tel: +32.2.232.18.77

LIST OF PROJECTS AND PARTNERS INVOLVED IN PROJECTS MENTIONED IN THE TEXT

ADVANCED MICROELECTRONICS

LIST OF PROJECTS MENTIONED

97
ADVANCED ALGORITHMS, ARCHITECTURE AND LAYOUT TECHNIQUES FOR VLSI DEDICATED DIGITAL SIGNAL PROCESSING CHIPS

PARTNERS
- IMEC V.Z.W.
- BELL TELEPHONE MFG. CO.
- SIEMENS AG
- RUHR UNIVERSITAT BOCHUM
- PHILIPS GLOEILAMPENFABRIEKEN
- SILVAR-LISCO N.V.

232
COMPOUND SEMICONDUCTOR MATERIALS & INTEGRATED CIRCUITS - I

PARTNERS
- PLESSEY COMPANY PLC
- PHILIPS/LEP
- THOMSON CSF/DCI
- SIEMENS AG

243
SUBMICRON BIPOLAR TECHNOLOGY - I

PARTNERS
- THOMSON CSF/DCI
- PLESSEY COMPANY PLC
- TECHNISCHE UNIVERSITAT BERLIN
- THOMSON CSF/LCR
- TELEFUNKEN ELECTRONIC GMBH

263
INTEGRATED OPTO-ELECTRONICS ON InP

PARTNERS
- CSELT S.P.A.
- CGE. LAB DE MARCOUSSIS
- HEINRICH HERTZ INSTITUT
- STC TECHNOLOGY LTD
- THOMSON CSF/LCR
- STANDARD ELEKTRIC LORENZ AG
- GEC RESEARCH LABORATORIES
- CNET

271
AUTOMATIC DESIGN VALIDATION OF INTEGRATED CIRCUITS USING E-BEAM

PARTNERS
- CSELT S.P.A.
- BRITISH TELECOM PLC
- IMAG
- TRINITY COLLEGE DUBLIN
- CNET

281
SUBMICRON BIPOLAR TECHNOLOGY - II

PARTNERS
- SIEMENS AG
- RTC-RADIOTECHNIQUE COMPELECTR.

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412 BICMOS
A HIGH PERFORMANCE CMOS-BIPOLAR PROCESS FOR VLSI CIRCUITS

PARTNERS
- PHILIPS GLOEILAMPENFABR. N.V.
- SIEMENS AG

491
MATERIALS AND TECHNOLOGIES FOR HIGH MOBILITY TFTS FOR LC DISPLAY BUS DRIVERS

PARTNERS
- AEG A.G.
- CNET
- CSEE

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554 SPECTRE
SUBMICRON CMOS TECHNOLOGY

PARTNERS
- CNET
- BRITISH TELECOM PLC
- BULL S.A.
- IMEC V.Z.W.
- SGS MICROELETTRONICA SPA
- UNIVERSITE CATHOLIQUE LOUVAIN
- MATRA HARRIS SEMI-CONDUCTEURS
- AARHUS UNIVERSITY
- TELETTRA S.P.A
- AERE-ATOMIC ENERGY RES.ESTABL.
- CNR-INSTITUTO LAMEL

574
HIGH RESOLUTION PLASMA ETCHING IN SEMICONDUCTOR TECHNOLOGY-FUNDAMENTALS, PROCESSING AND EQUIPMENT

PARTNERS
- FRAUNHOFER IM
- AERE-ATOMIC ENERGY RES.ESTABL.
- MONO LIGHT INSTRUMENTS LTD.
- LEYBOLD HERAEUS GMBH

802 CVS
CAD FOR VLSI SYSTEMS

PARTNERS
- CSELT S.P.A.
- AEG A.G.
- BRITISH TELECOM PLC
- ITAL TELEMATICA SPA
- SGS MICROELETTRONICA SPA
- MATRA HARRIS SEMI-CONDUCTEURS
- GMD-GES.F.MATHEMATIK&DATENVER.
- CNET
- CIT/ALCATEL

843
COMPOUND SEMICONDUCTOR INTEGRATED CIRCUITS

PARTNERS
- STC TECHNOLOGY LTD
- GEC RESEARCH LABORATORIES
- LAB DE PHYSIQUE APPLIQUEE
- THOMSON CSF/DCI
- SIEMENS AG
- PLESSEY COMPANY PLC
- FARRAN TECHNOLOGY LTD.

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887 ECIP
EUROPEAN CAD INTEGRATION PROJECT

PARTNERS
- BULL S.A.
- CIT-ALCATEL
- SGS MICROELETTRONICA SPA
- SIEMENS AG
- PHILIPS GLOIENLAMPENFABR. N.V.
- ICL

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888 AIDA
ADVANCED INTEGRATED-CIRCUIT DESIGN AIDS

PARTNERS
- SIEMENS AG
- ICL
- THOMSON SEMICONDUCTEURS

991
MULTIVIEW VLSI - DESIGN SYSTEM ICD

PARTNERS
- TECHNISCHE UNIVERSITEIT DELFT
- BRITISH TELECOM PLC
- INESC
- TECH. UNIVERSITEIT EINDHOVEN
- PCS-PERIPHERE COMPUTER SYSTEMS
- ICS HOLDING B.V.
- UNIVERSITY OF ESSEX

1007
0,5 MICRON X-RAY LITHOGRAPHY:SOURCES,MASKS,RESIST AND TRANSFERRED IMAGE

PARTNERS
- CNR/IESS
- CNRS
- KING'S COLLEGE LONDON
- THOMSON CSF
- SGS MICROELETTRONICA SPA

1043
ADVANCED MASK AND RETICLE TECHNOLOGY FOR VLSI SUBMICRON MICROELECTRONICS DEVICES

PARTNERS
- FERRANTI ELECTRONICS LTD.
- BRITISH TELECOM PLC
- SIEMENS AG
- VALVO BAUELEMENTE PHILIPS
- PLASMA TECHNOLOGY LTD.
- IMEC V.Z.W.

1056
ULTRASENSITIVE IMPURITY ANALYSIS FOR SEMICONDUCTOR STRUCTURES AND MATERIALS

PARTNERS
- IMEC V.Z.W.
- CAMECA
- SIEMENS AG
- PHILIPS RESEARCH LABORATORIES

1058
KNOWLEDGE BASED DESIGN ASSISTANT FOR MODULAR VLSI DESIGN

PARTNERS
- IMEC V.Z.W.
- INESC
- PHILIPS GLOEILAMPENFABR. N.V.
- SILVAR-LISCO N.V.

1128
LARGE DIAMETER SEMIINSULATING GAAS SUBSTRATES SUITABLE FOR LSI CIRCUITS

PARTNERS
- LAB DE PHYSIQUE APPLIQUEE
- UNIVERSITE CATHOLIQUE LOUVAIN
- WACKER CHEMITRONIC

1551 AMS
ADVANCED MANUFACTURING SYSTEM

PARTNERS
- THOMSON SEMICONDUCTEURS
- MARCONI ELECTRONIC DEVICES LTD
- SGS MICROELETTRONICA SPA

1563 ACAFS
AUTOMATIC CONTROL OF AN ASIC FABRICATION SEQUENCE AS DEMONSTRATED IN THE PLASMA ETCH AREA

PARTNERS
- SOCIETE BERTIN
- EUROPEAN SILICON STRUCTURES
- PLASMA TECHNOLOGY LTD.
- MIETEC N.V.
- LEYBOLD HERAEUS GMBH

SOFTWARE TECHNOLOGY

LIST OF PROJECTS MENTIONED

32 PCTE
A BASIS FOR A PORTABLE COMMON TOOL ENVIRONMENT

PARTNERS
- BULL S.A.
- GEC RESEARCH LABORATORIES
- OLIVETTI
- SIEMENS AG
- NIXDORF COMPUTER A.G.
- ICL

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125 GRASPIN
PERSONAL WORKSTATION FOR INCREMENTAL GRAPHICAL SPECIFICATION AND FORMAL IMPLEMENTATION OF NON-SEQUENTIAL SYSTEMS

PARTNERS
- MD-GES.F.MATHEMATIK&DATENVER.
- OLIVETTI
- TECSIEL SPA
- SIEMENS

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282 SPMMS
SOFTWARE PRODUCTION & MAINTENANCE MANAGEMENT SUPPORT

PARTNERS
- CIT-ALCATEL/CERSI
- CIT-ALCATEL/SESA
- SOFEMASA
- SEMA METRA
- DATA MANAGEMENT SPA

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300 REQUEST
RELIABILITY AND QUALITY OF EUROPEAN SOFTWARE

PARTNERS
- STC TECHNOLOGY LTD.
- AEG A.G.
- ELEKTRONIK CENTRALEN
- STC IDEC
- UK ATOMIC ENERGY AUTHORITY
- THOMSON CSF
- GESELLSCHAFT FUR REAKTORSICHERHEIT
- ESA CONTROL
- CISI/II

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315 RAISE
RIGOROUS APPROACH TO INDUSTRIAL SOFTWARE ENGINEERING

PARTNERS
- DANSK DATAMATIK CENTER
- BROWN, BOVERI & CIE.
- STC TECHNOLOGY LTD.
- ICL

348 GIPE
GENERATION OF INTERACTIVE PROGRAMMING ENVIRONMENTS

PARTNERS
- SEMA METRA
- BSO.BUR.V.SYSTEEMONTWIKKELING
- INRIA
- CWI-CEN.V.WISKUNDE&INFORMATICA

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390 PROSPECTRA
PROGRAM DEVELOPMENT BY SPECIFICATION AND TRANSFORMATION

PARTNERS
- UNIVERSITAT BREMEN
- ALCATEL STANDARD ELECTRICA SA
- SYSECA LOGICIEL
- UNIVERSITAT PASSAU
- UNIVERSITAT DES SAARLANDES
- UNIVERSITAT DORTMUND
- UNIVERSITY OF STRATHCLYDE
- DANSK DATAMATIK CENTER

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401 ASPIS
APPLICATION SOFTWARE PROTOTYPE IMPLEMENTATION SYSTEM

PARTNERS
- OLIVETTI
- CAP SOGETI INNOVATION
- TECSIEL SPA
- GEC RESEARCH LABORATORIES
- UNIVERSITE DE GRENOBLE

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410 SEDOS
SOFTWARE ENVIRONMENT FOR THE DESIGN OF OPEN DISTRIBUTED SYSTEMS

PARTNERS
- CNRS
- BULL S.A.
- UNIVERSITEIT VAN TWENTE
- ICL

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814 PIMS
PROJECT INTEGRATED MANAGEMENT SYSTEMS

PARTNERS
- CAP SOGETI INNOVATION
- BSO.BUR.V.SYSTEEMONTWIKKELING
- THE TURING INSTITUTE
- PACTEL

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835 PROSPECTRA DEMO
DEMONSTRATION OF PROSPECTRA METHODOLOGY AND SYSTEM

PARTNERS
- ALCATEL STANDARD ELECTRICA SA
- SYSECA LOGICIEL

938 IMPW
INTEGRATED MANAGEMENT PROCESS WORKBENCH

PARTNERS
- ICL
- CETE MEDITERANNEE
- VERILOG
- NIHE
- IMPERIAL COLLEGE

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951 PACT
PCTE-ADDED COMMON TOOLS

PARTNERS
- BULL S.A.
- EUROSOFT SYSTEMS S.A.
- OLIVETTI
- SYSTEM AND MANAGEMENT SPA
- SYSECA LOGICIEL
- ICL
- GEC SOFTWARE LTD

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974 KNOSOS
A KNOWLEDGE-BASE ENVIRONMENT FOR SOFTWARE SYSTEM CONFIGURATION REUSING COMPONENTS

PARTNERS
- ESI
- CIT ALCATEL
- MATRA
- DORNIER GMBH
- CNET

1072 DIAMOND
DEVELOPMENT AND INTEGRATION OF ACCURATE OPERATIONS IN NUMERICAL DATA PROCESSING

PARTNERS
- SIEMENS AG
- CWI-CEN.V.WISKUNDE&INFORMATICA
- NUMERICAL ALGORITHMS GROUP LTD.
- UNIVERSITAT KARLSRUHE

1158 ATES
ADVANCED TECHNIQUES INTEGRATION INTO EFFICIENT SCIENTIFIC APPLICATION SOFTWARE

PARTNERS
- INFORMATIQUE INTERNATIONALE
- PHILIPS GLOIENLAMPENFABR. N.V.
- UNIVERSITEIT VAN TWENTE
- UNIVERSITE DE PARIS VI & VII
- UNIVERSITE DE LIEGE

1257 MUSE
SOFTWARE QUALITY AND RELIABILITY METRICS FOR SELECTED DOMAINS : SAFETY MANAGEMENT & CLERICAL SYSTEMS

PARTNERS
- BRAMEUR LTD.
- CRIL
- RWTUEV

1258 TRUST
TESTING & CONSEQUENT RELIABILITY ESTIMATION FOR REAL-TIME EMBEDDED SOFTWARE

PARTNERS
- UNIVERSITY OF LIVERPOOL
- THE CITY UNIVERSITY
- LIVERPOOL DATA RESEARCH ASSOC.
- SOFTWARE ENGINEERING SERVICES
- JOHN BELL SYSTEMS

1262 SFINX
SOFTWARE FACTORY INTEGRATION AND EXPERIMENTATION

PARTNERS
- SFGL.SOCIETE FRANCAISE DE GENIE LOGICIEL
- CAP INDUSTRY LIMITED
- TECHNOPOLIS CSATA NOVUS ORTUS
- ERIA S.A.
- CRI-COMPUTER RESOURCES INTL.

1265 SEDOS DEMO
SEDOS ESTELLE DEMONSTRATOR

PARTNERS
- VERILOG
- E2S-EXPERT SOFTWARE SYSTEMS NV
- MARBEN

1277 SAPPHIRE
PCTE PORTABILITY

PARTNERS
- CAP INDUSTRY LTD
- GIE EMERAUDE
- SOFTWARE SCIENCES LTD.

1282 PAVE
PCTE AND VMS ENVIRONMENT

PARTNERS
- GEC SOFTWARE LTD
- SYSECA LOGICIEL

1520 ALF
ADVANCED SOFTWARE ENGINEERING ENVIRONMENT LOGISTICS FRAMEWORK

PARTNERS
- GIE EMERAUDE
- CIG-CENTRE D'INFORMATIQUE GEN.
- GRUPO DE MECANICA DEL VUELO SA
- UNIVERSITE DE NANCY-CRIN
- UNIVERSITAT DORTMUND
- ICL
- COMPUTER TECHNOLOGIES CO.
- CERILOR
- UNIVERSITE CATHOLIQUE LOUVAIN

1609 SMART
SYSTEM MEASUREMENT AND ARCHITECTURES
TECHNIQUES

PARTNERS
- CCS/SCYT
- CEA-DEIN/SIR
- MATRA
- UNIV.POLITECNICA DE CATALUNYA
- PAISLEY COLLEGE OF TECHNOLOGY
- II
- CRI

ADVANCED INFORMATION PROCESSING

LIST OF PROJECTS MENTIONED

25
ADVANCED ALGORITHMS AND ARCHITECTURES FOR SPEECH AND IMAGE PROCESSING

PARTNERS
- CSELT S.P.A.
- AEG A.G.
- THOMSON CSF
- POLITECNICO DI TORINO
- UNIVERSITA DI TORINO
- UNIVERSITE DE STRASBOURG-LSIT
- HITEC LTD

96
EXPERT SYSTEM BUILDER

PARTNERS
- PLESSEY COMPANY PLC
- CIMSA-SINTRA
- SOREN T.LYNGSOE A/S
- CSELT S.P.A.

256
TIME DEPENDENCY AND SYSTEM MODELING IN KBS DESIGN FOR INDUSTRIAL PROCESS APPLICATIONS

PARTNERS
- CISE
- FRAMENTEC

280
INTELLIGENT HELP FOR INFORMATION SYSTEM USERS

PARTNERS
- CRI-COMPUTER RESOURCES INTL.
- COURSEWARE EUROPE B.V.
- UNIVERSITEIT VAN AMSTERDAM TNO
- UNIVERSITY OF LEEDS
- ICL
- DANSK DATAMATIK CENTER

304
DESIGN OF TECHNIQUES AND TOOLS TO AID IN THE ANALYSIS AND DESIGN OF KNOWLEDGE BASED SYSTEMS

PARTNERS
- ICL NETWORK SYSTEMS
- SCS-SCIENTIFIC CONTROL SYSTEMS
- UNIVERSITEIT VAN AMSTERDAM TNO
- POLYTECHNIC OF THE SOUTH BANK

316
AN ARCHITECTURE FOR INTERACTIVE PROBLEM SOLVING BY COOPERATING DATA AND KNOWLEDGE BASES

PARTNERS
- CAP SOGETI INNOVATION
- CENTRE D'ETUDES RECH. TOULOUSE
- PHILIPS & MBLE ASSOCIATED
- CSELT S.P.A.

387
KNOWLEDGE REPRESENTATION AND INFERENCE TECHNIQUES IN INDUSTRIAL CONTROL

PARTNERS
- KRUPP ATLAS ELEKTRONIK GMBH
- BRITISH TELECOM PLC
- QUEEN MARY COLLEGE INTERACTIVE
- FRAMENTEC

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393 ACORD
CONSTRUCTION AND INTERROGATION OF KNOWLEDGE BASES USING NATURAL LANGUAGE TEXT AND GRAPHICS

PARTNERS
- CGE. LAB DE MARCOUSSIS
- BULL S.A.
- TRIUMPH-ADLER A.G.
- UNIVERSITY OF EDINBURGH
- UNIVERSITAT STUTTGART
- FRAUNHOFER INSTITUT

415
PARALLEL ARCHITECTURES & LANGUAGES FOR AIP - A VLSI DIRECTED APPROACH

PARTNERS
- PHILIPS GLOIENLAMPENFABR. N.V.
- AEG A.G.
- CSELT S.P.A.
- ESIEE
- NIXDORF COMPUTER A.G.
- TECHNISCHE UNIVERSITAT BERLIN
- TECHNISCHE UNIVERSITAT MUNCHEN
- STOLLMANN & CO. GMBH
- LIFIA
- GENERAL ELECTRIC COMPANY
- CWI-CEN.V.WISKUNDE&INFORMATICA
- BULL S.A.

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440 MADS
MESSAGE PASSING ARCHITECTURES & DESCRIPTION SYSTEMS

PARTNERS
- DELPHI
- CGE. LAB DE MARCOUSSIS
- VRIJE UNIVERSITEIT BRUSSEL

530 EPSILON
ADVANCED KNOWLEDGE BASE MANAGEMENT SYSTEM

PARTNERS
SYSTEMS AND MANAGEMENT SPA
BENSE KG
UNIVERSITAT DORTMUND
UNIVERSITA DI PISA
UNIVERSITE C.BERNARD DE LYON
CRISS

599
KNOWLEDGE BASED ASSISTANT FOR ELECTROMYOGRAPHY

PARTNERS
CRI-COMPUTER RESOURCES INTL.
JUDEX DATASYSTEMER APS
NORDJYDSK UDVIKLINGS CENTER
NAT.HOSP.FOR NERVOUS DISEASES
LOGICA UK LIMITED

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818 DELTA 4
DEFINITION AND DESIGN OF AN OPEN DEPENDABLE DISTRIBUTED COMPUTER SYSTEM ARCHITECTURE

PARTNERS
BULL S.A.
CNR-IEI
INESC
CNRS
MARI SOFTWARE SERVICES
UNIVERSITA DI BOLOGNA
TELETTRA S.P.A
LAB. DE GENIE INFORMATIQUE
JEUMONT-SCHNEIDER
GMD-GES.F.MATHEMATIK&DATENVER.
FERRANTI ELECTRONICS LTD.

820
DESIGN,EXPERIMENTATION OF A KBS ARCHITECTURE AND TOOL KIT FOR REAL TIME PROCESS CONTROL APPLICATIONS

PARTNERS
CISE
SNIAS-SOC.NAT.IND.AEROSPATIALE
FRAMENTEC
HERIOTT WATT UNIVERSITY
NEA-LINDBERG A/S
CAP SOGETI INNOVATION
ANSALDO IMPIANTI

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857 GRADIENT
GRAPHICS & KNOWLEDGE BASED DIALOGUE FOR DYNAMIC SYSTEMS

PARTNERS
CRI-COMPUTER RESOURCES INTL.
BROWN, BOVERI & CIE.
UNIVERSITAT KASSEL
UNIVERSITY OF STRATHCLYDE
KATHOLIEK UNIVERSITEIT LEUVEN

865
NON-MONOTONIC REASONING TECHNIQUES FOR INDUSTRIAL PLANNING APPLICATIONS

PARTNERS
BATTELLE INSTITUT
AERITALIA
ITALCAD
ELSAG SPA

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973 ALPES
ADVANCED LOGICAL PROGRAMMING ENVIRONMENTS SUPPORT

PARTNERS
CRIL
BULL S.A.
UNIVERSITE DE PARIS SUD/LRI
TECHNISCHE UNIVERSITAT MUNCHEN
UNIVERSIDADE NOVA DE LISBOA
ENIDATA SPA

1015 PALABRE
INTEGRATION OF ARTIFICIAL INTELLIGENCE, VOCAL I/O AND NATURAL LANGUAGE DIALOGUE - APPLICATION TO DIRECTORY SERVICES

PARTNERS
SESA
BRITISH TELECOM PLC
CNRS
POLITECNICO DI TORINO
SARIN S.P.A.
ERLI
CNET

1063 INSTIL
INTEGRATION OF SYMBOLIC AND NUMERIC LEARNING TECHNIQUES

PARTNERS
GEC RESEARCH LABORATORIES
COGNITECH
UNIVERSITE DE PARIS SUD/LRI

1106
FURTHER DEVELOPMENT OF PROLOG AND ITS VALIDATION BY KBS IN TECHNICAL AREAS

PARTNERS
PROLOGIA
ROBERT BOSCH GMBH
GIA
GIT.GES.FUR INGENIEURTECHNIKEN
DAIMLER-BENZ AG

OFFICE SYSTEMS

LIST OF PROJECTS MENTIONED

28 MULTOS
A MULTIMEDIA FILING SYSTEM

PARTNERS
- OLIVETTI
- BATTELLE INSTITUT
- CRETAN COMPUTER INSTITUTE
- TRIUMPH-ADLER A.G.
- MNEMONICA COMPUTER SERVICES
- ERIA S.A.
- CNR-IEI

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56 FAOR
FUNCTIONAL ANALYSIS OF OFFICE REQUIREMENTS

PARTNERS
- STC TECHNOLOGY LTD
- BET. INST. FUER ORG. UND AUT.
- GMD-GES.F.MATHEMATIK&DATENVER.
- THE EAST ASIATIC COMPANY LTD.

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59 MINSTREL
NEW INFORMATION MODELS FOR OFFICE FILING AND RETRIEVAL

PARTNERS
- NATIONAL SOFTWARE CENTRE LTD.
- DANSK DATAMATIK CENTER
- TRINITY COLLEGE DUBLIN
- GN DATA

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64 SPIN
SPEECH INTERFACE AT OFFICE WORKSTATION

PARTNERS
- CGE. LAB DE MARCOUSSIS
- AEG A.G.
- NIXDORF COMPUTER A.G.
- OROS
- CSELT S.P.A.
- UNIVERSITEIT VAN AMSTERDAM TNO
- CEA-DEIN/SIR
- NAT.TECHN. UNIVERSITY ATHENS
- SNS PISA
- SESA-SOCIETE ETUDES SYSTEMES AUTOMATIONS

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82 IWS
INTELLIGENT WORKSTATION

PARTNERS
- BULL S.A.
- CRETAN COMPUTER INSTITUTE
- OCE-NEDERLAND B.V.
- VRIJE UNIVERSITEIT BRUSSEL
- KATHOLIEKE UNIVIVERSITEIT NIJMEGEN
- INRIA

121 HERODE
HANDLING OF MIXED TEXT/IMAGE/VOICE DOCUMENTS BASED ON A STANDARDISED OFFICE DOCUMENT ARCHITECTURE

PARTNERS
- SIEMENS AG
- TITN
- UNIVERSITE DE NANCY-CRIN

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231 DOEOIS
DESIGN AND OPERATIONAL EVALUATION OF OFFICE INFORMATION SERVERS

PARTNERS
- ICL
- BULL S.A.
- TRINITY COLLEGE DUBLIN

234
COGNITIVE SIMULATOR FOR USER INTERFACE DESIGN

PARTNERS
- ALCATEL ESC
- GEC RESEARCH LABORATORIES
- MEDICAL RESEARCH COUNCIL
- LOGOS PROGETTI SRL

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249 UCOL
ULTRA WIDEBAND OPTICAL COHERENT LAN

PARTNERS
- INDUSTRY FACE STANDARD SPA
- POLITECNICO DI MILANO
- GEC RESEARCH LABORATORIES

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285 OSSAD
OFFICE SUPPORT SYSTEMS ANALYSIS AND DESIGN

PARTNERS
- INST.ORGANISATIONS TECHNOLOGIE
- CENTRE D'ETUDES DU MANAGEMENT
- IST. PER AUTOMAZIONE RISPARMIO
- UNIV. DEGLI STUDI DI MILANO

291
LINGUISTIC ANALYSIS OF THE EUROPEAN LANGUAGES

PARTNERS
- OLIVETTI
- ACORN COMPUTERS LTD
- TECHNOPOLIS CSATA NOVUS ORTUS
- UNIV. NACIONAL EDUCACION DIST.
- RUHR UNIVERSITAT BOCHUM
- UNIVERSITY OF PATRAS
- KATHOLIEK UNIVERSITEIT NIJMEGEN
- CNRS

295
THE PAPER INTERFACE

PARTNERS
- AEG A.G.
- OLIVETTI
- PLESSEY COMPANY PLC
- PHILIPS GLOEILAMPENFABRIEKEN
- TRENT POLYTECHNIC

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367 SOMIW
SECURE, OPEN, MULTIMEDIA, INTEGRATED WORKSTATION

PARTNERS
- BULL S.A.
- AEG A.G.
- INESC
- ITAL TELEMATICA SPA
- SOBEMAP S.A.
- SARIN S.P.A.
- INRIA
- CSELT S.P.A.
- CTRE ETUDE ENERGIE NUCLEAIRE

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385 HUFIT
HUMAN FACTORS LABORATORIES IN INFORMATION TECHNOLOGIES

PARTNERS
- FRAUNHOFER IAO
- BULL S.A.
- ICL
- PHILIPS GLOEILAMPENFABRIEKEN
- SIEMENS AG
- OLIVETTI
- HUSAT RESEARCH CENTRE
- UNIVERSIDADE DO MINHO
- WILHELMS UNIVERSITAT WESTFAHL.
- UNIVERSITY COLLEGE CORK
- THE PIRAEUS GRADUATE SCHOOL

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395 INCA
AN INTEGRATED NETWORK ARCHITECTURE FOR OFFICE COMMUNICATIONS

PARTNERS
- GEC RESEARCH LABORATORIES
- ATM COMPUTER GMBH
- OLIVETTI
- NIXDORF COMPUTER A.G.
- UNIVERSITY COLLEGE LONDON

563
A HIGH COMPRESSION PICTURE CODING ALGORITHM FOR PHOTOGRAPHIC VIDEOTEX

PARTNERS
- BRITISH TELECOM PLC
- CLETT
- INDEPENDENT BROADCASTING AUTH.
- NIXDORF COMPUTER A.G.
- KTAS
- DR. NEHER LABORATORIES
- CSELT S.P.A.

612
MODELING AND SIMULATION OF THE VISUAL CHARACTERISTICS OF MODERN DISPLAY TECHNOLOGIES UNDER OFFICE WORK CONDITIONS

PARTNERS
- OCE-NEDERLAND B.V.
- BARCO INDUSTRIES N.V.
- GEC RESEARCH LABORATORIES
- UNIVERSITEIT VAN TWENTE
- MYFRA S.A.
- CIMSA-SINTRA

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813 TODOS
TOOLS FOR DESIGNING OFFICE SYSTEMS

PARTNERS
- DORNIER GMBH
- ITAL TELEMATICA SPA
- POLITECNICO DI MILANO
- SEMA METRA
- THOMSON INFORMATIQUE SERVICES
- OCE-NEDERLAND B.V.
- CNR-IEI
- SYSTEM AND MANAGEMENT SPA
- UNIVERSITE PARIS 1 SORBONNE

901
AN INTELLIGENT GENERAL PUBLIC DATA, VOICE AND PICTURE STORAGE RETRIEVAL SYSTEM

PARTNERS
- PHILIPS GLOIENLAMPENFABR. N.V.
- BBC INTERACTIVE TELEVISION UNIT
- LOGICA UK LIMITED
- SEP
- BUREAU MARCEL VAN DIJCK N.V.
- UNIVERSITE DE NANCY-CRIN

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956 COCOS
COMPONENTS FOR FUTURE COMPUTING SYSTEMS

PARTNERS
- BULL S.A.
- ICL
- OLIVETTI
- SGS MICROELETTRONICA SPA
- NIXDORF COMPUTER A.G.
- INRIA

1024 PODA
PILOTING OF THE OFFICE DOCUMENT ARCHITECTURE

PARTNERS
- SIEMENS AG
- BULL S.A.
- OLIVETTI
- TITN
- ICL
- QUEEN MARY COLLEGE INTERACTIVE
- SERVICE ETUDES COM. POSTES TEL

1057 MIAC
MULTIPOINT INTERACTIVE AUDIOVISUAL COMMUNICATION

PARTNERS
- BRITISH TELECOM PLC
- CSELT S.P.A.
- INDUSTRY FACE STANDARD SPA
- STC TECHNOLOGY LTD
- TELECOM. RADIOELEC. & TELEPH.
- CNET
- DR. NEHER LABORATORIES
- TELEFONICA CTNE

1541
MULTI-LINGUAL SPEECH INPUT-OUTPUT ASSESSMENT, METHODOLOGY & STANDARDISATION

PARTNERS
- UNIVERSITY COLLEGE LONDON
- CSELT S.P.A.
- UNIVERSITEIT VAN AMSTERDAM TNO
- CNET
- JUTLAND TELCO (JTAS)

COMPUTER INTEGRATED MANUFACTURING

LIST OF PROJETS MENTIONED

9
EXPLOITATION OF REAL-TIME IMAGING FOR ARC WELDING

PARTNERS
- THE WELDING INSTITUTE
- BABCOCK POWER
- RWTH AACHEN
- MESSER GRIESHEIM

118
GENERAL PURPOSE SENSORY CONTROLLED SYSTEMS FOR PARTS PRODUCTION

PARTNERS
- SIEMENS AG
- COMAU SPA
- OLIVETTI
- SINCON SPA
- FRAUNHOFER INSTITUT

278
INTEGRATED SENSOR-BASED ROBOT SYSTEM

PARTNERS
- MARI ADVANCED MICROELECTRONICS
- ROBERT BOSCH GMBH
- UNIVERSIDADE NOVA DE LISBOA
- NAT.TECHN. UNIVERSITY ATHENS
- UNIVERSITY OF NEWCASTLE
- JOYCE LOEBL LIMITED
- FRAUNHOFER INSTITUT

319
DATA TRANSFER BETWEEN CIM SYSTEMS & MANAGEMENT INFORMATION SYSTEMS

PARTNERS
- MENTEC INTERNATIONAL LTD
- COMPUTER SYSTEMS DEVELOPMENT
- TRINITY COLLEGE DUBLIN

322
CAD INTERFACES — CAD-I

PARTNERS
- KERFORSCHUNGZENTRUM KARLSRUHE
- BMW-BAYERISCHE MOTORENWERKE AG
- CRANFIELD INST.OF TECHNOLOGY
- ERDISA
- KATHOLIEK UNIVERSITEIT LEUVEN
- LEUVEN MEASUREMENT & SYSTEMS
- RUTHERFORD APPLETON LABORATORY
- UNIVERSITAT KARLSRUHE
- GFS-GES.FUR STRUKTURANALYSE
- CISIGRAPH
- DANMARKS TEKNISKE HOJSKOLE
- N E H ENGINEERING

338
PRODUCT DESIGN FOR AUTOMATED MANUFACTURE & ASSEMBLY

PARTNERS
- CRANFIELD INST.OF TECHNOLOGY
- CIMAF
- RENAULT AUTOMATION
- COMAU SPA

418
OPEN CAM SYSTEM ALLOWING MODULAR INTEGRATION INTO FACTORY MANAGEMENT OF A WORKSHOP STRUCTURE IN FUNCTIONAL CELLS WITH VARIOUS LEVELS OF AUTOMATION

PARTNERS
- FABRIQUE NATIONALE HERSTAL S.A.
- UNIVERSITE DE BORDEAUX I
- MATRA
- PROCOS A/S
- RTM
- OLIVETTI
- LOGICA UK LIMITED
- CIG-CENTRE D'INFORMATIQUE GEN.
- RWTH AACHEN

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477 — COSIMA
CONTROL SYSTEMS FOR INTEGRATED MANUFACTURING: THE CAM SOLUTION

PARTNERS
- COMAU SPA
- DIGITAL EQUIPMENT CORP.GMBH
- RENAULT AUTOMATION

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504 — PAQO
PLANT AVAILABILITY AND QUALITY OPTIMISATION

PARTNERS
- STEWART HUGHES LTD
- ADERSA GERBIOS
- BATTELLE INSTITUT
- GESELLSCHAFT FUR REAKTORSICHERHEIT
- TECHNISCHE HOCHSC.DARMSTADT
- DANOBAT S.COOP
- AMTRI
- IKERLAN

623
OPERATIONAL CONTROL FOR ROBOT SYSTEM INTEGRATION INTO CIM

PARTNERS
- FRAUNHOFER IPK
- POLITECNICO DI MILANO
- UNIVERSITAT KARLSRUHE
- LADSEB
- PSI
- SERAM
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- UNIVERSITE DE VALENCIENNES
- UNIVERSITEIT VAN AMSTERDAM TNO
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- UNIVERSIDADE NOVA DE LISBOA
- KUKA SCHWEISSANL.&ROBOTER GMBH
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- FIAR SPA

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688 AMICE
AMICE,A EUROPEAN COMPUTER INTEGRATED MANUFACTURING ARCHITECTURE

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- CAP GEMINI SOGETI
- AEG A.G.
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- ITALSIEL SPA
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- SNIAS-SOC.NAT.IND.AEROSPATIALE
- RWTH AACHEN
- VOLKSWAGEN AG
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- PHILIPS & MBLE ASSOCIATED
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- GENERAL ELECTRIC COMPANY
- DIGITAL EQUIPMENT CORP.GMBH
- CIT-ALCATEL
- BULL S.A.
- AT.T & PHILIPS TELECOM.BEDR.

932
KNOWLEDGE BASED REAL TIME SUPERVISION IN CIM

PARTNERS
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- AEG A.G.
- BICC PLC.
- TITN
- FIAR SPA
- FZI KARLSRUHE
- SIS AV
- UNIVERSITE DE SAVOIE
- INDUSTRIE PIRELLI SPA
- SGN GRAPHAEL
- FRAUNHOFER-IPA
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955 CNMA
COMMUNICATION NETWORK FOR MANUFACTURING APPLICATIONS

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- AERITALIA
- TITN
- FRAUNHOFER IITB
- ICL
- OLIVETTI
- SIEMENS AG
- PEUGEOT
- NIXDORF COMPUTER A.G.
- GENERAL ELECTRIC COMPANY
- ELF
- BULL S.A.
- BMW-BAYERISCHE MOTORENWERKE AG

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975 TRACIT
TRANSPONDERS FOR REAL-TIME ACTIVITY CONTROL OF MANUFACTURING LINKS TO CIM INFORMATION TECHNOLOGY SYSTEMS

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33 ROSE
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- SIEMENS
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- ICL

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719 THORN
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- DFN
- ICL
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717 HERMES
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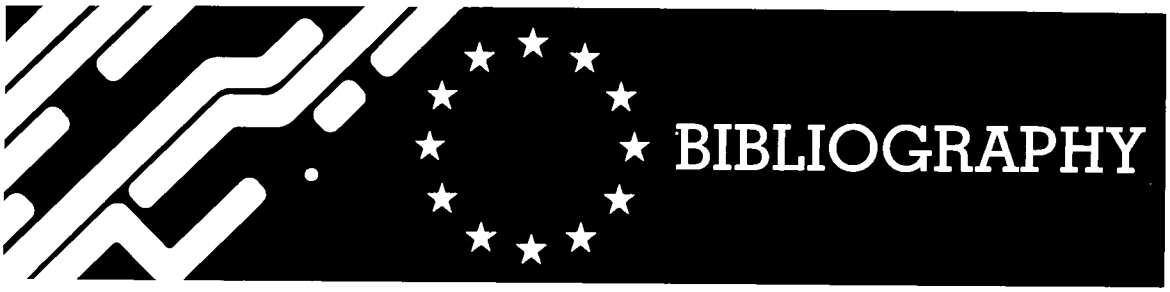

ESPRIT DOCUMENTATION

Available from:

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B-1049 Bruxelles
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INFORMATION

ESPRIT General Brochure
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ESPRIT Project Synopses - 7 volumes*
(Index,MEL,ST,AIP,OS,CIM,IES)
(EN only)

ESPRIT Information Package*
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ESPRIT Workprogramme*
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ESPRIT Basic Research Actions Information Package

ESPRIT Mid Term Review. 1985
(EN,DE,FR,NL,IT,DK)

ESPRIT - The First Phase, Progress & Results. 1986
(EN,DE,FR,NL)

ESPRIT - International Joint Collaborative AI, Special Session at IJCAI 87.
(EN only)

(* revised annually)

OFFICIAL DOCUMENTS

Official Journal L118, 6.5.88
Council Decision adopting the second phase of ESPRIT.

COM (86) 687 final ESPRIT - The First Phase Progress and Results. Communication from the Commission to the Council. Available in all languages.

COM (85) 616 Communication from the Commission to the Council and the Parliament concerning a review to assess the intial results of the programme ESPRIT. (DA, DE, EL, EN, FR, IT, NL)

COM (86) 269 Communication from the Commission to the Coucil - The Second Phase of ESPRIT.

COM (87) 290 final - TOWARDS A DYNAMIC EUROPEAN ECONOMY
Green Book on the development of the Common Market for Telecommunications Services and Equipment.

COM (88) 48 final - TOWARDS A COMPETITIVE COMMUNITY-WIDE TELECOMMUNICATIONS MARKET IN 1992
Implementing the Green book (above)

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Also available from North Holland are:

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Design Rules for a CIM System
By R.W. Yeomans, Istel Ltd, Coventry, UK, A. Choudry, University of Amsterdam, The Netherlands, and P.J.W. Ten Hagen, Center for Mathematics and Computer Science, Amsterdam, The Netherlands.

1985 x + 454 pages
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ISBN 0-444-87812-2

Human Factors of the User-System Interface
A Report on an ESPRIT Preparatory Study
Edited by B. Christie, ITT Europe Human Factors Technology Centre, Harlow, Essex, United Kingdom.

1985 xii + 272 pages
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Ada Components: Libaries and Tools
Proceedings of the Ada-Europe International Conference Stockholm 26-28 May 1987

Edited by Sven Tafvelin
Published 1987, pp292
ISBN 0-521-346363

OTHER PUBLICATIONS MENTIONED

Manual of Office Support Systems Analysis and Design
Author: De Antonellis et al
Published: January 1988

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A bimonthly publication on computer networking.

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