Esprit

European Strategic Programme for Research and Development in Information Technology

1988 Annual Report

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

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FOREWORD

by M. Carpentier, Director General

DG XIII

Telecommunications, Information Industries and Innovation

Commission of the European Communities

The Community's mandate for high technology, laid down in the Single Act, places unambiguous emphasis on strengthening the competitiveness of European industry. Its means for carrying out that mandate are primarily contained in the five-year Framework Programme for Research and Technology Development, approved by the Council of Ministers in September 1987, with a budget of 5.4 billion ECU. Approximately 40% of this is allocated to the programmes managed by DG XIII, including ESPRIT, which is the largest single R&D programme of the Community, and RACE, which paves the way towards a pan-European broadband network.

ESPRIT and RACE have brought together several hundred companies, universities and research institutes in the Community, focusing the work of 6,000 to 7,000 researchers on key technological objectives. These programmes link industry and the IT research community across European frontiers and across the commercial/academic divide, pooling work that was otherwise being duplicated or was not large enough to attain the necessary critical mass. Moreover, our programmes give companies access to a range of technology options they could not have covered on their own.

The programmes concerned with the direct strengthening of the scientific and technological base of European industry are embedded in an overall Community IT&T strategy, which has several lines of action. Firstly, we aim to create the conditions for a dynamic, unified market for information and communication technology equipment and services. This includes standardisation, opening up public procurement, ensuring open and fair competition, and encouraging market pull through European applications that demonstrate the innovative potential of new technology and services. Secondly, our actions contribute to the establishment of a common policy in telecommunications. This is vital for industry in the context of 1992.

On a broader front, we must prepare the transition to a society and economy in which information will play a paramount role. This includes education and training, and concerted action with the social partners. Moreover, it is very important to avoid widening the economic and social disparities between the metropolitan and the peripheral regions of the Community. An example of our approach here is the special telecommunications action for regional development, the STAR programme, which is a concerted effort to upgrade telecoms in the less-developed regions and keep them connected to the mainstream of economic development. Furthermore, on a global scale, it is our role to foster as much as possible a common approach for the Community in multilateral or bilateral negotiations in trade policy.

The proof that European collaboration works is evidenced by the excellent results of the R&D programmes which, for ESPRIT, are presented in this report. These results are reinforced by an overall Community strategy, which sets the conditions for success and amplifies the weight of Europe's collective presence on the world scene.

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INTRODUCTION AND PROGRAMME HIGHLIGHTS

J-M. Cadiou, Director ESPRIT - IT
Commission of the European Communities - DG XIII

1. INTRODUCTION

1988 was a particularly successful year for ESPRIT. It marked both the end of the first five-year period of ESPRIT I and saw the launching of ESPRIT II.

Before I report on the highlights of the year, I would like to make some remarks on the situation of the European IT industry, a context which demonstrates the great strides which have been taken, and pinpoints what still needs to be done.

Information Technology (IT) is one of the fastest developing and most influential areas of industrial activity. IT is a major industry in its own right - a 600 billion dollar worldwide market, with an annual growth rate in Europe of 10%, a level which is expected to continue well into the next decade. But more importantly, IT has a deeply felt impact on competitivity and employment in the economy as a whole: it is estimated that 70% of manufacturing and the tertiary sector are dependent on the ready availability and application of IT products and services to achieve or maintain a competitive edge.

Furthermore, IT is essential to removal of existing barriers towards the achievement of the Single Market. Electronic Trade Document and Data Interchange across borders is an example, as well as the Community-wide introduction of chipcards for providing services to the business community and to the citizens.

To gain an understanding of the present status and trends within the European IT industry it is useful to review their recent evolution. At the beginning of the 1980s European suppliers were in a weak position in several sectors, and the situation of the European IT industry in general was giving cause for concern. The European IT industry in the early 1980s was characterized by a decreasing market share, leading to lack of critical mass, low R&D and reduced capital investments.

Something substantial needed to be done to attempt to reverse this trend. It was generally recognized that the European scale was the only practical level for concerted action; the fragmented national markets were too small to provide the economies of scale required to compete and "national" companies could not find a sufficient space for expansion in their national market alone: worse yet, national public policies tended to polarize these too precisely towards their national markets.

The ESPRIT Programme

ESPRIT (European Strategic Programme for Research and Development in Information Technology) was defined after a thorough analysis undertaken in close liaison with industry in 1982 and 1983.

ESPRIT has the following three objectives:

- to provide European IT industry with the basic technologies to meet the competitive requirements of the 1990s;

- to promote European industrial cooperation in IT;

- to pave the way for standards.

The first phase of the ESPRIT Programme started in 1984. The total R&D efforts of the first phase amounted to 1,500 MECU, 50% of which were borne from the Community budget, the other 50% by the participants in the Programme.

The Programme is implemented by projects selected from public calls for proposals and based upon the annually updated Workplan. The Programme comprises collaborative pre-competitive research and development projects, carried out across frontiers by Community companies, universities and research institutes. Under ESPRIT I, 226 projects have been launched, each containing at least two independent industrial partners from different Member States. 3,000 engineers and scientists are working full-time on ESPRIT I projects, coming from 420 independent organisations. All indications are that ESPRIT I is well on its way to meeting its objectives.

In fact, even before the completion of ESPRIT I, ESPRIT II was initiated in 1988. It is a larger scale operation, but still preserves the mechanisms used in ESPRIT I - the cost-sharing between Community and partners, the consensus-building, the Workplan and the on-going assessment principle. The total of ESPRIT II is 3,200 MECU, of which 50% is allocated from the research budget of the Community. ESPRIT II is estimated to represent about 5% of the R&D expenditure in the IT industry. However, relative to the *precompetitive* part of R&D its share is much larger, and it has played an important catalytic role in stimulating a growth of total R&D investment up to levels which are now equal to that of US companies in terms of percentage of turnover.

Under the first call for proposals for ESPRIT II, after a severe selection process by independent experts, 156 proposals were selected to go through to contract. These 156 projects regroup 585 participating organisations and represent about half of the whole ESPRIT II Programme. ESPRIT II is broadening the process of industrial cooperation to include focused actions aimed at specific shortcomings which have been identified.

Results

The central element of the ESPRIT mechanism is cooperation. Indeed, after five years, we can clearly see that the basic idea of cooperation and resource-sharing has been working, perhaps beyond expectations: indeed, at the outset of the programme, many people doubted that it could be viable. The mechanism seems to be that, through a combination of result-sharing, work-sharing and risk-sharing, there is indeed, despite some inevitable overhead, a multiplier effect and an accelerator effect which enable the IT industry overall to achieve more that it would have done otherwise and to achieve it faster.

The cooperation in ESPRIT has produced a large number of direct results and projects nearing completion are delivering concrete results with major industrial impact. I refer to these in detail in the table below.

ESPRIT I Programme Statistics 1988

Number of ESPRIT I projects of which	226
Completed before 1988	37
Completed during 1988	54
Ongoing at end 1988	135
Participating organisations of which	526
Companies with fewer than 50 employees	62
Companies with 50-500 employees	84
Other companies	181
Universities and research institutions	199

As of December 1988, 130 of the 226 projects had provided a total of 166 major results. Out of these, 42 have contributed directly to products or services currently available on the market; 48 have contributed directly to products or services being developed for the market but not yet commercially available; 46 are being used outside the ESPRIT project, either within the company concerned or in another company (technology transfer); 30 have contributed to standardisation, either being 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.

Beyond these direct technological results, ESPRIT has had a number of indirect effects, or spin-offs.

All in all, the momentum and impact of the ESPRIT Programme can be felt in the way that the European IT industry is facing up to the technology challenge. Confidence and morale are higher. IT industry is achieving critical mass, not just in R&D cooperation, but also in spin-off partnerships beyond the original scope of particular ESPRIT projects, fostering strategic ventures. IT industry is also restructuring in order to tackle the entrepreneurial opportunities of the 1990s, including the achievement of the single market. There is increased credibility on the part of customers and suppliers, and European firms are taking an active role in developing world standards.

We are beginning to see the fruits of the combined efforts and, in strictly quantitative terms, the situation in the Information Systems industry is now quite different:

- European IT companies have doubled their R&D and capital investment in four years and are now investing in R&D and capital investment a proportion of their sales very close to that of US companies;

- based on an analysis of the top 25 data processing companies, European companies have considerably increased their market share in Europe from 33% in 1983 to 48% in 1987. US companies lost market share in the European market during this period.

However, these improvements do not mean the situation is satisfactory, far from it.

Remaining Points To Address

Although the European Information Processing industry seems on the way to overcoming some of its previous weaknesses, major problems still remain. The IT balance of trade is negative and the trend is also negative.

The Electronic Components industry has not progressed in Europe at the same rate as other sectors of the IT industry, making the IT industry even more dependent on foreign suppliers of critical and strategic components.

The situation is similarly critical in certain types of computer peripherals.

A further and critical weakness is the lack of trained personnel. Estimates of the required number of trained personnel vary widely but it is clear that not enough people with the right skills are being trained.

ESPRIT is well positioned to provide the European IT industry with an efficient platform to develop technology but also to act as a catalyst to further prepare the necessary joint-ventures and restructuring which are needed to face the challenges of the nineties.

The situation in the nineties will be quite different from that which we saw in the eighties, with major new opportunities, but each presenting major risks as well.

1992 and the integrated market will clearly mean extra overall economy growth. The IT market itself is expected to grow faster in Europe than the rest of the economy and also faster in Europe than elsewhere.

This extra growth will obviously attract the world IT industry. The question is whether the European IT industry will succeed in taking advantage of these opportunities in the presence of the increasingly competitive situation which they are likely to generate.

2. 1988 PROGRAMME HIGHLIGHTS

In the following sections, the overall strategy of each ESPRIT I area is outlined, and a selection of the most important industrial achievement of ESPRIT during 1988 is presented. For a wider discussion, and a full list of significant achievements, the reader is referred to the respective chapters of this Report. A complete list of ESPRIT I projects may be found on pages 79 to 89.

2.1 Advanced Microelectronics (MEL)

The Computer-Aided Design (CAD) tools and the manufacturing processes developed in the Advanced Microelectronics area of ESPRIT are increasingly finding their way into industrial fabrication plants. These advanced tools and processes allow the smallest feature on the circuits to be reduced to less than one micron, thereby permitting circuits with more than one million transistors to be put on a single chip. The microelectronics ESPRIT projects are also extending the scope of the tools and the applicability of the manufacturing and testing techniques to allow a wider variety of circuits. This will result in chips for products in the consumer, computer and communications fields which are both more flexible and cheaper.

In the CAD area, 1988 saw the emergence of a consensus on standards for the exchange of design data. Significant results from CAD research projects have also been achieved. For example, the CATHEDRAL design system for digital signal processing circuits was improved and applied in the design of chips employed in digital colour video filter circuits and compact disc audio players. The SPIRIT CAD system, produced by ICD from developments in ESPRIT Project 991, won prizes in the USA for production of the most compact layouts, which implies the cheapest cost. This system is used by Philips and is sold by ICD running on a workstation made by PCS, the other partner in the project.

ESPRIT's achievements in CAD also extend to circuits in the gallium arsenide (GaAs) compound semiconductor material. A package produced by ArguMens is available on avariety of computer workstations and out-performs other commercially available software packages. Projects designed to cut down the cost of testing fabricated chips include the use of the revolutionary technique known as Built-In Self-Test (BIST), where circuits to test the device are included on the chip itself. During 1988 ICL sompleted the design of their first commercial circuit using BIST, and thereby hope to greatly reduce their dependency on expensive external test equipment.

More demonstrator chips have been produced in the three major process technologies of complementary metal oxide semiconductor (CMOS), bipolar silicon, and mixed CMOS and bipolar (BICMOS). The SPECTRE project for CMOS is preparing for a 0.7 micron feature size process in 1989 and intends to fabricate circuits in five locations. Demonstrators produced by the submicron Bipolar II project led to further gate array families for Siemens' internal use and for commercial customers. Pilot runs on a 90 million ECU line led to full production of 1 micron scale static memory chips by the end of 1988.

A full range of multipliers, dividers and analog/digital converters have been produced in gallium-arsenide, which is an ideal semiconductor for high-speed applications and consumes little power. A wide range of circuit-making processes in GaAs is being tackled and the demonstration chips are performing to the best world standards. Real-time signal processing is among the applications which will increase the demand for these compound semiconductor circuits. In the peripherals area, research on magnetic materials for memory products has led BASF to launch a floppy disc with three times the capacity available hitherto.

2.2 Software Technology (ST)

The Software Technology (ST) area of ESPRIT was set up to provide the European IT industry with the methods and tools to produce more effective and efficient software systems. The main directions taken in 1988 were to further encourage the industrial take-up of the results emerging from the projects, and, through the integration of the ST and the Advanced Information Processing programmes (see next section), to establish a new point of departure for the second phase of ESPRIT. During 1988 progress was achieved in three major areas:

(a) Progress towards a common basis for software product development:

- The Portable Common Tool Environment (PCTE) project was completed during the year. It is now providing a supportive environment for the development of state-of-the-art software products. It is already in use in European industry and universities.

- Ten projects intended to widen the availability of PCTE-based systems were underway during the year, aiming to support their industrial use and hence influence the definition of international standards.

(b) Greater rigour in the development of software systems:

- There has been progress in developing methods which will significantly improve the efficiency of the software design process and the reliability of the end-product. Reliability is important because maintenance of software requires two-thirds of most companies' developmental resources.

(c) Effective management mechanisms for the control of very complex projects.

- Software development projects often suffer from cost and schedule overruns. One way to improve competitivity is to provide the managers of such projects with the tools to avoid these problems. A number of projects are successfully tackling this area, and a prototype has been produced for the development of an information system to support management activities in the software product lifecycle.

2.3 Advanced Information Processing (AIP)

The main goals in this area are to ensure the development of and to lay the foundations for the industrial application of knowledge engineering techniques 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.

The emphasis during 1988 has been on the industrial take-up of results and on integrating this area with the Software Technology area.

The results achieved can be classified into three groups: Knowledge Engineering, Computer Architecture and Interfaces. One example of each follows.

Knowledge Engineering: on the basis of ESB, Project 96, the Expert System Builder for Knowledge-Based Systems Development has been created. By the end of the project in September 1988, the Danish company Soren T. Lyngsoe had announced the commercial release of two products based on the results of this project, THOR and ODIN, for the automatic creation of power-plant applications. In addition Plessey is using this system internally, and TECSIEL has announced the commercialisation of their system builder on a range of machines. In other projects, basic tools have been developed both for knowledge acquisition and the creation of Knowledge-Based Systems, and the success of the demonstrators has assisted the transfer of this technology to industry.

In the Supernode project, work by THORN-EMI, RSRE, INMOS, TELMAT, APSIS, and the Universities of Grenoble and Southampton has brought to the market a low-cost high-performance multiprocessor system which provides the best price/performance ratio among minisupercomputers, leading to the two. T.NODE and PARSYS 1000 commercial product lines. Other systems will be commercialised based on the T800 floating point transputer which was also developed in the same project; 10,000 T800s are sold each month, many of them in Japan. The success of this project led to the decision by Thorn EMI to launch the new start-up PARSYS.

Interfaces: the hardware and software for a system for speech and image recognition and understanding has been developed in SIP, Project 26. The speech system has been developed to understand spoken sentences at a speed close to real time and will allow the on-line spoken interrogation of databases. The image processing system will be of great benefit in, for example, automated manufacturing systems by allowing robots on an assembly line to recognize components. The systems were demonstrated at the ESPRIT '88 Conference.

2.4 Office Systems (OS)

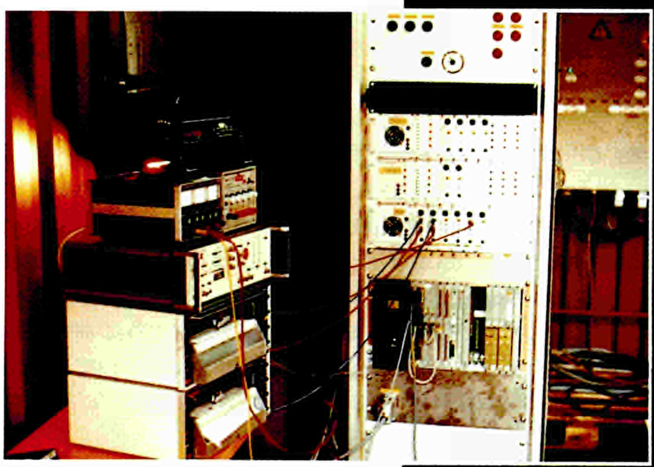
It has been evident for some time that employment is moving from factory to office and that competitivity depends on efficient office systems. The design of the office of the future is becoming clearer: it will use electronic means to replace gradually paper communication with electronic document communication. The diversity of computer installations complicates this objective. Key tasks in the office systems area are to ease the way humans deal with computer workstations, and to ensure simple and secure communications between different makes of computer equipment.

At the heart of the strategy is a multimedia office document architecture (ODA), which, it is hoped, will be adopted by the major equipment manufacturers and assist software producers. In 1988 the ODA standard gained wider acceptance within ESPRIT projects and within the industry. This format and method of sending documents has been adopted by the European Computer Manufacturers' Association (ECMA) and by the International Standards Organisation (ISO), and is included in the CCITT T.400 series of recommendations. ODA-based word processors and desktop publishing systems are expected on the market by 1990. Another project is fitting voice into the standard ODA framework.

New office products which go beyond traditional terminals, printers and facsimile transmission are also being developed. A large-scale display panel with computerised control of up to 251 individual panels was tried out in 1988. Coding of picture signals may lead to an international standard for digital - ISDN - telecom transmissions. Prototype workstations are also demonstrating advanced methods for handling text, pictures and graphics and also for filing them. They can also decipher handwritten information and accept spoken instructions. Bull and AEG are two partners considering marketing such products.

It is important to be able to read paper documents directly into machine-understandable code for display on a screen and for storage or manipulation. One achievement within ESPRIT is a high-resolution colour scanner which can be connected to a workstation. Colour documents and reproduction by printers are tackled by another project which expects industrial results by 1990.

Shifting large volumes of data - text, pictures, graphics and eventually voice messages - efficiently is a large part of the ESPRIT office systems area. Projects on local area networks, linking the terminals in an office building, are leading to new methods which can handle larger volumes. Optical fibres and packet switching at 140 Megabits/second have been demonstrated with gateways to lower volume ISDN networks and satellites. A videoconference in 1988 between Liège and Antwerp, in Belgium, proved the technology and specifications developed by the project partners. Optical fibre links within a metropolitan area have also been tested.



In ESPRIT II Project 2280, LAMA (Large Manipulators for CIM), AEG AG, Bertin & Cie, Casa-Construcciones Aeronauticas SA, Frauenhofer IPK and IPA, Moog Controls Ltd., Putzmeister-Werke Maschinenfabrik GmbH and Teknologisk Institut will cooperate in the task of equipping the largest machines with intelligence.

2.5 Computer-Integrated Manufacturing (CIM)

The benefits of the standards and technologies developed in the CIM area of ESPRIT were proved in working factory demonstrations during 1988. The setting of international communication protocols and interfaces within the open systems interconnection model enabled equipment from a series of major hardware makers to be linked together, and these systems were demonstrated publicly during 1988. Projects in the other three major areas of CIM are also influencing product development. This is clearly the case in the niche markets of design, graphics and engineering, in robotics and in manufacturing planning and control.

The nineteen organisations in the AMICE project on open systems architecture turned their 1987 key concepts publication into a working demonstration of the CIM-OSA philosophy in 1988. The Communications Network for Manufacturing Applications (CNMA) project continued to promote its standards, which are compatible with the Manufacturing Automation and Technical Office Protocols (MAP and TOP). CNMA outshone these two US multi-vendor environments with its production demonstration at the Enterprise Networking Event '88 in Baltimore, US. It was also applied in 1988 in BMW, British Aerospace and Aeritalia factories.

Interfaces with equipment in other stages of the manufacturing process have been developed in the areas of Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE). A CAD data exchange standard is close to international acceptance. Software tools for quicker production of CAD software and improvements to the way operators deal with their terminals are leading to redesigns of industrial products already on the market. Demonstrators of computer-aided lathe controllers with enhanced graphics have been installed at two plants in the UK with a third site at Bremen University ready for further experiments.

Robotics prototypes developed in ESPRIT have led directly to marketable products by project partners. Tactile image sensors and analysis, low-cost vision and highly adaptable sensorised gripper systems have led the partners to manufacture piezoelectric sensors and vision systems. The manufacturing planning and control system area of CIM looks at overall automation plans in the factory.

2.6 Infrastructure

The Information Exchange System (IES) provides facilities and communications mechanisms to support ESPRIT activities, and administers several ESPRIT projects which are targeted to support the development of OSI-conformant products. It is also a mechanism by which the Community can support improvements in the use of data communications infrastructures by European researchers.

The IES services have expanded significantly in 1988: the European mail and conferencing system now has over 1500 subscribers, and the circulation list of the IES newsletter has doubled, to 10 000 readers.

In the area of the development projects, the ROSE project successfully demonstrated working products at the ESPRIT Conference, with X.400 (message handling) and FTAM (file transfer) interworking across a heterogeneous network of machines from five different European manufacturers. The THORN project, developing OSI-conformant directory services, is now operating a pilot experimental service, covering the names of 20 000 people from about 1000 organisations. Significant input is being made to the standards development process in this area, and THORN is recognised as being at the forefront of development in the directories sector.

The CARLOS project is aimed at providing OSI interfacing for the benefit of users of personal computers. The Carlos Network Management Centre has been installed by the Danish Library Service, and the Virtual Terminal (VT) has been selected for use by British Telecom.

With respect to the support given to European researchers for their computer networking activities, the RARE (Réseaux Associés de la Recherche Européenne) message-handling project has doubled in coverage in 1988 and now involves over 350 sites worldwide.

The EUREKA COSINE project aims to provide an OSI-conformant networking infrastructure for the European research community. The specification phase of the project was completed during 1988.

The prime forum for disseminating the results of the programme is the ESPRIT Conference Week. In 1988 it was held in Brussels in mid-November. There were more than 4000 participants and, for the first time, a special ministerial session. The conference has a double focus: not only 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", decision-makers on the European political and economic scene discussed the political and industrial environment surrounding ESPRIT, while workshops offered ESPRIT participants the chance to discuss the detailed implementation of the programme and issues concerning project management.

At the exhibition during the Conference Week over 70 projects exhibited products and services developed as a result of the ESPRIT programme. Ministers visited the exhibition.

In 1989 the ESPRIT Conference Week will again be held in Brussels, from November 27 to December 1.

3. THE FUTURE: ESPRIT II

The following sections outline the main characteristics of ESPRIT II for each area covered by this second phase of the ESPRIT programme.

3.1 Advanced Microelectronics (MEL)

The integrated circuit market was worth 4.8 billion ECU in 1988 and it is expected to rise to 7.7 billion ECU by 1995. Application-specific circuits (ASICs) are expected to show especially strong growth from 21% of the market now to about 32% in 1993. The growth ratio of this sector alone is 20% per year. More than half of this - 56% - is expected to be high density CMOS silicon with up to 10 million transistors on each chip. Mixed technology is estimated to take 20% and high speed 24% of the ASIC market.

Accordingly, the ESPRIT II programme is intended to provide European industry with the means to produce components which are competitive in terms of price and performance. In the ASICs sector equipment and techniques for processing are to be developed which approach the limit of 0.3 micron imposed by the wavelength of light.

In the high-speed sector, a large-scale TIP (Technology Integration Project) will combine the European leaders in bipolar circuit technology in order to reach a minimum emitter width of 0.3 micron with a 50-100K gate demonstrator and a power-delay product of 10 fJ. Liquid and aircooled packaging are to be developed in parallel. In multi-function circuits, the design rules of the successful BICMOS technology will be reduced to 0.7-0.8 micron and the production capability demonstrated up to a density of 200 000 transistors on a chip.

ESPRIT's success in its microelectronic activities has also led two major chip-makers and three research institutes to link up for the third TIP so far launched. This will develop all the steps in making integration of high-density programmable read-only memories (PROMs) with CMOS logic circuits. These R&D investments, along with further CMOS, GaAs (gallium-arsenide) and process equipment projects in 1989, should eventually lead to an increase in Europe's share in the future marketplace.

During 1988, 30 new microelectronics projects were selected out of this first ESPRIT II call for proposals.

3.2 Information Processing Systems (IPS)

The IPS area is a combination of the previous Software Technology and Advanced Information Processing areas. This merger enables a better synergy between these two closely linked areas. IPS now consists of four subareas: system design, knowledge engineering, systems architecture, and speech and vision systems.

ESPRIT II aims to support the development of ever more complex systems by providing a set of projects that will balance the shorter-term and longer-term potentials for exploitation by European industry.

System Design

The proposals selected aim to consolidate the progress made in software engineering, and from this strong basis initiate the development of the necessary technology for the support of full systems development and maintenance. The importance of this technology stems from the need for reliability, and a growing concern about the increasing use of computer systems in safety-critical areas. The feasibility of a programme for the European certification of software quality will be investigated.

Knowledge Engineering

The proposals selected aim to improve industry's ability to tackle complex problems in a widening field of application domains in which services and manufacturing are two of the major segments. European IT industries should benefit from a growing market to build efficient and reliable large knowledge-based systems. Projects will provide the capability to develop advanced man-machine interfaces and techniques for knowledge acquisition and validation. The maturity of machine learning techniques is now sufficient for a start to be made on building an environment for use in the first stage of industrial exploitation.

Advanced Systems Architecture

The SUPERNODE results achieved in the first phase of ESPRIT on the development of high performance/low cost parallel architecture computers will be enhanced in the second phase. A comprehensive extension will be made to the range of European minisupercomputers developed in ESPRIT I which are now being built and marketed by a small French and a small British company. In ESPRIT II, SUPERNODE II is aiming mainly at designing and providing software tools to support the parallel programming techniques of the SUPERNODE machine. All the aspects of the exploitation of a distributed memory, message-passing architecture, including the development of an operating system compatible with standard user interfaces, language compilers and libraries, will be covered. The policy is to concentrate on important issues directly relevant to the usability of parallel machines. The aim is to achieve a balance between language support, the porting of PCTE on parallel machines of the transputer family and obtaining an efficient parallelisation of languages to support multi-instruction multi-data machines.

The feasibility of Europe entering the field of true supercomputing will also be investigated. The market for supercomputers, which at present is concentrated on a limited range of specialised applications, is expected to grow rapidly, with the emergence of high-performance machines for computer-aided design, and a range of scientific and engineering applications.

Speech and Vision Systems

Speech technology is now close to industrial application. Therefore three projects to implement complete systems are to be launched.

For vision, the projects under consideration realise complete systems through the use of available algorithms and processing technology. The approach provides for the evolution of a family of products over a long period.

In IPS, 45 new projects were selected in total out of the first ESPRIT II call for proposals.

3.3 Computer-Integrated Manufacturing (CIM)

The world market for CIM is forecast to double from 30 billion ECU in 1986 to 60 billion ECU in 1992. An important objective in ESPRIT II is to expand the Community share of this market (currently around 20%) to a level of domination in Europe and to achieve a significant penetration of non-Community markets. A second objective is to accelerate the modernisation process in a wide range of industries, from discrete parts production to the process industries, thus improving the competitiveness of European manufacturing industry.

The adopted strategy pursues three concurrent lines of attack:

- to identify integration paths based on open system concepts and to develop the associated methods and tools;
- to develop subsystems capable of exploitation within this framework;
- to demonstrate the success of this approach by early implementation in a wide range of production environments.

Work in CIM is pursued in five closely linked subareas:

CIM Architecture and Communications

The very successful work in ESPRIT I to establish a multi-vendor environment is extended by further projects on communication networks for manufacturing applications, factory customer premises networks and CAD geometric data exchange.

Manufacturing System Design and Implementation

The projects under this heading include the definition phase for an industrial automation Technology Integration Project (TIP) and a project, focused on the automobile industry, to develop a CIM system for multi-supplier operations.

Product Design and Analysis Systems

The state of the art in geometrical modelling techniques for computer-aided design (CAD) is rapidly advancing, thus the integration of product design, process planning and machine tool data becomes a challenge. Two projects address the development of a new generation of integrated product modellers which form the basis for future product innovation in CIM systems.

Management and Control of Manufacturing Processes

Twelve projects address the logistics of the manufacturing process, with an emphasis on configurability, flexibility, distributed control and fault tolerance.

Robotics and Shop-Floor Systems

Projects under this topic include advanced manipulators, vision systems for process inspection, mobile robots and advanced sensor systems.

42 new projects were selected in 1988 in CIM out of the first ESPRIT II call for proposals.

3.4 Office Systems (OS)

Networked systems are expected to account for more than 75% of the growth in the computer market by 1992. The island of information, which can be PCs or mainframes, are increasingly interconnected in networking throughout a building or a town or across the world. The islands, which have been autonomous, are often incompatible and work has to be done to make them compatible. Therefore the ESPRIT II strategy focusing on integrated distributed networks is based on open systems, architectures and standards.

In addition to such a distributed architecture for communication, there is a need for workstations which fit in well with the distributed operating environment and can serve a wide range of specialist domains. The technical workstation market will grow from around 1600 million ECUs in 1986 to around 6200 million ECUs in 1991. The development of a European high-performance technical workstation will be one of the objectives in the workstations area during the next phase.

Software development and support tools help user-organisations make effective use of the systems available. The objective now is to develop an integrated set of tools for the development of advanced computer applications in distributed environments. The main focus is on the needs of the applications engineer in the large and expanding market represented by office-oriented organisations in the financial sector, the utilities and government departments. Support tools dealing with the human, organisational and economic factors affecting the success of systems in practice will also be developed.

Research will take place in a variety of enterprises such as banks, hospitals, administrations, industry parks, large corporations and trading companies to identify commonalities and differences and to discover how recent developments in IT can be exploited there.

In order to match developments to requirements, and to validate results achieved, demonstrators and prototypes will be developed in a variety of different environments covering applications in the home as well as in the office and the broader business enterprise. Demonstrations of widearea information systems are also needed to show how these diverse environments can be effectively linked together in a common electronic network serving business and broader social and government communities.

Following the 1988 ESPRIT II call for proposals, 41 new projects were selected in the Office Systems area.

3.5 Basic Research (BR)

The acceleration in the application rate of knowledge of fundamental microelectronics, computer science and artificial intelligence should not be to the detriment of the necessary reservoir of fundamental knowledge. For this reason, basic research has been included in the ESPRIT programme. There are three areas: microelectronics, computer science, and artificial intelligence/cognitive science. A call for proposals in March 1988 elicited 283 proposals of very high quality from which 62 were selected. The cost, 63 million ECU, includes 3 million ECU for another 24 proposals which are funded as working groups. 285 organisations will participate, most of them new to ESPRIT.

The actions in microelectronics include work on high-temperature superconductivity, low-temperature electronics, semi-conductor effects, organic materials, optical computing, and formal methods for the computer-aided design of solid-state devices; those in computer science are of a formal and mathematical character, including the foundations of formal systems, languages, and the integration of different environments in distributed computing; the artificial intelligence and cognitive science actions concern fundamental work on formalisms for knowledge representation, robotics and vision, language processing, and neural networks.

ADVANCED MICROELECTRONICS (MEL)

1. Introduction

Microelectronics is the hardware foundation on which the information technology, telecommunication and consumer electronics industries are built. Integrated circuits, some with more than one million individual transistors, are the building blocks for computers, telephone switches and televisions. Not only are they valuable products in themselves but also other industries need them to keep their production processes competitive. Putting more transistors and components onto a chip reduces the cost in raw materials and processing. Every two to three years a new stage in integration is reached putting four times more functions on the same-sized chip, and this not only increases the usefulness of a given chip but, more importantly, reduces the cost of fulfilling a given requirement. Europe has leant heavily on US and Japanese semiconductor technologies for its microelectronics needs through joint ventures or the outright purchase of products. Now, by setting up joint research programmes and by joint strategic planning in certain key areas, Europe's microelectronics industry is improving its own technology and world market share in advanced circuit design and manufacturing.

The development of the latest design tools and production methods for very large-scale integrated (VLSI) circuits is a major target of the advanced microelectronics (MEL) part of the ESPRIT programme. These tools and processes are being put in place in Europe's microelectronics companies and research institutes. New projects will enable more complex and smaller geometry circuits to be made in a shorter time.

Achievements within individual ESPRIT projects are bringing down the minimum dimensions of circuit features to below the one micron size. Both computer-aided design (CAD) tools and the manufacturing processes for meeting these targets are being proved with demonstration circuits. Testing of these circuits in simulators and on silicon chips themselves is proving that the cost and time for accurate designs is being cut.

By the end of 1988, 27 of the 49 projects from the first phase of MEL reached completion. Many led to marketable products, particularly in the CAD field, or new processing techniques for the major chip making companies. Some projects established the limitation of particular technologies, others pointed the way to the application of new ones. This work established the main thrust of the programme on the basis of which the contracts for 30 new projects were negotiated in ESPRIT II.

In the design area the aim of MEL is to develop techniques which are widely available to a large community of circuit designers. This means software tools which adopt common interfaces and are adaptable to different types of chip-making technology. This is an area where universities and smaller companies can play a role. Expert - artificial intelligence - systems are also being tried out.

On the technology side, silicon is the key semiconductor material for sub-micron feature size in MOS (metal oxide semiconductor) and bipolar processes. The aim of the first five-year phase of ESPRIT is the capability to make chips with a 0.7 micron minimum feature size, with 1 million transistors in CMOS technology and more than 20,000 gates in bipolar technology. Gallium arsenide, optoelectronics and flat-panel displays are also being developed.

New targets are being set within the strategy of improving the competitiveness of European industry as the second five-year phase of ESPRIT gets underway. In the chip design area increased emphasis is being placed on high-level design to accommodate the increased complexity of circuits. On the technology side, the increasing needs for the large emerging market of application-specific integrated circuits (ASIC) are to be addressed.

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2. DESIGN TOOLS

Efforts within the computer aided design part of MEL are defining standards for a framework into which new tools can be fitted. This involves developing individual systems and tools which meet laid-down guidelines. This will make it easier for designers to use new tools and fit them into their existing system. It also means that CAD suppliers will have a larger market in which to sell their products.

The aim is a fast response, user-friendly facility capable of designing circuits with up to several million components. The framework for this integrated set of tools must be able to adapt to further changes in technology and offer designers the scope to turn around circuits quickly and accurately. It must include access to libraries of basic circuit building blocks and test facilities.

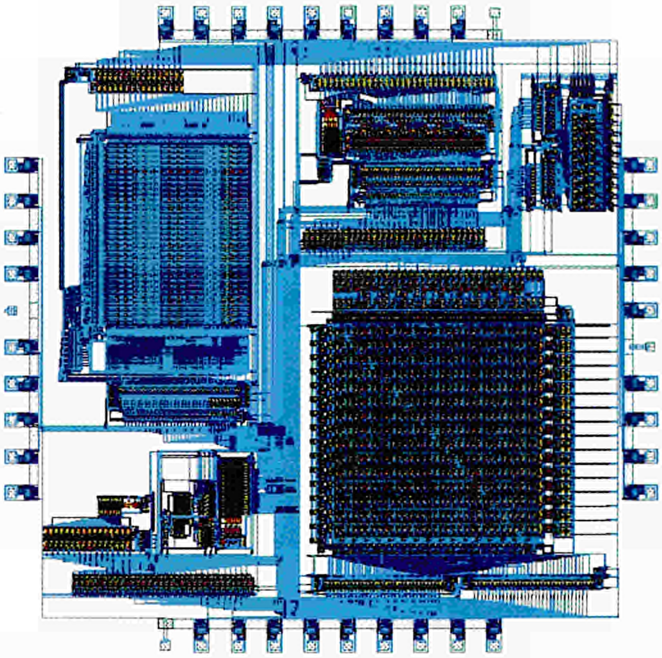
Individual projects in the CAD area of MEL are tackling all these areas. Also, to ensure that the design tools and systems will fit together, the European CAD Integration Project (ECIP) links the major circuit manufacturers in a project which has published recommendations for those developing CAD systems and tools. The guide was expanded and improved for its second edition in October 1988.

The six ECIP companies (Alcatel, Bull, ICL, Philips, SGS-Thomson and Siemens) have built an idealised model of how CAD systems should be constructed and communicate together. They want future CAD tools to follow this model so that they will work with existing tools and easily accept new ones. This will prevent designers having to retrain for each new tool and allow transfer of circuit data between tools.

The basic requirement for the communication of circuit data is tackled in the first ECIP guide and is beginning to be applied in CAD tools. An Electronic Design Interchange Format (EDIF) has already been granted interim standard status by the Electronic Industries Association. Transferring data on connectivity, layout and testing of a circuit from CAD to the foundry can now be handled in a standard way.

Further CAD integration will be required to speed up design and cut production costs. The ECIP project will be expanded in phase two of ESPRIT to tackle common standards for access to databases of circuit data and measuring the performance of individual CAD modules.

A project (number 97) on advanced algorithms, architecture and layout techniques for VLSI dedicated digital signal processing (DSP) chips has developed CAD tools. It involves Philips, Siemens, Bell Telephone Manufacturing, IMEC, Ruhr University in Bochum and Silvar-Lisco. It has already led to shorter design times and a third type of design system - Cathedral - for DSP circuits,



Chip layout of an adaptive digital filter designed in a highly automated way using technology developed in ESPRIT Project 97 (Advanced Algorithms, Architecture and Layout Techniques for VLSI Dedicated DSP Chips).

which is used widely in consumer and telecom products.

Cathedral's tools, which include hardware assignment, floor planning and performance testing, have been demonstrated on several designs including adaptive digital filters for use in compact disc players. In 1988 Cathedral demonstrated a design for a digital colour video filter. Algorithms and a first implementation has led to cell libraries at Siemens and Philips. Within the same project researchers at the Ruhr University have developed tools for the design of floating-point wave digital filters.

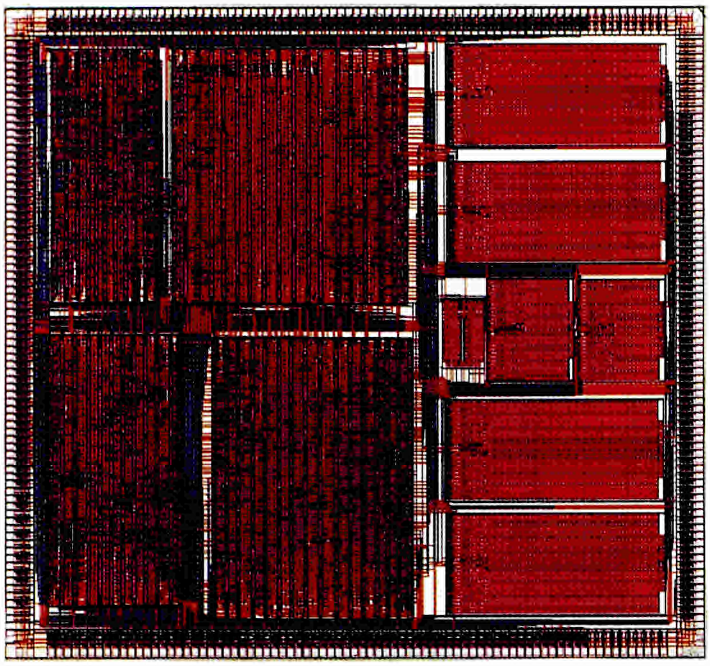
Turning Cathedral CAD tools into marketable products has led, in an intermediate step, to the Piramid system, which is being used inside Philips. The use of Cathedral in university courses will encourage technology transfer and IMEC is offering introductory courses and free use of Cathedral on its workstations, which offer an entry to a market estimated at US$ 1 billion.

Another tool being developed by many of the same actors, but in another ESPRIT project, is VERA, a rule-based verification assistant already used on several DSP circuits. The checking of designs makes sure they have the electrical and timing properties planned for them. Testing has become a costly bottleneck in making complex circuits. VERA has proved that it can pinpoint circuit problems and avoid lengthy computer simulation.

The project in which VERA is being developed involves IMEC, Philips, Silvar-Lisco and INESC, and has developed its own expert system to verify analog or digital circuits. It runs on most workstations. A routine to check a circuit of 4,400 transistors takes only five minutes of computer time and produces a set of corrections to the design.

Other test techniques have been developed within the Advanced Integrated-Circuit Design Aids (AIDA) project (number 888), which includes ICL, SGS-Thomson and Siemens as partners. These include the revolutionary built-in self-test which puts a testing programme onto the finished chip itself. ICL had prototypes of these cost-cutting chips fabricated during the second half of 1988.

Instead of chip-makers testing the working of newly designed circuits by external means,



Complex chip designed with the Siemens CAD system enhanced through AIDA (ESPRIT Project 888).

the process will be handled by self-test cells on the chip itself. The test routines are similar to external ones but expensive equipment will no longer be required. This test methodology developed and applied within ESPRIT ought to keep this circuit technology ahead of US and Japanese efforts.

Other techniques developed by the three partners of AIDA are cutting the design and testing turnaround time. Each has made large investments in in-house CAD systems for circuits with more than one million transistors. The project has developed a range of CAD tools and adopted common data exchange formats between the three CAD databases. This format is under consideration by ECIP.

The ICD design project has made further progress in 1988. It involves three companies, British Telecom, Periphere Computer Systems (PCS GmbH) and the Institute of Computer Software (ICS); two universities in Delft and Eindhoven; and the INESC institute in Lisbon. The system is installed in more then 200 locations and its open architecture allows tools to run in a distributed way on a series of workstations.

The first release from ICD incorporates all the major features and principles of the system. This prototype incorporates the expanding set of tools developed by the partners. Other less standard tools have also been converted to run on ICD. ICS has begun selling the spin-off SPIRIT commercial CAD package. Another partner, PCS, is building a specially designed computer workstation.

The intelligence of the system, which operates easily via windows on the computer screen, is being improved with expert systems. The incorporation of BT's Astra layout generation system for large custom chips has led to the design of several CMOS (complementary metal oxide semiconductor) chips. It is being followed up with a full silicon compiler, called Scorpio, which has already designed a processor array for image processing.

Other ICD achievements were the award of first prize in the 1988 IEEE Workshop on Placement and Routing for automatic chip and cell assembly systems. It produced the most compact layout meeting the test specifications. This ICD package is sold by ICS and used internally by Philips. INESC is close to commercialising a fault-simulation package to help foundries check their prototype circuits.

Design of circuits for fabrication in the compound semiconductor material gallium arsenide (GaAs) has been tackled by another MEL project, and ArguMens, a small German company, is offering a software package to run on different workstations. The MMIC-CAD package was verified and compared to other packages by Siemens and Telettra.

The package allows designers to model microwave monolithic integrated circuits with a variety of individual components operating to 20 GHz. With a variety of editors, noise analysers and optimising techniques, the best circuit layout can be planned. The first version of the software package will be available on the UNIX operating system at the beginning of 1989 with further editions, later in the year, transportable onto other operating systems, workstations and personal computers with at least 4 megabytes of memory.

The use of GaAs in broadband telecommunication is expected to grow rapidly by the mid-1990s while other applications in fields such as wireless communications, satellite broadcasting and radar are emerging.

The developments in the design projects in MEL are clearly improving the infrastructure needed to support a prosperous European microelectronics industry. In some cases turning prototype tools into marketable products will require further development financing, such as via venture capital. Once this takes place smaller firms making electronic products will design more of their own circuits.

The series of CAVE (CAD for VLSI in Europe) workshops, which were established five years ago under the Microelectronics Regulation, continue to act as an important focus for Community researchers to gather twice a year to discuss their work. A new series of ESPRIT CAVE workshops has been started in 1988 with terms of reference revised to reflect the growing maturity of the series.

One new feature is the establishment of a general theme which covers two consecutive workshops. The aim is to discuss strategic issues which are relevant in the Community and to produce some conclusions each year in the form of a report showing the consensus of a wide group of researchers. For example, this year the theme is 'A strategy for CAD Research'. The aim is to make recommendations for an optimum strategy for future microelectronics CAD research in order to improve the competivity of European IT-related industries.

In keeping with the increased emphasis on demonstration of results, this year has seen the publication of the initial trial version of the ESPRIT Microelectronics CAD Catalogue. This aims to provide a central reference point for information on advanced CAD tools and systems which exist in the Community. Priority is given to software stemming from ESPRIT projects or other relevant Community research programmes, but the catalogue is not limited to such results.

In this way it is planned to provide a useful service to the researchers in the Community while also demonstrating the importance of the results of ESPRIT in the context of the total European scene. Version 1 includes 65 entries from 19 organisations. If this trial is seen to be valuable, and if more good material is available, further releases will be made as appropriate.

Contracts awarded in 1988 in the second phase of ESPRIT extend European efforts to establish a strong position in circuit design. Specifically the ECIP project to establish a clearer framework and standards for CAD systems is to be expanded. One larger-scale technology integration project (TIP) will explore the best method for rapid production of ASICs. These circuits are becoming important as their market share is increasing.

The aim of this TIP is to turn a behavioural specification into a circuit on silicon within one month. In 1988, contracts for a short definition phase were awarded to two competing consortia. The final TIP will aim for a capability of 2 million transistors on a single chip at 0.7 micron feature size. Work on CAD, production line automation and common European component libraries is also included in this TIP.

3. TECHNOLOGY

Turning designs into working circuits is the task of the second major aspect of the MEL section of ESPRIT: process technologies. Several projects have singled out a series of key processes and achieved significant increases in the transistor packing density of ICs, as well as in the speed of operation, while reducing their power consumption. Demonstration chips have proved that these processing techniques for advanced circuit manufacture will work.

The various process steps of deposition, etching, lithography, doping and on-chip/off-chip interconnections have all been tackled at a scale of one micron (feature size) and in various process flows. Automation of the circuit-making process at the individual process island as well as at the factory level is also being developed to increase yield and throughput. In addition to work on process techniques, methods for testing finished chips, using, for example, scanning electron microscopy (SEM), have been successfully developed.

More advanced research, aimed at longer-term markets, is examining three-dimensional silicon integrated circuits. Another area where ESPRIT research is making pioneering efforts involves devices based on III-V compound semiconductors. Quantum devices, in particular, exploiting the intrinsic properties of these compounds,are capable of achieving very high performance integrated circuits with potential applications in communication systems.

Projects covering optoelectronics components have also made significant progress, as have those to develop flat-panel displays and mass memory devices. This latter area of peripherals is being expanded in second-phase ESPRITprojects.

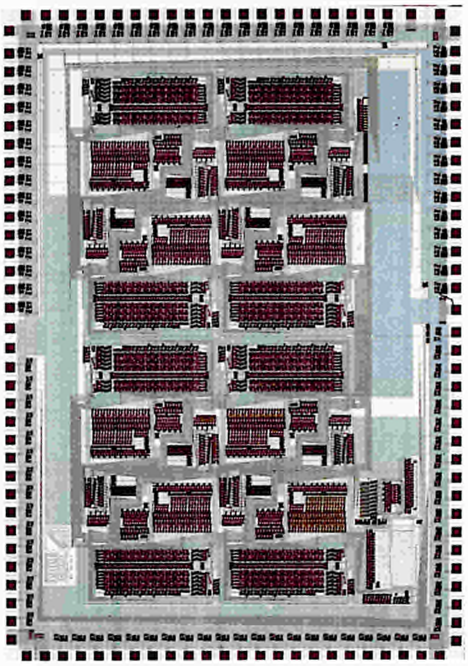
3.1 Silicon Technologies

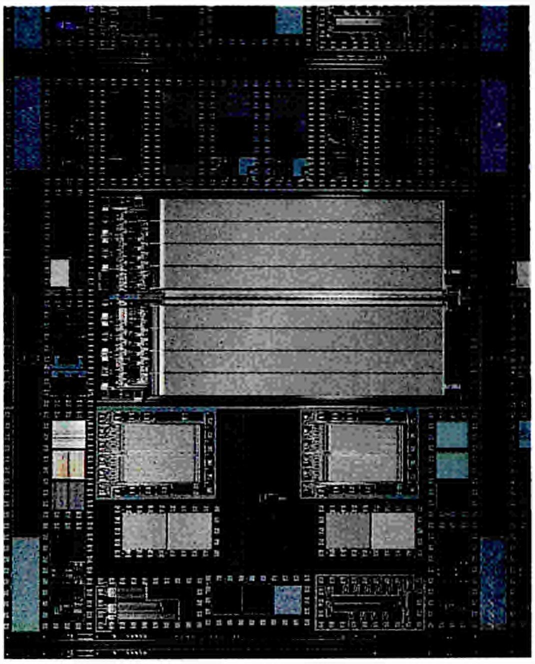
Silicon will remain the major semiconductor material for making circuits for the foreseeable future. Its use in a huge variety of analogue and digital circuits is unchallenged, with the volume of silicon circuits in computers, consumer electronics and digital telecommunications products continuing to grow. Overall demand for integrated circuits in Europe is expected to reach 8 billion ECU by 1993, and silicon will take the major part.

At the same time, the technology for making these circuits is moving rapidly ahead. Every two or three years chip manufacturers will reduce the minimum feature size of the integrated circuits that they produce. The leading part of the industry has moved from the 1.5 micron design scale to 1.2 micron, and, in similar stages, is expected to reach 0.5 micron by the mid-1990s. Each stage cuts the cost of circuits but adds a huge bill in R&D.

Bipolar and CMOS circuits are being incorporated on the same chip in a BICMOS process which retains the specific advantages of each of the technologies. In particular, BICMOS has achieved increases in circuit complexity at the same time as cutting the power consumption of fast processing applications. This has been accomplished with only a slight reduction in the speed of the circuit.

During 1988 the major Strategic Project for European CMOS Technology Research and Exploitation (SPECTRE) began its final two-year bid for 0.7 micron designs. It had already produced demonstration chips at the one micron minimum feature scale in 1987. For the final two years the initial contractors (CNET, IMEC, Catholic University of Louvain, Matra Harris Semi-conductors, SGS-Thomson, Bull and British Telecom) had been joined by Telettra and AERC.





Mulac (left), a 35 mm^2, 54 MHz logic circuit with 7000 transistors, realised in the 1 micron process developed within ESPRIT Project 554, SPECTRE. Results from the Project were used by Matra Harris to design and produce a 1 micron 64K static RAM (right).

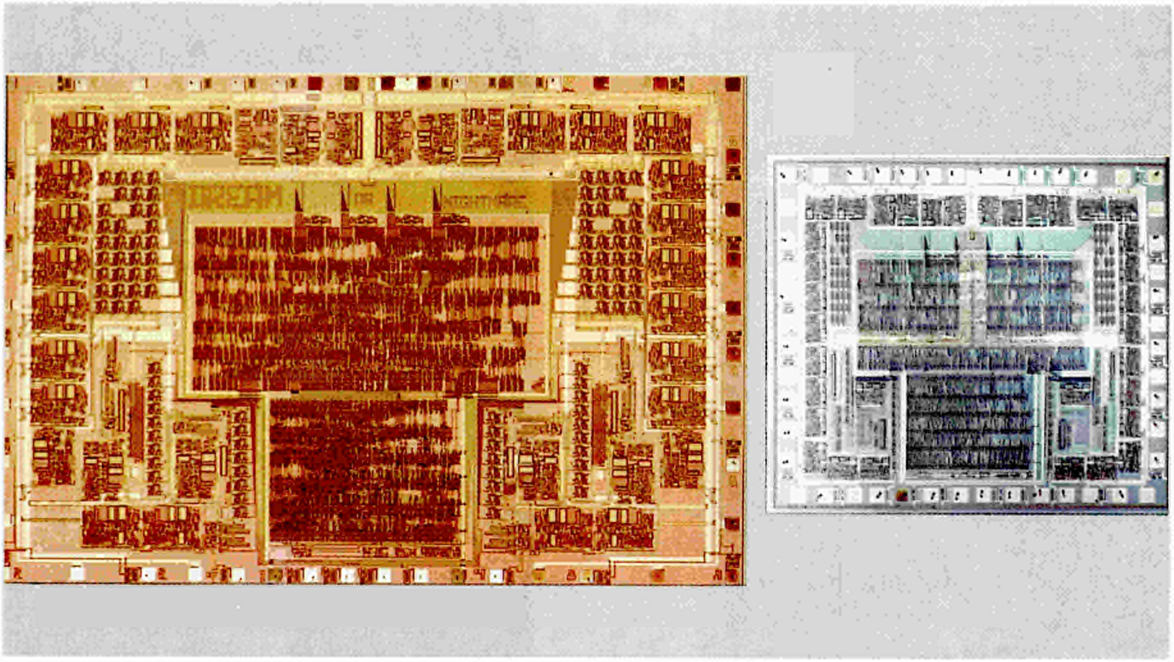
The SPECTRE project (number 554) has allowed leading chipmakers to share in the assessment of the latest process techniques. This has meant that some competing techniques were discarded in the final choice for the one micron demonstration. For instance, tungsten for very fast metal gate transistors had been proved on small complexity circuits, but equipment was not up to demonstration standards because low enough defect levels could not be guaranteed.

Several steps of the project's one micron CMOS process are already incorporated into Matra Harris Semiconductors' fast static RAMs production. These include transistor architecture, lithography and the double metal process. Some process steps are also to be used in gate array production. At SGS-Thomson polycide gate and barrier materials are being used to manufacture one megabit electrically programmable memories (EPROMS).

Further dissemination of the results is flowing from the latest sub-micron phase, and this technology transfer is enhanced by the use of five locations to make the next demonstration chips. The demonstration is being built around a core process flow with one research laboratory investigating the move to 0.5 micron design rules. Workshops on the critical process steps have been increased from two to four per year and include participants from other ESPRIT projects.

The Submicron Bipolar Technology II project involving Siemens and RTC-Compelec has led to two demonstration chips, improvements in yield, and production of a gate array family by Siemens for the commercial market. A third demonstrator for high speed circuits will further improve signal processing and computer performance through greater circuit integration and reduction in power-delay product.

Processing speeds are being raised from the present 600 megabits/second to 2 gigabits and mainframe computer power from 10 million instructions per second (Mips) to 40 Mips. Demonstrators are being designed with one micron design rules and a self-aligned



BICMOS-0 (2 micron, 30 nm^2, left) and BICMOS-1 (1.5 micron, 10 nm^2, right) demonstration chips (ESPRIT Project 412).

transistor structure with delay times of 100 picoseconds.

The first 10K CML demonstration gate array in 1986 has led Siemens to develop 66 different types of gate arrays for in-house use. For external sales another gate array family has taken the technology and improved the design rules. Gate delay has been cut by 30% and power delay product by 40%. This has led to a family of programmable speed/power arrays with up to 10K gate functions.

Since the second 4K ECL RAM demonstrator chip was produced in 1987, Siemens has invested over 90million ECU in a pilot line to commercialise one micron static RAMs. Pilot runs were expected to lead to full production at the end of 1988. Access times of 3 nanoseconds make them ideal for cache memories and control storage in computers.

In the mixed bipolar CMOS (BICMOS) project (number 412), design and process development are aiming for two complex demonstration chips to be processed and tested in mid-1990. They follow the first 20K transistor demonstrator circuit which consists of a microprocessor controlled stereo audio source selector and volume controller meeting stringent compact disc player requirements. It was processed by Philips in 1.5 micron technology. The other partner, Siemens, is providing process development and circuit optimisation for purely digital applications.

All the major semiconductor manufacturers around the world are developing BICMOS technology, and that produced within this ESPRIT project is among the best. It has met the key test of producing a high performance BICMOS circuit, which would have not been feasible by using separate bipolar and CMOS circuits.

At the same time the manufacturing process and cost have by no means doubled. Nor have the 12 mask steps of each process led to a combined 24-step BICMOS. By careful planning of the design and process steps the necessary economies have been made without impairing the performance of either the bipolar or CMOS parts of the circuit. With the reduction in chip size obtained by using higher definition lithography, higher yields and decreased costs may be achieved. This encourages the commercial use of BICMOS circuits.

A range of novel BICMOS circuits is now being investigated. Philips is to follow up the audio processor with circuits for the consumer market, in particular in the field of video processing. On the other hand Siemens will develop applications in telecommunications and data processing. The first demonstrator to be processed in 1.2 micron technology will be a 3K gate array with a 16K SRAM on the same chip.

Attempts to add a third dimension to silicon circuits have had mixed results. A project involving SGS-Thomson, Thomson- CSF, GEC, CNET, LETI, NMRC and Cambridge University has concluded that building two layers of silicon integrated circuits on top of each other to realise a three-dimensional structure may not be a feasible option for significant packing density and speed improvements.

The project, however, identified mixed technology chips as a potential area of applications of such stacked structures. The zone melting recrystallisation (ZMR) technique employing electron beams or lasers was used to produce devices in two-level monocrystalline silicon structures, with the two levels separated by a good quality silicon dioxide insulating layer.

A small test-bed smart power circuit containing DMOS power transistors in the bulk substrate and a CMOS logic circuit in the upper silicon-on-insulator (SOI) level was designed and successfully fabricated. The final demonstrator consisted of a working chip integrated in a prototype board activating a stepper motor.

Other successful silicon process technology projects in 1988 include Automatic Design Validation of Integrated Circuits using E-beam (ADVICE). This has led to the Avoset waveform averaging system being put on the market by British Telecom, one of the project partners. The others are CSELT, CNET, IMAG and Trinity College, Dublin. The system uses 25 pattern recognition techniques to align the electron beam for automatic diagnosis of faults.

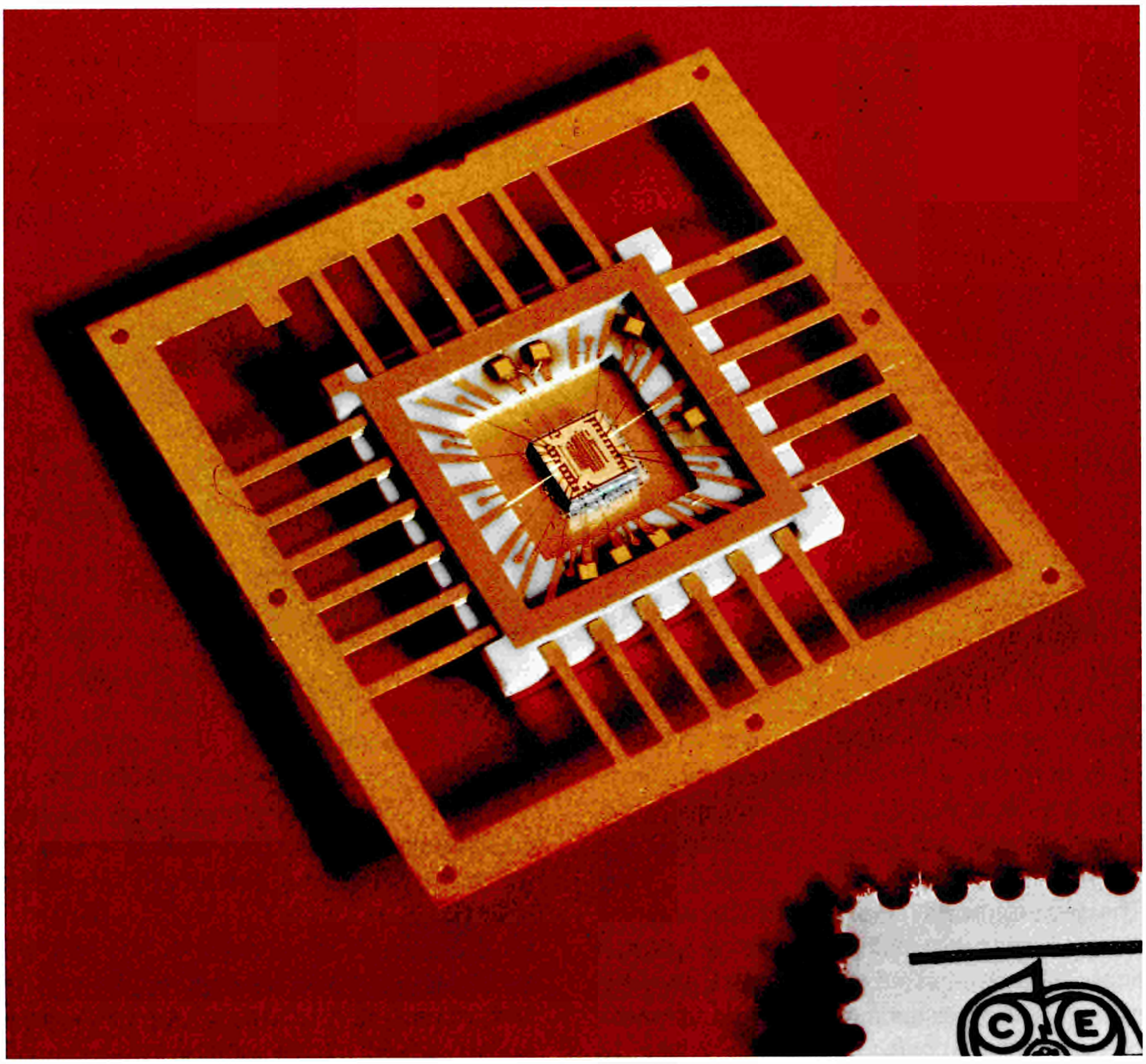
Another project is examining the properties of silicon oxynitrides for application in field isolation structures as well as in thin films for EPROMs and CMOS devices. Oxynitride films studied in this project are now being used in the production of 64K static RAMs by Matra Harris Semiconductors where the width of the "bird's beak" in the field isolation has been reduced from 0.5 micron to 0.2 micron.

High performance packaging for chips is being tackled in a project involving British Telecom, Bull and GEC Marconi. It aims to improve connection of the ever-smaller chips to the printed circuit board underneath. Tape automated bonding and laser drilling are allowing a greater number of finer connections to be made. Higher tolerances and faster connections will lead to the main commercial spin-offs during the second phase of ESPRIT.

3.2 Compound Semiconductors

Semiconductor circuits made from gallium arsenide (GaAs) and related III-V compound materials offer faster processing speeds and lower power consumption than silicon circuits. But the technologies to turn these materials into complex chips as efficiently as silicon are only now being tackled. The target of ESPRIT has been to develop basic circuit building-blocks in GaAs to demonstrate that high complexity circuits can be available to meet the demand in the 1990s for high-speed processing systems.

The major project on GaAs (number 843) involves STC Technology, Thomson-CSF, LEP (Philips), Plessey and Siemens. It has led to high performance demonstration circuits based on Metal Semiconductor Field-Effect Transistor (MESFET) technology. These chips have been made in one micron feature size which is abreast of silicon VLSI.



Mounted GaAs 4-bit analog/digital convertor with on-chip sample (1 Gsample/s) and hold and error-correction function. This mixed analog/digital chip has over 1200 active components, and its performance is equivalent to the best 0.6 micron ECL technology (ESPRIT Project 843, Compound Semiconductor Integrated Circuits).

The demonstrators have tried out various designs of 1K static RAMs and produced the fast access time of 1.4 nanosecond with only 220 milliwatt of power consumption. Programmable dividers with up to 100 logic gates or 600 transistors have been demonstrated as have 8 stage multipliers. The third demonstrator achieved a 4:1 multiplexer at 4.1 Gbit/s. The fourth, a 4-bit analog/digital converter operating at more than 1 gigahertz, is one of the most sophisticated MESFET technologies yet proven. It has over 1200 active components and its performance is equivalent to the best 0.6 micron ECL technology.

The development of GaAs integrated circuits is showing commercial prospects in high speed signal processing. Their performances are ideal for high frequency applications. But the limitations of MESFET GaAs are also being shown and other technologies such as HBT (Heterojunction Bipolar Transistor) and HFET (Heterojunction Field Effect transistor) may become more attractive.

The future of these compound semiconductor technologies will largely depend on their commercial potential. MESFET GaAs technology, developed in an earlier project, may take off if continuing trials of this technology in the latest Cray 3 supercomputer work out. A project, involving GEC and Plessey, has already led Plessey to demonstrate the 9.7 GHz clocking speed of a 4:1 divider based on HBT technology. The third partner, CNET, has transferred the know-how for production of epitaxial HBT wafers to Picogica, a small firm.

Another project in GaAs is trying out a HFET technology, using an excimer laser process, and demonstrators produced by the Research Centre of Crete are operating at 20Ghz with a noise level as low as 1.3 - 2 dB. This is a better performance than that reported for Japanese HFET chips for satellite broadcast receivers.

3.3 Optoelectronics

Development in optoelectronic components is aiming to put both electronic and optical circuits on the same chip. The aim is to reduce the cost and improve the reliability over previously hybrid optoelectronic circuits, such as laser-driver and detector-amplifier circuits. In late 1988 a demonstrator of a monolithically integrated detector-amplifier circuit (PIN-JFET) achieved a world record in sensitivity of minus 32.5 dBm at 560 Mbit/s. This approaches the performance of hybrid components and hence commercialisation is expected in the next few years.

3.4 Peripherals

Two main areas are being tackled in this part of the MEL programme, which will be expanded in the second phase of ESPRIT. The first covers the development of specific thin film transistors (TFTs) for flat-panel displays. The second covers mass memory products and has led to developments in thin films. BASF is turning an improved vacuum deposition method for magnetic material into a floppy disc product for computer disks with about three times the existing capacity. Second phase ESPRIT projects will continue the development of magneto-optical memories, flat-panel displays and printers.

SOFTWARE TECHNOLOGY (ST)

1. Introduction

The Software Technology programme aims to provide the means for the European IT industry to develop software systems effectively and efficiently. To support this aim, the programme of work defined within this sector is concerned with the management and control of system complexity, reducing development and operational costs, and improving the quality, reliability, and performance of systems.

The strategic approach has two thrusts. The first is to ensure that there is the means for the creation and operation of software tools which are independent of the hardware platform or operating system, are portable and are capable of running on distributed systems. The second is to ensure the availability of a full set of integrated tools to support the development and maintenance phases and the management of all aspects of the systems lifecycle.

The implementation of the first strategic aspect involves the creation of a common basis for software product development. The implementation of the second aspect involves the creation of a full set of tools and the development and implementation of new supporting methods and techniques.

The workprogramme is structured into five sectors:

A common basis for software product development

The strategy aims to create not only a portable common tool environment but also the requisite organisational structure to ensure its implementation. The core project, Project 32, the Portable Common Tool Environment (PCTE), is one of several early projects concerned with the environment and tools for software development support that were completed during the year.

Greater rigour in the development of software systems

Here, the strategy is to approach the development of software systems in a more formal way by combining informal and formal methods, by developing mathematically formal methods and by applying knowledge-based techniques to software system design. GRASPIN, Project 125, has produced and demonstrated an integrated tool set which supports all aspects of software system development. In other projects, which are still in progress, design methods have been defined and the requisite tools developed.

Effective management mechanisms for the control of very complex projects

Again, the strategy is to combine traditional methods with new methods. SPMMS, Project 282, has produced a prototype for the development of an information system to support management activities in the software product lifecycle. In other projects, after the mechanisms have been defined, the appropriate tools for the development of the management information systems are in the course of creation.

The definition of appropriate metrics

The main project in the area of metrics, REQUEST, Project 300, has produced models for quality and reliability control and prediction. In further projects, other aspects of software quality and reliability have been evaluated, such as the metrics for safety, management and clerical systems in MUSE, Project 1257.

The application of knowledge engineering techniques

A prototype system to assist in the analysis and design stages has been developed and demonstrated within the ASPIS, PROJECT 401, by building a Computer-Aided Software-Engineering environment. Prototypes have been made of software tools which incorporate knowledge-based systems of a type increasingly used in software development.

The main directions taken for 1988 were to further encourage the industrial take-up of the results emerging from the projects, and through the integration of ST and AIP, to establish a new point of departure for ESPRIT II. Currently there are thirty-six projects in progress. Eleven have been completed, including three during 1988.

Software Technology produces numerous acronyms. Here are some of the ones used in ESPRIT:

PCTE	Portable Common Tools Environment
PIMB	PCTE Interface Management Board
PICG	PCTE Interface Control Group
PACT	PCTE Added Common Tools
IEPG	Inter-European Program Group
TA13	Technical Area 13
ECMA	European Computer Manufacturers Association
TC33	Technical Committee 33
VIP	VDM Interfaces for PCTE

2. SOFTWARE DEVELOPMENT SUPPORT ENVIRONMENTS

The objective of the work in this subarea is to provide a framework of basic utilities for the effective computer support of the software development process which is independent of design method, high-level language and host computer. In ESPRIT, the Portable Common Tool Environment (PCTE) project, Project 32, has produced the necessary interface specifications, the basic utilities and the working prototypes of a development support environment which is at the core of the software technology programme.

PCTE offers the potential for establishing an international standard of European origin for support environment interfaces enabling the growth of a software tools market and the efficient, coherent development of large systems across multi-company development teams. The importance of this project has led to a number of projects and complementary actions being launched to widen the use and the availability of the PCTE:

- *Production of a set of general tools which run on top of PCTE* - PACT, Project 951, has a range of tools running on Bull and Sun computers and a PACT tool-set contributes to the EUREKA EAST development of PACT-based products.

- *Porting PCTE onto non-UNIX operating systems* - PAVE, Project 1282, has demonstrated an implementation of PCTE on a VAX station.

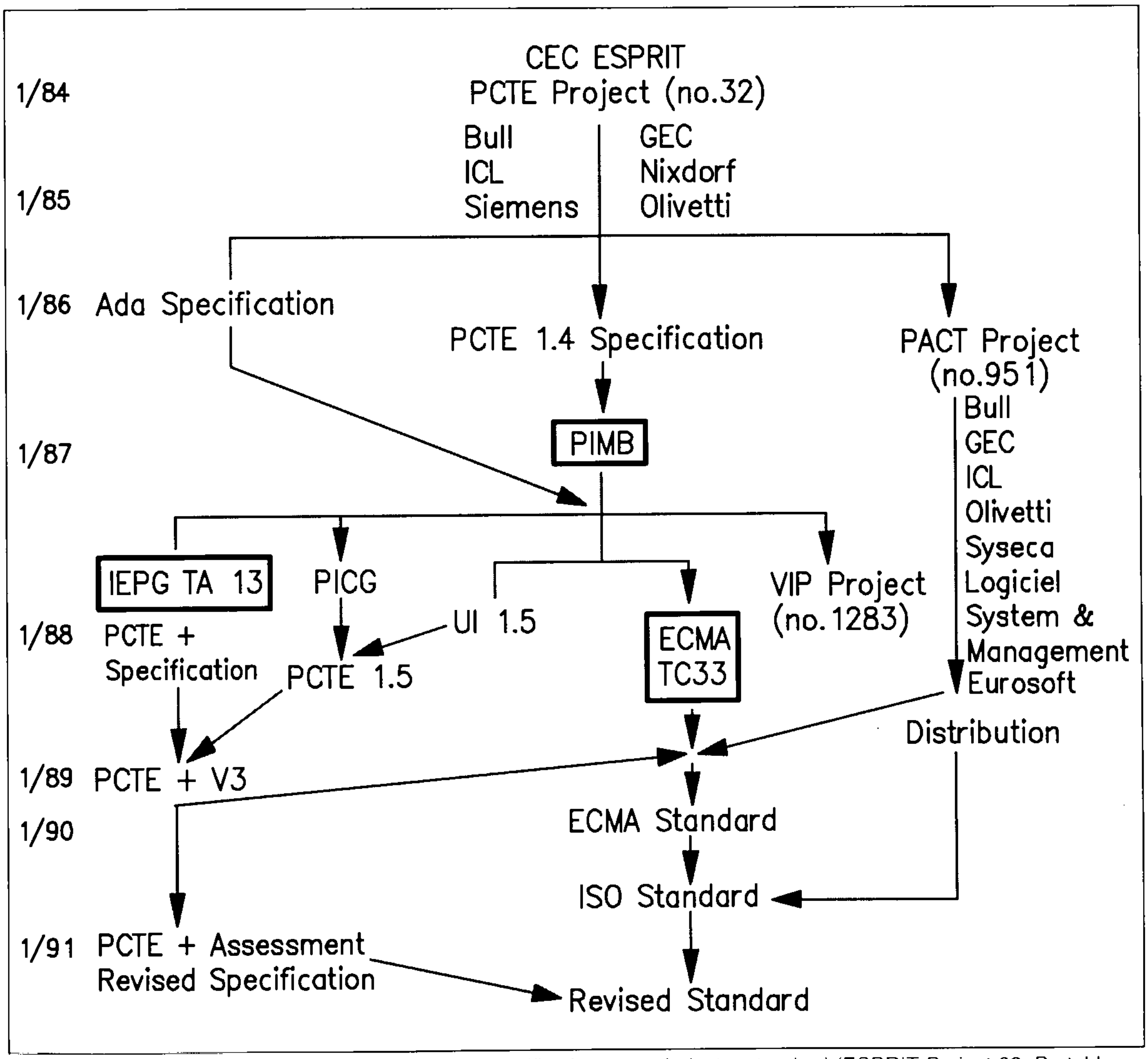
- *Development tools and services* - These are being marketed by Chorus Systèmes for a PCTE host-target distributed testing environment, developed from the results of APHRODITE, Project 1535.

- *Production of formal specifications of the PCTE interfaces* - VIP, Project 1283, has made a formal specification as a result of which proposals for changes have been made to the PCTE Interface Management Board.

PCTE provides a development support environment for ESPRIT projects, available to all participants in EEC-funded R&D programmes and to European universities. The Emeraude PCTE package has been distributed to over 150 universities and a total of more than 200 licences have been released. In addition, a number of national programmes and the EUREKA EAST and ESF projects are applying the PCTE results.

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 their industrial use, action has been taken to widen the availability of PCTE-based systems. One such action has been the launch of SAPPHIRE, Project 1277, which has ported PCTE-based systems to a range of widely used workstations from IBM, Sun, HP and DEC. Demonstrations were given at the ESPRIT Conference, and the Sun-based system and the Bull SPS 7-based system developed by GIE Emeraude are now available. The Eclipse software tool set produced in the Alvey programme has been transferred onto the PCTE and is currently undergoing industrial trials.

The PCTE interface specifications are managed by the PCTE-Interface Management Board (PIMB) which is independent of the Commission and is industry-led. To further encourage the adoption of the PCTE interface specifications by industry, particular attention is given to standardisation through the activities of ECMA Technical Committee 33. The progress made towards the realisation of an industry standard is shown in the diagram.



The route to adoption of the PCTE interface specification as an industry standard (ESPRIT Project 32, Portable Common Tool Environment)

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 the maintenance of upwards compatibility with PCTE is essential for ensuring adequate protection of the industrial investment in first generation, PCTE-based environments.

Full coordination of this work is under way, both within the ESPRIT programme and within EUREKA and other related programmes. 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.

The automatic generation of interactive programming environments from language specifications is being addressed by GIPE, Project 348. The first version of CENTAUR, which incorporates major improvements over its predecessor MENTOR, has been demonstrated to more than 50 research organisations. Distribution to academic and research laboratories has now begun and fourteen systems have been installed.

The development of techniques for the formal definition of methods used in the development of software is the province of TOOL-USE, Project 510. The project focuses on the DEVA language for building a support environment. This has been defined and documented and a prototype of a support tool - the method adviser - was demonstrated during the year.

3. DESIGN METHODS AND TOOLS

The workprogramme for this area balances the achievement of shorter-term and longer-term benefits. Shorter-term projects include the development of measures involving a combination of informal and formal methods, the reuse of components, the development of functional programming and working in target environments. Overall, the main emphasis has been placed on the development of formal design methods and the application of knowledge-based techniques to software system design.

3.1 General measures

A combination of informal and formal methods

From an industrial usage point of view, it is necessary to ensure that the gap between the informal and formal approaches is properly bridged and this issue is addressed by GRASPIN, PROJECT 125, by mixing informal diagrams with formal textual information. 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 prototype now runs on a number of systems and gives each partner his own opportunity for exploitation. GRASPIN is being marketed by Epsilon, by Tecsiel and by Olivetti, by whom it has been demonstrated to European universities under the academic support programme for UNIX. It is also being ported by CTI to desktop computers.

Reuse

The general objective in the reuse part of the programme is to develop methods, tools and environments supporting the reuse of components, specifications and application-domain knowledge.

The development of the reusability of software components is important because of its potential for improving productivity and quality. An experimental research project, REPLAY, Project 1598, is testing the reuse of software development plans, and the operational properties are being explored through building a prototype of a medical expert system.

The development of methods for the pragmatic reuse of software concepts at the design stage is being studied in PRACTITIONER, Project 1094. A linguistic approach to classification and retrieval is being made, and tool construction has begun. The foundations are being laid for the development of a support environment which will be readily exploitable by the consortium.

The objective of DRAGON, Project 1550, is the development of methods and the provision of tools for designing reusable software for distributed real-time applications of a long-life nature such as Flexible Manufacturing Systems and telecommunications application systems. Problems of distribution and real-time performance have been resolved, a library and classification scheme is under development and a maritime surveillance system has been selected as the setting for a case study. An object-oriented approach will be followed.

A knowledge-based environment for software system configuration through reusing components is under development by KNOSOS, Project 974. It allows the configuration of large and reliable software systems from a database of tens of thousands of reusable components. There are good prospects of reducing the costs of software development caused by specification changes and by implementation errors, particularly in space and telecommunications. The representation, storage and retrieval of the components has been demonstrated in the first prototype, and the transfer of the results to space applications is planned by the partners.

Functional programming

The feasibility of developing a prototype of a general-purpose, system description language based on system semantics has been demonstrated by FORFUN, Project 881. Functional programming tools provide the basis for specifying languages for system designers. Functional programming tools provide the basis for specifying languages for system designers, and case studies demonstrate the feasibility of describing various types of digital and analogue electronic circuits by this approach. A support environment for the use of the language has been defined and is under development.

The aim of STAPLE, Project 891, is the development of a functional programming system for the efficient support of prototyping. The study of a hospital dispensary has been completed as a model application and the development of a functional programming environment with persistent storage is in progress.

Target environments

The objective of HTDS, Project 1261, is to develop a prototype of an integrated tool system based on a PCTE environment to support automatic testing, high-level fault diagnosis and remote maintenance. A preliminary specification for testing has been written, and human-machine interfaces are being defined.

The objective of CHAMELEON, Project 1256, is to build a Dynamic Software Migration system to enable the migration and subsequent execution of active objects throughout a heterogeneous computer network. Demonstrations of software migration in a homogeneous environment using abstractions of two intermediate machine models were given during the year. Testing of real-time Ada systems is covered by DESCARTES, Project 937, where an Ada fault diagnosis system for internal use by ES Dassault, a partner in the aerospace industry, has been developed.

PCTE aspects of host-target environments covered by APHRODITE, and the metrics aspects covered by TRUST, Project 1258, are described in the corresponding paragraphs.

3.2 Formal Mathematical Methods

In the long term, the provision of an underlying, more formal, basis, similar to that now available in other engineering disciplines, such as electronics, may be necessary for software 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.

The application of formal methods to industrial software development, supplemented by the integration of the tools within a single framework, should provide a key for easy access. However, existing methods and tools are inadequate for the large and complex projects concerned with the development of such large and complex systems. An example of such complexity is a telecommunication system, which can run to several hundreds of thousands of lines of code. It is difficult and expensive to design, develop and maintain such systems and the penalties for operational failures are very high.

METEOR, Project 432, is directed to remedying this situation. Notable among its results is the development of a software-engineering toolbase through the establishment of a generic environment. This facilitates the work of the project teams and provides a setting for the investigation of the various formalisms. Industrial achievements include the development of a requirement engineering methodology based on an extension of the entity-relationship model ERAE, and the definition of a powerful formal design language, COLD. Both these tools are currently under field test in real-life software product development. Use is made of the methods developed in this project by the academic partners; for example, the RAP rapid prototyping system is taught at the University of Passau, and the PLUSS algebraic specification language developed by the Université d'Orsay is used by LRI and CGE.

The need for validation and verification of the system design at each phase of the development process has led to the definition of a number of methods based on mathematical theory. The definition and support of these formal methods has constituted an important part of the ESPRIT Software Technology programme. One method in particular, the so-called Vienna Development Method (VDM), has figured prominently in ESPRIT projects.

RAISE, Project 315, has produced a preliminary systems development tool set. Industrial trials of the language, method and tools are in progress and the tool set is being used by ICL and Asea Brown Boveri.

A further advantage foreseen from the use of formal methods is the gradual movement towards automatic transformation from high-level design descriptions to code. PROSPECTRA, Project 390, and PROSPECTRA DEMO, Project 835, have 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 to ensure portability between different programming environments.

Besides the formal specification of the PCTE interfaces, which would be particularly important for the process of international standardisation of interface specifications, 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 SEDOS, Project 410, in which the ESTELLE and LOTOS languages were refined and stabilised. These languages have already achieved draft international standards status through CCITT and ISO, and the standard for the ESTELLE language was scheduled to be finalised by the end of 1988. The SEDOS Demonstrator, Project 1265, continues the work of SEDOS by the development of an industrial prototype, the ESTELLE Workstation, which, with the addition of a set of tools, is running on Sun and Apollo machines. Distribution of the ESTELLE environment to European universities is due in early 1989. A product is being built which the partners will market.

3.3 Application of Knowledge-Based Techniques to Software System Design

An entirely 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 GRASPIN above) and the coupling of formal methods with knowledge engineering techniques.

This work is carried out in close association with the activities under way within the knowledge engineering part of the Advanced Information Processing area. The close technical and managerial coordination between Software Technology and Advanced Information Processing maintained during the year formed a prelude to their combination in the ESPRIT II workprogramme.

Knowledge-engineering approaches show promise in several software development areas, where they have the potential to augment staff skills in undertaking requirements analysis and software systems design. 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. In particular, a prototype system to assist in the analysis and design stages has been developed and demonstrated within ASPIS, Project 401, by building a computer-aided software-engineering environment. The demonstrator for this has been successfully applied in the field of access control systems - the chosen application domain - and a product is under definition by Tecsiel.

The overall aim of DAIDA, Project 892, is to contribute to the definition and implementation of knowledge-based tools for the production of quality software products for data-intensive applications. Progress towards formulating concepts for a uniform design of the several environments has been substantial and the initial experiments with the components to be included have been completed.

The objective of GENESIS, Project 1041, is to create a meta-system for the generation of proof environments from descriptions of the syntax and semantics of the formalisms used, and a version of the prototype, suitable for academic use, has been released.

4. MANAGEMENT OF SOFTWARE DEVELOPMENT PROJECTS

Software development projects have been characterised in the past by cost and time-scale overruns. The problems encountered in 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 style, SPMMS, Project 282, has produced a prototype for the development of an information system to support management activities in the software product lifecycle. In so doing, the project has contributed to the common data schema and the vocabulary common to several ESPRIT management tool projects. Implementation of the easily customisable prototype in a PCTE environment and client applications by GSI-TECSI are in progress. 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. PIMS, Project 814, employs a rule-based management system for use as a consultant or training system for the management of software projects. The results are being used by CAP-Sogeti and PACTEL and industrialisation and marketing are scheduled for 1989. There has also been an exchange of results with the Integrated Product Management Workbench, Project 938, and a transfer to the EUREKA ESF. PIMS draws on the results of Project 938, where a project manager workbench has been defined for project planning, project control and general decision support. It includes a generic cost estimation tool whose definition is well advanced.

5. METRICS FOR SOFTWARE DEVELOPMENT AND SOFTWARE SYSTEMS

Metrics for software development productivity and software product characterisation - that is, measurements of quality, reliability, performance, etc. - though badly needed, have so far evaded general definition. An expert working group, which concluded its work during the year, attempted to identify and define the key metrics and this target is now being pursued by co-operation between projects.

The main project in the area of metrics, REQUEST, Project 300, has produced models for quality and reliability control and prediction together with the associated support tools for data collection and analysis, and has provided definitions for software metrics standards which are used in other ESPRIT projects. The data model has been implemented within a data library which holds results from a number of projects across Europe.

Other complementary projects concentrate on the metrics associated with the specific application domains of fault-tolerant systems in SMART, Project 1609; systems quality and reliability testing in MUSE, Project 1257; and real-time embedded systems in TRUST, Project 1258. In SMART, studies have been made of information systems for a space shuttle, a power plant and an aircraft to derive the characteristics of fault-tolerant architectures, and a first release has been made of the SMART tool requirement specification. In MUSE, demonstrations have been made of an Expert System for measuring the quality of safety-critical systems, the use of quality metrics, tools within a SMALLTALK environment, and tools for the assessment of conformity to standards by code analysis. In TRUST, tools and prototypes have been developed for use in monitoring and analysing real-time systems embedded in target computers.

ADVANCED INFORMATION PROCESSING (AIP)

1. Introduction

The aim of this workprogramme is to provide the basis for developing economically viable advanced information processing systems which can deal with the demand for applications of increasing complexity.
To achieve this the workprogramme has been designed to provide the requisite methods, tools and advanced architectures to facilitate the implementation of complex systems and their operation.

Projects tackle three separate, mutually supportive areas: knowledge engineering, computer architectures and advanced system interfaces.

The development and application of knowledge engineering

The strategy in this part of the workprogramme is to strengthen the capability for managing complexity by developing tools applicable to further categories of knowledge-based system applications and by raising awareness of their use through their demonstration in strategically chosen applications. The "Expert System Builder", which has been created in Project 96, provides a complete environment for the development of expert systems. In other projects, basic tools have been developed for knowledge acquisition and for the creation of knowledge-based systems (KBS). The success of the demonstrators has assisted the transfer of this technology to industry.

The development of new computer architectures for symbolic and numeric processing and multi-sensor systems

The aim is to develop highly concurrent architecture systems. It is also necessary to make available the application software to exploit their computational concurrency effectively. The Supernode computer and the T800 transputer which were developed in Project 1085 have been particularly successful in demonstrating parallel architectures which now require their own operating systems to exploit their potential fully. When projects now launched have achieved this, Esprit will have created a new level of computing power.

The development of advanced systems

The strategy is to develop interfaces for effective communication between a computing system and the user. Computer understanding of the environment is to be achieved from external sensors, and advanced man-machine interfaces are being provided as steps towards improved information provision and automatic control. SIP, Project 26, has developed a coordinated set of algorithms and architectures for image and speech recognition and understanding. This set of algorithms has applications in various sectors including automated manufacturing. Other projects, through providing more natural interfaces and the modules to create them, have provided the basis for work directed to the industrialisation of results.

The main direction taken in 1988 was to further the industrial take-up and to start the integration of these three areas with Software Technology. During the year, thirteen projects were concluded. Twenty-seven are in progress at the year-end.

2. DEVELOPMENT AND APPLICATION OF KNOWLEDGE ENGINEERING

Work has been organised into four sections:

- the development of methods and techniques for knowledge acquisition and knowledge representation;
- the development of domain-specific systems and demonstrator applications;
- an evaluation of the experience of introducing and using knowledge-based systems;
- the development of application-independent knowledge-based system shells, supporting languages and interfaces.

2.1 Knowledge Acquisition and Knowledge Representation

Three methods of knowledge acquisition, the starting point for building an expert system, are addressed. The most established method is to store knowledge obtained from human experts. The Expert System Builder (ESB), implemented in Project 96, follows this approach. It provides mechanisms for knowledge representing and reasoning suitable for a broad range of applications. Users who are less experienced in dealing with artificial intelligence are provided with a complete environment for dealing with expert systems. Users who are experienced are equipped with a familiar framework for the expression of knowledge, thus reducing reliance on knowledge engineers. The ESB compares well with the current market leaders, and demonstrations have been given on several types of machine.

By the end of the project in September 1988, Soeren T. Lyngsoe had announced the commercial release of the derivative products THOR and ODIN for the automatic creation of power plant applications. Plessey was industrialising the ESB and Tecsiel had announced the commercialisation of the system on a range of machines. Wide use is planned for ESB in Esprit II projects.

The second method of knowledge acquisition is the automatic machine generation of a knowledge base from an analysis of field data. This approach has been adopted in INSTIL, Project 1063, which provides tools for the formulation of a set of rules in the application domain from an analysis of examples. Large-scale tests have been made of the system in the diagnosis of crop disease, object recognition, image understanding and medical diagnosis, among others. Applications to air traffic control are being developed by GEC and University of Paris.

A third approach, where knowledge is derived by deduction from a formulation of analytically deduced rules, is illustrated by the application of Prolog II to fault diagnosis, described below.

2.2 Domain-Specific Systems and Demonstrator Applications

This section covers both generic systems such as process control and database access, and applications targeted to a specific domain such as the financial services sector.

Real-Time Control

The adaptive control of an industrial process in real-time may bring both immediate rewards and serve as building blocks for use in the integrated control of a larger system.

A set of tools to facilitate the development of the requisite Expert Systems has been created in KRITIC, Project 387. Two demonstrators, the first for the control and diagnosis of advanced telecom switching systems and the second for the control of power distribution systems networks, have been completed. The tools, which are being ported to a commercial machine, are being used by the partners in other projects.

A further application in the rewarding field of process control and industrial automation is being made in Project 820, QUIC, whose tool-kit provides a set of KBS tools for automating such tasks as monitoring, fault diagnosis, feedback control, simulation and training. The tools are being validated in three demonstrators: by Ansaldo and CISE in the control of a thermal power plant, by Aerospatiale and Framentec in the control of satellite altitude, and by Smidth, CAP, Sogeti Innovation and Heriot Watt University in the control of cement manufacture.

Database Enhancement

Now that databases are widely available, action enhancement, extension and increased exploitation are all economically justified. Several directions are possible. These include their incorporation within other systems such as computer-aided design, and improvements to human-computer interfaces to allow enquiries to be phrased in more natural and powerful forms. System enhancement through integrating databases with knowledge bases is also possible.

LOKI, Project 107 provides the technology for the development of knowledge representation, knowledge use and knowledge consultation systems, and other aids to the development of knowledge and database systems. Friendly graphics and natural language are being combined in a single interface. A parser-generator pair (LOQUI) for English and German to support dialogue and access to databases in natural language is available as a prototype product which SCICON plans to market. Another instance of exploitation is to be found in the marketing of an efficient interface between BIM-Prolog and two relational databases. This Prolog implementation includes a compiler with a fast object-code execution and is arguably the most efficient of its kind commercially available.

The objective of KIWI, Project 1117, is to develop a knowledge-based user-friendly system for managing access to external information bases. The OOPS language and its prototype implementation, together with specification of the architecture of the global system have been defined and are available. The combination of the deductive power of logic programming with the data management capabilities of a large relational databases will result in powerful computing environments.

Techniques that allow a combination of rules and relational algebraic expressions have been developed in EPSILON, the advanced knowledged-based system (KBS) in Project 530. Prototype workstations allowing the use of UNIX-based Prolog and a relational database in one system, and connecting database management system workstations to form an integrated KBMS, have been applied to two domains. A prototype system has been developed to assess company creditworthiness in accordance with the financial and credit policies of the Italian administration. A further system is to assist bankers in their assessment of customer loan applications.

Industry-Specific Applications

TAO, Project 1592, uses oncology as the application domain, and along with Project 569 (which deals with electromyography) is linked to the Community's medical programme, AIM. Support for the production of complex documents is being provided by INDOC, Project 1542. These and other demonstrators provide a starting point from which further KBS applications can be developed to provide a strategic coverage of industrial sectors.

KBS-SHIP, Project 1074, aims to assist ship's crews in duties ranging from voyage planning to alarm handling. Its concern with the development of design concepts for the implementation of advanced information technology systems onboard ship provides the stimulus for engaging industry-wide support for the introduction of knowledge-based systems expected by the early 1990s.

The work has provided the basis for two products. An expert system for navigation - the Voyage Pilot Expert System - is to be developed into a product by Krupp-Atlas Elektronik, and an expert system for machinery operation is to be developed by Soeren T. Lyngsoe.

The Project is encouraging the acceptance of Artificial Intelligence technology by the European marine industry through the development of an acceptance procedure by Lloyd's Register for expert systems onboard a ship. The project is also expected to influence international standards for local area networks onboard ship and the design of maritime surveillance and control equipment.

2.3 Application-Independent, Knowledge-Based System Shells, Support Languages and User Interfaces

The development of application-independent, knowledge-based system shells, support languages and user interfaces is supported by the many tool improvements which are being addressed by a number of projects. Among them is the integration of reasoning mechanisms and numeric processes in Prolog III, Project 1106. The new prototype version of Prolog is based on the efficient integration of constraint resolution and builds on the framework provided by earlier versions of the language. Two companies, Robert Bosch and Daimler Benz, are among the partners applying the language to the diagnosis of motor vehicle faults. The approach aims to replace reliance on expert experience in regard to the repair of injection systems for cars by deducing knowledge from an analysis of the functional and structural design.

Making the best use of an information system has always been a problem for new users. EUROHELP, Project 280, addresses this problem by providing intelligent computer-based assistance from the terminal while the system is in use and tailors the advice to individuals from knowledge of the use each has made of it. Several demonstrations have been made of modules of a prototype Intelligent Help System Shell whose development is well-advanced.

The problem of integrating data-based and knowledge-based management systems has been tackled by ISIDE, Project 1133, in which an object server with sufficient flexibility to interface with rule-based, object-oriented and SQL languages has been built. Prototype systems have been demonstrated and performance evaluation studies started. Prototypes of message-passing architectures and description systems for expert systems that will exploit highly parallel machines have been developed in MADS, Project 440, as a first step to industrialisation, and the use of LISP in parallel processing and appropriate knowledge representation is being investigated.

ACORD, Project 393, has demonstrated a friendly interface allowing users to interact with a knowledge base by using graphics and natural language. It works in English, French and German and the development has entailed novel forms of linguistic analysis.

3. DEVELOPMENT OF NEW COMPUTER ARCHITECTURES

The demand for the capability to process large volumes of symbolic and numeric information quickly will increase substantially over the next few years. ESPRIT has concentrated on the development of highly-parallel machines and the appropriate software to achieve the high performance levels required. Such parallelism exploits the transputer basis to bring the additional benefit of providing scaleable architecture sufficiently flexible to provide for a wide range of system performance. The involvement of systems enterprises offering dedicated application systems is a major achievement, as it opens another market channel for parallel computers in addition to the general applications met by the manufacturers.

The following achievements are among the results to date.

A high-speed input/output interface (100M bits/sec) to the Supernode computer has been developed for real-time vision applications, in SUPERNODE, Project 1085. The T800 transputer also developed from this project, with its spin-offs, has been the basis for 500 designs worldwide. It is produced by INMOS and the Supernode computer is marketed by Telmat and PARSYS, a new subsidiary of Thorn-EMI.

Among other applications and products that have resulted from this project are the LUCKY-LOG logic simulator in the CAD for VLSI area, now presented as an add-on card for PCs; several image-processing applications; digital signal-processing applications; applications of image generation by the ray-tracing method; multi-transputer architecture studies in CAM; and the provision of fault diagnostics and Occam and Fortran libraries. The project has attracted wide interest among workers in computer architectures.

The continuation of the development of the transputer-based machine for running LISP and Prolog and a VLSI implementation of a content-addressable memory is in progress in PADMAVATI, Project 967. PIPES, the first prototype realisation of a Prolog transputer-based machine where the transputers are fully interconnected using a packet-switched network, is targeted for real-time applications in speech and vision understanding in SIP, Project 26.

PALAVDA, Project 415, was launched to study the performance of the different approaches to symbolic processing on parallel architecture computers as a step towards establishing a European standard for a generic architecture for logic, functional and object-orientated language. Exploratory work on the integration of declarative languages has resulted in the realisation of first prototypes of DOOM, the distributed object-oriented language of the parallel data-based machine DDC, and of a dataflow machine for relational database applications. 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 and in use.

DELTA-4, Project 818, has developed a technique of automatic reconfiguration to give distributed computer systems protection against local station failures. Demonstrators of an RT Unix prototype and of a Remote Service Request prototype have been developed, and work is under way on a Delta-4 system architecture and computational model. The interconnection equipment for heterogeneous systems to be delivered by this project is particularly relevant for distributed applications in Computer Integrated Manufacturing and Office Systems. Product marketing is planned by Bull, and Ferranti is marketing a UNIX-based real-time system derived from work on this project.

The investigation of programming languages and parallel architectures for the integration of symbolic and numeric processing is the objective of SPAN, Project 1588. The definition of a common virtual machine which will establish a standard software-hardware interchange on parallel computers has been completed. It has been implemented on Padmavati and Supernode, and a new machine has been defined to give a fast performance implementation.

Work is continuing in parallel language definition and architectures, and in four application areas - image interpretation, real-time expert systems, partial differential equation solvers, and parallel relational DBMSs.

4. DEVELOPMENT OF ADVANCED SYSTEMS

The prime objective of this part of the programme is to achieve computer understanding of the environment from external sensors and to provide advanced man-machine interfaces as steps towards improved information provision and automatic control. The work has concentrated primarily on image interpretation, on natural language understanding and on speech processing.

4.1 Image Processing

Examples of the application of the work in image processing are to be found in industrial visual quality inspection, non-destructive testing, medicine, robotics, computer-controlled manufacturing systems, and monitoring systems for traffic control and for security. The success of the work in this area depends on developing the capability for the analysis of both static and dynamic, and of 2D and 3D scenes.

SIP, Project 26, is one of the larger projects and has been the source of applications in sound, vision and robotics. A coordinated set of algorithms and architectures for image recognition and understanding has been developed and demonstrated. The foundation for solving computer vision applications in medicine, in industry and in other domains is provided by a parallel computer architecture and the appropriate software for the image-processing algorithms. Project results also support the development of intelligent workstations to support both graphic processing and image processing.

In COUSTO, Project 866, a copy of the parallel machine for high-level understanding is to be transferred to Selenia for use as a development environment for applications in radar imaging systems.

The feasibility of a low-cost system for on-line testing for surface defects has been successfully demonstrated in PHOX, Project 898, by a prototype combining optics and electronics technologies. Know-how on non-destructive testing methods acquired through work in holographic inferometry is to be marketed by one of the partners.

A breakthrough in the speed of measurement of scene depth in GENEDIS, Project 532, matches the pace of interpretation of changes in the scene from stereo images. Real-time applications, such as the identification of grasp points for robots, have become possible. A prototype of a low-price system to deliver range images for industrial scenes is under development.

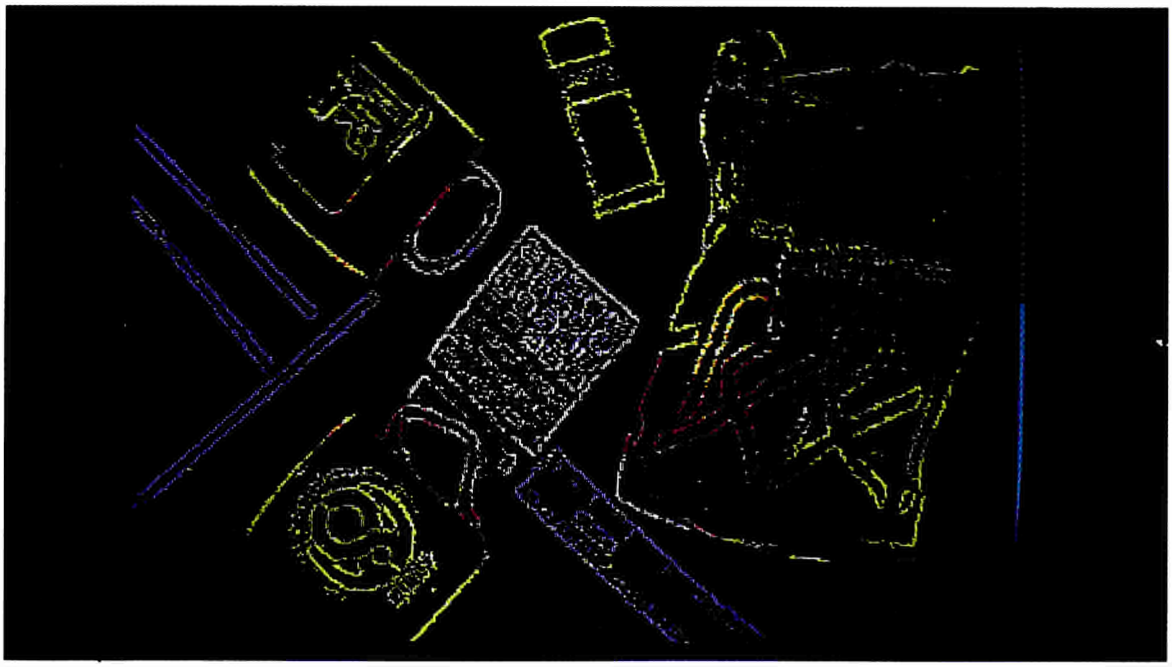
DMA, Project 940, is concerned with the use of vision for vehicle navigation and robotic tasks. Basic methodologies for reconstruction from 3D stereovision and from 2D flow field have been established. DMA has provided systems that recognize objects well enough for a robotic inspection to be made both from mobile and stationary platforms and for their positions to be estimated with sufficient accuracy for them to be grasped by a robot hand. Vision systems resulting from work in this project are being developed by ELSAG, MATRA and ITMI.

4.2 Natural Language Understanding and Speech Processing

A system capable of recognising continuous speech under restricted conditions at a speed close to real-time has been developed in SIP, Project 26, and is a step towards the long-term goal of understanding continuous speech in noisy environments. The development of industrial applications based on know-how acquired in SIP is in progress, and an advanced voice-assisted parcel distribution system for postal services is envisaged by Elsag. In another industrial use, the feasibility of applying the speech recognition algorithms to the handling of collect-call telephone calls without operator assistance has been demonstrated by CSELT, the Italian telephone company.

These new algorithms for low - level speech recognition have been incorporated by AEG in their word recognisers, enhancing their capabilities in vocabulary, speaker - independence and rate of recognition.

The low-price GENEDIS prototype provides depth information about industrial scenes. Images of the same point (shown here in red and green) come from two aligned cameras (ESPRIT Project 532).



Depth is computed from displacement, and is shown here in false colour (eg, blue designates floor-level).

OS

OFFICE SYSTEMS (OS)

1. Introduction

A decade ago, the benefits of "office automation" were believed to lie in productivity gains to be made at the clerical and secretarial levels of the organisation through stand-alone systems limited in their application coverage. In the late 1970s and early 1980s, associated in large part with the rise of the personal computer, managers and professionals became aware of the potential benefits to their own work of using the new technology. During this period, sales of personal computers (PCs) increased dramatically, and by 1984 over 50% of the overall growth in computers came from sales of PCs. This situation is itself changing. Now that PCs and other electronic office products (word-processors, fax machines, mobile telephones) have achieved sufficient penetration, user-organisations are increasingly interested in linking equipment into networks that will make it easier to communicate and to share resources. Networks are becoming the new growth area. It is in the area of fully integrated networked systems that the major steps forward in office systems can be made.

For the European Information Technology industry to compete effectively in this area, the challenge is to have a clear vision of the evolution of real business needs and to develop cost-efficient solutions to meet them. An understanding of business needs must be combined with an ability to bring the underlying technologies closer to the user, so that the technologies are made more accessible and more understandable to the target audience, who will then fully benefit from them.

The contribution of ESPRIT to the development of European office systems is to promote key precompetitive research and development that will lead to competitive product developments in each major aspect of such systems, from communications through to advanced workstations.

There were a total of forty-five projects in the Office Systems area in ESPRIT I. Of these, eight were completed by the end of 1987, seventeen finished during 1988, and twenty continued into 1989. Many of the achievements of these projects have already been reported, and the following account covers only those achievements during 1988.

2. OFFICE DOCUMENT ARCHITECTURE

The development of effective integrated office systems requires that the technologies involved are linked to the needs of real business enterprises. Architectures, standards and associated software tools were developed for a wide variety of domains, covering a broad range of functions from document-handling through to decision support. The most significant achievement is in the domain of ODA (Office Document Architecture).

Working with documents is still the main application in many organisations using IT, and the ability to exchange documents electronically is critical in practice to the success of many IT systems. A key objective therefore is to facilitate the successful transfer of documents between machines from different manufacturers by developing suitable standards to which the different machines can work.

Major steps towards meeting this objective have been made under ESPRIT in the development of ODA. ODA provides standards for the exchange of documents, with individual manufacturers designing their own converters to change documents to and from the ODA interchange format.

ODA has gained wide support within and beyond ESPRIT, and has formed the basis for a number of standards adopted by the European Equipment Manufacturers Association (ECMA) and the International Standards Organisation (ISO), as well as recommendations of the Comité Consultatif International Telegraphique et Telephonique (CCITT), including ECMA 101, IS 8613, and T.411 to T.418 in the CCITT T.400 series of recommendations.

The industrial partners working on the current ODA project, PODA (Project 1024), are building on this success by developing products based on the ODA concept, including word processors and desktop publishing systems. Some products are expected to be commercially available by 1990. The project partners - Siemens (D), Bull (F), ICL (UK), Nixdorf (D), Océ (NL), Olivetti (I), Queen Mary College Interactive (UK), Service d'Etudes Communes des Postes et Telecom (F), TITN (F) - are also working to extend the system to handle voice input, so that users can transmit a document accompanied by verbal comments. The hardware, software and user-interface for an audio content editor have been developed and presented. TITN is actively pursuing standardisation through the appropriate international bodies.

The exchange of documents between machines requires suitable security measures, and work on the security aspects of ODA is in hand. A security model for documents relating to various users, their needs and security class has been established. This work will be used as a baseline for incorporating security in future versions of the ODA standard. A user-interface to secure documents based on a smart card has been developed and demonstrated as part of the security research prototype developed under the project.

3. APPLICATIONS SYSTEMS ENGINEERING

Successful integration of complex application systems into the day-to-day operation of a user-organisation requires the application of an appropriate methodology which takes adequate account of user needs and which has appropriate support tools associated with it.

Dornier (D), Ital Telematica (I), Politecnico di Milano (I), Sema Metra (F), Thomson Informatique Services (F), Océ-Nederland (NL), CNR-IEI (I), System and Management (I), and the Université Paris 1 Sorbonne (F) have been working together to help meet this need by developing "Tools for Designing Office Systems (TODOS)" (Project 813). TODOS proposed a complete methodology and design support tools from the requirements analysis to system specifications and architectural choices.

A powerful tool-handling office data dictionary for data collection, diagnosis of current office situations, analysis, requirements refinement and interfaces with design activities has been developed, and will be used by the industrial partners for further internal developments on office systems design methodologies based on requirements analysis. This tool is based on and compatible with the results partly achieved from an earlier ESPRIT project on "Functional Analysis of Office Requirements (FAOR)" (Project 56) (performed by STC Technology Limited (UK), BIFOA (D), EAC Data (DK) and GMD (D)).

According to the logical design a database for conceptual specifications has been developed and a graphical interface to the specification database has been realised. The research parties plan to continue developments in the direction of intelligent applications design and advanced query languages and functionalities.

Océ plans to extend the prototypical implementation of a performance modelling tool to a performance model including additional distributed OIS services (mail services, print services, gateway service) and to use such models for additional descriptions of systems software and hardware components in their product line.

A further contribution to the development of support tools comes from work by IOT (D), the Centre d'Etudes du Management (F), the Istituto per Automazione Risparmio (I) and the Università degli Studi di Milano (I). The project (285) has used Petri nets as a starting point for developing a formal method of describing the office which can be used by designers for modelling office requirements. It is planned to publish the OSSAD results in a textbook (OSSAD Manual) and to later integrate the OSSAD methodology in a software package that IPACRI plans to put to use in the banks associated with their institute.

4. BUSINESS SYSTEMS

The demands on office systems vary as a function of the type of business which the office serves. Research is needed in a variety of real enterprises (eg banks, hospitals, administrations, industry parks, large corporations, trading companies, and other types of enterprise) in order to identify commonalities and differences, and to develop a framework for understanding the application of office systems to business needs.

This is being addressed by SOGEI-Soc. Generale d'Informatica (I), Bull (F), Olivetti (I), I/S Datacentralen (DK), Arcos Conseil (F), Datenzentrale Schleswig-Holstein (D) and Criai (I) in a study of "Advanced and Integrated Office Systems Prototypes for European Public Administrations (ASTRA)" (Project 831). The main objectives of the project are to contribute to a common understanding of the office automation problems of public administrations in different European countries, and the integration of the state-of-the-art technology, concepts and results derived from ESPRIT projects. It is also contributing at an application level to the implementation of international standards.

Focusing on different governmental administrations or local authorities, the project has examined user needs in Italy, France, Denmark and Germany, and has produced an analysis of system requirements and system modelling for an integrated office system (mailing, filing, archiving, etc.) and the corresponding specifications. Pilot sites are planned to be implemented to demonstrate the system's capabilities.

Relations between servers and user applications are examined in the client-server model developed by ASTRA. The facilities in ASTRA include an archive server, file server, mail server, directory server, and gateway server. The clients, which are in principle applications, will cover the functions of document production and management, filing and retrieval, and mailing.

5. HUMAN FACTORS AND HUMAN-MACHINE INTERFACES

Recent years have seen increasing interest in multi-tasking, multi-user and networked applications, creating new demands on the interface between the system and its users. Human-machine interface designs which were suitable for supporting interaction between a single user and a single application now give way to interfaces which are more appropriate for supporting interaction between multiple users and multiple applications in many and varying combinations. Attention needs to be given not only to the design of the immediate interaction between the users and the system, but also to user training and support as well as to the broader social and organisational factors that affect the success of IT-uptake programmes within user organisations.

5.1 Human Factors in Product Design

Important contributions to the design of effective user-system interfaces have come from a wide range of projects, especially those concerned with workstations and with research in other areas leading towards products with an interface to a human user. Beyond these projects, effort in the human factors area under ESPRIT has been concentrated on "Human Factors in Information Technology" (HUFIT Project 385). As well as providing inputs to specific product developments, the HUFIT project has contributed a human factors toolset for use by design teams; this has already been used by Bull, ICL, Philips and Siemens in internal developments outside the project. HUFIT runs a programme of seminars to help disseminate the findings from human factors research, and also operates an information and consulting service.

Two applied research centres share the main responsibility for the organisation of the HUFIT project: the Fraunhofer Institut für Arbeitswirtschaft und Organisation (D) and the HUSAT Research Centre (UK). The industrial partners include Bull-MTS (F), ICL (UK), Olivetti (I), the Philips Institute for Perception Research (NL), and Siemens (D), working in collaboration with the Universities of Münster (D) and Minho (P), the Wilhelms University Westphalia (D), University College Cork (IRL), and the Piraeus Graduate School (GR).

5.2 A New Type of Interactive Panel

One of the key bottlenecks in communication between the electronic system and its users is the visual display, which is typically small and, even with suitable windowing techniques, restricted in the amount of information it can present at any one time. A human being, in contrast, is very good at scanning large areas and dealing with large arrays of information. While a very large display is not always necessary, the use in practical situations of tables, whiteboards, and even office walls themselves to provide large work areas attests to the fact that a large work area can sometimes be very useful.

IABG (D), MODULEX (DK), Scaitech (DK), Riso National Laboratory (DK) and the Technical University of Munich (D) have developed an interesting solution to this problem as part of the research on Project 878, ProMInanD. The ProMInanD interactive panel device is a wall-panel made up of a number of boards, each about A3 in size. Up to 255 can be linked together to form panels of varying sizes. Small plastic bricks can be placed on the panel and moved around at any time, and these are recognised by the underlying computer system.

The consortium plans to develop turnkey systems incorporating the panel in the areas of equipment monitoring and CIM. The panel was shown at ESPRIT '88, where it was demonstrated in an application for a shipping agency responsible for monitoring the continuous movements of containers in a geographical region and to generate reports and forms without the need of a keyboard/VDU interface. The panel provided an overview of the current container situation, while the computer system stored the history of container movements and generated reports on demand via an attached printer.

5.3 Picture Coding Techniques

Visual images are likely to remain one of the principal means of communication in electronic systems for the foreseeable future, both as a means of communication from computers to humans, and from human to human through a network (as in videoconferencing). There is consequently a need to develop techniques which allow visual images to be transmitted to as high a quality as possible given the available bandwidth. Two projects under ESPRIT I have made significant contributions to this objective.

British Telecom (UK), the IBA (UK), KTAS (DK), Dr Neher Laboratories (NL), CSELT (I), CLETT (F) and Nixdorf (D) have been working on this problem with regard to the transmission of still images under the PICA project (563). One of the algorithms developed has been selected and proposed as a world standard.

CIT-Alcatel (F), Telefonica (E), STA Elettronica Automazione (I), TE.KA.DE. (D), STE Anonyme Telecommunications (F), and GEC Research Laboratories (UK) (925) have been developing coding techniques for the real-time transmission of moving images over a 64 Kbits/s line. The algorithm developed has been submitted to the CCITT and could become a world standard, allowing the use of ISDN as a carrier for video conferences.

5.4 Human Factors in IT-Uptake

In order to achieve successful uptake of IT on the scale required for the success of the IT industry at large and for the benefit of European industry generally, it is necessary to pay adequate attention to the human, organisational and economic factors that influence user organisations in their uptake of IT systems.

This objective has been addressed by Memory Computer (IRL), Empirica (D), the Work Research Centre (IRL) and STC Technology (UK) in their work on IT-Uptake (1030). This project has produced a model of the IT-uptake process and a comprehensive package of practical guidelines covering human, organisational and economic factors that can be used by IT managers and others concerned with the uptake process. Illustrative applications of the model to a wide range of real user-organisations, and an analysis of the impact of teleworking on future demand for IT systems, also form important outputs from the project. A new company, "IT-Uptake", has been set up in Ireland to help exploit the results of the project. In addition, the research done forms a good basis for further development of training and guidance materials in IT-uptake under ESPRIT II. Several aspects of the project are being published as books.

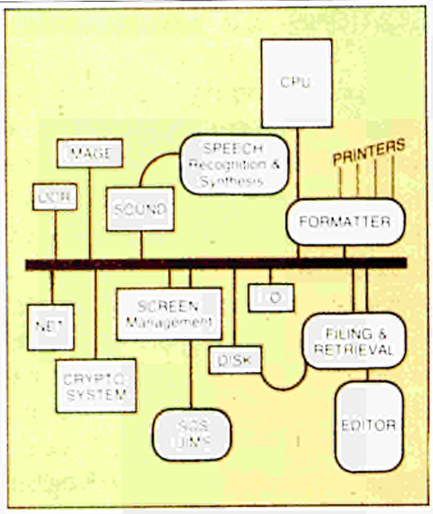
6. WORKSTATIONS

The workstation is playing an increasing role in office systems. It is becoming the principal point of contact between the user and the underlying networks, and provides the user with access to a whole range of services, including in-house corporate office services as well as commercial and public services. Recent years have seen an expansion of the workstation market by more than 30% per year, but it has been dominated by products from the US rather than from Europe. Continued expansion is expected as advances in basic technologies, packaging and software development environments provide opportunities to address increasingly sophisticated user needs and expectations, and there is continued opportunity for Europe to develop products which can compete effectively in this important world market which has been estimated (Alpert M., Fortune, October 1988, p.76) at 20 billion ECU in 1993.

6.1 A Multimedia Office Workstation

One of the key trends in office systems is towards a multimedia environment, evidenced for example in the multimedia document filing system developed by Olivetti and partners (28) and in the work by Philips and partners on the Imageur Documentaire (901).

Consistent with this trend, Bull (F), AEG (D), INESC (P), ITALTEL Telematica (I), Sobemap (B), Sarin (I), INRIA (F), CSELT (I), CEN/SCK (B) and Iselqui (I) have been developing a "Secure, Open, Multimedia, Integrated Workstation (SOMIW)" (367). The workstation integrates a set of functions which have never before been together in an office workstation, and which provide the user with a friendly interface able to deal with various combinations of information including text, pictures and graphics. The workstation can decipher written information and can accept spoken instructions. Secure communication is provided between workstations.



System architecture (left) and a typical screen layout (right) of a prototype based on the Metaviseur workstation developed in ESPRIT Project 82, IWS.

The workstation, known as "Metaviseur", is the most advanced of its kind and will help to put Europe in a competitive position in this segment of the market. The workstation was shown at ESPRIT '88. A commercial version of the SOMIW image editor is already marketed by Bull (under the name RAPHAEL) for the publishing market, and will be followed in 1989 by BALZAC, a text editor. It is expected that a number of the partners in the project will manufacture and market products derived from the project by the early 1990s at prices which will bring them within reach of the average computerised office.

The Metaviseur workstation produced in this project is used by INESC and CRC for their developments and was the basis for the Bull DPX1000 product.

6.2 Application of Knowledge-Based Systems

A second important trend is towards greater use of knowledge-based systems, and work by Bull (F), FORTH (GR), Océ (NL), VUB (B), INRIA (F), and KUN (NL) on the "Intelligent Workstation" (82) illustrates some of the ways in which such intelligence can be usefully applied within an office workstation. It uses this knowledge to assist its owner in achieving his office goals. Cooperative computer-supported work is provided with automatic document exchange via an X400 electronic mail service. The IWS application analyses received mails and time events and relates them to the organisation and procedure models for assisting its owner in its office task, according to administrative rules and organisation choices of its work environment. In addition to processing, storing and retrieving information, the system provides advice to the user on what to do in order to achieve office goals. A prototype based on the "Metaviseur" was demonstrated at ESPRIT '88. It incorporates KRS, a knowledge representation system built and now marketed by VUB on several UNIX systems; CAMS, an expert system under development at Bull for cooperative computer-supported work; and a set of natural language processing tools for smart text editors and natural language dialogue developed by KUN and Océ.

The results of the project will be immediately transferable into a broad spectrum of products which will play a key role in office information systems in the 1990s.

6.3 The Paper Interface

Despite the increasing use of electronic systems, paper-based information still plays a crucial role in most organisations today and can be expected to continue to do so for the foreseeable future. (One aspect of this is the growth in desktop publishing systems, estimated to grow from around 600 million ECU in 1987 to approaching twice that in 1992; Business Week, 28.11.88, p.71). A key objective in designing effective office systems must therefore be to provide adequate links between the paper-based and electronic systems on which organisations rely. This objective is being addressed by AEG (D), Olivetti (I), Plessey (UK), and Philips Gloeilampenfabrieken (NL) in collaboration with Trent Polytechnic (UK). Their work on the "Paper Interface" (295) is contributing to techniques for automatic transfer of information between electronic systems and paper documents. A prototype system has already been demonstrated which integrates many of the specific functions into a single system.

Part of the work on the paper interface is concerned with the scanning of existing paper documents, their decomposition into "image", "graphics" and "text", and the recognition and encoding of the information for further electronic processing. One of the key achievements here has been the development of a high-resolution multi-colour scanner (300 pixels per inch, 8 bits per pixel), which can be connected to a PC or a workstation. Olivetti has realised prototypes and integrated them both in the interim demonstrator of the present project and in the complementary 853 project, which deals more specifically with colour processing and representation in documents. Some scanner optional extra features will be developed during the remaining part of the project in order to offer the possibility of deriving a set of commercial products with a wide range of costs and performance. Assessing the actual importance of treating colour documents in the office environment is also in the scope of this activity. AEG is involved in the encoding and processing of the scanned information. Their exploitation plans includes the optimisation of the present software implementation and its industrialisation into future products.

A second area of development is concerned with the real-time recognition and encoding of typical text and graphics as produced by the human hand, and algorithms for this are currently under development.

A third concern is with generating paper documents from electronically filed information. Here, the ODA standard developed under ESPRIT has been used as a basis for a printer controller which is now operational. A conversion to Postscript has also been developed.

One of the major problems in linking paper-based information to electronic systems has been the capturing, processing and reproduction of true colour images. This problem has been researched by Olivetti (I), Intersys Graphic (B) and the Katholieke Universiteit Leuven (B) (853). Great attention has been paid to the acquisition system in order to comply with the requirements of most of the images that can be found on paper, in terms of both geometrical resolution and chromatic range. The high degree of information content of the scanned images required the development of sophisticated image-processing algorithms for storage, retrieval and print-out. To this end, second-generation image coding and compression techniques, based on human perception characteristics, have been investigated and developed, together with advanced algorithms, to reproduce continuous tone images with digital techniques and to achieve a good colour restitution. The algorithms for colour image processing and enhancement have been optimised with respect to the technology adopted in the colour printing prototype developed for this project. Interesting software packages and hardware equipment have been developed. As regards the development of software, it must be noted that image processing applications have already settled in the market and the forecast future growth in this sector is very attractive. The development of the CIPLY (Colour Image Processing LibrarY) must be considered of great importance, coupled with the possibility of building a low-cost package including a text layout system and an image package with which true colour/grey images can be easily created. Great interest can also be envisaged in the development of specialised software for coding and compressing complex images, either for integration in a more complete software package or as a starting point for a hardware implementation, necessary when reduced processing time is required. Concerning the development of hardware equipment, great industrial interest can be envisaged in the availability of a low-cost high quality non-colour printer; on the other hand, the integration of a high resolution multicolour document scanner in an image handling system widens the range of the products which can be proposed in the field of image acquisition systems, thus opening up new market opportunities.

7. NETWORKS AND DISTRIBUTED SYSTEMS

In support of the trend towards networking and integration, a key objective is to develop effective means of linking different types of networks more easily. Associated with this is a need to develop systems that can best use the information, equipment and other resources distributed across the various networks.

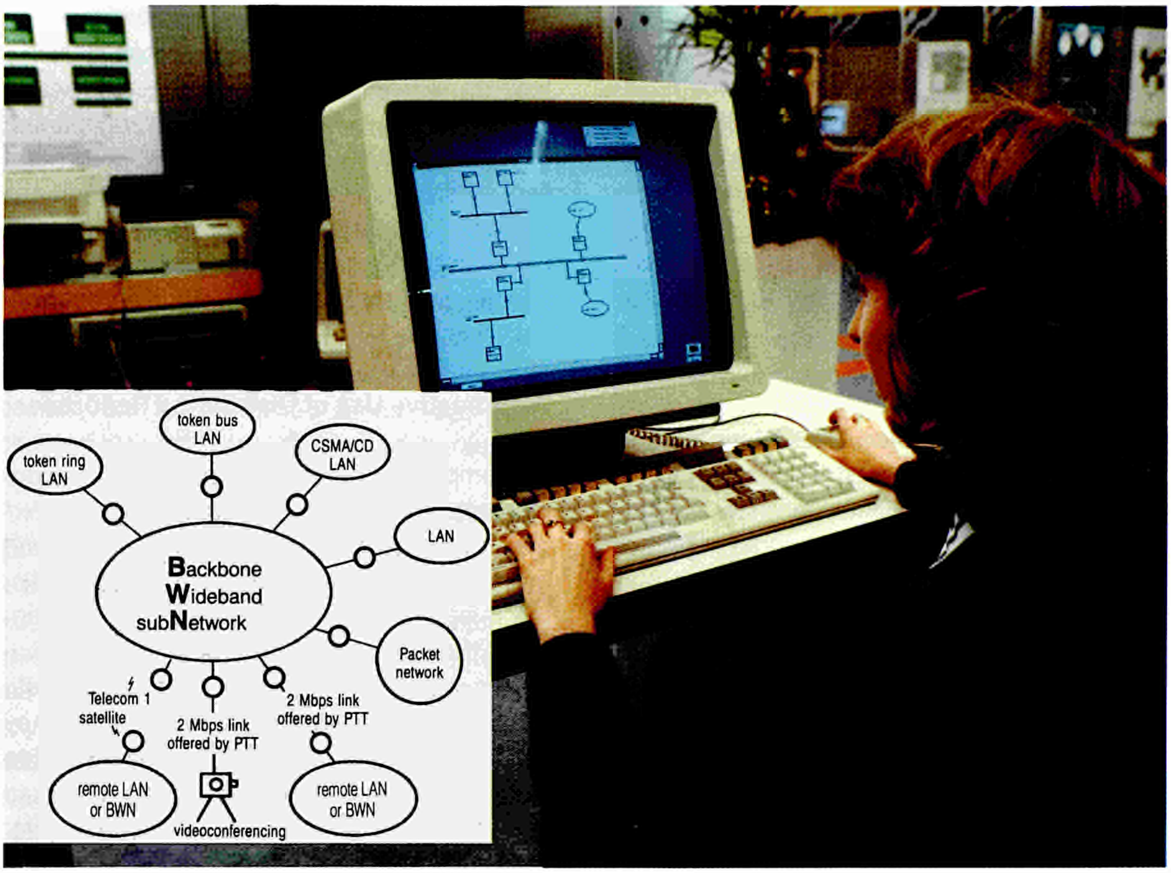
Starting from the concept of "open systems" and the OSI Reference Model, work under ESPRIT has recognised the importance of further elaboration of OSI standards and the development of wideband communications technologies complying with these standards. Broadband communications for local- and wide-area networks, together with the definition and implementation of distributed systems, have been the main issues in this area.

7.1 Interworking Between Different Networks

As the uptake of IT progresses, more and more businesses are installing local area networks (LANs), often in several locations. Different LANs may be installed in various buildings covering a broad area such as an industrial park or a university campus, as well as on different floors of the same building. One LAN may have been installed in order to interconnect existing equipment, while another may have been installed to connect new equipment required for some special application. For the business to operate efficiently, the various LANs need to be connected to one another and to public networks.

The corporate communication system of today may be described as a 3-level hierarchy. The backbone network (the upper level) interconnects standard LANs (the medium level), which are themselves connected to capillary networks (the lower level), to which user equipment is directly attached.

Progress on this problem is being achieved by ACEC (B), Alcatel/Bell Telephone (B), Stollmann (D) and France Cables and Radio (F), the University of Liège (B), CISI TM Conseil (F), the National Technical University of Athens (GR), and DNAC (F) in the "Broad Site Local Wideband Communication System (BWN)", Project 73. The project involves the development and the demonstration of an application involving three hierarchical levels. Packet switching via optical fibre is used to interconnect heterogeneous data networks at high speed (140 Mbps) across a broad site, with gateways to ISDN (Integrated Services Digital Network), PSTN (Public Switched Telephone Network) and satellite networks. To illustrate the multimedia capability of the BWN and its ability to carry on synchronous traffic through a connectionless network, a video-conference application at 2 Mbps has been developed and was demonstrated between Liège and Antwerp in June 1988 as well as at the exhibition of the 5th ESPRIT Conference. A full-scale prototype is being installed on the University of Liège campus. Consistent with



The Broad Site Local Wideband Communications System (BWN), Project 73, has built a high speed (140 Mbps) corporate network as the basic structure for the interconnection on a broad site of heterogeneous standard LANs.

The BWN is connected to the various LANs through router gateways (diagram, above left) able to sustain a throughput of 2 Mbps full duplex. The backbone and its associated LANs offer a connectionless network service to all corporate users.

The development of the BWN includes extensive management capability. The performance management associated with specially built testing equipment was demonstrated at the 5th ESPRIT Conference (photo, above right). The testing environment of the BWN is one of the most advanced ever built and it will pave the way for the development of the complete network management based on a Network Control Centre able to handle all management aspects, such as configuration management or performance management, which will be needed in an operational system.

the emphasis in ESPRIT on open systems, the network is OSI-compatible in order to make it easier to set up multivendor networks in high data-rate communication environments.

A significant industrial spin-off from the BWN project has been the design and production of two chips (Elbn and CRC) performing at 140 Mbits/sec.

Beyond the "broad site", there is a need to link different installations within a "metropolitan area", such as a town. Progress towards this objective is being made by CSELT (I), TITN (F), NKT (DK) and British Telecom (UK), together with the Universities of Toulouse (F) and Patras (GR), in the LION or "Local Integrated Optical Network", Project 169. This project is developing a high-speed network (aiming for 560 Mbits/sec and beyond), based on optical fibre, and capable of handling real-time as well as other types of information. LION is based on a modular design fully conforming to the Open System Interconnection (OSI) model developed by the International Organisation for Standardisation (ISO), and uses a new multi-access protocol based on hybrid circuit and packet switching. Several international patents, issued or pending, cover the most innovative technical solutions.

Major steps in achieving the project goals were demonstrated at the CeBIT Fair in 1988 in Hanover. These demonstrations used significant business applications to show the capability of the network to handle different kinds of traffic (from "stream" to "bursty"), and narrow-band to wideband (2 Mbits/sec) communications. The five-year project is now entering its final stage and it will be ready for industrial implementation next year.

At the end of 1988, a three-node LION prototype was implemented at 140 Mbits/sec by including service applications, management functions, fault tolerance and traffic emulation (for assessing the network performance under full-load conditions). Each node has user interfaces with different features in relation to the mix of traffic supported for the demonstration. Specific objectives of the final experiment are to highlight LION's versatility and flexibility in adapting to a wide range of services, including file transfer, access and management (FTAM), message-handling systems (MHS), and computer-aided design (CAD). Gateways to external networks will also operate on the network.

As well as the development of the network itself (with embedded applications), the participants are undertaking two related experimental studies. The first concerns the integration of LION's physical level by using application-specific integrated circuits (ASICs) to reduce the chip count and power consumption in the 140 Mbit/sec prototype. The other task relates to the design and laboratory development of the transmission subsystem at 565 Mbit/sec, suitable for the second LION generation.

The end of the project (first quarter of 1989) will not be the end of LION, as two new objectives will be pursued: commercial exploitation, with the focus on applications; and evolution towards a second network generation addressing the communication needs arising in a metropolitan area with a massive concentration of information-based companies. Standardisation will complement both activities.

7.2 Effective Use of Distributed Resources

As companies develop more and more complex networks, ofen incorporating many different computers (mainframes, minis and micros) allocated to different main tasks, there is a need to be able to write applications that can draw on these various machines as and when required to make efficient use of the distributed resources they provide. A single application may need to make use of several different programs held on different machines, and data spread over yet further machines.

The development of application software for this type of situation is currently labour-intensive and costly, especially where many machines are interconnected and are expected to cooperate while handling volumes of data, often including both text and graphics as well as other media. The current absence of a uniform mechanism for coupling independently-coded software modules, possibly written in different programming languages, provides a major hindrance for the reuse of software which has been written, tested and paid for.

One of the key objectives must be to develop appropriate methods and tools for the COnstruction and MANagement of Distributed Office Systems, and this objective is being addressed in the COMANDOS project (834) being undertaken by Olivetti (I), ARG (I), Trinity College Dublin (IRL), ICL (UK), INESC (P), Nixdorf (D), Bull (F), IMAG-Laboratoire de Genie Informatique (F), CNR-IEI (I), Fraunhofer Institut/University of Stuttgart (D) and the University of Glasgow (UK).

The project is designing and building an integrated support layer for the development, management and operational control of applications distributed on a heterogeneous network, and should be of great benefit to application programmers and system administrators. It is taking an innovative approach based on the integration of operating systems, programming languages, and database technologies. A unifying view of these is provided by a model and system architecture based on an object-oriented approach coupled with persistent distributed storage.

An implementation architecture was defined during 1987, and prototypes based on this architecture have been developed during 1988. Bull are using the results of the project in developing products for the Unix environment, and at ESPRIT '88 demonstrated a very sophisticated desktop publishing system based on the COMANDOS system kernel placed on top of Unix, running Unix applications as objects and accessing Unix data files as objects across several machines.

Short-term exploitation of the results of COMANDOS includes the use by the partners of some tools (performance modelling tool, system observation and control facilities, etc.) developed under the project, as well as the acquisition and exploitation of the object-oriented technology for the design of a distributed directory service, a hypermedia system, and document management facilities. In the longer term, the projects provides a basis for a pre-industrial integrated application development environment based on standard building blocks such as X/OPEN-POSI interfaces, existing programming languages and standard protocols.

The COMANDOS work will form an important contribution to the OSF (Open Software Foundation) Programme and to the definition of standards, especially in regard to ISO (International Standards Organisation) ODP (Open Distributed Processing).

A second key objective must be to develop a general architecture that can encompass all office systems software in a distributed environment, and important contributions to this have come from work by Plessey (UK), Mari Advanced Electronics (UK), Philips (D), Synergie Informatique et Développement (F), DNAC-UPMC (F), and ITK (D) in the CSA or "Communications Systems Architecture" project (237), using an object-oriented approach. The work is providing a research base for the development of new products and is influencing new international standards for distributed computer and telecommunications systems.

7.3 Security

Security is a requirement even in stand-alone systems, but it becomes a much greater problem when different computers are linked together to form networks through which information can be passed or can be altered by remote command. Security is being addressed by Christian Rovsing (DK), Bertin (F), Protexarms (F), and COPS (IRL) in collaboration with the Universities of East Anglia (UK) and Köln (D) in MARS, Project 998. This project is studying the current state of the art in the areas of physical and logical security and integrity of office systems in order to develop a model, produce substantial innovative proposals dealing with the needs of future office systems, and provide inputs to relevant standards activities. A complete set of security guidelines for system managers and system designers was produced. For purposes of illustration, the project has also defined the requirements for key management and end-user security facilities in a treasury management system.

7.4 New Services

GEC (UK), AEG (D), Nixdorf (D), Olivetti (I) and University College London (UK) (Project 395, INCA) demonstrated an OSI distributed directory at ESPRIT '88. The system, called "QUIPU", follows the draft CCITT X.500 recommendations and ISO DIS 9594, and is the first public geographically distributed demonstration of an X.500 system.

The demonstration showed how the system allows the various parts of a distributed database, perhaps administered by different organisations, to cooperate in information exchange and replies to queries. A Network Management System was also demonstrated as an example of an "open" management system.

A set of tools were developed in INCA for the support of the implementation of communication systems. VAP is one of them, which enables any system to implement any protocol written in the EFSM notation. The end product is a C-code definition which ensures portability to other systems using VAP. Currently the exploitation of VAP is taking place within the AEG group of companies in Europe. Plans have been made to market it in the US.

At Nixdorf the results of the project were exploited in different ways and to different degrees. The outcome of the project has strongly influenced Nixdorf's office product, "Targon Office".

One of the few (but important) hardware components prototyped within the project was the high resolution display, which was further developed to a commercial stage outside INCA. The 17" display is now available as an option in the Professional Workstation (PWX) made by Nixdorf. This development allowed Nixdorf access to technology which facilitates the presentation of high quality graphic output to the office user. This was formerly only available on expensive CAD/CAM workstations.

When the work was started, no experience was available in Europe on how to deal with the high bandwidth (160 MB pixel-rate) needed to build such displays cost effectively, nor to support the European hard radiation regulations. The most significant and cost-effective achievements are a flicker-free high resolution (120 pixel per inch) A4 page display of black characters on a white background, the softscroll on the complete display, and the hardware support for graphics commands. An additional commercial spin-off is a 20" portrait display, now under development. Derived in part from work within the same project, Olivetti has launched a range of networking products under the generic name "Olinet".

British Telecom (UK), CSELT (I), CNET (F), Industrie FACE Standard (I), STC Technology (UK), TRT (F), Dr Neher Laboratories (NL), and Telefonica CTNE (E) have been collaborating on the development of a Multipoint Interactive Audiovisual Communication (MIAC) system (Project 1057). This is a hi-fi system based on 64 Kbits/sec transmission, with potential upgrade to ISDN. The multipoint nature of the system makes it attractive to organisations that need to hold conferences across a number of different sites. The high quality sound makes natural discussion possible between conference participants. Participants can also send and receive facsimile documents, colour still images or written messages. All of the communications are carried on a single digital line.

The project has achieved international acceptance through the international standards organisations of the infrastructure it has proposed, and has demonstrated prototype equipment, including a multipoint link between six locations in the UK, Italy, Holland, and France, and a demonstration at ESPRIT '88. The industrial partners are working to build on this success by developing products based on the system. User organisations will be able to choose the terminal that best meets their requirements, confident in the knowledge that interworking between the products of the different companies concerned will be possible.

8. STORAGE AND RETRIEVAL SYSTEMS

Networks are used not only for communications but also to provide access to repositories of information. For electronic storage and retrieval systems in an office environment to provide effective, practical alternatives to paper-based systems, they must be capable of storing at least the same diversity of types of information. This means that it is necessary to develop office information servers (OIS) that are capable of holding in digital electronic form all office information, including that which is currently committed to paper.

Significant progress towards this objective has been made by ICL (UK) and Bull (F) in cooperation with Trinity College Dublin (IRL), the University of Stuttgart (D) and the Fraunhofer-Institut für Arbeitswirtschaft und Organisation (D) in DOEOIS, Project 231.

The project has successfully demonstrated a prototype OIS providing access to information in a variety of forms including both data and documents, as well as to procedural information concerning, for example, the progress of claims forms or other items through the necessary office procedures. The prototype shows how it is possible within a single system to retrieve not just items of data or text but also to answer queries such as "Where has my expense claim got to?" and "How many sales have reached the contract stage?". A number of outputs are used or built into products by the partners : Bull is exploiting the ODA/ODIF encoding-decoding functions, ICL is extending the FM Query Language and plans to exploit it in a semantic database project, and IAO is actively using the office analysis methodology.

A longer term industrial impact is planned on third-generation database management systems. The results of DOEOIS will rectify some of the known deficiencies of relational database systems concerning, for example, large or composite objects. In addition, the OIS interface is seen as the platform for the high-level portability of OIS applications.

A further dimension to office information is the mixing of different media within a single item. For example, papers may contain text and graphics as well as tables of statistical information. Electronic documents can in principle include other media as well, such as voice annotation. In order to realise this technological potential in practice it is necessary to develop electronic filing systems that can handle multimedia documents, and this is being achieved through the cooperation of a number of key companies and their ESPRIT partners - Olivetti (I), the Battelle Institute (D), the Cretan Research Centre (GR), Triumph-Adler (D), Epsilon (GR), Eria (E), and CNR-IEI (I) - in MULTOS, Project 28.

The user interacts with a MULTOS system through a client subsystem, which provides a friendly user-interface to the server holding the documents. Two types of server are used, the "dynamic server", for documents which need to be updated or accessed frequently, and the "archive server", for more stable documents which are accessed less frequently.

A first prototype system demonstrating how the principles involved could be applied to text documents was implemented in 1987. The second prototype, currently under development, extends the application of the same principles to the problem of storing and retrieving graphics as well as text, and includes an optical disc unit to provide the mass storage capability required for large volumes of multimedia documents.

COMPUTER-INTEGRATED MANUFACTURING (CIM)

1. Introduction

Manufacturing industry represents a large and exciting market for the European IT industry and is a key sector in the economy of the Community. The varied nature of manufacturing activities from design and engineering through to manufacture, test and distribution, provide a wide range of applications for innovative hardware and software systems. By bringing together IT vendors, users and systems houses, the CIM area within ESPRIT seeks to develop cost-effective approaches to manufacturing which will promote the competitiveness of European industry in world markets. It achieves this by promoting the development of methodologies and tools within a framework of open systems interconnection, thus creating an environment in which multivendor systems can be implemented easily and progressively to meet the requirements of the user.

The developments within the CIM area of ESPRIT are outlined below in four areas:

Architectures and communications

Significant progress has been made towards creating an infrastructure to integrate the many elements of CIM.

Design, graphics and engineering

A number of subsystems have been developed to support the integration of design with production engineering and manufacture.

Robotics and shop-floor systems

A combination of advanced programming and sensor technology is increasing the versatility of robots and extending their range of applications.

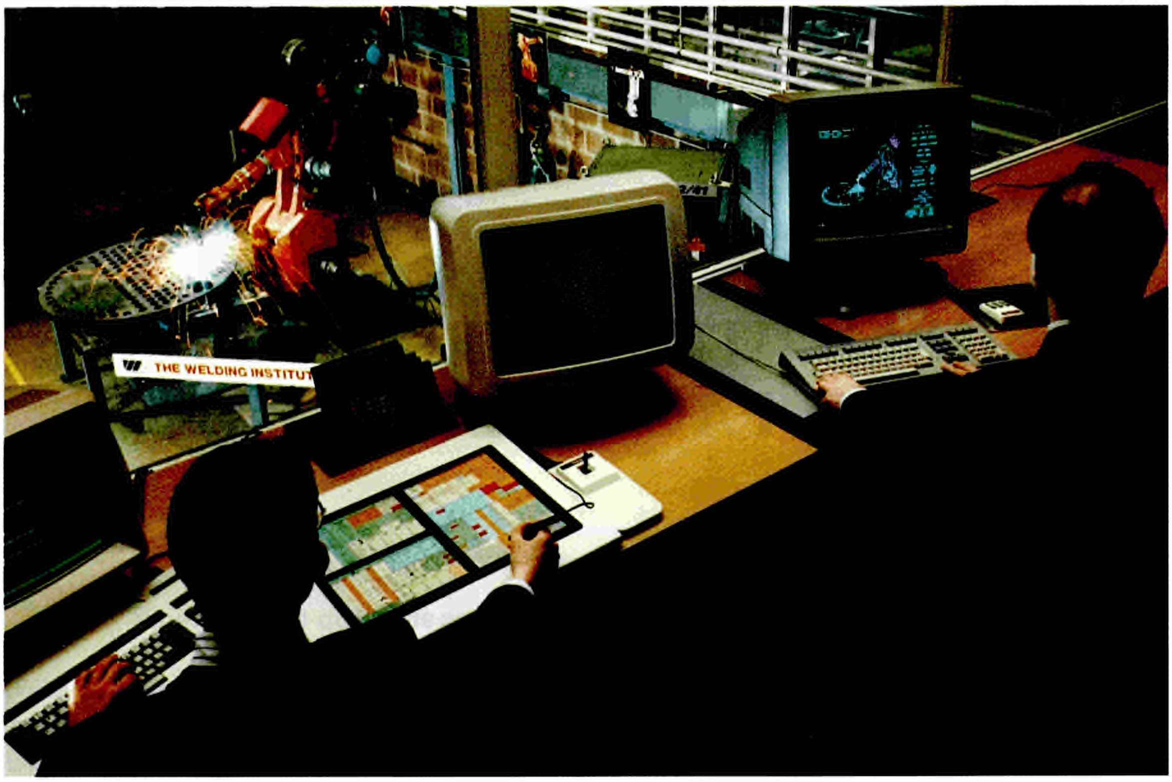
Manufacturing planning and control

Systems for scheduling production and shop-floor systems for controlling quality and monitoring output have been examined.

2. ARCHITECTURES AND COMMUNICATIONS

In recent years there has been a proliferation of computer-based design and manufacturing subsystems, but progress towards linking these subsystems to provide a cost-effective integrated solution to a user's needs has been limited by incompatibilities of languages, data formats, protocols and communications modes between the products of different vendors. This area of integration is being approached through a number of major projects.

CIM-OSA (Project 688) is an open systems architecture for CIM developed by a collaboration of nineteen major European and international organisations. The architecture is a modular framework for supporting the



Welding in progress in the FMS weld cell constructed at TWI, Cambridge. The centre CAD screen shows 3-D product data, which is transferred to the off-line programming facility shown on the right (ESPRIT Project 595, The Application of CIM to Welded Fabrication, involving the Welding Instititute, Aalborg Shipyard Ltd, Italsiel SpA, Università di Genova, Odense Steel Shipyard and the Danish Welding Institute). (Acknowledgement: The Welding Institute).

development of CIM systems throughout the whole systems life cycle. Following on from its publication of key concepts in 1987, the project this year has used an object-oriented programming language to develop a demonstrator as part of an integrated support environment for explaining to a user the concepts and application of the CIM-OSA approach.

Success in achieving integration between computers and controllers in CIM depends largely upon communication. The Communications Network for Manufacturing Applications Project (CNMA - Project 955) aims to specify, implement, validate and promote emerging communication standards, suitable for European users, within the International Standards Organisation (ISO) model for Open Systems Interconnection (OSI). Its approach is compatible with the MAP and TOP initiatives being developed in the USA, and in June 1988 CNMA provided the only real production environment at the Enterprise Networking Event (ENE) '88 International, the biggest multivendor demonstration of the year, which took place in Baltimore, USA. The conformance testing part of the project developed and supplied the necessary conformance test tools to allow the event to proceed. An agreement for the reciprocal use of test tools at the ENE was negotiated between the CNMA team and COS (the US-based Corporation for Open Systems). After the success at Baltimore, a longer-lasting agreement was concluded and signed.

In addition, the CNMA project consortium of six vendors, five users and two systems houses implemented three live production pilots during 1988. In BMW's new car factory in Regensburg, the CNMA communications system supports real-time transmission of production-line error information, which is vital to the maintenance of the "just-in-time" concept of the plant. At the British Aerospace plant at Samlesbury, computers, controllers and communications software use a CNMA-network to control a flexible manufacturing system for the production of AIRBUS components. The third CNMA demonstrator is located in an Aeritalia factory in Turin, and controls an assembly cell for the manufacture of wire harnesses. These applications represent the world's first industrial implementations of a Manufacturing Message Specification (MMS), a major service of MAP version 3. Future work by the consortium will continue to address industrial communication protocols, and to place specific emphasis on the development of functional standards.

Under Project 812 an experimental centre is being developed at the premises of ELSAG in Genoa (CRCE - Experimental Centre for System Integration in CIM). The Centre aims to provide an environment in which tools, subsystems and prototypes developed in ESPRIT CIM projects can be integrated, tested and refined in a near-production environment. A detailed design for the centre has been completed, specifying the communication networks, data structure, hardware and software subsystems, configurations and layout. The implementation phase of the centre is underway with a view to making it available as a test-bed for CIM in late 1989.

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3. DESIGN, GRAPHICS AND ENGINEERING

Several projects are addressing the difficult problem of interfacing Computer-Aided Design (CAD) to computer-aided analysis systems and to production planning systems.

The Computer Aided Design I project (CAD Interfaces, Project 322) has developed a family of compatible interfaces which are vendor-independent and which facilitate the exchange of product definition data between CAD systems and production analysis systems, such as finite element models. While until now research has concentrated on data exchange between CAD systems, in 1988 it was possible for the first time to download CAD data, in the neutral file format of Computer Aided Design I, to a robot control unit. A number of interface processes have been successfully tested in an industrial environment and are being exploited commercially by the partners. The project has had considerable influence on the proposed ISO STEP standard for data exchange, which is expected to be available in 1989.

Project 384 is concerned with the development of an integrated information-processing system covering the design, planning and control phases of small batch assembly. Its aim is to provide designers with a knowledge-based support system reflecting the company's manufacturing capabilities, which allows the design of products for automated manufacture and assembly in the most cost-effective and efficient way, avoiding unnecessary investment in new plant and machinery. A first prototype has been developed and applied to the assembly of electromechanical components.

The first objective of the VITAMIN project (Visualisation Tools in Manufacturing Industry, Project 1556) is to develop a hardware and application-independent tool kit of software modules, which will simplify the construction and use of graphic displays in man-machine interfaces on the shop floor in order to promote the efficient use of manufacturing resources. Two application areas are currently being developed:

- an Active Management Dashboard (AMD) to provide assistance in managing production systems;

- an Active Control Dashboard (ACD) designed so that the operator of a production system can carry out remote control and supervision tasks.

These applications have been evaluated in industrial test-beds and the results are influencing the redesign of the user interface of a number of industrial products supplied by the consortium members.

In pursuing the technology that leads towards more fully integrated CIM systems it is important not to overlook the needs of people working within the systems and the accumulated skills and knowledge they can contribute. The objective of Project 1199 has been to develop several "human-centred" CIM building blocks in which people are given responsibility for those tasks best performed by human skills, while the use of computerised systems in support of shop-floor operators is optimised. Three main systems have been developed within the project. The CAD system consists of an electronic sketch-pad which acts as a means of data entry and an effective means of visual communications between designers and manufacturing staff. The Computer-Aided Planning (CAP) system is a shop-floor monitor and controller which provides operators with scheduling and production management support. The Computer-Aided Manufacturing (CAM) system is a lathe controller with enhanced graphics capabilities which enables skilled lathe operators to produce part programmes efficiently on the shop-floor. These systems have been installed at two industrial test and demonstration sites at the Selectro plant of BICC (UK) and the Leavesden plant of Rolls-Royce (UK). A third demonstration site has been set up at the University of Bremen (D) as an experimental site at which further development work can take place.

4. ROBOTICS

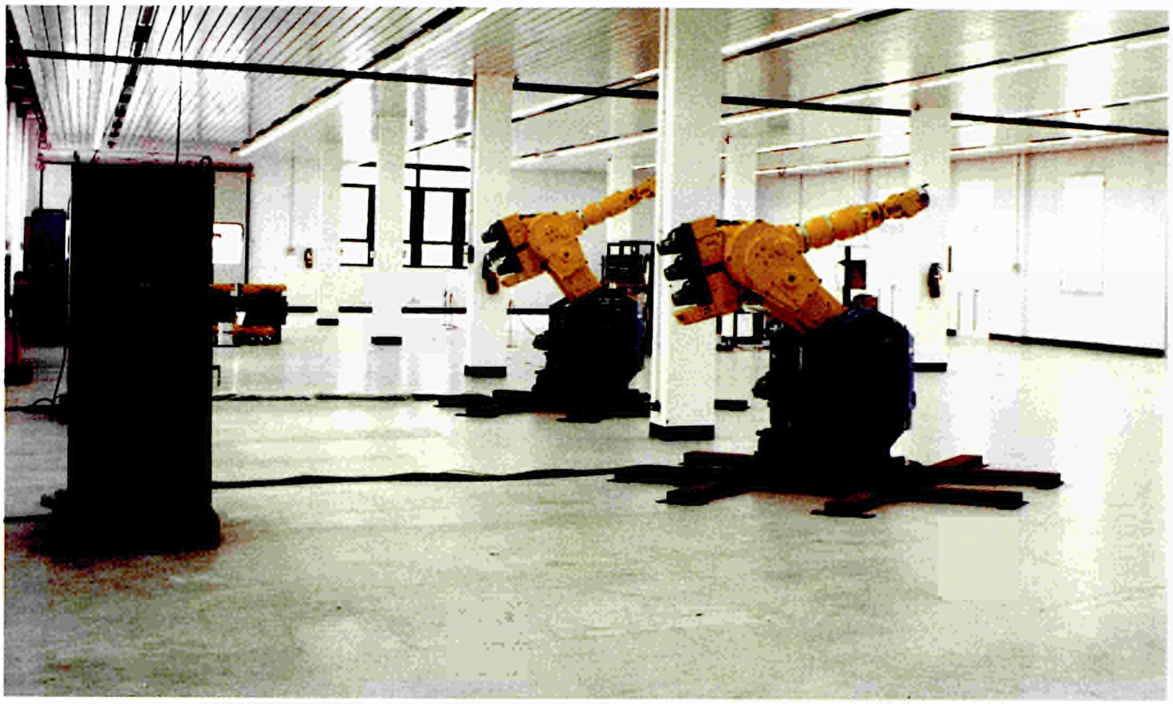
Several projects are seeking to improve and extend the applications of robotics to flexible manufacturing by developing better sensors and more intelligent control systems, and through producing better planning tools to allow robots to be integrated more easily into the manufacturing environment. Within Project 278 (Integrated Sensor-Based Robot Systems) the project team has produced and demonstrated fully functional prototypes of tactile image sensors and analysis systems, easy-to-use low-cost vision systems for workpiece recognition and location, a highly adaptable sensorised gripper system, and a robot controller capable of integrating these systems. The prototypes have led directly to exploitable products for the partners: MARI (UK) manufactures and markets the piezoelectric tactile sensor systems; the vision systems are being offered by Joyce Loebl (UK), and Robert Bosch (D) offers customers an enhanced range of components for vision-guided robot control applications.

The SACODY project (Project 1561 - A High-Performance Flexible Manufacturing Systems Robot with Dynamic Compensation) focuses on the development of techniques and tools for the advanced control of high speed robots in flexible assembly environments. By using an active control concept these control techniques will overcome problems of flexion and torsion, which can severely limit the current capabilities of robots. The project has already produced an impressive laboratory demonstration and plans are underway to incorporate the techniques into a KUKA GmbH robot in an industrial assembly environment.

5. MANUFACTURING PLANNING AND CONTROL

Shorter product life-cycles and uncertain markets require a quick and flexible response to frequent changes both in design and in manufacturing batch quantities. A major objective of computer-integrated manufacturing systems is to create this flexibility, but as the development and implementation costs of computer-integrated manufacturing systems can be high, it is important that the resources of the system are utilised effectively in order to achieve high output and low unit cost. Several on-going projects are developing systems to promote better work scheduling and control of work flow through all stages of manufacture.

The aim of the COSIMA project (Control Systems for Integrated Manufacturing, Project 477) is to create a set of tools to develop a Production Activity Control (PAC) system to be used in both production planning and manufacturing control using data automat-



The Experimental Centre for System Integration in CIM, developed in ESPRIT Project 812 by ELSAG SpA, Aeritalia, RWTH Aachen, CAP SESA, Philips and MBLE, and Politecnico di Milano.

ically gathered from the shop floor. The PAC system is based upon five fundamental building blocks: Scheduler, Dispatcher, Mover, Producer, and Monitor. A simulation facility allows a user to configure and test a PAC system to match the requirements of a particular production environment. Over the year work has concentrated on developing an implementation model to be realised at the Clonmel (IRL) manufacturing plant of the Digital Equipment Corporation. The concepts are being tested in a pilot implementation at workcentre level in the electronic assembly areas of machine insertion, hand assembly and solder wave. This pilot version of the system is due to be completed by early 1989.

Project 809 (Advanced Control Real Time CIM Systems and Concepts for Flexible Automation) is also concerned with small batch manufacture. Its aim is to achieve a more flexible use of resources and a decrease in the economic batch size by creating a system which integrates control functions (such as scheduling, workstation control and monitoring) and which is connected on-line to the production equipment on the shop floor. The system developed is modular and can be applied irrespective of the level of shop-floor automation. The general concepts of the system are being tested in a pilot implementation in an existing factory environment of Morskate BV (NL), a small trading and manufacturing company making transmission components.

Quality is a matter of increasing concern. The greater the degree of mechanisation, the greater the need for control of quality at every operation in order that no defective components are passed on to a subsequent operation. Component quality is achieved by process control, and a number of projects are developing better tools to provide the information by which this control can be effected. The DASIQ project (Distributed Automated system for Inspection and Quality control, Project 1136) is specifically aimed at the introduction of automated inspection and quality control into flexible manufacturing cells. It approaches the problem from a number of directions. Inspection of the parts leaving the machine will give better assurance that only good components continue through to subsequent operations. Cutting tools are also measured after every machining operation, and, from a combination of parts and tool inspection, tool wear may be detected to prevent machining the next part with defective tools. Diagnosis systems are being developed to evaluate probable causes of poor quality, and better methods are being developed to integrate the on-line inspection and data diagnosis with FMS control software. Several prototype systems have been designed using contactless vision sensors.

The technologies of infra-red thermography and image processing are being brought together in a novel approach to the non-destructive testing of laminate and wafered composite materials (Project 197). Such materials are being increasingly used for high technology applications due to their high strength and light weight, and accurate inspection techniques are vital both for control of the production process and for periodic in-service examinations. Complex algorithms have been developed to analyse thermal images at the materials surface. This enables flaws to be detected, their position accurately located, and the nature of the flaw classified. Such techniques can be implemented on medium-cost commercially available image-processing systems. A prototype of the acquisition and processing system has been set up at Barr and Stroud (UK) and tested on a number of applications, including thermograms of honeycomb wafered composites recorded at Westland Helicopters (UK).

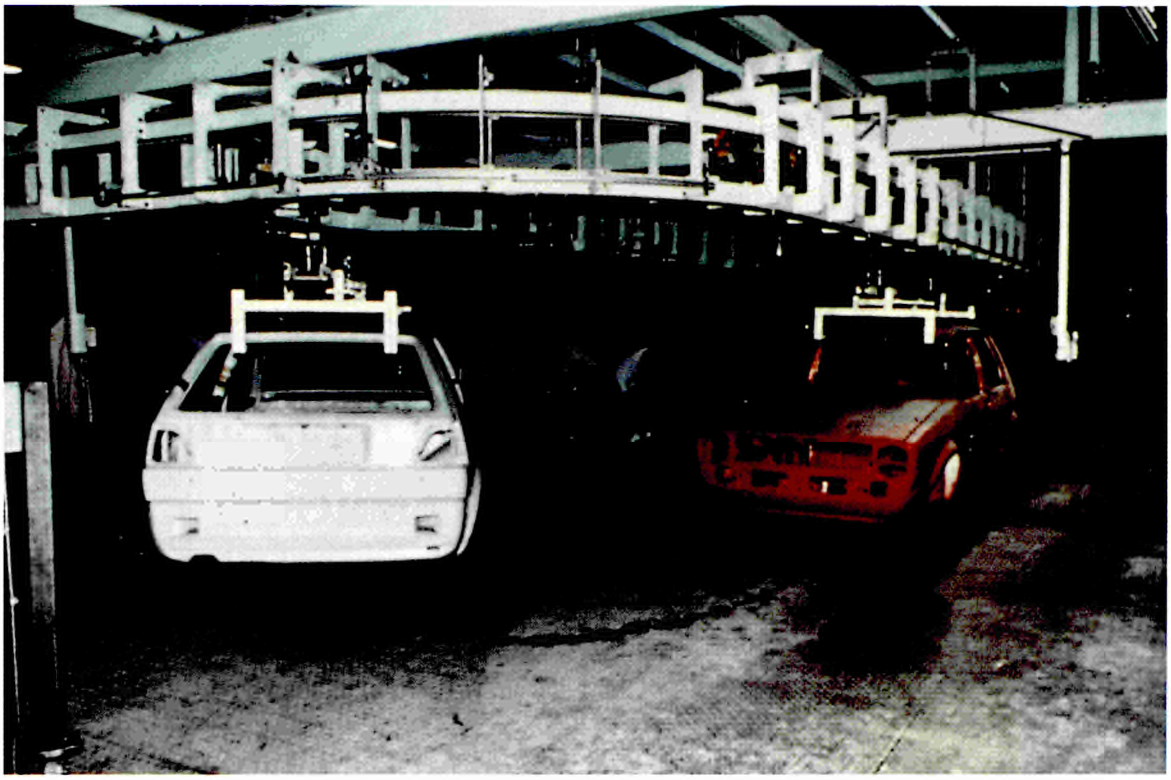
The implementation of CIM involves considerable financial investment which has to be justified by evaluating and accounting for all the benefits to be derived from CIM against its cost. Better tools are required to identify and quantify these benefits to help determine an optimum level of investment in CIM. This area is being addressed by Project 909 (Development of Tools for Economics Evaluation of CIM in Smaller Manufacturing Companies). Based upon a survey of the requirements of over 50 CIM users, the project has developed a methodology supported by a set of decision-support tools (to be known as C-BAT) which can be tailored to the needs of SMEs and run on a range of widely available personal computers. C-BAT has been demonstrated within a medium-sized engineering firm by using it to evaluate a proposed implementation of a flexible manufacturing cell to machine gearbox housings across an entire product range of small, medium and large units.

The availability of such cost-benefit analysis tools is likely to prove of considerable value to many sectors of European manufacturing industry, as managers will be able to decide with greater confidence on the appropriate level of investment in CIM technologies that will achieve maximum competitiveness.

6. INTEGRATION

In an area where integration is a key element of the strategy, there is a particular need to manage the projects so that convergence on common themes is encouraged. This is assisted by the parallel activity of CIM EUROPE, which supports a growing number of multidisciplinary special interest groups. CIM Europe allows project teams to meet regularly and informally, and to be aware of emerging trends in CIM and other areas. The yearly conference (held in Madrid in 1988) and the frequent workshops offer newcomers the opportunity to identify partners, and to position themselves in the field.

A further boost to integration resulted from this year's ESPRIT Conference Week, where, for the first time, the availability of a 3-phase power supply and a heavy-duty floor-loading gave CIM teams the chance to demonstrate shop-floor systems. The quality of the demonstrations and the generally stimulating atmosphere of the Conference Week intensified cross-fertilisation between project teams and also between developers and users.



Test-site at Volkswagen AG (Wolfsburg) for a transponder system used in the identification of individual assemblies flowing through automated assembly plants (Project 975, TRACIT, with REDAR Nah-Ortungstechnik and Polydata).

BASIC RESEARCH ACTIONS (BR)

THE NEED FOR BASIC RESEARCH IN INFORMATION TECHNOLOGY

1. Introduction

ESPRIT Basic Research actions constitute a new element of the ESPRIT programme. Basic Research in Information Technology is important to the continued health of industrially-oriented precompetitive R&D for IT. It provides a reservoir of knowledge and skills for applied R&D and is at the same time a source of highly trained manpower. It is estimated that around 75% of ongoing ESPRIT projects draw upon this reservoir.

The ESPRIT Basic Research Actions contribute to maintaining and expanding European knowledge and expertise in the scientific foundations of Information Technologies.

They provide an opportunity for international collaboration at the European level and enable the undertaking of research efforts, often interdisciplinary, that would otherwise be too ambitious to pursue.

The objectives of ESPRIT Basic Research Actions are:

- to support collaborative fundamental research in selected IT areas;
- to increase the involvement of leading research teams in ESPRIT.

The main criteria used to select the areas that define the scope of the Basic Research Actions are:

- that they should have the potential to produce future breakthroughs or important advances even though they might not have any immediately visible applications;
- that they should fall in areas that clearly would benefit from collaborative research on a European scale.

2. THE FIRST CALL FOR PROPOSALS

The first call for proposals was published in the Official Journal of the European Communities on March 25, 1988. The closing date for proposals was June 13, 1988. Altogether about 300 valid proposals were received in response to the call, representing a total requested funding of 485 MECU; the total cost of the proposed research was in excess of 1 BECU. The proposals involved around 1400

European participants, drawn from universities (74%), research establishments (20%), and industry (6%).

The response to the call for proposals was much larger than had been anticipated. Furthermore, the proposals were generally of a very high quality and involved virtually all the European teams working in the forefront of basic IT research. The large number of proposals meant that only those of exceptional quality could be funded.

The procedure used for the evaluation of Basic Research proposals was that, after an initial classification into areas, the proposals were allocated to external expert referees (altogether some 270 were used). Each proposal was refereed by at least three experts. More than 95% of the referees responded promptly within the time limits allowed, and the quality and extent of their reports was impressive. The consistency of the referees' reports for each proposal was very high.

A panel of rapporteurs evaluated the proposals, based on the referees' reports. The rapporteurs' work was completed by September 5, 1988. The advice of the ESPRIT Advisory Board (EAB) was received in early October, and the evaluation procedure was completed with the meeting of the ESPRIT Management Committee (EMC) at the end of the same month. The evaluation results were officially announced at the 1988 ESPRIT Conference.

3. OVERVIEW OF LAUNCHED ACTIONS

As a result of the evaluation procedure and the recommendations of the EAB and the EMC, 62 proposals involving 285 different organisations were selected. In addition, 24 proposals were joined in working groups and given limited support to facilitate cooperation through travel and workshops. In total, a funding level of 63 MECU is expected to cover work over a 30-month period.

Principal research topics addressed in each of the three main areas are:

Microelectronics

- low temperature electronics;
- high temperature superconductivity: theory, thin-films, devices;
- semiconductors: quantum effects, interface characterisation;
- organic materials: molecule-size devices;
- optical computing: devices, interconnections, architectures;
- next generation design systems: formal methods and algorithms.

Computer Science

- algebraic and logical foundations of formal systems;
- unified description and analysis of concurrent systems: logics, languages, and models;
- formal specification and verification of complex systems;
- integration of programming styles, algorithms;
- dependability, databases and distributed computing.

Artificial Intelligence and Cognitive Science

- 3D vision and robotics in dynamic environments;
- hardware implementations of neural networks;
- formalisms for knowledge representation and inference;
- large lexical databases and discourse processing;

- formal theories of design for manufacturing processes;

- generalised predictive models for human-computer interaction.

Even though each proposal, for practical purposes, was assigned to a specific area, many proposals were of an interdisciplinary nature and defined research topics that crossed the boundaries between areas. Some examples are:

- VLSI architectures and CAD: here techniques from different areas meet in the development of new routes to system description, specification, and design.

- computational logic, with the objective of providing the foundations for an integrated logic-based software environment for problem solving by combining logic programming, AI, and deductive databases.

- Integration of speech and natural language processing: this aims to overcome current limitations of industrial speech-recognition techniques using novel neural network/connectionist pattern recognition methods, and to overcome the long-standing gap between the processing of speech and natural language.

ESPRIT Basic Research Actions will maintain and extend the interdisciplinary links between the actions by encouraging and supporting broad information dissemination.

4. CONCLUSIONS

During the evaluation it became clear that the massive effort put into the preparation of proposals has already led to new communication and cooperation channels within the European research community. These developments will be reinforced by the actual launching of the actions and the establishment of the working groups. It should also be pointed out that about 75% of the researchers involved were newcomers to ESPRIT.

The important task of linking Basic Research Actions to industrial research will be accomplished both through direct industrial participation and effective links with ongoing or planned ESPRIT Projects. Action monitoring and reviews will follow up on the relationships established to facilitate the eventual transfer of results from basic to industrial research.

It can confidently be stated that the Actions launched, taken together, constitute a strong and wide-ranging European collaboration towards key future technological developments in the areas addressed. The Actions also define a standard of attainment and quality only achievable through transnational collaboration. By its very nature, Basic Research requires a long sustained effort to be successful, and there is every reason to believe that the Actions launched will provide a solid basis for such an effort.

INFORMATION AND RESULTS

1. Information Exchange Systems

The particular environment that is found in ESPRIT projects requires that engineers and scientists communicate with each other not only by traditional methods, such as the conferences and seminars which are the subject of part 2 of this chapter, but also that they should be in immediate contact with their partners in other organisations or countries. Moreover, to ensure effective cross-fertilisation of new ideas and developments, participants should be able to contact participants in other ESPRIT projects and have immediate access to the Community scientific databases in Luxembourg. It is also desirable that participants in other Commission programmes, and indeed European scientists generally, should have access to the same network. Accordingly, the Council decision for ESPRIT includes in the accompanying measures the creation of efficient communications mechanisms and associated services to support the execution and management of the programme. These are collectively termed the Information Exchange Systems (IES).

The strategy for the provision of electronic communication services is built around the gradual development and increasing availability of computer communication products which conform to Open System Interconnection (OSI) standards.

The strategy has three parts:

- the provision of services to ESPRIT participants;
- development projects targeted to accelerate the availability of OSI-conformant computer communications software.
- harmonisation of standards implementations and Europe-wide research networking activities such as the EUREKA COSINE project, in order to enable interworking between researchers and their computers across all participating countries.

These three types of activities are closely related; the services provided are improved as development takes place and users point to the need for new developments, which are influenced by the need for harmonisation.

1.1 IES Services

Although there has been the requirement for the provision of operational IES services since the Council decision for the adoption of ESPRIT on 28th February 1984, it is only now that conformant applications such as X.400 electronic mail are emerging as products onto the marketplace. The policy has therefore been to provide a useful service even if conformant products were not yet available to provide Europe-wide connectivity to those project participants who otherwise would have had no such services available. Now, with the emergence of appropriate products, the emphasis is more and more being placed on the implementation of OSI-conformant services as far as possible.

EuroKom

This important element of the IES provides an electronic mail and conferencing service.

Computer or electronic conferencing is a computer-based analogue of a face-to-face dialogue or group meeting. Participants send and receive messages through the host computer that organises and keeps track of usage and otherwise facilitates the exchange of information. Messages are grouped by topic into what are called conferences, and the system contains tools for structuring the message database so that in the event of a user being faced with an overwhelmingly large volume of messages to process he may selectively receive just those messages that he requires to process at that moment. At the beginning of the year the existing host computer was replaced by a more powerful machine, and the technically complex and organisationally difficult task of migrating the existing service, with over 1200 users, was undertaken. The success of this migration activity, without loss of any messages, represents a significant achievement on the part of the staff of University College Dublin who were responsible.

Since the new machine has become operational, improvements in performance and reliability have been noted, and although a certain decrease in activity could have been expected due to the ending of some of the ESPRIT I projects, in fact the user base has grown from 1200 to around 1500, with user groups from other Community programmes such as RACE increasing their use of the system.

An X.400 gateway has also been implemented on the new machine, and this facility was demonstrated at the ESPRIT Conference. The opportunity was also taken to demonstrate interoperability with the IES Rose project (see below).

EUROCONTACT

This service provides a means by which potential programme participants may identify other organisations who are also interested in a particular research subject, in order to support the formation of the necessary consortia for making a project proposal. Access is provided to a database which contains information on the organisations and the areas in which they are seeking cooperation.

During 1988 the service was operated in support of the ESPRIT II call for proposals, and details of over 1600 organisations were registered.

Experience with the operation of the service has shown the opportunities for introducing improvements, especially by providing support at the national level, so that assistance may be made available, in the local language, by someone who is conversant with the operation of the system and who, if possible, can also answer more general questions concerning the programme.

A new version of the system has therefore been developed that operates on a distributed basis through the support and cooperation of national support points. A pilot version of this new system was demonstrated at the ESPRIT Conference and is planned to be operational in 1989.

IES Data Collections

Recognition of the importance of information systems concerning the Commission programmes and European IT research has resulted in the definition of the CORDIS (Communities R&D Information System) project, which is specifically targeted to address this activity for the whole of the Framework programme.

The IES Data collections are seen as a valuable forerunner to the services planned to be provided by CORDIS, and the SDC-1 database covering IT projects contains 3500 records and is one of the most heavily used databases on the ECHO (Luxemburg) host, with 80-90 connect hours per month.

In order to improve the ECHO service, a menu-driven user interface has been developed and improved user documentation has been produced. Both these tasks are expected to be of considerable benefit to CORDIS.

In line with the aim of enabling prototypes to be brought to the market place, a pilot database service (PROTEAS) has been set up which enables details of prototypes which are thought by the developers to be ready for product development to be advertised on a Europe-wide basis. This is intended to contribute to forging the necessary links to other manufacturers or venture capitalists.

A demonstration of 36 "live" entries was held on-line at the ESPRIT conference and the interest expressed provides evidence of the potential of PROTEAS as a viable database service.

IES Newsletter

The IES Newsletter, published every 2 months, doubled its circulation during 1988, and over 10 000 copies are now distributed. The articles continue to be targeted at those people interested in computer networking, particularly researchers, and a section on COSINE news is now a regular feature. Agreement has recently been made with CEN/CENELEC that material for another supplementary sector, covering topical and interesting developments in the area of standardisation, will also be provided in future.

User Support

As well as the more usual user support functions such as documentation and help lines, a User Forum was held during the ESPRIT Conference. This gave the opportunity to discuss the performance of the IES services as perceived by the users over the last year, to outline plans for the future, and to receive valuable feedback.

It appeared from the participants of the User Forum that while the more heavily used IES services, namely EuroKom and the IES Newsletter, were in the main appreciated and recognised as providing a valuable support function, nevertheless there exists a general feeling that the user-friendliness of the IES services could be improved. Much interest was therefore shown in the presentation of future intentions concerning National Support Centres aimed at giving more direct support to end-users, and to the plans to define Remote Intelligent Front End functions (RIFEs), which it is hoped will give the possibility of providing gateways, access control and authentication, session level service switching and local language command strings at the national level.

1.2 The IES Development Projects

The IES initiative to encourage the development of OSI-conformant telecommunications software has continued, with emphasis placed on developments for both UNIX-based systems and personal computers (PCs) running under MS-DOS.

The ROSE Project (33) is now drawing to a close, and successfully demonstrated working products at ESPRIT Conference Week 1988. The partners exhibited two commercial versions of CCITT X.400 Message-Handling Software (MHS) and three versions of File Transfer, Access and Management (FTAM), interworking between 9 machines from 5 manufacturers (Bull, GEC, ICL, Olivetti, Siemens). Both the MHS and FTAM versions have been extensively tested against the standardised Conformance Test Service (CTS) models. A further presentation of much interest was the first known demonstration of an implementation of Basic Network Administration, which is an early intercept of the ISO Network Management Draft Proposal (ISO DP 9595), running on and reporting the actions of four different machines. Project partners have provided significant input to standards-making bodies, especially the ISO working group for Network Management during this year. All the partners now have OSI-conformant software modules in their product catalogues.

With the continuing emergence of OSI-conformant services for messaging and file transfer, awareness of the need for directory services has increased.

The THORN Project (719) was originally conceived as a study of directory services, leading to a precompetitive development conforming to the only standard then available, namely the European Computer Manufacturers' Association (ECMA) TR/32. The software developed was produced and this implementation was subsequently ported to many machines within a Large Scale Pilot Experiment (LSPX), which was carried out at project participants' sites.

A second phase of the project has been defined for implementation of an ISO-conformant version, and is now being implemented.

The LSPX, which is presently operating using the ECMA conformant software developed under Phase 1, has grown a great deal during the course of 1988. It currently runs at 16 sites in 6 countries, storing directory information for about 1000 organisations and 20 000 names, and now includes a number of academic institutions not previously associated with the project. Considerable experience of the operation of distributed directories has been acquired within the LSPX, which will be of assistance to organisations proposing to implement such directories for future operational activities. Following the cutover to the OSI-conformant version, it is anticipated that the LSPX will grow even further, with new installations being made by French, German, Italian and UK academic institutions, as well as by some industrial concerns. Testing and data-loading tools have been developed to reduce the effort and time taken to achieve new implementations. The project is intimately bound up with the standard-making groups, and its input has been significant. We believe that THORN is probably the leading directory project worldwide, especially in terms of the actual operating experience gained from the LSPX.

The CARLOS Project (718) was aimed at the provision of solutions for the communications problems of existing PCs. To this end, both hardware and software were developed to communicate via the publicly available packet-switched services. The initial development - "OSI-PC" - was a stand-alone personal computer, running under the Concurrent CP/M operating system, with software to interconnect with the packet-switched service. The next major item to be developed was the "OSI-BOX", which was a larger implementation of the OSI-PC, designed to provide communications services for multiple PCs. Following redirection of the Project to include the development of the Network Management Centre (NMC), a prototype was developed and installed to manage the Danish Library Service's data communications system. The CARLOS implementation of Virtual Terminal (VT) has been selected by British Telecom for use on a commercial basis.

After successful prototype trials and demonstrations, it was realised that some of these developments would require further evolution. This led to the definition of subsequent phases of the project. In consequence, a project extension - CACTUS - was approved in 1987 to provide X.400 messaging for clusters of PCs, grouped around a UNIX-based server, providing the Message Transfer Agent and Message Store facilities. The development is nearing completion and is expected to be a highly competitive product. Prototypes will be demonstrated during the first quarter of 1989 and commercial implementations should be available during the third quarter.

In addition to the need for X.400 messaging, it was recognised that there is a large potential demand for advanced communications facilities for PCs including File Transfer, Access and Management (FTAM) and Virtual Terminal (VT). Hence in 1988 a further extension to the project - SESTA - was approved to develop a full CCITT X.25 capability for PCs based on a plug-in interface card, which will handle all the processes other than the man-machine interface. The "SESTA-CARD" and its software will be completed by the summer of 1989 and is expected to be commercially available towards the end of 1989.

1.3 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.

During 1988 the RARE Message-Handling Project has doubled its coverage and approximately 350 sites are now connected worldwide. A comprehensive migration activity to X.400 (1984) conformant systems using standard attributes for addressing has been undertaken, with about half of the sites now conforming. A major update on the documentation was undertaken, information (as user directories) has been added, and an information package has been prepared for other counties that are interested in joining. Connection to public X.400 services is either implemented or is in the process of being tested in 7 out of the total of 17 countries participating in the project.

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 ESPRIT 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.

1988 has seen the completion of the COSINE specification phase. The technical work, undertaken by RARE, has resulted in ten reports containing descriptions of user requirements, technical specifications and recommendations for the implementation of the COSINE project. ESPRIT, via the IES, has been actively supporting the definition of a pilot X.25 (1984) backbone to support the European Research Community, and has agreed to provide start up funding to ensure that this important initiative gets off the ground.

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2. ACCESS TO THE RESULTS OF THE PROGRAMME

Special efforts are made to ensure that information about the programme is made easily available. During 1988, in the various member states:

- ESPRIT Projects gave demonstrations at 16 exhibitions and conferences;
- 28 ESPRIT Information Days and similar events were held;
- 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 1988 ESPRIT Conference

As in previous years, the annual ESPRIT Conference was the place for ESPRIT project participants, industrialists and government IT policy makers to meet and to discuss the results, achievements and impact of the ESPRIT programme. The Conference, organised in November in Brussels under the theme 'Putting the Technology to Use', was attended by around 2000 persons, participating in various different events:

The exhibition held during the ESPRIT Conference Week in Brussels.

- a three-day technical conference, during which more than 130 papers were presented in plenary and parallel sessions, complemented by panel discussions;
- the IT Forum day, giving leading European decision-makers in the IT field the opportunity to describe the prospects for the European IT industry from their perspective;
- a presentation of the present status of the ESPRIT II programme, including the Basic Research Actions;
- a major exhibition, where more than 70 projects were demonstrating the results of their work.

The Conference was also visited by the member state government officials responsible for research and development, who attended a special ministerial presentation of some major ESPRIT projects and visited the exhibition, as well as by several members of the European Parliament. The President of the Commission, J. Delors, and a group of Commissioners also visited the Conference. The Conference was well covered by the media and the technical press.

2.2 Facilities for Forming Consortia

In connection with each ESPRIT call for proposals, at least one proposers' days is organised each year. 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 the first Proposers' Day organised for the first ESPRIT II call was attended by some 800 people during 1987 ESPRIT Conference Week. In February 1988 the second Proposers' day concerned with ESPRIT II proposals attracted 950 people.

Another facility provided for the same purpose is EUROCONTACT, which is described above in section 1.1, IES Services.

2.3 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 following pages.

TECHNICAL INTEREST GROUPS

The following ESPRIT Technical Interest Groups (TIGs) were active during 1988. 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; their 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 in 1987, has the following objectives:

- exchanging views in the field of optical, E-beam and X-ray lithography.
- promoting standardisation of metrology procedures.

The group aims to meet once or twice a year. 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: Leo Karapiperis - 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;
- collating 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 1988 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

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 1988

- Ada-Europe Conference in Munich, held in June.
- Regular Working Group meetings on Ada-relatedissues.

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 1988

- VDM'88 Symposium, Dublin, held in September;
- 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 1988, workshops and meetings identified three main areas for action: software certification, software experimentation, and a European software laboratory.

Contact Point: Dr. 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 the preparation of an international standard for the programming language Lisp. This group is open to all European parties interested in the definition and the use of a standardized Lisp.

Principal Activities in 1988

- participation in the creation of the ISO WG16 Lisp;
- 5 meetings devoted to the preparation of a draft proposal to be submitted at ISO WG16. Hosting the third;
- hosting the third meeting of the ISO/IEC JTC1/SC22/WG16 Lisp in November 1988 at Brussels.

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 to investigate whether there is an underlying common model.

Contact Point: Annie Leclerc
CAP Sogeti Innovation
Tel: +33.76.90.80.40
Fax: +33.76.41.06.29

GRAPHICS IN ESPRIT

Formed in 1988 with the objective of encouraging information exchange in the computer graphics field.

Principal Activities in 1988

- Graphics in ESPRIT Workshop, Brussels;
- session during the ESPRIT Conference.

Contact Point: D. A. Duce
Rutherford Appleton Laboratory
Chilton, Didcot
OXON OX11 0QX, UK
Tel: +44.235.44.55.11
Fax: +44.235.44.58.31

CIM EUROPE

CIM-Europe, now in its fourth year, continued to expand its role in disseminating information and encouraging reaction, discussion and application so that the results of ESPRIT-CIM and the general benefits of CIM are better known and utilised.

CIM-Europe is based on the following Special Interest Groups, which are open to all 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

In 1988 there were 12 technical and discussion meetings of its Special Interest and Advisory Groups. There were two workshops: ODETTE in Brussels, and one covering the results of two ESPRIT-CIM projects in Dublin. In addition, CIM-Europe contributed sessions to other major conferences in Bordeaux (CIMEX International and CAD/CAM and Robotics) and Karlsruhe (SYROCO '88).

The highlight of the year was, as usual, the Annual Conference, which in 1988 was hosted by the Spanish Ministry of Industry and Energy in Madrid. More than 300 delegates attended to exchange experiences and to hear over 40 quality presentations.

Principal Events in 1988

Date	*Place*	*Event*
January 7	Brussels	3rd Workshop on Interfaces in the Automobile Industry
March 16-17	Bordeaux	AIP session CAD-CAM and Robotics Conference
May 18-20	Madrid	Fourth CIM-Europe Annual Conference
June 6-8	Baltimore	CNMA at ENE
June 7-9	Birmingham	MAP-TOP-OSI Symposium
October 5-7	Karlsruhe	Robotics session SYROCO '88
October 11-13	Bordeaux	AIP session CIMEX INTERNATIONAL
October 27	Dublin	Workshop on Projects 319 and 496

Contact Point: Barry Lewendon
CIM-Europe Secretariat - CEC
DGXIII/A5
Tel: +32.2.235 97.88

ESPRIT I PROJECTS AND PARTNERS

ADVANCED MICROELECTRONICS

10
High Level CAD for Interactive Layout and Design
AEG AG, Bull SA, General Electric Company Plc, Plessey Company Plc

14
Advanced Interconnect for VLSI
General Electric Company Plc, Plessey Company Plc, Teg-Telefunken Electronic GmbH, Thomson-CSF-DTE-Division Tubes Electroniques

42
Description Languages for VLSI
Nederlandse Philips Bedrijven BV, Siemens AG

71
A Compiler for Advanced Signal Processor
Bell Telephone Mfg Co., Katholieke Universiteit Leuven, Thomson-CSF

97
Advanced Algorithms, Architecture and Layout Techniques for VLSI Dedicated Digital Signal Processing Chips
Bell Telephone Mfg. Co., Imec VZW, Philips Gloeilampenfabrieken NV, Ruhr Universität Bochum, Siemens AG, Silvar-Lisco NV

232
Compound Semiconductor Materials & Integrated Circuits - I
Laboratoire de Physique Appliquee, Plessey Company Plc, Siemens AG, Thomson-CSF-DCI

243
Submicron Bipolar Technology - I
Cemota, Plessey Company Plc, Technische Universität Berlin, TEG-Telefunken Electronic GmbH, Thomson-CSF-DTE Division Tubes Electroniques, Thomson-CSF-Laboratoire Central de Recherche

244 HYETI
High Yield High Reliability Ultra-large Scale Integration System through Reconfigurability
British Telecom Plc, Brunel University, Bull SA, CEA-LETI, Cirrus Computer Ltd, IMAG-LGI-Laboratoire Genie Informatique, INPG-Institut National Polytechnique de Greno, SGS-Thomson Microelectronics, Technische Hochschule Darmstadt

245
SOI Materials and Processing Towards 3-D Integration
CEA-LETI, CNET, General Electric Company Plc, National Microelectronics Research Centre, SGS-Thomson Microelectronics, University of Cambridge

255
CAD Methods for Analog GAAS Monolithic IC's
CISE SpA, Politecnico di Torino, Siemens AG, Telettra SpA

263
Integrated Opto-Electronics on INP
CGE-Laboratoires de Marcoussis, CNET-Centre National d'Etudes des Telecommuni, Cselt-Centro Studi e Laboratori Telecomunicaz, GEC Marconi Research Centre, Heinrich Hertz Institut, Standard Elektrik Lorenz AG, STC Technology Ltd., Thomson-CSF-Laboratoire Central de Recherche

271
Automatic Design Validation of Integrated Circuits Using E-Beam
British Telecom Plc, CNET, CSELT-Centro Studi e Laboratori Telecomunicaz, IMAG-LGI-Laboratoire GENIE Informatique, Trinity College Dublin

281
Submicron Bipolar Technology - I
RTC Radiotechnique Compelectr., Siemens Ag

305
Assessment of Silicon MBE Layers
AEG AG, General Electric Company Plc, ISA Riber

334
Plasma Deposition Technology for Magnetic Recording Thin Film Media
Basf AG, Leybold Heraeus GmbH, Sagem

369
Physical Chemical Characterization of Silicon Oxynitrides in Relation to their Electronic Properties
Aere-Atomic Energy Research, Imec VZW, Matra Harris Semiconducteurs (MHS), Philips Gloeilampenfabrieken NV, Universiteit Van Utrecht

370
Silicon-on-Insulator Systems Combined with Low Temperature Silicon Epitaxy
General Electric Company Plc, Imec VZW, Mietec NV

380
Optical Interconnect for VLSI and High Bit Rate IC's
GEC Marconi Research Centre, Telettra SpA, University of Southampton

412 BICMOS
A High Performance CMOS-Bipolar Process For VLSI Circuits
Philips Gloeilampenfabrieken NV, Siemens AG

443
Molecular Engineering for Optoelectronics
CNET-Centre National d'Etudes des Telecommuni, Faculte Universitaire Notre-Dame de la Paix, Imperial Chemical Industries Plc, Thomson-CSF-Laboratoire Central de Recherche

456
Improvement of Yield & Performance of ICS by Design Centering
AEG AG, SGS-Thomson Microelectronics, Teg-Telefunken Electronic GmbH, Universität Stuttgart

491
Materials and Technologies for High Mobility TFTS for LC Display Bus Drivers
AEG AG, CETIA, CNET-Centre National d'Etudes des Telecommuni, CSEE

509
Substrates for CMOS VLSI Technology
Imec VZW, Matra Harris Semiconducteurs (MHS), SGS-Thomson Microelectronics SpA

514
Quantum Semiconductor Devices
General Electric Company Plc, Thomson-CSF-Laboratoire Central de Recherche

519
Dopant Profiling for Submicron Structures
AEG AG, General Electric Company Plc, Imec VZW

522
Compound Semiconductor Materials & Integrated Circuits - I
Bell Telephone Mfg. Co., CNET-Centre National d'Etudes des Telecommuni, Farran Technology Ltd, General Electric Company Plc, STC Technology Ltd, TEG-Telefunken Electronic GmbH

544
Investigation of all Aspects of the Interconnection of High Pincount Integrated Circuits
BPA Techn. & Management Ltd., British Aerospace Plc, Lucas Stability Electron, National Microelectronics Research Centre

554 SPECTRE
Submicron CMOS Technology
Aarhus Universitet, Aere-Atomic Energy Research, British Telecom Plc, Bull SA, CNET, CNR-Istituto Lamel, Imec VZW, Matra Harris Semiconducteurs (MHS), Sgs-Thomson Microelectronics SpA, Telettra SpA, Universite Catholique Louvain

574
High Resolution Plasma Etching in Semiconductor Technology-Fundamentals, Processing and Equipment
Aere-Atomic Energy Research, Fraunhofer IM, Johnson Matthey Chemical, Leybold Heraeus GmbH, Mono Light Instruments Ltd.

802 CVS
CAD for VLSI Systems
AEG AG, British Telecom Plc, CIT-Alcatel, CNET, CSELT-Centro Studi e Laboratori Telecomunicaz, GMD-Gesellschaft für Mathematik und Datenver, Italtel Telematica SpA, Matra Harris Semiconducteurs (MHS), SGS-Thomson Microelectronics SpA

824
Wafer Scale Integration
British Telecom Plc, CEA-LETI, INPG-Institut National Polytechnique de Greno, National Microelectronics Research Centre, SGS-Thomson Microelectronics, Technische Hochschule Darmstadt

830
Packages for High Speed Digital GAAS Integrated Circuits
Mo Valve Company Ltd, Thomson-CSF-Laboratoire Central de Recherche

833
Large Area Complex Liquid Crystal Display Addressed by Thin Film Silicon Transistors
AEG AG, Aristotle University of Thessaloniki, CNET-Centre National d'Etudes des Telecommuni, General Electric Company Plc, Modulex A/S, Thomson-CSF-Laboratoire Central de Recherche, Universita di Bologna

843
Compound Semiconductor Integrated Circuits
Farran Technology Ltd, General Electric Company Plc, Laboratoire de Physique Appliquee, Plessey Company Plc, Siemens AG, STC Technology Ltd, Thomson-CSF-DCI

887 ECIP
European Cad Integration Project
Bull SA, CIT-Alcatel, ICL-International Computers Ltd, Nederlandse Philips Bedrijven BV, Philips Gloeilampenfabrieken NV, SGS-Thomson Microelectronics SpA, Siemens AG

888 AIDA
Advanced Integrated-Circuit Design Aids
ICL-International Computers Ltd, SGS-Thomson Microelectronics, Siemens AG

927
Basic Technologies for Gainas Misfets
Aixtron, Laboratoire de Physique Appliquee, RWTH Aachen (Rheinisch-Westfaelische Technisc, Wacker Chemitronic

958
High Performance VLSI Packaging for Complex Electronic Systems
British Telecom Plc, Bull SA, GEC Research Laboratories

962 EVEREST
Three Dimensional Algorithms for Robust and Efficient Semiconductor Simulator
Analog Devices BV, General Electric Company Plc, Imec VZW, National Microelectronics Research Centre, Nederlandse Philips Bedrijven BV, Rutherford Appleton Laboratory, SGS-Thomson Microelectronics SpA, STC Technology Ltd., Trinity College Dublin, Universita di Bologna, University College of Swansea

971
Technology of GaAs Bipolar Integrated Circuits
CNET-Centre National d'Etudes des Telecommuni, Farran Technology Ltd., General Electric Company Plc, Plasma Technology Ltd., Plessey Company Plc

986
Optical Interconnect for VLSI and High Bit Rate ICS
GEC Marconi Research Centre, Telettra SpA, University of Southampton

991
Multiview VLSI - Design System ICD
British Telecom Plc, ICS, INESC-Instituto De Engenharia de Sistemas E C, PCS Peripheral Computer Systems, Technische Universiteit Delft, Technische Universiteit Eindhoven, University of Essex

1007
0,5 Micron X-Ray Lithography:Sources,Masks,Resist and Transferred Image
CNR-IESS, CNRS-Centre National de Recherche Scientifique, King's College London, SGS-Thomson Microelectronics SpA, Thomson-CSF-Laboratoire Central de Recherche

1043
Advanced Mask and Reticle Technology for VLSI Submicron Microelectronics Devices
BMP Plasmatechnologie, British Telecom Plc, Imec VZW, Plessey Semiconductors, Siemens AG, Valvo Bauelemente Philips

1056
Ultrasensitive Impurity Analysis for Semiconductor Structures and Materials
CAMECA, Imec VZW, Philips Research Laboratories, Siemens AG

1058

Knowledge Based Design Assistant for Modular VLSI Design

Imec VZW, INESC-Instituto de Engenharia de Sistemas E C, Philips Gloeilampenfabrieken NV, Silvar-Lisco NV

1128

Large Diameter Semiinsulating GAAS Substrates Suitable for LSI Circuits

Laboratoire de Physique Appliquee, Universite Catholique Louvain, Wacker Chemitronic

1270

Advanced Processing Technology for GAAS Modulation Doped Transistors and Lasers

CNET-Centre National d'Etudes des Telecommuni, Elltec SA, Plessey Company Plc, Research Center of Crete - Cretan Computer In, University of Wales I.S.T.

1551 AMS

Advanced Manufacturing System

Marconi Electronic Devices Ltd, SGS-Thomson Microelectronics, SGS-Thomson Microelectronics SpA

1563 ACAFS

Automatic Control of an Asic Fabrication Sequence as Demonstrated in the Plasma ETCH Area

Bertin & Cie, European Silicon Structures SA, Leybold Heraeus GmbH, Mietec NV, Plasma Technology Ltd.

SOFTWARE TECHNOLOGY

32 PCTE

A Basis for a Portable Common Tool Environment

Bull SA, General Electric Company Plc, ICL-International Computers Ltd, Ing. C. Olivetti & C. SpA, Nixdorf Computer AG, Siemens AG

125 GRASPIN

Personal Workstation for Incremental Graphical Specification and Formal Implementation of Non-Sequential SY

Epsilon GmbH, Etnoteam SpA, GMD-Gesellschaft für Mathematik und Datenver, Ing. C. Olivetti & C. SpA, Siemens AG, Tecsiel SpA, Universitet Kaiserslautern, University of Patras

266 PEACOCK

Software Development Using Concurrently Executable Modules

Eurosoft Systems SA, Plessey Company Plc, Polytechnic of Hatfield, Universität Dortmund, Universität Karlsruhe

267 ASSET

Automated Support for Software Engineering Technology Feasability Study

GPP Gesellschaft für Prozessrechnerprogrammi, Plessey Office Systems Ltd.

282 SPMMS

Software Production & Maintenance Management Support

CIT-Alcatel-CERSI CIT-Alcatel-SESA, Data Management SpA, Sema Metra, Sofemasa

283 FOR-ME-TOO

Formalisms, Methods and Tools

CSELT-Centro Studi e Laboratori Telecomunicaz, Siemens AG, Syseca Logiciel

300 REQUEST

Reliability and Quality of European Software

AEG AG, CISI-Informatique Internationale, Elektronik Centralen, Esacontrol SpA, GRS Gesellschaft für Reaktorsicherheit, STC IDEC Ltd., STC Technology Ltd, Thomson-CSF, UKAEA Atomic Energy Authority

302

Investigation of Performance Achievable with Highly Concurrent Interpretations of Functional Programs

CAP SESA Innovation, ICL-International Computers Ltd, INRIA, University of Stirling

315 RAISE

Rigorous Approach to Industrial Software Engineering

Brown, Boveri & CIE., CRI A/S, ICL-International Computers Ltd., STC Technology Ltd.

348 GIPE

Generation of Interactive Programming Environments

BSO-Bureau voor Systeemontwikkeling, CWI-Centrum voor Wiskunde & Informatica, INRIA, Sema Metra

390 PROSPECTRA

Program Development by Specification and Transformation

Alcatel Standard Electrica SA, CRI A/S, Syseca Logiciel, Universität Bremen, Universität Dortmund, Universität Passau, Universität Saarbruecken, University of Strathclyde

401 ASPIS

Application Software Prototype Implementation System

CAP SESA Innovation, General Electric Company Plc, Ing. C. Olivetti & C. Spa, Tecsiel SpA, Universite de Grenoble

410 SEDOS

Software Environment for the Design of Open Distributed Systems

Bull SA, CNRS, ICL-International Computers Ltd, University of Twente

432 METEOR

An Integrated Formal Approach to Industrial Software Development

ATT & Philips Telecommunication BEDR, CGE-Laboratoires de Marcoussis, COPS (Europe) Ltd, CWI-Centrum voor Wiskunde & Informatica, Philips & Mble. Associated, Philips Gloeilampenfabrieken NV, Txt-Tech.Soft e Telematica, Universität Passau, Universite de Paris Sud

510 TOOL USE

An Advanced Support Environment for Method Driven Development and Evolution of Packaged Software

CISI-Informatique Internationale, Generics Software Ltd., GMD-Gesellschaft für Mathematik und Datenver, Onera-Centre d'Etudes Recherches Toulouse, Universite Catholique Louvain

814 PIMS

Project Integrated Management Systems

BSO-Bureau voor Systeemontwikkeling, CAP SESA Innovation, London School of Economics, Pactel, The Turing Institute, Universiteit van Amsterdam, University College of London

835 — PROSPECTRADEMO

Demonstration of Prospectra Methodology and System

Alcatel Standard Electrica SA, Syseca Logiciel

881 — FORFUN

Formal Description of Arbitrary Systems by Means of Functional Languages

Bell Telephone Mfg. Co., Katholieke Universiteit Nijmegen, Sagantec BV, Technische Universiteit Delft

891

Development of an Efficient Functional Programming System for the Support of Prototyping

ICL International Computers Ltd, Non Standard Logics, University of St Andrews, University of Twente

892 — DAIDA

Advanced Interactive Development of Data-Intensive Applications

BIM SA, Cretan Computer Institute, GFI, SCS Scientific Control Systems, Universität Frankfurt

928 — RUBRIC

"A Rule Based Approach to Information Systems Development"

BIM SA, James Martin Associates, Micro Focus Ltd., UMIST-University of Manchester Institute of Science and Technology

937 — DESCARTES

"Debugging and Specification of ADA Real-Time Embedded Systems"

ESD-Electronique Serge Dassault, Foxboro Nederland NV, GSI Tecsi Software, Systeam Kg, Technische Universiteit Eindhoven, University of Stirling

938 — IMPW

Integrated Management Process Workbench

CETE Mediterannee, ICL-International Computers Ltd, NIHE-National Institute for Higher Education, The Imperial College of Science, Technology A, Verilog

951 — PACT

PCTE-Added Common Tools

Bull SA, Eurosoft Systems SA, GEC Software Ltd, ICL-International Computers Ltd, Ing. C. Olivetti & C. Spa, Syseca Logiciel, Systems and Management SpA

974 — KNOSOS

A Knowledge-base Environment for Software System Configuration Reusing Components

CIT-Alcatel, CNET-Centre National d'Etudes des Telecommuni, Dornier System GmbH, ESI, Matra Datavision (Espace), Yard Software Systems Ltd.

1033 — FORMAST

Formal Methods for Asynchronous System Technology

Advanced System Architectures, ERNO Raumfahrttechnik GmbH, Loughborough University Technology, The Imperial College of Science, Technology A, Universität Kaiserslautern

1041

A General Environment for Formal Systems Development-Genesis

Imperial Software Technology Ltd., Philips Gloeilampenfabrieken NV, The Imperial College of Science, Technology A

1072 — DIAMOND

Development and Integration of Accurate Operations in Numerical Data Processing

CWI-Centrum voor Wiskunde & Informatica, Numerical Algorithms Group Ltd, Siemens AG, Universität Karlsruhe, University of Bath

1094 — PRACTITIONER

Support System for Pragmatic Reuse of Software Concepts

Brunel University, CRI A/S, Nordisk Brown Boveri A/S, PCS Peripheral Computer Systems

1158 — ATES

Advanced Techniques Integration into Efficient Scientific Application Software

CISI Ingenierie SA, Philips & Mble. Associated, UFR-Universite Paris 7, Universite de Liege, Universiteit van Twente

1252 — AMADEUS

A Multi-Method Approach for Developing Universal Specifications

BIM SA, HITEC Ltd., Interprogram BV, Telefonica CTNE, UMIST-University of Manchester Institute of Science and Technology

1256 — CHAMELEON

Dynamic Software Migration between Cooperating Environments

Delphi, Harlequin Ltd., Non-Standard Logics, Universite de Paris Sud

1257 — MUSE

Software Quality and Reliability Metrics for Selected Domains : Safety Management & Clerical Systems

Brameur Ltd, CRIL, EBO, TUEV (Technischer Ueberwachungs-Verein E.V.)

1258 — TRUST

Testing & Consequent Reliability Estimation for Real-Time Embedded Software

City University of London, John Bell Systems, Liverpool Data Research Assoc., SES Software Engineering Services GmbH, University of Liverpool

1261 — HTDS

Host Target Development System

Logica UK Ltd., Marconi Defence Systems Ltd., SESA-Societe Etudes Systemes Automation, SFGL-Societe Francaise de Genie Logiciel, Softlab GmbH

1262 — SFINX

Software Factory Integration and Experimentation

CAP Industry Ltd., CRI - Computer Resources Intl., ERIA, SFGL-Societe Francaise de Genie Logiciel, Tecnopolis Csata Novus Ortus

1265 — SEDOS DEMO

Sedos Estelle Demonstrator

Agence de l'Informatique, Bull SA, CNET-Centre National d'Etudes des Telecommunications, CNRS -Laas-Laboratoire Automatique/Analyse Des, E2S - Expert Software Systems NV, ENTEL SA, Marben, Universidad Politecnica de Madrid, Verilog

1271 — SED

SETL Experimentation and Demonstrator

CNAM-Centre National des Arts et Metiers, Enidata SpA, Hildesheim Hochschule, Thomson-CSF-DSE, University of Patras

1277 — SAPPHIRE

PCTE Portability

CAP Industry Ltd., GIE Emeraude, Software Sciences Ltd., University College of Wales

1282 — PAVE

PCTE and VMS Environment

GEC Software Ltd., Syseca Logiciel

1283 — VIP

VDM Interfaces for PCTE

CWI-Centrum voor Wiskunde & Informatica, Oce-Nederland BV, Praxis Systems Plc, PTT Nederland NV, University of Leicester

1520 — ACCUEIL DE LOGICIEL FUTUR,ALF

Advanced Software Engineering Environment Logistics Framework

Cerilor, CIG Industry, Computer Technologies Co., Crin/Adilor, GIE Emeraude, Grupo de Mecanica del Vuelo SA, ICL-International Computers Ltd., Universität Dortmund, Universite Catholique Louvain

1527 — SPEM

Software Productivity Evaluation Model

CERCI, Fuigi Italiana, O Dati Espanola S.L., Sofemasa, UK Atomic Energy Authority, Verilog

1535 APHRODITE
A PCTE Host-Target Distributed Testing Environment
Bull SA, Chorus Systemes, Delphi, Ferranti Computer Systems Ltd, Philips-Trt., Universite de Liege

1550 DRAGON
Distribution and Reusability of ADA Real-Time Applications through Graceful and On-line Operations
Dornier System GmbH, GSI TECSI Software, Politecnico di Milano, TXT-Tech.Soft e Telematica, Universita di Genova, Universität Passau, University College of Wales, University of Lancaster

1598 REPLAY
Replay and Evaluation of Software Development Plans Using High-order Meta Systems
Alpha S.A.I., CISI-Informatique Internationale, CRI Computer Resources Intl., E2S - Expert Software Systems NV, ONERA-Centre d'Etudes Recherches Toulouse, Universite Catholique Louvain

1609 SMART
System Measurement and Architectures Techniques
Bull SA, CCS/SCYT, CEA-Commissariat a l'Energie Atomique, CISI Ingenierie SA, CRI - Computer Resources Intl., Matra Datavision (Espace), Paisley College Of Technology, Universitat Politecnica de Catalunya

ADVANCED INFORMATION PROCESSING

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Advanced Algorithms and Architectures for Speech and Image Processing
AEG AG, CSELT-Centro Studi e Laboratori Telecomunicaz, Hitec Ltd., Politecnico di Torino, Thomson-CSF, Universita di Torino, Universite de Strasbourg

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Expert System Builder
CIMSA Sintra, CSELT-Centro Studi e Laboratori Telecomunicaz, Plessey Company Plc, Soren T.Lyngsoe A/S

107 LOKI
A Logic-oriented Approach to Knowledge and Data Bases Supporting Natural User Interaction
BIM SA, BP-Research Center, Cranfield Institute of Technology, Cretan Computer Institute, Fraunhofer IAO, INCA, Scicon Ltd., SCS Scientific Control Systems, Technische Universität München, Universität Stuttgart

112
Knowledge Integration and Management Systems
Bull SA, CGE-Laboratoires de Marcoussis, INRIA, Prologia, Siemens AG, Universite de Paris Nord

256
Time Dependency and System Modeling in kbs Design for Industrial Process Applications
CISE SpA, Framentec

280
Intelligent Help for Information System Users
Courseware Europe BV, CRI A/S, Dansk Datamatik Center, ICL-International Computers Ltd., Universiteit van Amsterdam, University of Leeds

304
Design of Techniques and Tools to Aid in the Analysis and Design of Knowledge Based Systems
ICL-International Computers Ltd., Network Systems, Polytechnic of the South Bank, SCS Scientific Control Systems, Universiteit van Amsterdam

311 ADKMS
Advanced Data & Knowledge Management Systems
Bull SA, Hildesheim Hochschule, Ing. C. Olivetti & C. SpA, Nixdorf Computer AG, Technische Universität Berlin, Universita di Bologna, Universita di Torino

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An Architecture for Interactive Problem Solving by Co-operating Data and Knowledge Bases
CAP SESA Innovation, CSELT-Centro Studi e Laboratori Telecomunicaz, ONERA-Centre d'Etudes Recherches Toulouse, Philips & Mble. Associated

387
Knowledge Representation and Inference Techniques in Industrial Control
British Telecom Plc, Framentec, Krupp Atlas Elektronik GmbH, Queen Mary College

393 ACORD
Construction and Interrogation of Knowledge Bases Using Natural Language Text and Graphics
Bull SA, CGE-Laboratoires de Marcoussis, Fraunhofer IM, TA Triumph-Adler AG, Universität Stuttgart, University of Edinburgh

415
Parallel Architectures & Languages for AIP-A VLSI Directed Approach
AEG AG, Bull SA, CSELT-Centro Studi e Laboratori Telecomunicaz, CWI-Centrum voor Wiskunde & Informatica, ESIEE-Ecole Sup. d'Ingenieurs Electr./Electrot., General Electric Company, INPG-IMAG, Nixdorf Computer AG, Philips Gloeilampenfabrieken NV, Stollmann & Co. GmbH, Technische Universität Berlin, Technische Universität München

419
Image and Movement Understanding
CAPTEC-Computer Appl.Technics, Katholieke Universiteit Nijmegen, Trinity College Dublin, Universita di Genova, Video Display Systems Srl

440 MADS
Message Passing Architectures & Description Systems
CGE-Laboratoires de Marcoussis, Delphi, Vrije Universiteit Brussel

527
Communication Failure in Dialogue: Techniques for Detection and Repair
ITT Industries Ltd., Linguistics Institute of Ireland, Memory Computer Plc, St. Patrick's College, Universita di Pisa, University of Leeds

530 EPSILON
Advanced Knowledge Base Management System
Bense KG, Criss, Systems and Management SpA, Universita di Pisa, Universität Dortmund, Universite de Lyon 3

532 GENEDIS
Real Time Generation and Display of the 2.5D Sketch for Moving Scenes
Barr & Stroud Ltd., Ing. C. Olivetti & C. SpA, University of Strathclyde, Zeltron

599
Knowledge Based Assistant for Electromyography"
CRI A/S, Judex Datasystemer APS, Logica UL Ltd., National Hospital for Nervous Diseases, NUC - Nordjysk Udviklingscenter

818 DELTA 4

Definition and Design of an Open Dependable Distributed Computer System Architecture

Basf AG, Bull SA, CNR-Consiglio Nazionale delle Ricerche, CNR-IEI, CNRS-Laas-Laboratoire Automatique/Analyse Des????, Ferranti Electronics Ltd., Fraunhofer Gesellschaft, GMD-Gesellschaft für Mathematik und Datenver, GSO Informatica SpA, IMAG-LGI-Laboratoire Genie Informatique, Inesc Instituto de Engenharia de Sistemas E C, Jeumont-Schneider Telecommunications, Mari Advanced Microelectronics Ltd., Plessey Semiconductors, Telettra SpA., Universita di Bologna

820

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

Ansaldo Impianti, CAP Sesa Innovation, CISE SpA, Framentec, Heriot-Watt University, NEA-Lindberg A/S, SNIAS-Societe Nationale Industrielle Aerospat

857 GRADIENT

Graphics & Knowledge Based Dialogue for Dynamic Systems

CRI A/S, Gesamthochschule Kassel, Katholieke Universiteit Leuven, Nordisk Brown Boveri A/S, University of Strathclyde

865

Non-Monotonic Reasoning Techniques for Industrial Planning Applications

Aeritalia, Battelle Institut, Elsag SpA - Elettronica San Giorgio, Italcad

866 COUSTO

Integrated Optic Technologies for Real Time Wideband Optical Signal Processing

General Electric Company Plc, Selenia SpA, University College of London

867 ARTS-IP

Adaptive Real-Time Strategies for Image Processing A Case for Satellite Data

CCIP-Chambre Commerce & Industrie Paris, Dornier GmbH, ESIEE-Ecole Sup. d'Ingenieurs Electr./Electrot, General Electric Company, Hunting Technical Services Ltd., Politecnico di Milano, Polytechnic of Central London, Selenia SpA, Thomson-CSF-Laboratoire Central de Recherche

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Integrated Environment for Reliable Systems

Jeumont-Schneider Telecommunications, Mari Advanced Microelectronics Ltd., Telettra SpA, Universita di Bologna

898

External Interface for Processing of 3-D Holographic and X-Ray Image for Analysis and Control

BIAS, General Electric Company Plc, IRAM, Scanray A/S, Universität Dortmund

940 DMA

Depth and Motion Analysis

CGS-ITMI, ELSAG SpA - Elettronica San Giorgio, General Electric Company, INPG-IMAG, INRIA, Matra Datavision, Noesis, Universita di Genova, University of Cambridge

957

High Density Mass Storage Memories for Knowledge and Information Storage

Basf AG, Bogen Electronic GmbH, Bull SA, CEA-Leti, Glaverbel SA, Simulog, Thomson-CSF-Laboratoire Central de Recherche

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Parallel Associative Development Machine as a Vehicle for Artificial Intelligence

CIMSA Sintra, CSELT-Centro Studi e Laboratori Telecomunicaz, General Electric Company Plc, Non-Standard Logics, Thomson-CSF

973 ALPES

Advanced Logical Programming Environments Support

Bull SA, CRIL, Enidata SpA, Technische Universität München, Universidade Nova de Lisboa, Universite de Paris Sud

1005 MUST

Next Generation Data Base Management System

ABSY, Syseca Logiciel, Universität Kaiserslautern

1015 PALABRE

Integration of Artificial Intelligence, Vocal I/O and Natural Language Dialogue - Application to Directory

British Telecom Plc, CNET-Centre National d'Etudes des Telecommuni, CNRS-Centre National de Recherche Scientifiqu, ERLI, Politecnico di Torino, Sarin SpA, SESA

1035

2-D Coherent Optical Dynamic Processor

General Electric Company Plc, Thomson-CSF, Thomson-CSF-Laboratoire Central de Recherche, Vrije Universiteit Brussel

1063 INSTIL

Integration of Symbolic and Numeric Learning Techniques

Cognitech, GEC Research Laboratories, Universite de Paris Sud

1074

Shipboard Installation of Knowledge Based Systems Conceptual Design

Danish Maritime Institute, East Asiatic Company Ltd., Krupp Atlas Elektronik GmbH, Lloyd's Register of Shipping, National Technical University Athens, Soft International BV, Soren T. Lyngsoe A/S

1085 SUPERNODE

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

APSIS, Inmos Ltd., RSRE-Royal Signals and Radar Establishment, Telmat SA, Thorn EMI Ltd., Universite de Grenoble, University of Southampton

1098 KADS

A Methodology for the Development of Knowledge Based Systems

CAP Sesa Innovation, Polytechnic of the South Bank, Scicon Ltd., SCS Scientific Control Systems, STC Technology Ltd., Universiteit van Amsterdam

1106

Further Development of Prolog and its Validation by KBS in Technical Areas

Daimler-Benz AG, GIA-Universite d'Aix-Marseille I, GIT Gesellschaft für Ingenieurtechniken, Prologia, Robert Bosch GmbH

1117 KIWI

Knowledge Based User Friendly System for the Utilisation of Information Bases

Consorzio per le Ricerche e le Applicazioni d, Dansk Datamatik Center, Enidata SpA, INRIA, Philips Gloeilampenfabrieken NV, Universita di Roma La Sapienza, Universitaire Instelling Antwerpen

1133 ISIDE

Advanced Model for Integration of DB and KB Management Systems

Agusta SpA, Ars SpA, CRIL, INRIA, Sagem, Simulog

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A Preliminary Study of a Vector Processing-Oriented Parallel Architecture

Bull SA, Siemens AG

1542

Intelligent Documents Production Demonstrator

Arg-Applied Research Group SpA, Inesc-Instituto de Engenharia de Sistemas E C, Mnemonica Computer Services

1558 EQUUS

Efficient Qualitative and Quantitative use of Knowledge-Based Systems in Financial Management

Citymax Integr. Inf. Systems Ltd., Dataid, Riada & Co., University College of London

1560 SKIDS

Signal and Knowledge Integration with Decisional Control for Multi-Sensory Systems

British Aerospace Plc, C.F.R., CNRS-Laas-Laboratoire Automatique/Analyse des, Krupp Atlas Elektronik GmbH, Maps Informatica Industrial, Matsra Datavision, Mediprint, Universitat Politecnica de Catalunya, University of Oxford, University of Patras

1570

Application of Experts Systems to Industrial Chemical Analysis

Katholieke Universiteit Nijmegen, Organon International BV, Pye Unicam Ltd., Vrije Universiteit Brussel

1588 SPAN

Parallel Computer Systems for Integrated Numeric and Symbolic Processing

Cimsa Sintra, Computer Technology Institute, Inesc-Instituto fe Engenharia fe Sistemas E C, PCS Peripheral Computer Systems, Thorn EMI Ltd., University College of London

1592

Therapy Adviser for Oncology

CITSA, Medimatica Ltd., Sanofi, University of Leeds

1613 ITS

Evaluation of an Intelligent Tutoring System Shell for Industrial/Office Training

Datamat SpA, Education Technology Institut., ITT Industries Ltd.

OFFICE SYSTEMS

28 MULTOS

A Multimedia Filing System

Battelle Institut, CNR-IEI, Cretan Computer Institute, ERIA, Ing. C. Olivetti & C. SpA, Mnemonica Computer Services, Philips Datasystems, TA Triumph-Adler Ag

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Standardisation of Integrated Lan Services and Service Access Protocols

British Telecom Plc, Bull SA, CSELT-Centro Studi e Laboratori Telecomunicaz, GEC Marconi Research Centre, Nixdorf Computer AG, OCE-Nederland BV, Philips International BV, Plessey Office Systems Ltd., Reseaux Communication Entreprise, SESA-Societe Etudes Systemes Automations, TITN, University of Twente

56 FAOR

Functional Analysis of Office Requirements

East Asiatic Company Ltd., GMD-Gesellschaft für Mathematik und Datenver, STC Technology Ltd., Universität Koeln

59 MINSTREL

New Information Models for Office Filing and Retrieval

Dansk Datamatik Center, GN Data, National Software Centre Ltd., University College Dublin

64 SPIN

Speech Interface at Office Workstation

AEG AG, CEA-Commissariat a l'Energie Atomique, CGE-Laboratoires de Marcoussis, CSELT-Centro Studi e Laboratori Telecomunicaz, National Technical University Athens, Nixdorf Computer AG, Oros, Sesa, SNS Pisa, Universiteit van Amsterdam

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Broad Site Local Wideband Communication System

ACEC SA, ACT, Bell Telephone Mfg Co., CISI-Informatique Internationale, D.G. Sg2 Genie Informatique, FCR/SI - ING RN, National Technical University Athens, Stollmann & Co. GmbH, Universite de Liege

82 IWS

Intelligent Workstation

Bull SA, Cretan Computer Institute, INRIA, Katholieke Universiteit Nijmegen, OCE-Nederland BV, Vrije Universiteit Brussel

121 HERODE

Handling of Mixed Text/Image/Voice Documents Based on a Standardised Office Document Architecture

CRIN/ADILOR, Siemens AG, TITN

169 LION

Local Integrated Optical Network

British Telecom Plc, CSELT-Centro Studi e Laboratori Telecomunicaz, NKT-Nordiske Kabel Og Traadvaerker A/S, Politecnico di Milano, TITN, Universite de Paris, Universite de Toulouse-Paul Sabatier, University of Patras

231 DOEOIS

Design and Operational Evaluation of Office Information Servers

Bull Sa, ICL-International Computers Ltd., Trinity College Dublin, Universität Stuttgart

234

Cognitive Simulator for User Interface Design

Alcatel ESC, General Electric Company Plc, Logos Progetti Srl, Medical Research Council

237 CSA

Communications Systems Architecture

Mari Advanced Microelectronics Ltd., Philips Kommunikations Ind. AG, Plessey Company Plc, SYD-Synergie Informatique & Developpement

249 UCOL

Ultra Wideband Optical Coherent Lan

GEC Marconi Research Centre, Industrie Face Standard Spa, Politecnico di Milano

285 OSSAD

Office Support Systems Analysis and Design

Centre d'Etudes du Management, Institut für Organisationsforschung & Techno, IPACRI- Istituto per l'Automazione delle Cass, Universita di Milano

291

Linguistic Analysis of the European Languages

Acorn Computers Ltd., Ing. C. Olivetti & C. SpA, Katholieke Universiteit Nijmegen, LIMSI-CNRS, Ruhr Universität Bochum, Tecnopolis Csata Novus Ortus, UNED, University of Patras

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The Paper Interface

AEG Olympia AG, Ing. C. Olivetti & C. SpA, Philips Gloeilampenfabrieken NV, Philips Kommunikations Ind. AG, Plessey Office Systems Ltd., Trent Polytechnic

367 SOMIW

Secure, Open, Multimedia, Integrated Workstation

AEG Olympia AG, Bull SA, CSELT-Centro Studi e Laboratori Telecomunicaz, INESC-Instituto de Engenharia de Sistemas E C, INRIA, Iselqui SpA, Italtel Telematica Spa, Prodata, S.C.K. - C.E.N., Sarin SpA, Sobemap SA

385 HUFIT

Human Factors Laboratories In Information Technologies

Bull SA, Fraunhofer IAO, Husat Research Centre, ICL-International Computers Ltd., Ing. C. Olivetti & C. Spa, Philips Gloeilampenfabrieken NV, Siemens AG, The Piraeus Graduate School, Universidade do Minho, University College Cork, Wilhelms Universität Westfalen

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395 INCA

An Integrated Network Architecture for Office Communications

General Electric Company Plc, Ing. C. Olivetti & C. SpA, Modcomp, Nixdorf Computer AG, Systems Wizards Srl, University College of London

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

British Maritime Technology, Fincantieri, ICL-International Computers Ltd., Voice Systems International

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A High Compression Picture Coding Algorithm for Photographic Videotex

British Telecom Plc, CLETT, CSELT-Centro Studi e Laboratori Telecomunicaz, Independent Broadcasting Auth., KTAS, Nixdorf Computer AG, PTT Nederland NV

612

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

Barco Industries NV, Cimsa Sintra, General Electric Company Plc, MYFRA SA, OCE-Nederland BV, Universite de Paris, University of Twente

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813 TODOS

Tools for Designing Office Systems

CNR-IEI, Dornier GmbH, Italtel Telematica SpA, OCE-Nederland BV, Politecnico di Milano, Sema Metra, Systems and Management SpA, Thomson Informatique Services, Universität Koeln, Universite de Paris 1 Sorbonne

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831 ASTRA

Advanced and Integreted Office Systems Prototypes for European Public Administrations

Arcos Conseil, Bull SA, CCRIAI-Consorzio Campano di Ricerca per l'Inf, CESIA, Datenzentrale Schleswigholstein, GSI Iecsi Software, I/S Datacentralen Af 1959, Ing. C. Olivetti & C. SpA, MC2, Sogei - Societa Generale d'Informatica

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834 COMANDOS

Construction and Management of Distributed Office Systems

ARG-Applied Research Group SpA, Bull SA, CNR-IEI, Fraunhofer IM, ICL-International Computers Ltd., Imag-LGI-Laboratoire Genie Informatique, Inesc-Instituto De Engenharia de Sistemas E C, Ing. C. Olivetti & C. SpA, Nixdorf Computer AG, Trinity College Dublin, Universität Stuttgart

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853

Acquisition, Compression & Reproduction of True-Colour Image Documents

Ing. C. Olivetti & C. SpA, Intersys Graphic, Katholieke Universiteit Leuven

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855

European Typewriters and Other Workstation Integration

Ing. C. Olivetti & C. SpA, Olympia AG, Politecnico di Torino, TA Triumph-Adler AG

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870 TALON

Testing and Analysis of Local Area Optical Networks

Cossor Electronics Ltd., NKT-Nordiske Kabel Og Traadvaerker A/S

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878 PROMINAND

Extended Office Process Migration with Interactive Panel Displays

AEG GmbH, Modulex A/S, Riso National Laboratory, Scaitech A/S, Technische Universität München

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890 PANGLOSS

Parallel Architecture for Networking Gateways Linking OSI Systems

7-Technologies APS, CAP Scientific Ltd., PCS Peripheral Computer Systems, Universite de Liege, University of Reading, University of Twente

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An Intelligent General Public Data, Voice and Picture Storage Retrieval System

BBC Interactive Television Unit, Bureau Marcel van Dijk NV, CROM/ADILOR, Logica UK Ltd., Philips Gloeilampenfabrieken NV, SEP

925

Coding for Moving Picture & Still Picture at 256 Kbits/S and 64 Kbits/S

CIT-Alcatel, General Electric Company Plc, SAT-Societe Anonyme Telecommunications, STA Elettronica Automazione, TE.KA.DE., Telefonica CTNE

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954 IKAROS

Intelligence and Knowledge Aided Recognition of Speech

CGE-Laboratoires de Marcoussis, Fraunhofer IAO, General Electric Company Plc, Universität Stuttgart

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956 COCOS

Components for Future Computing Systems

Bull SA, ICL-International Computers Ltd., Ing. C. Olivetti & C. SpA, INRIA, Nixdorf Computer AG, SGS-Microelectronics SpA

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998 MARS

Highly Secure Office Information Systems-Definition Phase

BBN Communication A/S, Bertin & Cie, COPS (Europe) Ltd., Protexarms, Universität Koeln, University of East Anglia

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1024 PODA

Piloting of the Office Document Architecture

Bull SA, ICL-International Computers Ltd., Ing. C. Olivetti & C. SpA, Nixdorf Computer AG, OCE-Nederland BV, Queen Mary College, Service Etudes Communications Postes Tel, Siemens AG, Software Sistemi SpA, TITN, University College of London

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1030 IT-UPTAKE

Human and Economic Factors in IT Uptake Processes

Empirica, Memory Computer Plc, STC Technology Ltd., Work Research Centre Ltd

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1032 ERW

An Office Systems Research Workstation for Europe

Ing. C. Olivetti & C. SpA, Queen Mary College, Siemens AG, University of Sussex, Vrije Universiteit Amsterdam, Whitechapel Computer Works Ltd.

1051

Amorphous Silicon Contact Imager for Office and Graphic Applications

Agfa Gevaert, CNRS, Imec VZW, MBB Messerschmitt Bolkow Blohm Gmbh

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1057 MIAC

Multipoint Interactive Audiovisual Communication

British Telecom Plc, CNET-Centre National d'Etudes des Telecommuni, CSELT-Centro Studi e Laboratori Telecomunicaz, Industrie Face Standard SpA, PTT Nederland NV, STC Technology Ltd., Telefonica CTNE, TRT-Telecommunications Radioelec. & Teleph.

1059 DAMS

Dynamically Adaptable Multi-Service Switch

Jeumont-Schneider Telecommunications, Plessey Company Plc, TN Telenorma

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1533 MIS

Multilingual Information System

Bull SA, ICL-International Computers Ltd., Ing. C. Olivetti & C. SpA, Nixdorf Computer AG

1541
Multi-Lingual Speech Input-Output Assessment, Methodology & Standardisation
CNET-Centre National d'Etudes des Telecommuni, CSELT-Centro Studi e Laboratori Telecomunicaz, JYSK Telefon (JTAS), Universiteit van Amsterdam, University College London, University College of London

1573 IBASS
Intelligent Business Application Support System
Bull SA, Datamont SpA, Langton Ltd., Nixdorf Computer AG, Polytechnic of the South Bank

COMPUTER-INTEGRATED MANUFACTURING

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Exploitation of Real-Time Imaging for Arc Welding
Babcock Power, Messer Griesheim, RWTH Aachen Rheinisch-Westfaelische Technisc, Welding Institute of Cambridge

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Design Rules for Computer Integrated Manufacturing Systems
ISTEL

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Design Rules for the Integration of Industrial Robots into CIM Systems
Fraunhofer IPK, Renault Automation, Universität Karlsruhe, University College Galway

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A Computer Integrated Production Insula;Design Rules and Standards
Logica Uk Ltd

118
General Purpose Sensory Controlled Systems for Parts Production
Comau SpA, Fraunhofer-Gesellschaft Ipa, OCN-PPL SpA, Siemens AG, Sincon SpA

179
Integrated Electronic Subsystems for Plant Automation
AEG AG, GEC Marconi Research Centre

197
Computer Aided Thermal Image Technique for Real Time Inspection of Composite Material
Barr & Stroud Ltd., CNR-IROE, University of Strathclyde

278
Integrated Sensor-Based Robot System
Fraunhofer-Gesellschaft Ipa, Joyce-Loebl Ltd., MARI Advanced Microelectronics Ltd., National Technical University Athens, Robert Bosch GmbH, Universidade Nova de Lisboa, University of Newcastle

293
Knowledge & Decision Support for Material Handling Systems
CGE-Laboratoires de Marcoussis, CGP-Compagnie Generale de Productique, Fraunhofer IPK, IBM Deutschland GmbH, Instituto Superior Tecnico

319
Data Transfer between CIM Systems & Management Information Systems
Computer Systems Development, Mentec International Ltd., Trinity College Dublin

322 CAD-I
Cad Interfaces
BMW Bayerische Motorenwerke AG, Cisigraph, Cranfield Institute of Technology, Danmarks Tekniske Hojskole, Erdisa, GGS Gesellschaft für Strukturanalyse, Katholieke Universiteit Leuven, Kernforschungszentrum Karlsruhe, Leuven Measurement & Systems, NEH Engineering, Rutherford Appleton Laboratory, Universität Karlsruhe

338
Product Design for Automated Manufacture & Assembly
CIMAF, COMAU SpA, Cranfield Institute of Technology, Dunaiturria y Estanconia, Renault Automation

384
Integrated Information Processing for Design Planning and Control of Assembly
AEG AG, Fraunhofer IPK, GEC Research Laboratories, Induyco/Investronica, Telemecanique, TNO Netherlands Organisation for Applied Scie.

409
Development of an Integrated Process and Operations Planning System with the Use of Interactive 3-D Modelli
Exapt-Verein zur Foerderung des Exapt-Systems, Matra SA, Volkswagen AG

418
Open CAM System Allowing Modular Integration into Factory Management of a Workshop Structure in Functional
CIG-Centre d'Informatique Generale, Fabrique Nationale Herstal SA, Ing. C. Olivetti & C. SpA, Logica Uk Ltd., Matra Datavision, Procos A/S, RTM, RWTH Aachen (Rheinisch-Westfaelische Technisc, Universite de Bordeaux 1

477 COSIMA
Control Systems for Integrated Manufacturing: The CAM Solution
Comau SpA, Digital Equipment GmbH, Renault Automation

496
Design and Specification of Configurable Graphics Subsystem for CIM
Generics Software Ltd., GTS GmbH, Trinity College Dublin

504 PAQO
Plant Availability and Quality Optimisation
ADERSA, AMTRI-Advanced Manufacturing Technology Inst., Battelle Institut., Danobat S. Coop, GRS Gesellschaft für Reaktorsicherheit, Ikerlan, Stewart Hughes Ltd., Technische Hochschule Darmstadt

534
Development of a Flexible Automated Assembly Cell and Associated Human Factors Study
Dantec Elektronik, Medical Research Council, RISO National Laboratory, Vrije Universiteit Brussel, Westland Plc

595

The Application of CIM to Welded Fabrication

Aalborg Shipyard Ltd., Danish Welding Institute, Italsiel SpA, Odense Steel Shipyard, Universita di Genova, Welding Institute of Cambridge

623

Operational Control for Robot System Integration into CIM

Fiar SpA, Fraunhofer IPpk, Kuka Schweissanlagen + Roboter GmbH, Ladseb-CNRP, Politecnico di Milano, PSI Gmbh, Renault Automation, Seram, Universidad Politecnica de Madrid, Universidade Nova de Lisboa, Universität Karlsruhe, Universite de Valenciennes, Universiteit van Amsterdam, University College Galway

688 AMICE

AMICE, An European Computer Integrated Manufacturing Architecture

AEG AG, AT & T en Philips Telecommunicatie Bedrijven BV, British Aerospace Plc, Bull SA, CAP Sesa Innovation, CIT-Alcatel, CRI A/S, Digital Equipment GmbH, Dornier GmbH, Fiat SpA, GEC Electrical Projects, Hewlett-Packard-France, IBM Deutschland GmbH, ICL-International Computers Ltd., Network Sys., Italsiel SpA, Philips & Mble Associated, Procos A/S, RWTH Aachen (Rheinisch-Westfaelische Technisc, Seiaf SpA, Selenia SpA, Siemens AG, SNIAS-Societe Nationale Industrielle Aerospat, Volkswagen AG

809

Advanced Control Real-Time CIM Systems and Concepts for Flexible Automation

ICL-International Computers Ltd., Krupp Atlas Datensysteme GmbH, TDS Dextralog Ltd., Technische Universiteit Delft, Universiteit van Twente

812

Experimental Centre for System Integration in CIM

Aeritalia GVC, ELSAG SpA - Elettronica San Giorgio, Philips & Mble Associated, Politecnico di Milano, RWTH Aachen-Rheinisch-Westfaelische Technisc, Sesa-Societe Etudes Systemes Automation

850

Predesign of FMS for Small Batch Production of Electronic Cards

CSEA, ERIA, Eurosoft Systems SA

909

Development of Tools for Economic Evaluation of CIM in Smaller Manufacturing Companies

AMTRI-Advanced Manufacturing Technology Inst., BIBA, CIMAF, Danmarks Tekniske Hojskole, Mentec International Ltd., WTCM/CRIF

932

Knowledge Based Real Time Supervision in CIM

AEG AG, ARS SpA, BICC Technologies Ltd., CEA-Commissariat a l'Energie Atomique, Fiar SpA, Fraunhofer Ipa, FZI Karlsruhe, Industrie Pirelli Spa, Philips GmbH, Philips Komunikations Ind. AG, Politecnico di Milano, SGN Graphael, SIS AV, TITN, Universite de Savoie

955 CNMA

Communication Network for Manufacturing Applications

Aeritalia, BMW Bayerische Motorenwerke AG, British Aerospace Dynamics, Bull SA, CGE-TITN, Elf Aquitaine, Fraunhofer Gesellschaft, General Electric Company, ICL-International Computers Ltd., Nixdorf Computer AG, Olivetti G4S - Ricerca, PSA, Siemens AG

975 TRACIT

Transponders for Real-Time Activity Control of Manufacturing Links to CIM Information Technology Systems

Polydata Ltd., Redar NAH-Ortungstechnik GmbH, TM Technics Dieren BV

1062 ACCORD

Computer-Aided Engineering Software for Advanced Workstations in the CIM Environment

Athens School of Economics, Bertin & Cie, GEC Research Laboratories, Nederlandse Philips Bedrijven BV, Philips Gloeilampenfabrieken NV, Societe Genrale de Techniques et d'Etudes, Trinity College Dublin, Universita di Genova, Vector Fields Ltd

1136 DASIQ

Distributed Automated System for Inspection and Quality Control

CEA-LETI, Microtecnica SpA, Sagem, Universität Hannover, Visitec

1199

Human Centred CIM System

BICC Technologies Ltd., Danmarks Tekniske Hojskole, Greater London Enterprise, Krupp Atlas Elektronik GmbH, NEH Engineering, R & D Advisory Services, Rolls Royce Plc, Teknelogisk Inst., Universität Bremen, University of Manchester

1556 VITAMIN

Visualisation Standard Tools in Manufacturing Industry

Fraunhofer Gesellschaft, IMAG-LGI-Laboratoire Genie Informatique, Mannesmann Kienzle GmbH, Politecnico di Milano, Syseca Logiciel, Team Srl, Universite de Valenciennes

1561 SACODY

A High Performance Flexible Manufacturing System Robot with Dynamic Compensation

AEG AG, Bertin & Cie, Katholieke Universiteit Leuven, Kuka Schweissanlagen + Roboter GmbH, Leuven Measurement & Systems, University College Dublin

1572

Basic Technologies for High Performance Solid State Image Sensors

Thomson-CSF-DCI, Valvo Bauelemente Philips

1652

Methods for Advanced Group Technology Integrated with CAD/CAM

CETIM, LVD Company NV, Michel van de Wiele NV, Microin S.A.L., WTCM/CRIF

1653

Intelligent Process Control by Means of Expert Systems

Centre d'Estudis Avancats de Blanes, CNRS-LAAS-Laboratoire Automatique/Analyse des, Dornier GmbH, Eltec Elecktronik Gmbh, Miniwatt SA, Nederlandse Philips Bedrijven BV, RTC Compelec, Universitat Politecnica de Catalunya

INFORMATION EXCHANGE SYSTEMS

33 ROSE

Research Open Systems for Europe

Bull SA, General Electric Company, ICL-International Computers Ltd., Ing. C. Olivetti & C. SpA, Siemens AG

630

The Unix-United Aspects of the IES

D.G. Sg2 Genie Informatique, Mari Advanced Microelectronics Ltd.

700 ELAN

ESPRIT/European Local Area Network

Bull Sa, ICL Belgium, Olivetti SA, Siemens Data SA

706 EUROKOM

Computer Conferencing and Electronic Mail for ESPRIT

University College Dublin

710

IES Support Services

ECAT, IEGI, Infoarbed Sarl

717 HERMES

Message Handling Survey and Trends for the IES user Community

Fisher & Lorenz

718 CARLOS

Communications Architecture for Layered Open Systems

Case Group Plc, ESTSET-M, ETS Ingenieros Telecomunication-UPM, Fisher & Lorenz, RC Computer, Sysware

719 THORN

The Obviously Required Name-Server

Bull SA, CERN, DFN, General Electric Company, ICL-International Computers Ltd., Ing. C. Olivetti & C. SpA, INRIA, Siemens AG, Systems Wizards Srl, University College of London

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CGP-COMP. GEN. DE PRODUCTIQUE	F
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COMAU SPA	I

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ESI	F
ESIEE	F
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PHILIPS/TRT	F
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SEP	F
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SG2	F
SGI-SOC.GENERALE D'INFORMATICA	I
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THOMSON CSF/DCI	F
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VDO LUFTFAHRTGERÄTE WERK	D
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WHITECHAPEL COMPUTER WORKS LTD.	UK
YARD SOFTWARE SYSTEMS LTD.	UK
ZELTRON	I

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AdeRSA/GERBIOS	F
ADR	F
AERE-ATOMIC ENERGY RES.ESTABL.	UK
AGENCE DE L'INFORMATIQUE	F
AMTRI-ADV.MANUF.TECH.RES. INST.	UK
ATHENS SCHOOL OF ECONOMICS	GR
BATTELLE INSTITUT	D
BP RESEARCH CENTER	UK
BRITISH MARITIME TECHNOLOGY	UK
BRUNEL UNIVERSITY	UK
CCETT	F
CEA-DEIN/SIR	F
CEA/LETI	F
CEN/SCK	B
CERT	F
CESIA	F
CETE MEDITERRANNEE	F
CETMA-CEN.D'ETUDES DU MANAGEM	F
CFT-CEN.FOR MANUF.TECHNOLOGY	NL
CNAM	F
CNET	F
CNR-ISTITUTO LAMEL	I
CNRS	F
CNRS/LAAS	F
CNRS/LIMSI	F
COMPUTER TECHNOLOGY INSTITUTE	GR
CRANFIELD INST. OF TECHNOLOGY	UK
CRETAN COMPUTER INSTITUTE	GR
CRIAI	I
CWI-CEN.V.WISKUNDE & INFORMATICA	NL
DANISH MARITIME INSTITUTE	DK
DANISH WELDING INSTITUTE	DK
DANMARKS TEKNISKE HOJSKOLE	DK
DANSK DATAMATIK CENTRE	DK
DATENZENTRALE SCHLESWIG-HOLSTEIN	D
DR. NEHER LABORATORIES	NL
ELEKTRONIK CENTRALEN	DK
EMPIRICA	D
ESIEE	F
FORSCHUNGSZENTRUM INFORMATIK	D
FRAUNHOFER-IAO	D
FRAUNHOFER-IITB	D
FRAUNHOFER-IM	D
FRAUNHOFER-IPA	D
FRAUNHOFER-IPK	D
GIA	F
GMD-GES. FÜR MATHEMATIK & DATENVERARBEITUNG	D
GRS-GES.FÜR REAKTORSICHERHEIT	D
HAHN MEITNER INSTITUT	D
HEINRICH HERTZ INSTITUT	D
HERIOT WATT UNIVERSITY	UK
HILDESHEIM HOCHSCHULE	D
HOPITAL LA PEYRONIE	F
HUSAT RESEARCH CENTRE	UK
IAB GMBH	D
IASI	I
IEI-CNR	I
IESS-CNR	I
IET-INST.OF EDUCATIONAL TECHN.	UK
IKERLAN	E
IMAG	F
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INST.SUP.TECNICO DE LISBOA	P
INSTITUT GEOGRAPHIQUE NATIONAL	F
IOT	D
IRAM	F
IROE	I
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KATH. UNIVERSITEIT NIJMEGEN	NL
KERNFORSCHUNGZENTRUM KARLSRUHE	D
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LIFIA	F
LINGUISTICS INST. OF IRELAND	IRL

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MEDICAL RESEARCH COUNCIL	UK
NATIONAL INSTITUTE FOR HIGHER EDUCATION	IRL
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CITY UNIVERSITY	UK
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CNET-GRENOBLE	F
CNR-CENTRO DI STUDIO PER LE RICERCHE DI FONETICA	I
CNR-CONSIGLIO NAZIONALE DELLE RICERCHE	I
CNR-IEI	I
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CNRS MULHOUSE	F
CNRS-CRIN	F
CNRS-LAAS-LABORATOIRE AUTOMATIQUE/ANALYSE DES SYSTEME	F
CNRS-LABORATOIRE AUTOMATIQUE DOCUMENTAIRE ET LINGUISTIQUE	F
COMMUNICATION AND MANAGEMENT SYSTEMS UNIT	GR
COMPUTER TECHNOLOGY INSTITUTE	GR
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CRIF/WTCM	B
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DEMOCRITUS UNIVERSITY OF THRACE	GR
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IIRIAM-INSTITUT INTERNATIONAL DE ROBOTIQUE ET D'INTELLIGENCE ARTIFICIELLE	F
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IMAG-LGI-LABORATOIRE GENIE INFORMATIQUE	F
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INFRATEST INDUSTRIA	D
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INSTITUTO SUPERIOR TECNICO	P
IRIAC	F
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KATHOLIEKE UNIVERSITEIT NIJMEGEN	NL
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NIHE-NATIONAL INSTITUTE FOR HIGHER EDUCATION	IRL
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Official Journal L118, 6.5.88
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Council Decision adopting the second phase of ESPRIT.

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Communication from the Commission to the Council and the Parliament concerning the final programme assessment for the Microelectronics Programme.
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COM (88) 102 final - 29.2.1988.
Revised proposal for a Council Decision concerning ESPRIT.
(ES, DA, DE, GR, EN, FR, IT, NL, PT)

COM (88) 687 final - 8.12.1986.
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COM (88) 269 final 21.5.1986.
Communication from the Commission to the Council - The Second Phase of ESPRIT.
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