ISSN 1018-5593

ESPRIT

European strategic programme for research and development in information technology

Progress and results 1990/91

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

ESPRIT

European strategic programme for research and development in information technology

Progress and results 1990/91

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

EUR 13583 EN

Published by the
COMMISSION OF THE EUROPEAN COMMUNITIES

Directorate-General
Telecommunications, Information Industries and Innovation

L - 2920 Luxembourg

LEGAL NOTICE

Cataloguing data can be found at the end of this publication

Luxembourg: Office for Official Publications of the European Communities, 1991

ISBN 92-826-3132-X

Catalogue number: CD-NA-13583-EN-C

Printed in Germany

Contents

List of illustrations

Foreword

by Michel Carpentier, Director-General, DG XIII

☐ At the end of June, the Community entered the last 18 months of the countdown to the completion of the internal market in the most sombre business climate since the single-market clock was set ticking in 1985. Competing against a falling dollar and yen, and with high interest rates in several Member States holding back investment, industry also faced stalled GATT talks, slumped share prices and a post-Gulf recession.

☐ It would have been no surprise to find that the build-up of momentum towards the open market had abruptly slowed in the past few months, braked by defensive national reactions. Yet the drive to complete the groundwork for the European Community of the twenty-first century has, if anything, been stepped up. And with electronics underpinning so much of the modern economy, a successful European strategy in information technology and communications will be one of the mainstays of the whole '1992' edifice.

☐ In 1960, more than half the workforce in the industrialized countries were employed in the direct manufacture of products. The figure now is less than one in five. The Community has been created during the transition from a basically manufacturing economy to an information-processing one. Information technology is itself a leading manufacturing sector, with world markets expected to be worth more than ECU 1 000 billion by the year 2000.

☐ Yet the Community's trade deficit in electronics has doubled over the past four years to reach ECU 31 billion by the end of 1990, while the world market for electronics doubled in the same period. The traditional heavy dependence of European electronics companies on domestic markets has been a fundamental handicap. No European semiconductor manufacturer, for instance, has reached the 5% world market share reckoned to be the minimum necessary for industrial competitiveness, whereas 90% of the world market for 1 Mbit and above memory chips is controlled by Japanese companies.

☐ The perception in Europe that there is no future in a national go-it-alone approach has, of course, driven the whole 1992 enterprise. I believe that the recent recessionary pressures have confirmed the validity of a pan-European approach to information and communications technologies by highlighting the structural weaknesses of the European market:

- the potential single market is still compartmentalized by restrictive public procurement rules and incompatible technical standards;
- it lacks dynamism: European industry's consumption of electronics is very much less per capita than in the USA or Japan;
- consumer preferences for established products and big-name suppliers lead to innovative new enterprises (especially the smaller ones) paying a high price as they strive to break into the market.

☐ Nor is the competition for dominance on the global scale taking place on a level playing-field, what with significantly higher R&D financing costs in Europe than in Japan, defence and other government contracts succouring US high-tech companies, and the US-Japan chip pact obstructing free international trade negotiations.

☐ These structural weaknesses in the European environment and distortions in international competition are now being addressed even more relentlessly by the Community after what I hope will be a short — but unfortunately sharp — recessionary shock. Late last year the Council of Ministers discussed a set of guidelines for a Community industrial policy, prepared by the Commission, which was followed this April by a paper *(The European electronics and information technology industry: state of play, issues at stake and proposals for action)* applying the principles formulated to the Community's information technology and electronics industry. The five main lines of action proposed involve the stimulation of demand, the refocusing of R&D, more and improved education and training, more even-handed international trading relations, and an improved environment for business.

☐ I want to emphasize that the analyses and proposals build on the achievements of the 1980s and to stress that an open competitive environment will remain a central plank of Community policy in the 1990s. While the Community's role is to deliver the conditions in which European companies can achieve international competitiveness fairly and squarely by their own efforts, the main responsibility lies with the firms themselves. Given equitable conditions, the European information technology and electronics industry has the potential to be fully competitive on a world scale: for example, of 13 key emerging technologies identified in a US Department of Commerce report, 10 are related to electronics, and of these, Europe is ahead or level with the USA in seven and with Japan in six.

☐ This technological potential is amply confirmed by the results of Community R&D initiatives, such as ESPRIT, which have made a substantial contribution to coordinating R&D in Europe and forging, through transnational partnerships, a new climate of confidence. ESPRIT itself has led, for instance, to a world-leading wafer-stepper using deep ultraviolet laser technology capable of defining the less than 0.35 micron geometries required for 64 Mbit memory chips and beyond, while more than 500 products world-wide have stemmed from ESPRIT work on the transputer, giving Europe a strong position in the fast-growing market for high-performance, low-cost parallel computers. Many other outstanding technology results, including standards, are evidenced in this report.

☐ Europe has been in on the ground floor of the transition to open standards, which is effecting a profound change in the supplier-user relationship (open standards mean open markets). In the high-growth areas of software, services and systems design and integration, Europe maintains a strong capacity. In numerically controlled machine-tools, Europe was already responsible for over half the world's production in 1988 and has made tremendous progress since in computer-integrated manufacturing. In consumer electronics, Europe has taken the initiative in promoting the world-wide adoption of the most suitable HDTV standard, and with CD-I (Compact Disk Interactive) has launched a totally new product concept. And European companies have built solid positions in telecommunications, now entering a period of unprecedented international expansion as Community action creates a liberalized, harmonized single market for advanced equipment and services.

☐ The information technology industry in Europe is far more than just a handful of long-established names: the Community has more than 13 000 IT companies. Completing the single market and furthering the necessary accompanying policies — in collaborative research, innovation and technology transfer, standardization, advanced trans-European communications, education and training — are priorities for the Commission as it works for an environment in which these companies can flourish.

Introduction

by J-M. Cadiou, Director, ESPRIT

Highlights

I am very pleased to report that over the past 18 months a significant number of major results from all work areas of the programme have been added to ESPRIT's already substantial slate of achievements. By mid-1991 a cumulative total of nearly **500 major results** had been reported by ESPRIT projects, either leading directly to commercial products or services, contributing to the establishment of international standards, or in the form of tools, methods and processes taken up by industry.

In the period under review, a further 107 **new projects** were launched (including three forming part of the start-up phase of JESSI, the industry-led Joint European submicron silicon initiative), and 43 **exploratory actions** initiated to further increase the already considerable involvement of SMEs in ESPRIT. An additional special action was started to promote SME usage of ASIC technology, and **special regional actions** were launched in Greece, Portugal and Spain, for example to accelerate the take-up of microelectronics technology. **ESPRIT clubs,** inaugurated in most Community Member States and some EFTA countries, have already started to increase awareness of the programme as a whole.

The **Basic research initiative,** launched in 1989, rapidly gained momentum in 1990/91; nearly all research actions have now completed their first 18 months of activity, several results have been produced with imminent industrial significance, and the proportion of actions with industrial participants has risen to over a quarter. The first three '**networks of excellence**' were set up early in 1991 to reinforce cooperation between research teams. Furthermore, joint NSF/DARPA/ESPRIT workshops were held to explore possible areas of collaboration between the US and European fundamental research communities.

Also on the international front, substantial progress has been made in drawing up commonly acceptable terms of reference for a study covering the feasibility of cooperative research into advanced computer-integrated manufacturing systems. The discussions have involved Europe (the Community and EFTA), the USA, Japan, Canada and Australia.

This period also saw the thorough preparation of the **next phase of ESPRIT,** based on close consultation with representatives of all interested parties in the IT industry, a wide spectrum of user industries and the research community. The Council of Ministers gave its formal approval to the new phase on 8 July 1991, and the first general call for proposals was launched very shortly afterwards. Several **large-scale targeted projects** are currently under consideration: these will pull together technology advances to address the most critical issues of the 1990s. They include R&D projects and accompanying measures, as appropriate. The preparation of these projects is at different stages, with some ready for immediate implementation, and they are briefly described towards the end of this introduction.

The results achieved by ESPRIT on the technological side have had a major impact on the software, parallel processing, distributed computing and computer-integrated manufacturing fronts and in some critical areas of semiconductors. However, overall the IT and electronics industry is experiencing severe difficulties, and not just in Europe. Before analysing this and going on to outline the Community's response, I will first describe in more detail some of the technology results directly arising from ESPRIT projects.

ESPRIT technology results

Results from ESPRIT projects can be grouped into three broad categories. First are those consisting of advanced technology, ranging from improvements to breakthroughs, leading to products or services brought to the marketplace. Second, projects can produce tools, methods or processes which enhance the development or performance of industrial manufacturing processes, leading to shorter development times, higher quality, better yields and reduced costs. In the third category are results which make key contributions to the work of the various international standardization committees, and lead to the specification, drafting and ratification of IT standards.

The table shows an analysis of the 495 major results reported as of mid-1991.

Results arising from ESPRIT projects as of mid-1991	
Contributing directly to products or services	270
Tools and methods used outside ESPRIT	167
Contributions to international standards	58
Total results	495

Some illustrative examples of results from these categories are given below.

- As a direct result of project 2048,[1] ASM-L (NL) has brought to the market a deep-UV stepper, a key piece of lithography equipment used in the manufacture of integrated circuits. Considered the most advanced R&D tool of its kind in the world, it can define structures as small as 0.18 microns, and is being used to develop the processes required for making chips at the 64 Mbit DRAM level and beyond. The advanced optics required for the production version of this deep-UV stepper are being developed in project 5002.
- Anacad Computer Systems, a spin-off company from the CVS project consortium (project 802), recently signed an agreement with SGS-Thomson Microelectronics to supply more than 300 copies of ELDO, their high-precision, high-speed analogue simulator.
- The transputer microprocessor from SGS-Thomson (F) is now the most widely sold 32-bit RISC processor in the world, with total sales already beyond the 450 000 unit mark. In April 1991 Inmos (a member of the SGS-Thomson group) announced the new-generation T9000. This is one of the world's most powerful RISC processors, with a peak performance of 200 Mips (or 25 Mflops). It was developed through work in SUPERNODE (projects 1085 and 2528), PUMA (project 2701) and GENESIS (projects 2447 and 2702). Today's transputer-based products provide supercomputing power at one-fifth of the cost of a conventional supercomputer. Through continuing development, the processing capabilities of the transputer have increased more than 10-fold in three years.
- The portable common tool environment (PCTE) developed in PCTE (project 32) was confirmed in December 1990 as an international standard by ECMA, the European Computer Manufacturers Association. It is currently being validated by NATO. PCTE environments are now commercially available from Bull (F), DEC (USA), Hewlett-Packard (USA), IBM (USA) and SUN (USA). Software environments and PCTE-compliant tools are being offered by SFGL (F), Syseca (F), GIE Emeraude (F) and IPSYS (UK).
- Redar Nah-Ortungstechnik (D) has sold several thousands of the transponder developed by Redar and Polydata (GR) in TRACIT (project 975) to Volkswagen. This device, which employs radio communication to receive and transmit information, is used by Volkswagen to identify automobile chassis as they pass through the factory and to record, and furnish on demand, relevant details of the manufacturing and assembly operations carried out on each. 'Reading' a chassis' status at various points along the

[1] Every ESPRIT project has a number and most have an acronym as well. For more information about a project, look it up in the Index (p. 147) or the Projects and participants list (p. 97).

assembly line enables the right operations to be carried out on it at a particular station, as well as automatically routeing it to the next appropriate one. This technique, enabling production planning to be decentralized and bringing greater flexibility to the manufacturing process, makes small-batch customized production runs more economic and so allows a greater choice to be offered to the customer. The system has also been sold to Hoesch, the German steel company, for identifying wagons in an in-plant railway system.

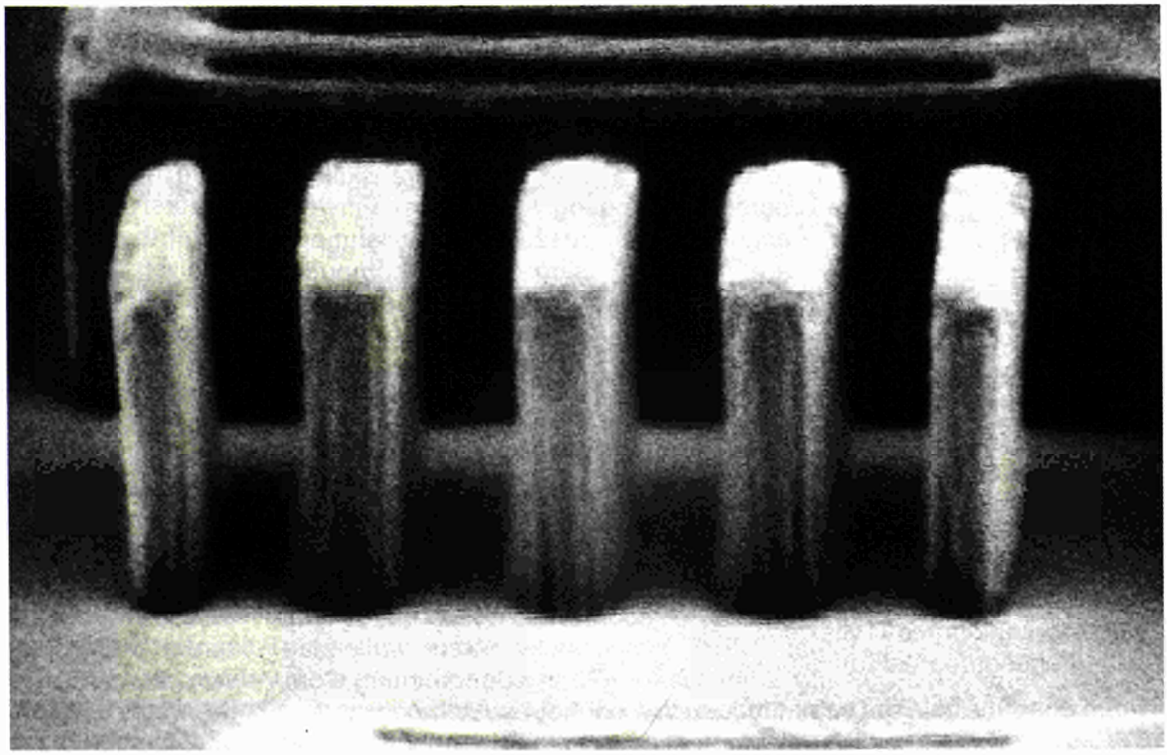
- CADEX (project 2195) has provided BMW with prototypes of the software required by the company for the exchange of data between 60 different types of CAD systems throughout its own organization and its 350 suppliers. Further demonstrations have been made at Fiat Aviazione, and the interface processors are scheduled for launch on the European market by the end of 1991.

- In March 1991 the Distributed Computing Model, Bull's major product in open systems, was announced at C-Bit '91. It incorporates key contributions from eight different ESPRIT projects, notably COMANDOS (projects 834 and 2071).

- Philips is launching Compact Disk Interactive (CD-I) in the USA and Japan in October 1991. CD-I, a consumer product integrating a microcomputer with a CD drive in one unit, will enable hypermedia products to be accessed using a TV set as the monitor. The European launch is scheduled for 1992. The CD-I concept was developed in DOMESDAY (project 901). The full video image facility, an important marketing feature, was made possible through a coding algorithm (MPEG or ISO standard 11172) developed in COMIS (project 2012).

- Work in APACHIP (project 2075) has enabled MCTS (F) to bring to market tape for automated bonding (TAB) for IC packaging. TAB replaces the customary wires that connect a chip to its ceramic substrate and external pins, improving reliability and allowing higher packaging density. Vertical cooperation, notably between MCTS (TAB producer), Hoechst-Ceramtec (producer of ceramic packages) and Bull and Siemens-Nixdorf, enabled the achievement of this technical success, which is being further exploited in the production of flat screens, HDTVs and other consumer electronics applications.

- Thomson-LCD (F) has announced a 15 x 15 cm flat-panel liquid crystal display (LCD). This high-resolution colour display (1024 x 1024 pixels and 16 colours), already used for instrument readouts in a prototype aeroplane, is based on the outcome of MATRIX-LCD (project 2283).



0.25 micron structures *printed using ASM Lithography's world-leading PAS 5000/70 deep-UV wafer-stepper (developed in project 2048) in combination with the photoresist technology of project 2265. The lithographic process determines the size of the smallest feature in an IC — the smaller the feature, the more densely packed the components, and the more powerful the chip. ASM-L's deep-UV stepper can define the features required for new-generation 64 Mbit memory chips and beyond.*

- An advanced IC design software package marketed by Mentor Graphics (USA) was developed by IMEC (B) and Philips (NL) in CATHEDRAL (project 97).

- Apple Computers (USA) has set up a joint venture with Acorn (UK) to further develop and exploit the ARM, a RISC-type microprocessor. Its main feature is the amount of computing power obtained — 15 Mips — with an energy requirement of a mere 0.4 watts, which makes it a good candidate for portable workstations. The ARM-3 is a result of MULTIWORKS (project 2105).

- CHORUS, a distributed operating system extension to Unix, is being distributed by Unisys (USA). Chorus Systèmes (F) developed CHORUS by integrating results obtained through their participation in several ESPRIT projects: APHRODITE (project 1535), GENESIS (2447), PUMA (2701), MULTIWORKS (2105), COMANDOS (2071), ISA (2267) and EWS (2569).

- The VLSI design action (3700), set up to increase the number of students trained in VLSI design from 1 500 to 3 000 per year, has already exceeded this target: more than 5 000 students have been trained in the first year of operation, with 350 VLSI designs drawn up and 200 fabricated. The action now involves more than 200 academic institutions together with five major European foundries.

- The Parallel computing action (PCA), launched under the aegis of Information processing systems, has enabled over 300 researchers a year to acquire skills in parallel computing techniques. Fifty-five academic and research establishments are involved, using parallel computing systems based on the T800 transputer, and the action is helping to push forward development in this key area.

This selection of ESPRIT results demonstrates that despite its present difficulties, the European IT and electronics industry is able to develop and bring to market products and services with a winning edge, as well as playing an important role in the development of global standards. Of course, the collaborative R&D that ESPRIT successfully fosters, while playing a necessary role in strengthening Community industry, cannot by itself constitute a sufficient response to the current crisis.

In crisis: the IT and electronics industry

With an annual growth rate of around 15% throughout the 1980s, well in excess of the rise in GDP, the IT and electronics market has become one of the biggest sectors of the European economy, and is expected to become the largest by the end of the decade.

What makes the IT and electronics industry so strategic a sector for the Community is not only its size, but also its all-pervasive and catalytic nature. Its impact on employment is considerable: an estimated 60 to 65% of the working population is directly or indirectly dependent on these technologies and their applications. Its products and services provide a vital part of society's infrastructure, and its technologies are now used in virtually all economic and social activities. As a result, the IT and electronics industry has a major role to play in maintaining and strengthening the competitiveness of European industry as a whole. Yet the IT and electronics industry is now facing a serious crisis, which is affecting the USA and not just Europe alone.

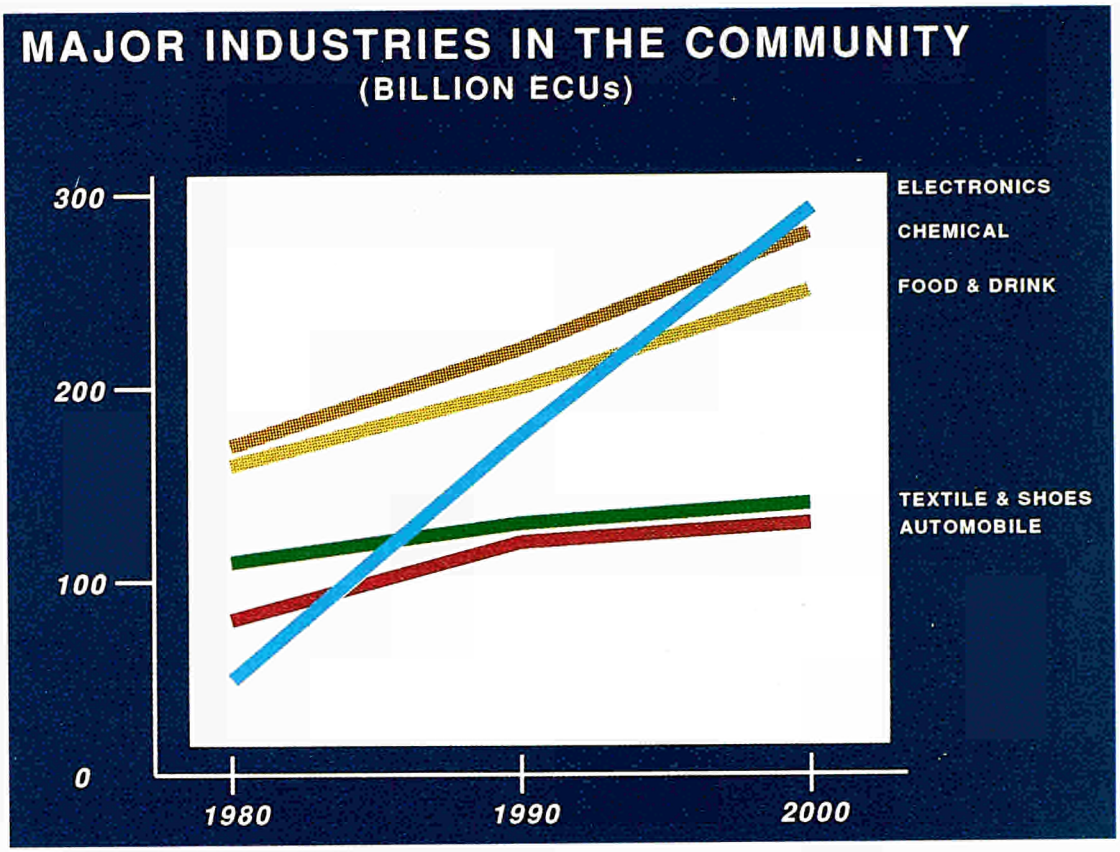
The elements of the crisis

This crisis has both short-term and long-term, more structural, components. In the short term, the market is being affected by at least two factors. The first is the slow-down in demand precipitated by the Gulf crisis and other political uncertainties, which have pushed many users into delaying decisions on investing in new computer systems. At the time of writing, there are no signs yet of a recovery from this slow-down in demand: the results for the first quarter of 1991 still indicate a demand lower than for the same period last year, and analysts expect improvements only in the second half of 1991 at best. The second short-term cause is the depreciation of the dollar and the yen, which has made products from the USA and Japan more price-competitive than their European counterparts.

There are deep structural causes to the present crisis as well. The most important is the trend from proprietary to open systems, which is causing a complete reorientation of the IT industry and a drastic lowering of manufacturers' profit margins. At the same time, the rate of technology change is becoming faster than ever, with new generations of products now launched every three years on average.

This leads to escalating capital costs that have to be amortized over ever-shorter periods. Overall, the R&D investments of computer companies (in percentage of revenue terms) are more than twice the average of manufacturing industry as a whole, and those of semiconductor companies more than three times this figure.

This combination of increasing costs and reduced profit margins forces companies to increase volume, either through internal growth, which is difficult, by restructuring (via mergers and acquisitions), or by strategic alliances, all of which cause short-term difficulties before their advantages can take effect.



The largest industry: *the IT and electronics sector is likely to become the largest industry in the European Community, in terms of annual turnover, by the year 2000. These 'enabling' technologies are permeating the whole of our social and economic fabric and are now an integral part of the Community's development strategy. With their major impact on the competitiveness of the whole of the modern economy, on economic growth, and on the level of employment, IT and electronics are of crucial importance to the success of the unified internal market, and essential factors in Europe's control of its own destiny.*

The high cost of capital

Considerable financial resources are necessary to cope with the increased investment required on the one hand by shorter product development cycles and by industrial restructuring on the other. European companies have severe difficulty in mustering these, given that capital markets in Europe are generally not properly geared to financing long-term or high-risk operations. Nor is public funding of sufficient scale available. In the USA, public funding for R&D in IT is very high: at least USD 5 billion per year, of which about half comes from DARPA, NSF, DoE and other agencies, and the other half from the R&D part of the total USD 100 billion spent on defence procurement contracts. In Japan the mechanisms are different, but the scale of the financial savings in R&D costs enjoyed by the IT companies is similar. Recent major studies, including one by the Federal Reserve Bank of New York, have compared the full cost of capital for R&D, taking into account not only interest rates but also factors such as the taxation system and requirements for equity in relation to debt. They show that Japanese companies have much lower long-term capital costs for R&D than their European counterparts. The difference — 10 percentage points during 1989 — effectively doubles the actual cost of R&D for European firms, and led to an estimated R&D cost saving of USD 6 billion for Japanese IT companies in 1989 alone (and note that previously the relative cost of capital in Japan was even lower). Under these circumstances, one needs to assess carefully whether or not European high technology companies, especially IT companies, are truly placed in a situation of fair competition.

European companies are also suffering more than their counterparts elsewhere in the

present difficult situation because they are in transition from a period when the Community market was highly fragmented to one when the single market will operate in a fully integrated way — but this will obviously take many years.

The efforts of the European IT industry

Despite these conditions, European companies have persevered. Facing up to their difficulties, they are engaged in restructuring operations, stepping up their efforts to reduce costs and increase productivity, and are striving to speed up their response to rapid changes in demand. The European IT industry, it should be stressed, is made up of over 13 000 companies of all shapes and sizes, and not just the few large ones in the public eye. Between 1984 and 1989 the whole IT industry managed to increase its market share in Europe from 47 to 55%, that is by eight percentage points, which is a very impressive accomplishment in such a competitive and fast-growing sector. Overall, total R&D investment more than doubled over that period, and the revenue of SMEs tripled. And the industry has demonstrated its ability to compete in global markets: even in the brutally competitive semiconductor area, for example, heavily dominated by Japanese companies, SGS-Thomson is now third in the world in non-volatile memories, which represents more than a quarter of the total semiconductor memory market, and first in Europe; while Siemens has gained an acknowledged presence in the DRAM market, the main area of strength of Japanese producers, where it now supplies 6% of the global demand for 1 Mbit chips, and is starting production of the 4 Mbit generation.

These are just a few examples, but they show that European IT companies can produce technologically competitive products and market them successfully. Yet it is an uphill struggle, as the current turmoil in the industry demonstrates, and the continuing survival of an independent European capability in this area is far from certain. Indeed, a careful analysis of the situation, and an examination of the factors putting European companies at a disadvantage relative to their competitors, leads to the conclusion that a comprehensive, structured policy is needed at Community level — one designed to create a more favourable climate for the industry to operate in.

A Community strategy

In April 1991 the Commission presented a communication to the Council of Ministers that addressed these issues, identified the key elements of an IT policy, and proposed a framework for mobilizing national resources throughout Europe in a series of strategic initiatives. This document — *The European electronics and IT industry: state of play, issues at stake and proposals for action* — is designed to open up a full debate on the issue at Community level, involving Member States, Community institutions, the industry, users and investors. Five general lines of action are proposed, and these are summarized below:

- **Demand** must be stimulated, in particular by promoting computerized links between companies and administrations and by launching projects designed to modernize IT and communications infrastructures in the education, transport, public health and environmental fields. The recently launched European nervous system (ENS) programme, aiming to develop links between the networks that already exist between national governments, industry and individual citizens, will play an important role.

- In the **training** area, the aim must be to provide scientists and engineers capable of developing and making maximum use of IT. The education system does not adapt as fast as it should to Europe's changing needs, and specific training initiatives should be addressed to both prepare the specialists required by the IT industry and train users to get the best profit from the use of IT. In particular, networks of excellence (as conceived by ESPRIT Basic research), composed of both academic and industrial teams geographically distributed throughout the Community, should continue to be set up in order to provide a critical mass of complementary knowledge and expertise, and help to share limited and expensive resources.

- In the **external relations** area, a trade policy is needed based on an open international trading system, access to the markets of the main trading partners, and the integration of European markets. A level playing-field has to be established together with fair 'rules of the game' in order to ensure equitable conditions of

competition and market access between the different regions of the world.

- It is also necessary to develop a **healthy business environment** by improving financing systems, supporting standardization, and developing the infrastructure needed for cooperation to develop and flourish. Current financing conditions in Europe militate against industries which need considerable investments in R&D and production capacity. The cost of such financing is much higher in Europe than in Japan: this severely distorts competition, and must be remedied.

- And in the area of **technology,** a 'second generation' of R&D is needed, ranging from fundamental research to industrial projects with a clear potential for commercialization. It is here that ESPRIT will play a major role.

The new phase of ESPRIT

ESPRIT's new phase is making a major contribution to implementing, in particular, the technology initiative identified in the Commission's paper. The programme continues to stimulate cooperative R&D projects and to focus on well-defined strategic objectives and technological priorities that take full account of the fast-changing industrial scene. Looking into the future, the overall industrial context and the necessity of higher investments in R&D make ESPRIT's cooperation mechanism, if anything, more necessary now than ever. The new phase of ESPRIT is part of the third framework programme for Community R&D activities, agreed for the period 1990-94, which foresees that out of ECU 5.7 billion earmarked for Community R&D, ECU 1.35 billion will be devoted to information technology. This new phase consists of four technological areas plus Basic research; a horizontal initiative in Open microprocessor systems; a set of supporting initiatives; and five large-scale 'second generation' targeted projects in line with the Commission's communication to the Council. These areas and initiatives are outlined below.

Microelectronics

The key objectives are to strengthen the Community's ability to design and manufacture leading-edge ICs and to ensure their ready availability to a broad range of user companies. Particular attention will be paid to working in conjunction with JESSI, the Joint European submicron silicon initiative, and to creating favourable conditions for the use of application-specific integrated circuits (ASICs) by SMEs.

Software engineering and information processing systems

The objectives in this area are to apply software-intensive systems design and engineering techniques to user needs; to develop information servers and their interfaces that are appropriate to different users' tasks and levels of expertise; and to develop advanced architectures and their applications. The R&D tasks will take into account the major technology transfer and awareness initiative, ESSI, one of the 'second generation' large-scale targeted projects.

Advanced business and home systems — Peripherals

The work in this area aims to develop user-friendly support for cooperative working; promote the development and use of multimedia systems; demonstrate loosely coupled distributed systems; promote the introduction of information technology into the home; and develop selected peripheral technologies.

Computer-integrated manufacturing and engineering

The main aim is to demonstrate how the manufacturing and engineering industries can benefit from the application and integration of IT in products and processes. Taking an integrative approach, in which social, economic, organizational and environmental factors will play a decisive role, the work will centre around the following themes: promoting the use of open systems; promoting the development of modular and compatible system components that lend themselves to an incremental approach and which SMEs can afford; and developing new generations of handling systems.

Basic research

Basic research will continue to have four key aims: to enhance the potential for future

technological breakthroughs in IT; to benefit from the added value offered by cooperation at the European level; to contribute to the attainment of the programme's objectives from a position upstream of the market; and to reinforce interdisciplinary links. The results of any single Basic research project are expected to feed through into several projects and areas of technological R&D by providing the underlying knowledge and expertise needed to create future breakthroughs.

Open microprocessor systems initiative

The goal of the Open microprocessor systems initiative is to extend the concept of open systems and standards to the microprocessor systems environment, by providing an open framework based on the macrocell approach and software portability. It will interact with and build on the results of all the technological areas of ESPRIT, as well as on standards and other relevant developments world-wide.

Large-scale targeted projects

These will address the following domains:

- **Software,** to increase productivity by concentrating on production methods and tools and their early transfer to users. This is an area where R&D must be accompanied by broad dissemination of results and training activities, and the pilot phase of a major European system and software initiative (ESSI) will be launched early next year.
- **CIM,** to strengthen European manufacturing capabilities.
- **Microelectronics,** to develop IC design and manufacturing technologies for both standard ICs and ASICs. ESPRIT will collaborate with the Eureka JESSI programme in the area of submicron silicon technology.
- **Peripherals,** developing, in particular, high-resolution flat-panel display technology.
- **High-performance computing,** notably to take advantage of the possibilities offered by progress in the field of parallel processing.

The new phase of ESPRIT represents an important element of the Community's new approach towards IT and electronics: more tightly focused and integrated; more concerned with feedback between users and suppliers, in order to link technology push with market pull; looking upstream to strengthen training in advanced topics and techniques; and directing more effort towards technology transfer. It will contribute to the Community objective of creating the conditions for the European IT industry to improve its competitiveness both on its home ground and in the wider international arena.

Yet, important as it is, this programme is not enough. The financial amounts currently involved are too small to compensate for the enormous advantages which IT companies enjoy in other regions of the world. Furthermore, an R&D programme can only be one part of an overall strategy. For the European IT companies' own efforts to bear fruit, the Community must show the political will and determination to provide them with the right environment: through technology, it may be the shape and future of our whole society which is now at stake.

Microelectronics

Overview

Objectives

The Microelectronics (MEL) activities of the ESPRIT programme concentrate on stimulating the creation of the design tools, process technologies, equipment and support industries required by European electronics goods manufacturing companies to create their own integrated circuits (ICs) tailored for specific uses — the so-called application-specific integrated circuits (ASICs). ASICs are a more efficient and cost-effective alternative to purchasing standard, non-optimized components.

Sales of electronic systems amounted to ECU 630 billion world-wide in 1990 and consumed ECU 77 billion-worth of microelectronic components, including ASICs, which currently make up about 30% of the world IC market. Microelectronics provides the technology foundation for information technology (IT) and telecommunications, and has extended its impact far beyond these sectors, representing a significant source of added value in a growing range of products, ranging from toys to telephones and word-processors to washing-machines. The competitiveness of Europe's IT industry depends on its early mastery of microelectronics, and this means gaining fast access to emerging technologies at the definition stage and being able to incorporate them into future generations of products.

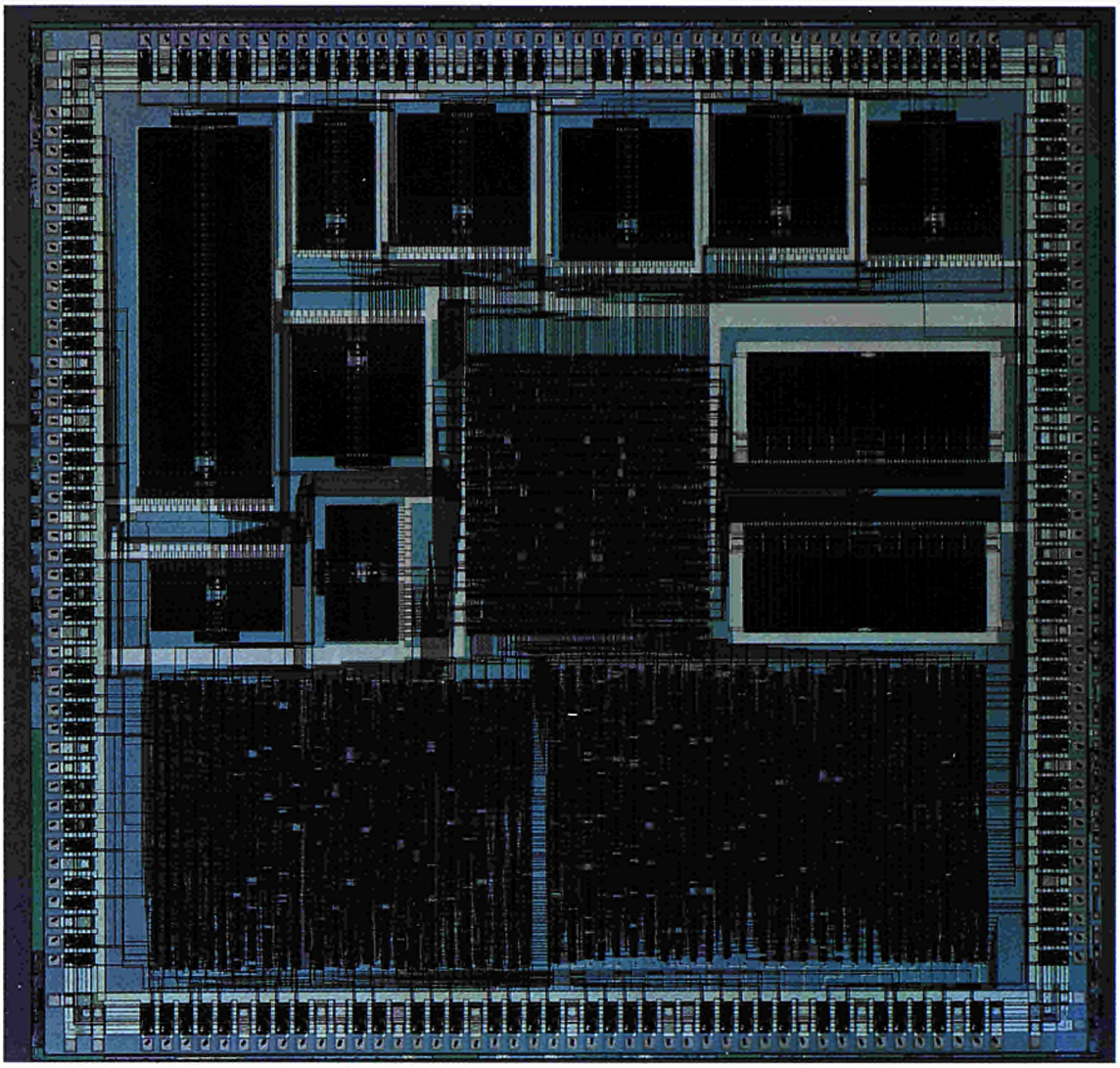
Trends

The key to success in the IT market as a whole — and in the microelectronics sector in particular — is the rapid update of technologies, as the industry is marked by a high rate of product innovation, leading to ever-shorter life-cycles of increasingly 'intelligent' products. Microelectronics companies have to invest on average 16% of their sales in R&D compared to 10% in the IT industry overall and 3 to 4% in the aerospace, automotive and chemical sectors. Furthermore, with capital investment running at around 20% of sales, the total investment in a new technology is comparable to the total revenue accrued from the previous generation. Hence both firms and governments invest substantially in R&D. Cooperation between competitors at the level of pre-competitive R&D allows the growing costs of research to be shared, spreads the risk of new ventures, and fosters the industrial restructuring required to give companies the chance of a significant presence in global markets.

During 1990 there were a total of 64 ongoing microelectronics projects. Seven projects were completed. The industrial character of the programme has been stressed through the launch of several demand-driven projects, with specific attention paid to the establishment of cooperation between manufacturers and users.

Community participation in JESSI

The background to the present participation of the Community in JESSI lies in the shared strategic purpose of the microelectronics actions within JESSI and ESPRIT. Both aim to consolidate the foundations of microelectronics in Europe to the benefit of systems houses of all sizes. The main difference between the two strategies is that ESPRIT, by its very nature, is precompetitive, addressing a broad range of technologies in order to cover the very varied spectrum of needs in the Community; while JESSI, in line with its inclusion in the Eureka programme, is more strongly market-oriented and has advanced CMOS technology as its focus. In the area of submicron CMOS technologies, there is thus a great potential for fruitful collaboration



Help for IC designers: *using the macrocell design techniques and tools developed in AIDA (project 888), Siemens has produced a 32-bit coprocessor for automation systems, pictured here, that integrates more than 300 000 transistors. As VLSI circuits become more complex, CAD techniques, software tools and design methods must advance to match them. AIDA has extended the capabilities of a wide range of individual CAD tools so that tools for different tasks, developed in different companies, can be used in combination. A notable feature of the AIDA system is the incorporation in the IC designs of built-in test modules which make it possible to test the manufactured chip at a much lower cost than before.*

between the ESPRIT and JESSI programmes. The participation of the Community in JESSI will be in those activities which, by virtue of their characteristics, expected benefits and particular participants, are best carried out at Community level.

Provision has been made for effective exchange of technology and results between ESPRIT and JESSI projects, which extends to organizations in countries currently outside the JESSI programme.

CAD and design methodology

Computer-aided design (CAD) is one of the key enabling technologies needed to support the electronics systems and components industries. It is also the basis of a self-supporting industry which, until now, has been dominated by a small number of US-based companies. However, the market in Europe is currently expanding more rapidly than elsewhere, and there is evidence that the investment in CAD over recent years is starting to pay off. From a total of 28 CAD projects in ESPRIT, 68 firm commercial results have been reported. Of these, 62% contribute directly to products or services, 26% relate to tools and methods, and the rest have made contributions to international standards. Some of the more important results are detailed below.

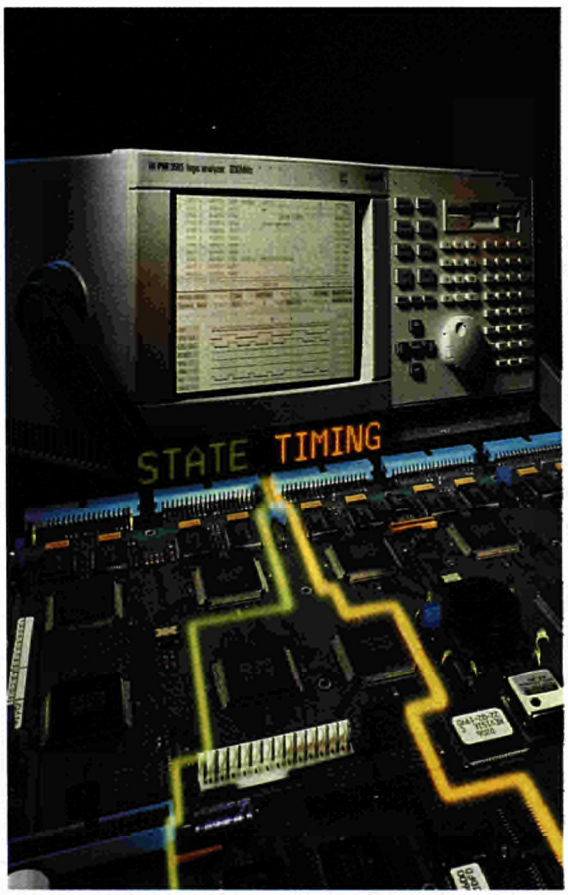
SNI, Siemens-Nixdorf-Informationssysteme (D), which has emerged onto the world electronics CAD scene with the SIGRAPH-EL product, is already selling the CALANY floorplanner tool resulting from AIDA (project 888). CALANY gives cost improvements resulting from a reduction of 50% in total block area and performance improvements of up to 35% in total wire length.

Anacad Computer Systems, a small German company arising from CVS (project 802), has

signed an agreement with SGS-Thomson Microelectronics (F) to supply more than 300 copies of ELDO, their high-precision, high-speed analogue simulator, for integration with SGS-Thomson's MOZART multi-level digital simulator, also partially developed in CVS.

The latest mainframe computer from Bull, the DPS 7000 series, is the most powerful in Europe, capable of more than 220 transactions per second and of handling up to 4 000 terminals. The 11 VLSI chips used (with up to 500 000 transistors per chip) were all tested using the CATI system which Bull developed in collaboration with other companies in EVEREST (project 2318) and IDPS (projects 2426 and 5075). The fault-diagnosis tools made it possible to design and test these complex chips without any increase in cost or time compared with the previous chip generation.

Cryptech, a small Belgian firm, has developed a single-chip hardware implementation of the DES encryption algorithm. It is being manufactured in Belgium by Mietec. This product gives cheap and easy access to all users of the standard DES algorithm and is proving a major success, helped by its world-beating conversion speed (in excess of 18 Mbit/s). Cryptech used the CATHEDRAL design methodology, transferred with the help of IMEC (B) from the results of projects 97 and 1058.



Testing PCBs: *the Philips Logic Analyser at the top of the picture has been designed to use boundary scan test (BST) practices, resulting from project 2478, to simplify test and fault diagnosis procedures. The BST technique allows the testing of complex digital printed circuit boards (PCBs), like the one shown, via serial access from the edge connector to the periphery of the integrated circuits on the PCB. This method is much cheaper than conventional electronic testing.*

SGS-Thomson Microelectronics (F) has demonstrated the capabilities of the CAD tools developed in CANDI (project 2268) by designing and fabricating a colour decoder chip that can decode digital luminance and chrominance to analogue RGB signals. The prototype will be used in the 1 000 HDTV sets supplied for the forthcoming Olympic Games in Barcelona.

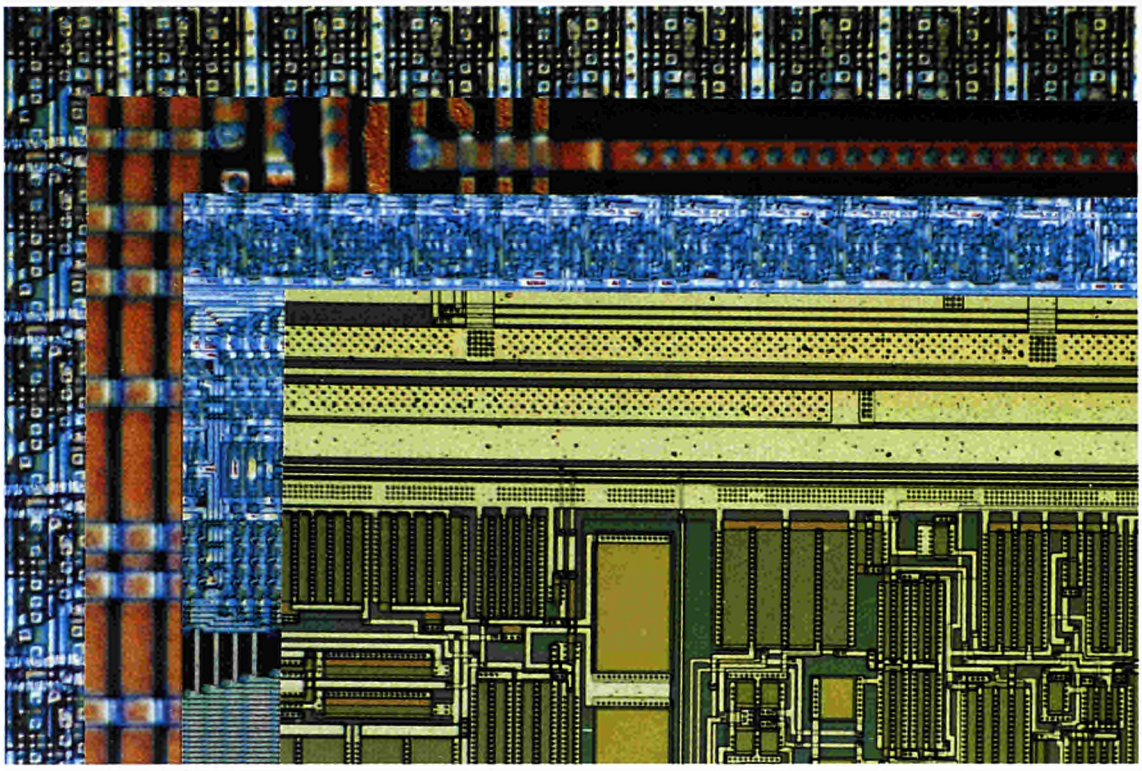
CAD standards and infrastructure

ECIP (project 2072) is paving the way for internationally accepted standards in CAD for VLSI in several domains. The longest established of these is in design data exchange. One of the organizations in the project, Manchester University (UK), in addition to representing Europe on the international EDIF (Electronic Data Interchange Format) Technical Committee, has established an EDIF validation service which satisfies a world-wide demand for checking conformity of data to the new standard.

A new development in CAD standards is the initiative to agree guidelines for standards in CAD frameworks. Through the initiative of organizations working in JESSI CAD-Frame (project 5082) and in ECIP, significant contributions are being made to this important area. Each technical subcommittee has either a chair or co-chair from Europe, and at least one of the four CFI meetings is held in Europe each year. A first prototype is being demonstrated at the Design Automation '91 conference in San Francisco, alongside other commercially developed prototypes. SNI (D) has announced a product, FrameWare, based on the early results of CAD-Frame.

Validation and test

In the drive towards ever-increasing system complexity and with more and more demands on performance, one of the major bottlenecks is in verification and testing. Up to one-half of the final cost of a complex chip or printed-circuit board can be attributed either directly or indirectly to test problems. The strategy for answering this hitherto intractable question is through constraining design methodologies in order to ensure testability. Two projects are attacking this problem in different areas.



Joint logic: *a collage of detailed segments from a four-channel digital signal processor (produced by Alcatel-Mietec) destined for telecommunications applications. The combination of analogue and digital circuit elements on the same flexible CMOS chip stems from work in project 5080 (JOINT LOGIC), which brings together the major IC manufacturers in Europe to develop the basic fabrication concept for a competitive 0.5 micron CMOS technology suitable for a broad range of applications.*

The first is 'Research into boundary scan test implementation' (project 2478). The effective and efficient testing of chips, boards and systems can be dramatically affected by incorporating the boundary scan philosophy into both standard ICs and ASICs. The project has had great influence on the specification and implementation of world test standards by creating a data model which has been incorporated into the electronic data interchange format (EDIF) as well as strongly influencing the work of the IEEE 1149 test standards committee. Philips (NL), a partner in the project, has decided to commercialize the results and to enter the tester market with a low-cost range of products specifically designed to test chips, boards and systems equipped with boundary scan.

EVEREST (project 2318), the second project in this area, has made a major contribution to the test view of the EDIF standard, where the definition has been led by an international team largely made up of EC members. An example of software which has already undergone successful exploitation is the SPHINX tool. This has already been used to produce several chips, including one containing 120 000 transistors that worked correctly in its first implementation.

Silicon technologies

Research activities in this area are mainly directed towards the development of technologies needed for the medium- to high-volume production of consumer, telecommunications and industrial ICs. The work encompasses a wide range of process technologies and is carried out under the headings of five IC process activities:

- core CMOS, for digital applications,
- flexible CMOS, for multifunctional applications,
- bipolar, for high-performance and high-speed digital, analogue and mixed analogue-digital circuits,
- BiCMOS, for fast digital and mixed analogue-digital circuits,
- high voltage.

Provisions are made in the projects to stimulate the take-up of results and to encourage the use of advanced technology by incorporating demonstrators applied to real applications, and by involving qualified users, including SMEs. Links have been established with other CAD, design and library projects in

all activities, and the methodologies used pave the way towards second-sourcing capabilities.

Flexible CMOS

Flexible CMOS technologies are created by the addition of process options to a core submicron CMOS process. The building of the core process is currently undertaken in two projects: JOINT LOGIC (project 5080) and ACCES (project 5048).

Three projects — JOINT LOGIC (project 5080), ADCIS (project 2193) and APBB (project 2039) — are building options to these cores to extend the process features to enable low voltage operation (down to 1.5 V), lower power consumption, optimization for embedded memories (DRAM and SRAM), and the inclusion of fundamental analogue components.

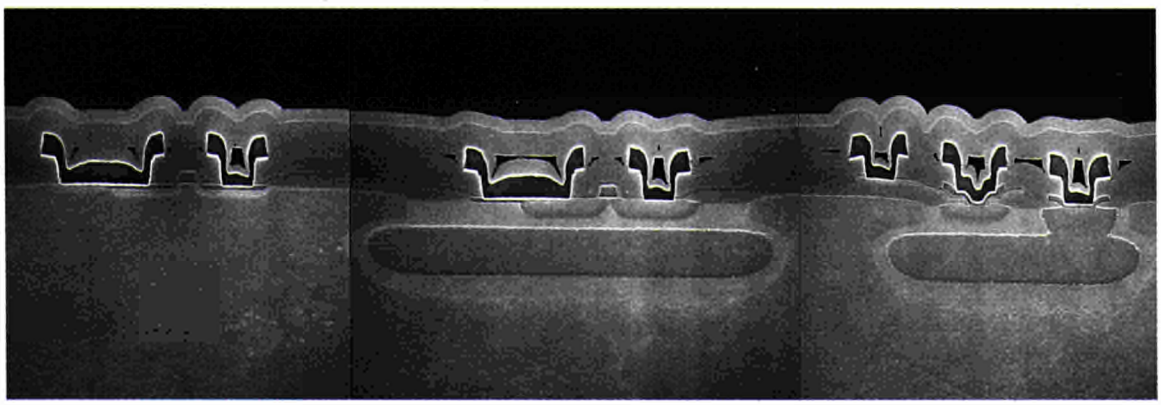
The JOINT LOGIC project is developing analogue and memory options to be added onto a 1 and 0.7 micron digital CMOS process developed in the same project, and a special low-voltage (1.5 V) CMOS process. Micro-controllers, digital signal processors, ICs for smart cards, battery-operated circuitry, composite arrays and applications in the audio, TV, telecommunications and automotive markets are under development.

In the ADCIS project, a 1 micron CMOS process is being adopted and characterized for mixed analogue/digital functions by Mietec (B), Matra-MHS (F) and CNET (E). At the same time, the development of design tools for building a system capable of producing silicon compilers, an analogue cell library and analogue basic converter functional blocks are being developed. The software related to the first version of this CAD tool (block placement, global router, simulation system), mixed layout generators, and specific compilers (analogue/digital/analogue converters) are being commercialized by Anacad Computer Systems (D). In addition, a complex video processor for telecommunication, multimedia terminal and videophone applications is being designed and fabricated.

The APBB (Advanced PROM building blocks) project has achieved the integration of EPROM and EEPROM memory devices into 1 and 1.2 micron CMOS processes (GEC-Plessey (UK) and SGS-Thomson (I)) and into a low-voltage (1.5 V, 2 micron design rule) CMOS process (Eurosil (D)). To exploit the key features of this technology, adequate CAD tools, building blocks for system designers and appropriate test methods have also been developed. Early access to the results has been provided to a number of SMEs to further increase the impact of the project: the resulting collaborations have led to the building of a number of demonstrators, including a gate array with embedded EEPROM, a microcontroller with on-board EPROM and EEPROM, low-voltage ICs for identification applications, an intelligent battery-charger for optimizing NiCd battery life, and ICs for electricity meters, smart cards and musical instrument applications.

BiCMOS

Although the performance of BiCMOS processes will always be a compromise between the best bipolar and best CMOS processes, the combination of bipolar features (analogue parameters, speed, driving capabilities) and CMOS properties (density, memory) creates a very challenging opportunity for many system designers. The BiCMOS market is expected to expand very quickly, with a cumulative annual growth rate of 60% from ECU 500 million in 1990 to ECU 5 billion in 1995 — an increase from 1 to 6% of the total IC market in only five years.



BiCMOS: *a cross-section of the three basic transistors used in project 2430 on submicron BiCMOS (bipolar/CMOS). This project has developed a VLSI technology combining high-density CMOS with bipolar circuitry of similar density, but better suited to tasks such as analogue interfacing.*

There are two projects in this field, BiCMOS and CANDI. In BiCMOS (project 2430), Philips (NL) has now completed the development of its 1 micron bipolar CMOS process with double poly, self-aligned n-p-n transistors and a silicide polysilicon emitter, while Siemens (D) has produced the first demonstrators in their 0.8 micron, digitally oriented process with very advanced trench isolation. An advanced demonstrator design, a one-chip video-bandwidth analogue/digital converter with an accuracy of more than 12 bits, has been realized. On the digital side, a 16 kbit ECL-driven SRAM has been made with an access time of only 3.5 ns, one of the best performances achieved world-wide to date.

In CANDI (project 2268), SGS-Thomson (F) and Telefunken (D) have demonstrated the compatibility of their 1.2 micron BiCMOS technology. The aim of this project is to transfer bipolar and CMOS processes originating from other ESPRIT projects. The main result lies in the sophisticated designs using BiCMOS technology for different application areas: an HDTV-RGB decoder, a mobile receiver for cellular networks, and shuffler/scramble circuits for asynchronous telephone networks. A library with more than 100 cells has been created in order to facilitate the use of the technology by systems users.

The next steps in these projects are to extend the processes to wider analogue use; for example, the implementation of vertical p-n-p with the addition of only one mask step. The evaluation and implementation of a RISC 3000 or 4000 processor is planned, as well as a self-calibrating 16-bit resolution analogue/digital converter and advanced FIR filter designs for HDTV.

BiPolar

BASE, the technology integration project (2016) aiming to develop bipolar technologies, builds on the results of the earlier ESPRIT projects 243 and 281. New transistor architectures have been developed and lateral and vertical device dimensions shrunk in order to meet the requirements for applications such as mobile telephones. The newly developed technology pushes the performance of silicon technology closer to that of III-V technology, but at lower production costs.

In particular, the designs achieved gate delays below 30 ps and significant reductions in power consumption, power delay product and noise. This performance is equivalent to the best results reported in the literature, and is three times better than that achievable by the production technologies presently available.

In addition to the development of pre-production technology, very advanced device structures have been realized. These include a silicon device architecture (BASIC) with minimized parasitic structures, especially suitable for optimum analogue performance, and a device structure realized using selective deposition of silicon with a speed performance beyond the specifications for standard technology. Furthermore, bipolar transistors have been fabricated containing epitaxial strained layers of germanium-doped silicon (23 nm thick $Si_{0.75}$ $Ge_{0.25}$ capped with silicon). Although the introduction of these layers in integrated circuits imposes new demands on device architectures and processing, they have the potential to improve speed and noise figures in bipolar circuits five-fold.

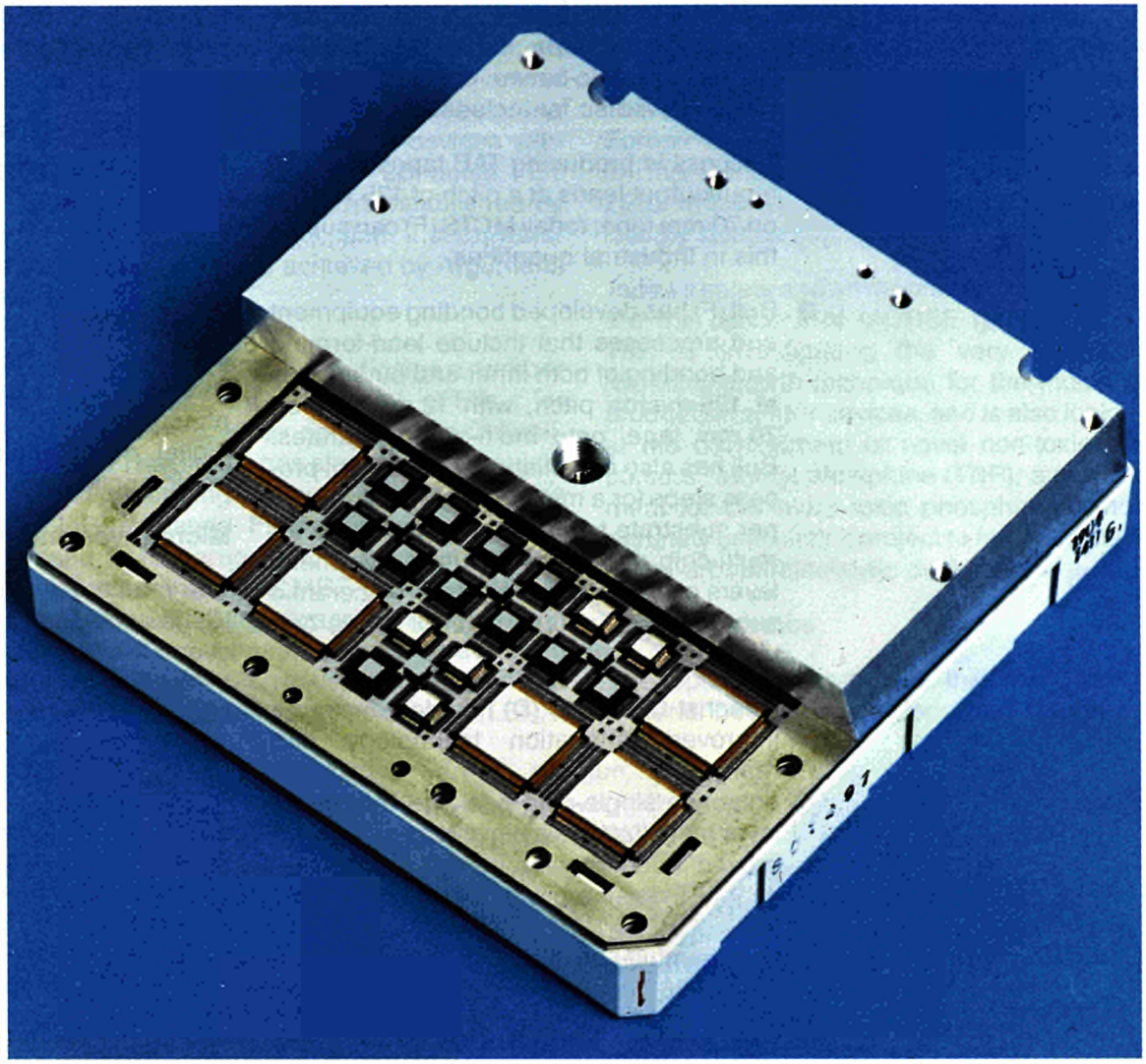
The BASE technology has been used by Plessey (UK) to design a 10 Gbit/s 64-1 multiplexer demonstrator for RACE project 1052, and SGS-Thomson (I) has established close collaboration with RACE project 1036 for the demonstration of a 2.5 Gbit/s fibre-optic system.

The project partners are the most competent manufacturers of bipolar circuits in Europe, with each partner concentrating on specific optimizations of the technology for speed, complexity, and analogue and digital functionality. These different technologies strengthen the European industrial position in application areas such as consumer electronics (Philips), telecommunications (Siemens), and radio and instrumentation (Telefunken, Plessey). The 1989 world bipolar market of ECU 13.6 billion is expected to increase to ECU 16.2 billion by 1994.

High voltage

In SMILE (project 2272), a high-voltage IC technology suitable for lamp ballast applications has been designed and demonstrated. The devices are combined with low-cost high-voltage packaging technology and are under evaluation to identify any critical behaviour in performance and reliability related to the high voltages involved.

Different types of high voltage devices such as IGBT (insulated gate bipolar transistors), LDMOS (lateral double diffused MOS), and



Packaging for high performance: *a demonstrator from APACHIP (project 2075), showing a multichip mainframe computer module from Siemens-Nixdorf which uses a high-density organic substrate with 16 VLSI and 32 LSI devices mounted by tape automated bonding (TAB). The VLSI devices are 12 mm square and have 316 input/output connections. APACHIP aims to provide advanced packaging solutions for multichip modules and single-chip package applications. As well as packaging techniques, the project covers the development of high-density, high-performance substrates, a new connector concept, reliability aspects, and new inspection methods.*

other n- and p-type BJT (bipolar junction transistors) up to 650 V have been integrated on the same silicon chip while remaining fully isolated from each other.

Supporting models for circuit simulation have been generated and parameters extracted. Macro cells comprising a high-voltage bridge driver, control circuits, low-voltage power-supply and start-up circuit, and a high-voltage full-bridge dedicated to lamp circuits have been designed and demonstrated under 250 V operating conditions, showing that a fully integrated solution is practical. A redesigned version is being developed using a 650 V technology which will extend bulb lifetime, save energy, and allow features such as dimming and flicker suppression to be added.

The global market for lamp-bulbs is expected to reach ECU 30 billion in 1995, of which ECU 3.6 billion will be for ballast applications and ECU 1.2 billion for electronic components such as those demonstrated in SMILE. In addition, the technology has application in a wide range of sectors such as domestic appliances, industrial controllers, intelligent power supplies and telephone exchange components.

VLSI packaging

In order to gain maximum advantage from ESPRIT's technology innovation projects, a complementary improvement is needed in the materials and structures of chip packaging. Two ESPRIT projects are creating compatible packaging and assembly schemes for high pin-count functions as well as accounting for high speed and high reliability needs.

APACHIP (project 2075) covers all areas of packaging, ranging from high density chip assembly and interconnection using very fine substrates, to packaging and testing for high-density, high pin-count applications for advanced VLSI circuits. These products cover both packaged electronic assemblies (multi-

chip modules) and packaging material supplies needed for tape automated bonding (TAB) and ceramic-based packages. Major results achieved so far include:

- Success in producing TAB tapes with 316 input/output leads at a pitch of 125 micron on 70 mm tape; today MCTS (F) can supply this in industrial quantities.
- Bull (F) has developed bonding equipment and processes that include lead-forming and bonding of both inner and outer leads at 125 micron pitch, with 12 mm ICs on 70 mm tape, onto multi-chip substrates. Bull has also established the different process steps for a multi-layer polyimide-copper substrate technology as the basis for multi-chip modules with up to five metal layers on a 10 cm square co-fired ceramic substrate (100 micron pitch of tracks and via holes).
- Hoechst Ceramtec (D) has demonstrated improved fabrication technology and realized a number of new packages, notably a single-chip package with multi-layer metallization, a pin grid array with improved heat transfer (using a tungsten-copper insert), a pin grid array with inner lead pitch of 200 micron, and a 10 cm square multi-chip package substrate containing 888 connector pads.
- High-density organic multi-chip substrates have achieved world-class specifications in terms of low resistance conductor tracks at pitches down to 80 micron, via holes as small as 30 micron in diameter, controlled impedance tracks, and up to 17 metal layers (signal and power/ground). The aim is to exploit this track definition capability to build complete mainframe central processor units on a single substrate requiring fewer layers.
- Extensive thermal modelling has led to the successful development of several water-cooled and air-cooled demonstrators. The multi-chip modules of Siemens, Bull and Hoechst Ceramtec, described above, have been used in evaluations of thermal and mechanical characteristics.

PLASIC (project 5033) is providing guidelines on how to build, model and evaluate plastic packages for VLSI devices in telecommunications, industrial control and automotive applications requiring high reliability. This project provides the major submicron integration technology projects with a low-cost high-reliability packaging route.

Compound semiconductor technologies

III-V compound semiconducting materials offer a unique range of very attractive properties; low power consumption, high operating speed and the ability to process both optical and electrical signals. Materials such as gallium arsenide (GaAs) and indium phosphide (InP) are suitable for analogue, digital, mixed analogue-digital and optoelectronic applications.

Microwaves and millimetre waves

The market for GaAs microwave and digital ICs is expected to grow world-wide at a rate over 50% per year to reach over ECU 1.2 billion by 1994. This growth is mainly concentrated in the computer, automotive, communications and broadcasting sectors of the market.

Five ESPRIT projects were launched in 1990 to address applications in the automotive, mobile communications and direct broadcast by satellite (DBS) areas. The current total of six projects make up a comprehensive programme on compound semiconductors for microwave and millimetre applications in the 1-60 GHz range.

Among these, AIMS (project 5032) is focused on applications between 20-30 GHz for short-hop land links and very small aperture satellite terminals. A range of generic monolithic microwave ICs are being developed covering transmit/receive switches, low-noise amplifiers, non-linear circuits, voltage-controlled oscillators and solid-state power amplifiers. The project has already demonstrated heterojunction field-effect transistors (HFETs) with world-class noise figures and power capabilities.

COSMIC (project 5018) concentrates on components for applications between 1-20 GHz. On the L-band, the key demonstrators are trans-impedance amplifiers for optical receivers and RF amplifier/mixer monolithic microwave ICs (MMICs) for mobile communications, global positioning by satellite applications and broadband ISDN. On the X-band, MMICs are targeted at the highly competitive market of DBS receivers. On the K/Ku-band, ICs are being developed for point-

to-multipoint communications. State-of-the-art results have already been obtained, such as the novel self-aligned high electron mobility transistor (HEMT) process implemented by Siemens (D) for devices with submicron gate length, the 2D noise FET (field-effect transistor) model established by Politecnico di Torino (I), and the on-wafer noise measurements achieved by Argumens (D).

GIANTS (project 2035) investigates a number of advanced InGaAs-based FETs for microelectronic and optoelectronic applications. The project has already met its objective of generating a secure European source of InGaAs-based FETs. Picogiga, a Paris-based SME participant, is gaining a global presence in the field of MBE-grown epi-wafers through making significant improvements in its MBE material. Important results have been obtained in quasi-2D modelling for device and circuit design. A software package, HELENA, has been developed by université de Lille (F) and is being commercialized.

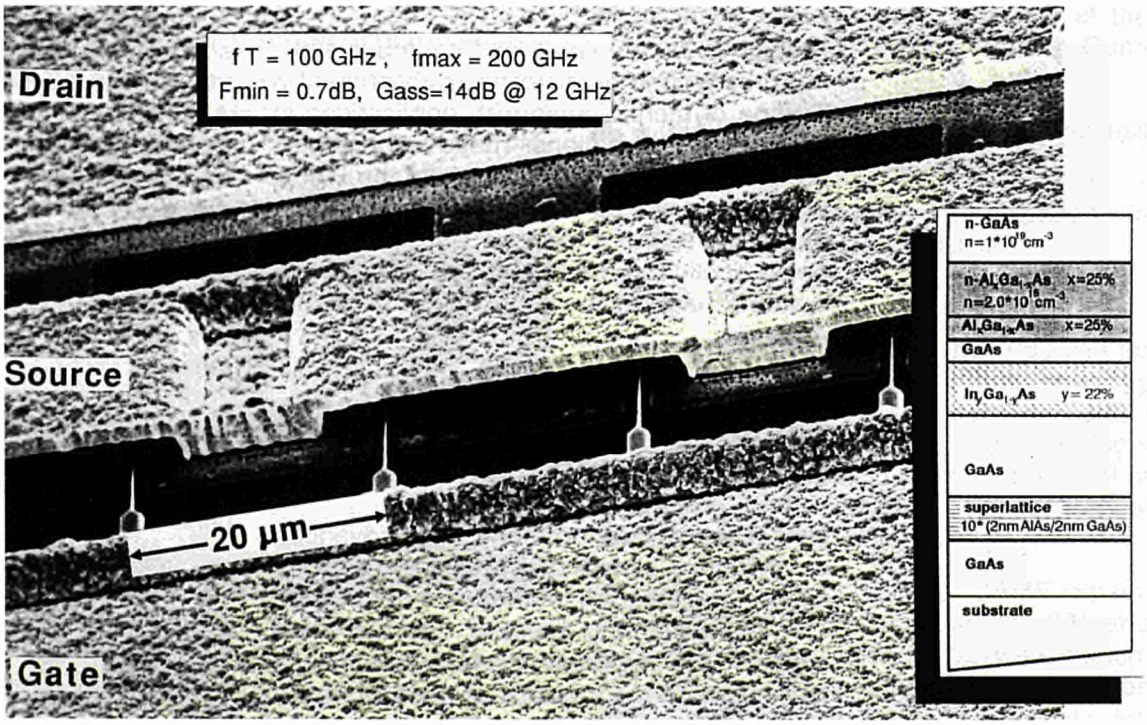
Besides this technology development work, two projects are focused on the development of very advanced III-V material deposition equipment. PLANET (project 5003) addresses high throughout, multi-wafer MOVPE reactors suitable for growing hetero-structures such as GaAs lasers and InP waveguides, and has already delivered a new 7" x 2" device to European user companies. This project is expected to further strengthen Europe's world-leading position by building on the results of ESPRIT projects 927 and 2518, which are currently being commercialized by Aixtron (D).

Today's safety and environment requirements are the concern of MORSE (project 5031). This is investigating the very promising MOMBE growth technique for the industrial production of III-V devices, and is also looking at the development of novel non-toxic precursors. Tributyl phosphine (TBP), a replacement for the more toxic phosphine, is now routinely used in this project to fabricate state-of-the-art optoelectronic devices.

Optoelectronics

The optical properties of InP make it the material best suited for long wavelength optical communications. The main application area is in the data-processing, communications, industrial and automotive sectors, where the market is forecast to double to ECU 5 billion by 1995.

Significant advances have been made under OLIVES (project 2289) in the technologies of holographic optical elements, low-loss waveguides, optical modulators, receiver arrays and component mounting for applica-



III-V devices: *a photomicrograph of a very advanced hetero-junction field-effect transistor (HFET) structure supplied by Daimler-Benz. The device, developed in AIMS (project 5032), has achieved world-class performance and is suited for applications involving very small aperture satellite terminals. AIMS is one of the core projects in ESPRIT's research into low-cost III-V based MMICs (monolithic micro/millimetre wave ICs) and appropriate CAD tools and manufacturing processes.*

tions in optical interconnections for VLSI and electronic systems. A variety of demonstrators have shown first-class results:

- Using chip-level region-to-region optical clock distribution produces a six-fold increase in clock speed. A simulation of a 1 000-node neural network shows the technique can offer a performance gain of two orders of magnitude.

- Reduction in the volume occupied by the interconnection medium, increased flexibility in the interconnection topology, and, at high data rates, an increase in the density of interconnections.

- Hybrid integration of optoelectronic components and silicon circuits, as demonstrated on a 64 MQW modulator array. Assessment of the performance of individual hybridized elements on the same design has shown the best reported results for long wavelength refractive devices.

Project 263, completed in December 1989, has greatly contributed to the establishment in Europe of technologies with applications in optical communications. These technologies are already being exploited under the RACE programme, where high-quality lasers, optoelectronic ICs and low-loss waveguides are being applied in a range of communications systems and also in optically switched networks.

Manufacturing, process equipment and materials

New technologies, no matter how advanced or innovative, cannot be exploited unless efficient manufacturing methods are employed. The manufacturing process has two main aspects: the materials support (machinery, facilities) and the logistics of their organization (automation, CAM, etc). The optimization of the overall production process in order to maximize yields and reduce unit costs is the subject of manufacturing science. In recognition of its vital importance, an ambitious project, 'Manufacturing science and technology' (project 5081), grouping together all the major European IC manufacturers, was launched in 1990. Europe has a strong position, worldwide, in materials for semiconductor manufacturing (process gases and chemicals, resists, wafers, etc.), while it is relatively weak in the domain of equipment, with only a 10% world market share in the area of wafer processing.

Lithography equipment

ESPRIT provides comprehensive coverage of all the main aspects of advanced lithography. This includes equipment, materials and the related processes for deep-UV steppers, E-beam lithography, and reticle processing and handling.

A wafer-stepper is one of the most strategically important pieces of equipment for IC manufacturers. At present, minimal feature sizes in production are in the 0.7 micron region, and are expected to reach 0.35 micron by 1995 in state-of-the-art memories, with ASIC applications following close behind. New techniques will have to be developed for lower ranges. The most promising is the use of deep ultra-violet (DUV) light, but this poses formidable problems, principally in the areas of lens optics, alignment precision, and resist materials. All these aspects are being very successfully tackled in DEEP-UV (project 2048). A prototype stepper was fabricated at ASM-L (NL), with a lens made by Carl Zeiss (D) incorporating some unique features, such as through-the-lens alignment. The system demonstrated record-beating performance in resolution, alignment accuracy and throughput, and is the most advanced stepper of its kind in the world. Several units based on this prototype have been sold to IC R&D facilities around the world.

Complementing this work, single and multilayer DUV-specific resists have been developed by Hoechst and Siemens with the close cooperation of IC manufacturers. Evaluation of the results of these projects is being performed by IMEC (B) and LETI (F), who have both acquired DUV steppers. DRYDEL (project 2265) is extending DESIRE, a single-layer resist technique, to cover the deep-UV region, whilst in the reticle generation area FREE (project 5030) has been recently launched.

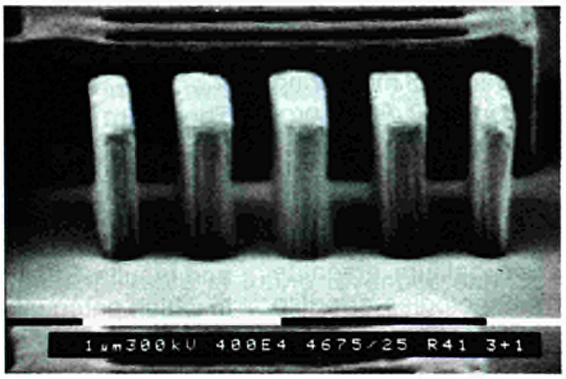
Multi-process/multi-chamber equipment

The increasingly stringent constraints on the quality of the thin films constituting ever more miniaturized ICs demands a new trend in wafer processing: the grouping together of related process steps and their sequential performance in several clustered vacuum-processing and transfer chambers. It is

estimated that with feature sizes of 0.5 micron and below, the use of multi-process/ multi-chamber vacuum-sealed equipment will be a necessity for certain critical process steps. This approach requires new equipment designs and the development of modified or new processes.

During the first phase of MCBRIDE (project 2403), which includes ASM-I (NL), LETI (F) and SGS-Thomson (I), a prototype multi-chamber reactor has been developed which allows the deposition of inter-poly ONO (oxide-nitride-oxide) films in a single integrated wafer-processing system. This equipment is suitable for the most sophisticated EPROM and EEPROM devices. This first prototype (consisting of a high-frequency cleaning module, LPCVD and oxidation reactors plus wafer handler and elevator units) has been installed at LETI for further testing and evaluation. Complementary work on process characterization and preliminary engineering of the next version of the reactor are in progress at ASM-I.

In support of MCBRIDE, PROMIMPS (project 5041) was launched in 1990 involving equipment manufacturers, users, and three research institutes. The objective of the project is to realize the integration of different processes in multi-chamber 'cluster' tools. The



0.25 micron structures *printed using ASM-L's PAS 5000/70 deep-UV wafer-stepper (developed in project 2048) in combination with the photoresist technology of project 2265. 0.18 micron has been achieved using a special mask and resist.*

application areas chosen are silicide metallization, CVD blanket deposition of tungsten, and inter-metal dielectrics.

Manufacturing science

The completion of AMS (project 1551) in December 1990 has led to the participants obtaining attractive solutions to IC manufacturing problems, particularly with respect to contamination control and yield improvement as well as in interfaces and communication protocols for IC production equipment. Further collaborative work of a more advanced nature in process automation is now being undertaken within 'Manufacturing science and technology' (project 5081) using as a basis the know-how developed in AMS. The project participants, all of them IC manufacturers, are examining each step in the IC manufacturing process in order to increase the cost-effectiveness of their VLSI manufacturing operations. The project is producing common recommendations and standard guidelines for process equipment and materials manufacturers that will also enable the latter to improve their products.

Accompanying measures

Microelectronics activities in ESPRIT also aim to stimulate awareness through the dissemination of information and the encouragement of new users, in particular SMEs. This goal is being addressed in four ways:

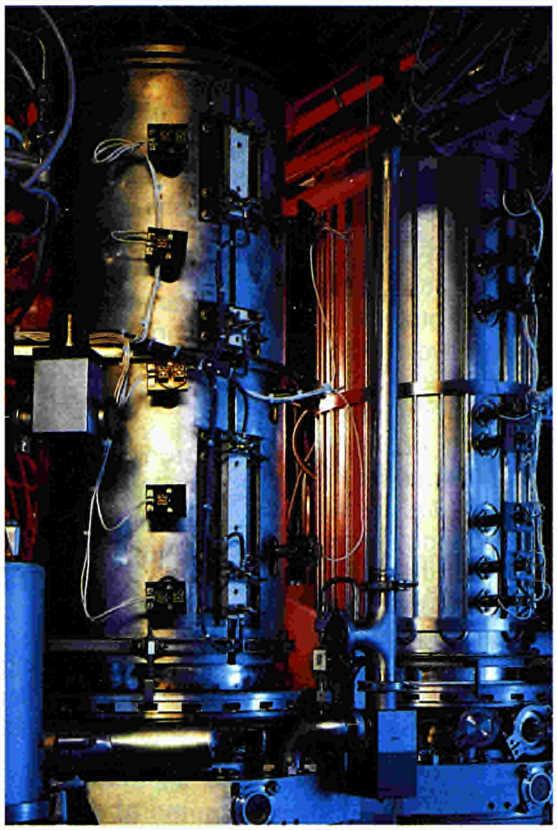
- by increasing user participation in technology demonstrators (for example, SME participation in the APBB project);
- by three special actions targeted at the more peripheral regions of the Community;
- within the Concerted technology access for SMEs (CTA-SME) special action;
- through encouraging participation in Special interest groups (SIGs).

Special actions

Following the evaluation of the 1989 call for proposals, it was apparent that specially tailored actions were needed in certain peripheral regions, notably Spain, Portugal and Greece, in order to promote the level of awareness and industrial application of microelectronic technologies.

In 1990/91 the first phases of GAME (Spain, action 5083), AICI (Portugal, action 5691) and VLSI-DPE (Greece, action 5692) were launched. Each was set up after close consultation with the respective national administration and aims to:

- encourage links and the transfer of technology from other ESPRIT microelectronics actions or projects in order to bring the organizations concerned into closer involvement with the European microelectronics R&D community;
- build on and mobilize existing resources, both intellectual and material, in the countries involved;



Multi-chamber equipment: *a view of the multi-chamber reactor developed for the deposition of ONO (oxide-silicon-oxide) layers in MCBRIDE (project 2403). The machine has been designed for use in the production of EPROM and EEPROM memories and non-volatile ASICs. With feature sizes of 0.5 micron and below, the use of multi-chamber/multi-process vacuum-sealed equipment will become a necessity for certain critical process steps.*

- promote local cooperation between research institutes, academia and industry with the objective of enabling local industry to better benefit from existing local know-how.

In the first year of operation, considerable success has been achieved in terms of mobilizing existing resources, and some 50 ASIC projects, predominantly involving first-time users, have been initiated. The application of ASICs has become a common (but not the only) theme of these actions. Additional activities in high-voltage smart power, gallium arsenide and integrated sensor technologies are also under way.

Concerted technology access for SMEs (CTA-SME)

ASICs are considered to be key to the competitiveness of European companies, especially small and medium-sized industries. However, it has been estimated that only around 2 000 of the estimated 25 000 SMEs in the Community have incorporated ASICs into their products, mainly due to a lack of awareness and training.

Measures designed to encourage SMEs in the use of microelectronic technologies are taking place or being planned in several Member States. CTA-SME (action 5084) plans to generate links between these initiatives (including the ESPRIT special actions described earlier) in order to bring about closer collaboration and the cross-fertilization of ideas.

In addition to convening workshops and setting up training activities, the pilot phase of CTA-SME is preparing (in collaboration with the relevant Member State programmes) technology transfer packages covering training aspects, documentation, design tools, component libraries, etc., and information on the market analysis, economic assessment, design and fabrication of ASICs. Initially drawing on the results of existing ESPRIT microelectronics projects, these packages will be made available to SMEs and national SME service centres throughout the European Community.

If the pilot phase, after independent evaluation, is found to have been successful, the Commission will propose the launch of a five-year action with the aim of making available a wide portfolio of emerging technologies (such as BiCMOS, non-volatile CMOS ASICs, smart power and GaAs, etc.) to the large number of European SMEs that could, as recent surveys indicate, incorporate ASICs and other microelectronics components into their products and so gain a competitive advantage in the global information technology market.

Special interest groups (SIGs)

There are now six SIGs operating in the microelectronics area. These groups have generated many reports, guidelines and *ad hoc* inter-company standards in addition to acting as a forum for the exchange of ideas and results. SIGs create the fertile conditions in which potential future ESPRIT projects are conceived. In addition to the four groups that have been operational for several years, two new ones were launched in 1990, covering reliability and analogue design issues. The SIGs currently supported are:

- CAVE (CAD for VLSI in Europe),
- VLSI manufacturing automation and standards,
- Lithography,
- Analogue circuit design,
- Reliability,
- Electronic materials.

Further details are given in the chapter on awareness activities.

Information processing systems

Overview

The Information processing systems (IPS) area of ESPRIT aims to provide a selected range of generic technologies that are critical for the development of IT products likely to come onto the market in the 1990s. The generic nature of these technologies makes them applicable to a wide range of system products, offering a real advantage to vendors and providing high value to users.

The main objective of IPS is to produce more powerful and reliable systems at an affordable cost by supporting projects in four key sub-areas: Advanced system architectures, Information servers, Systems design and engineering, and Signal processing systems. Forty-one new projects and 17 exploratory actions were launched as a result of the general call for proposals that closed in January 1990. The competition for projects was particularly strong in IPS, which received 220 proposals, half of the total submitted. This clearly indicates that European enterprises, and in particular SMEs, continue to demonstrate an appetite and a drive to invest in the development of advanced technologies that are seen as a critical source of future revenues and competitiveness.

In the course of the past 18 months, four important trends have been apparent:

- **Continuing commercialization of earlier results**

  A market is now developing for the high-performance parallel computer systems explored and developed in a number of earlier ESPRIT projects, and this has been matched by the emergence of an increasing number of European suppliers, mostly small but all now experiencing a period of rapid growth. New software products are reaching the marketplace, such as commercial implementations of the Portable Common Tool Environment (PCTE). In addition, European knowledge-based system products and companies show a sharp increase in their share of a world market estimated to exceed ECU 20 billion by the end of decade.

- **Intensified standards-related activities**

  In all sub-areas, major projects are tackling the issue of establishing standards in order to increase the range of choice available to end-users while lowering the risks and costs experienced by system developers and vendors.

- **Towards integrated systems and object orientation**

  Individual technologies and disciplines are being combined to address wider problems. For example, the drive towards a new generation of information servers relies extensively on the progressive fusion of work in advanced architectures, intelligent interfaces and deductive knowledge-based systems. Object orientation lends itself to conceptual modelling and software design methods. Similarly, object-oriented options are increasingly favoured in the development of new generations of information management systems.

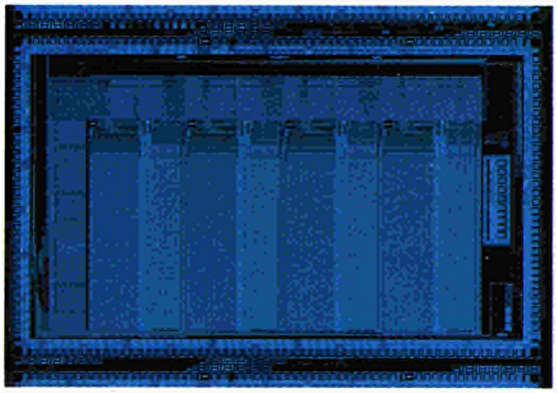
- **Excellent progress in technology transfer**

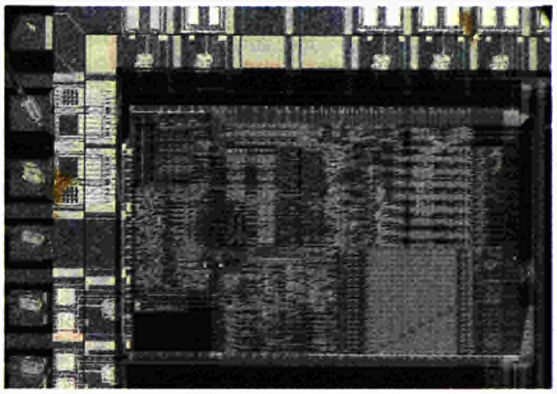
  The Parallel computing action (PCA) has enabled 55 academic and research establishments to acquire parallel systems, and over 300 researchers a year

are now being trained in parallel computing techniques.

Advanced systems architectures

Since its inception, this area of IPS has been pursued with the view that future computing needs cannot be adequately met by implementing conventional processing systems using ever-more exotic technology to increase basic clockrates and processing power. Work on highly parallel systems is now achieving dramatic reductions in cost/performance ratios, and the potential redundancy offered by multiprocessor systems is leading to ever higher levels of overall system dependability. The new generation of parallel processing systems are now offering supercomputer levels of performance at minicomputer costs, and, importantly, they are scalable, with low levels of incremental cost.





The next generation: *the T9000 transputer, launched in April this year, will accelerate the progress of parallel computing into the mainstream. Shown are test chips for the cache memory (left) and communication (right) subsystems, developed in PUMA (project 2701).*

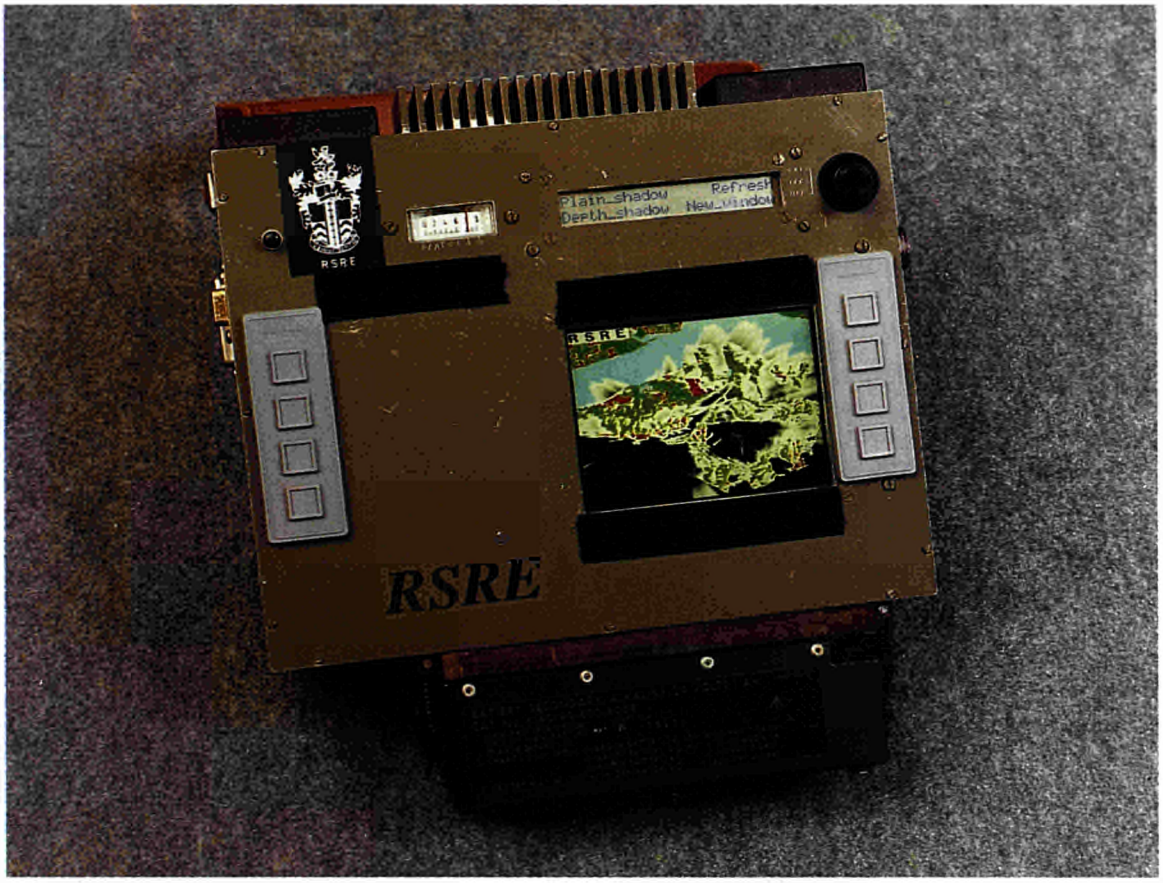
To date, IPS projects in this area have resulted in the construction of several prototype systems. An increasingly used standard component, the T800 transputer, has been developed and is now employed as the basis for a variety of commercial products. The T800 transputer, developed within SUPERNODE (project 1085), is the key component in a range of parallel systems offered by a group of rapidly growing SMEs that includes Telmat (F), Parsytec (D), and Meiko and Parsys (UK). By 1990, 240 000 T800 transputer chips had been sold, bringing sales to 400 000 units, the highest achieved for any RISC microprocessor. By 1995, the overall transputer market is expected to reach ECU 1 billion. Further improvement of the basic architecture for large-scale parallel systems and their fundamental components is now being addressed by PUMA (project 2701) and GP-MIMD (project 5404).

High-performance components show dramatic improvements

In April 1991, following the successful development of the T800 transputer in the SUPERNODE project, Inmos (UK) announced its successor, the T9000. This is one of the world's most powerful RISC processors, with a peak performance of 200 Mips or 25 Mflops, and with four 20 Mbyte/s communications channels per chip. The T9000 is aimed at low-cost architectures and works with a 5 MHz clock (compared with 33 MHz for current scalar products). Today's transputer-based products range from 25 to 600 Mflops, providing supercomputing power at one-fifth of the cost. Through continuing development, the processing capabilities of the transputer have increased more than ten-fold in three years.

Complementing the processing performance of the T9000 is a new communication chip, the C104, developed in PUMA (project 2701). A joint patent has been applied for by two of the partners, Inmos (UK) and Siemens (D). The improved communication mechanism is critical to improving the ability to scale up transputer-based parallel-processing systems, raising the number of nodes from, say, 1 000 to 10 000 in a single system. A combination of an order of magnitude improvement in basic node performance together with a further order of magnitude improvement in the number of nodes that can be deployed now offers a potential 100-fold boost to current Supernode-type systems.

PADMAVATI (project 967) explored the architecture and environment appropriate for real-time artificial intelligence (AI) applications, for example in speech and image understanding. Such applications often require a dynamic routing capability in communication and an associative capability in



SUPERNODE: *the* Mousetrap *is a prototype handheld computer, ruggedized for field use, based on a miniaturized Supernode processor module delivering 200 Mips. Developed by DRA (formerly RSRE), the* Mousetrap *system incorporates a 5" colour liquid-crystal display. In the picture, this is showing a false-colour contour map of the Isle of Wight, generated from software that simulates what a hypothetical observer could see from a particular viewpoint (black is below the horizon). An application being explored is the siting of transmitters in accordance with both technical (line-of-sight) and environmental considerations.*

data access. To meet these specific needs, a dynamic routing chip (DYNET) produced by Thomson-CSF (F) and a state-of-the-art CAM (content-addressable memory) from GEC (UK) are now commercially available. These results represent a major step forward in the development of architectures suitable for AI applications where real-time requirements must be met.

Architectures: further exploration and the need for standards

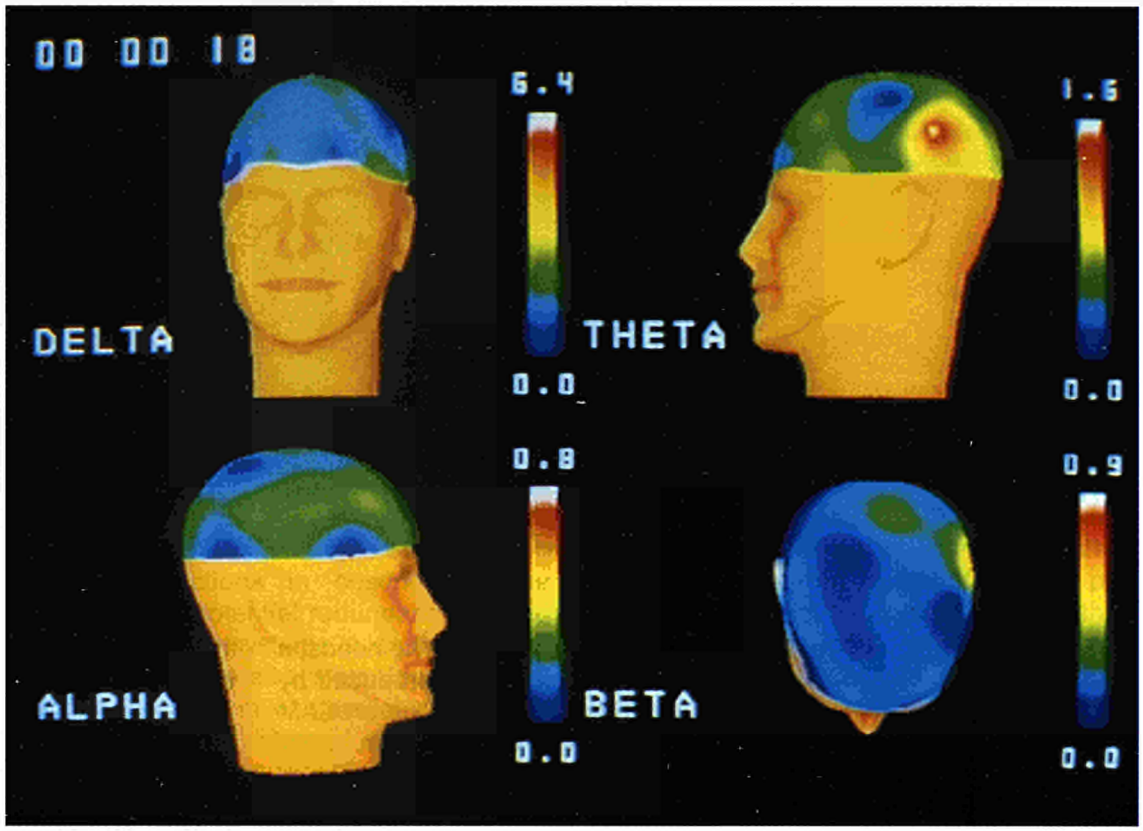
GP-MIMD (project 5404) brings together a substantial group of European organizations concerned with the development and exploitation of transputer-based systems. In addition to work designed to point the way forward to a new generation of message-passing computers, there is a strong emphasis on the development of a standard machine architecture and standard applications support interfaces. Operating systems providers Chorus Systèmes (F) and Perihelion (UK) are collaborating to provide an improved operating system environment that builds on their current products (the Chorus micro-kernel and the Helios tools and environment, providing X-Windows and Unix capabilities).

Communications are important for parallel processors and have received significant attention within IPS, with new computational models and architectures being developed. The parallel random access machine (PRAM) model is a topic of research in PUMA (project 2701) and GP-MIMD (project 5404). GENESIS (project 1041) examines the issues to be addressed for ultra-fast distributed-memory architectures, and the current phase of the project concentrates on the challenging software issues. AMUS (project 2716) is exploring the development of ultra-fast, multi-processor, scalar-processing nodes.

The growth of distributed-processor architectures offers both a challenge and an opportunity with respect to systems reliability and dependability. Both of these related issues have been addressed by DELTA-4 (project 818), where the main industrial partners Bull (F), Ferranti (UK) and SEMA (F) have an open-architecture, fault-tolerant demonstration distributed banking system for Crédit agricole and a further manufacturing demonstrator with Renault.

Software: making systems more accessible

The 1990 Call strengthened the software component in the domain of high-performance architectures with the addition of COMPARE (project 5399), which is examining basic compilation technology and aims to extend, where appropriate, the technology in tools for compiler generation for parallel machines. It joins SUPERNODE II (project 2528) as the second major software project (software issues will be the main focus for future actions in the area). SUPERNODE II has already ported a version of the Portable Common Tool Environment (PCTE) onto a Supernode system together with the world-leading standard numerical libraries from Numerical Algorithms Group (UK) and state-of-the-art simulation algorithms.



Brain waves: *Telmat's T. Node supercomputer, derived from SUPERNODE (projects 1085 and 2528), takes just one second to analyse and display electrical signals from the brain monitored by electroencephalography. The key to unlocking the processing power of parallel computers is to provide software tools that make program-writing easier, and the SUPERNODE II project is producing a range of software to meet this need.*

New approaches: neurocomputing and optical processing

To complement the tools and methods developed in knowledge engineering, which are largely based on logical representation and deduction models, new kinds of information processing, generally referred to as neural computing, have been the subject of intensive R&D activities and growing industrial interest. The neural computing approach, inherently parallel and capable of dealing with incomplete information, is expected to lead to more powerful and flexible information processing systems through the fuller exploitation of the possibilities offered by massively parallel architectures.

The approach taken in ESPRIT has been to evaluate the new technology of neural networks over a range of industrial applications, development tools and environments. These activities have been mainly carried out in ANNIE (project 2092), whose results are being delivered through a set of awareness and technology transfer actions. Another area of work aims to provide application developers with a complete software and hardware environment. PYGMALION (project 2059) delivered the MIMENICE software environment now commercially available from the Thomson-CSF (F) spin-off company Mimetics. The hardware environment is now under development in GALATEA (project 5293), where a silicon compiler for neural network ASICs is being produced.

Optical computing has the potential to play an important role in future information process-

Supercomputers: *the T.Node range sold by Telmat, spanning 30 Mflops to 4.4 Gflops.*

ing systems. The development of basic optical interconnection technologies is taking place in the Microelectronics area of ESPRIT, while the more speculative area of 'computing using light' has been investigated in COOP (project 1035) and is currently under examination in NAOPIA (project 2288). In conjunction with research on the basic technologies required to provide the appropriate range of components, the task of placing prototypes in industrial environments is under way. A hybrid acousto-optical image-processing system for parts recognition has shown promising results in COUSTO (project 866), and has been further improved in NAOPIA (project 2288) to a point far beyond the current video processing rate of 50 images/s — NAOPIA has demonstrated 1 000 images/s, adequate for HDTV-quality applications.

Information servers

Work on Information servers is aimed at overcoming the constraints placed on users by the current speed of access to computer-based information and the data manipulation and presentation facilities presently available. R&D activities in this area address the representation, distribution, availability and integrity of large volumes of complex, diverse information. The challenge is to achieve this in a way appropriate to the task to hand and the user's level of expertise. The projects concerned draw extensively on previous work on advanced architectures and knowledge engineering.

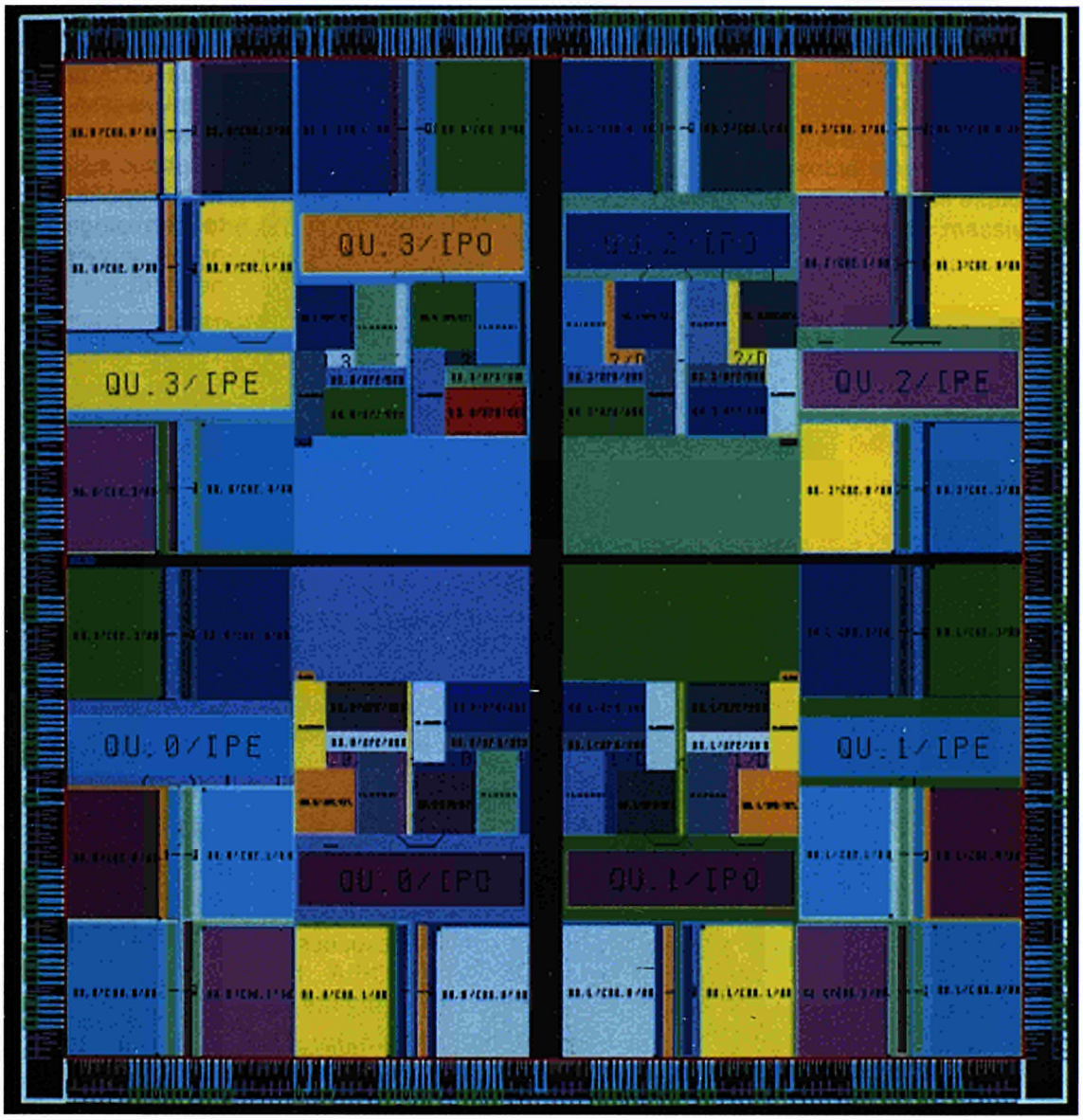
Current information management systems have difficulty in meeting the growing requirement for handling mixed-media information comprising images, graphics, speech and text. Dealing with an ever-growing volume and complexity of data is another challenge, equalled by pressure from users for more convivial ways of interacting with systems. Overall, it is estimated that traditional database systems are at present able to cope with only 5% of the total information available to the average organization. A new generation of information management technologies is needed.

These considerations have been the driving force behind this new focus of interest. It draws on work undertaken in the Advanced architectures sub-area, where highly parallel systems offer a clear potential for meeting the system performance figures required and where object management issues have been extensively explored. It also incorporates activities initiated in the Knowledge engineering sub-area, where knowledge-based approaches have been used to improve the quality of human/computer interaction and have addressed the question of increasing 'intelligence' within the information store itself.

Higher performance — the continuing challenge

Good progress towards a parallel engine front-ending a database with deductive capabilities has been made by the major project in this field, EDS (project 2025). EDS is evaluating the capabilities of the system in a selected range of commercial applications. The project has already established leading-edge results both in parallel computing, with the development of a distributed shared-store system, and in the relational database domain, with extensions to SQL. The three main commercial partners, ICL (UK), Bull (F) and Siemens (D), intend to exploit the EDS results in their future product lines.

In a complementary line of research, significant improvements in memory management have been achieved by STRETCH (project 2443). This project is concerned with systems supporting the representation and manipulation of large knowledge-bases, and the project team, coordinated by Alcatel Alsthom Recherche (F), has developed a very fast main-memory object manager and is progressing towards a full-scale demonstrator.



Information server: *the EDS (project 2025) delta network, optimized for high-performance parallel processing, is based on a 400 000 transistor ASIC designed by Siemens. Shown is the block layout for the ASIC displayed on a workstation during the chip design process. The EDS project is developing an information server to meet the challenges of handling ever-growing volumes of information and more and more complex application systems.*

Making information more available: database distribution and integration

Integration of new systems with existing databases is a key factor in encouraging IT uptake, and good progress has been made towards solving one aspect of this problem in EPSILON (project 530). The project has successfully developed an environment which facilitates the building of a distributed knowledge-based management system layer on top of existing database management systems. The system is being used for a banking application and as part of a treasury management support system, and its implementation on parallel architectures is being further explored in the EDS project.

Heterogeneity in database systems is another factor which has to be addressed, and this is being tackled by KIWIS (project 2424) and AIMS (project 5210). KIWIS has implemented a 'federation' of KIWIS nodes and is investigating interfaces to SQL. AIMS places considerable emphasis on extending traditional database functionalities in addition to incorporating knowledge components as well as methods of reusing existing information sources. Both KIWIS and AIMS draw on results from previous ESPRIT projects.

Making information more accessible: improving the utility and knowledge components

All of the above projects address, in a variety of complementary ways, the addition of 'intelligence' to the information stored within the system and advances in the manner of the interaction with the user. Further recent additions to the IPS portfolio in this general do-

main are PLUS (project 5254) and EMIR (project 5312), examining the use of linguistics to support information retrieval.

Systems design and engineering

Software and related services are already the second largest component of the IT industry and are forecast to become the dominant source of business in the course of the decade. Europe accounted for 23% of the ECU 63 billion world market for software and services in 1984, and this share is estimated to grow to 33% of an ECU 353 billion world market by 1993. Furthermore, this leading position does not take into account the activities in software development undertaken in user organizations, estimated to be an order of magnitude larger than that accounted for by the traded software sector.

Software is now clearly positioned as the major added-value component in most IT systems. Moreover, given the critical contribution of these systems to the efficiency and responsiveness of the organizations in which they are deployed, a capability to design and realize such systems in a cost-effective, predictable manner and to appropriate quality standards is vital to the future success of both the European vendor and user industries.

IPS activities in systems design and engineering have contributed substantially to methods, tools and standards that are laying a basis for a strong European capability in this domain. Work to date has demonstrated the increasing convergence of traditional software design and engineering with the newer field of knowledge-based systems engineering.

Work on systems design has focused on developing improved methods for the design of software applications, providing new tools to support these methods and establishing a standard framework within which the tools can be deployed to support project teams.

Systems design standards

The IPS-led work on a Portable Common Tool Environment (PCTE) has led to the definition of a standard which was recently (December 1990) confirmed by the European Computer Manufacturers Association (ECMA) as ECMA Standard 149. The work leading to the standard originated in a cluster of ESPRIT projects centred around the original PCTE research (project 32), and was subsequently pursued, with ESPRIT's support, through the standardization procedures of ECMA and the technical committee responsible for its definition.

The standardization work attracted wide international support and encouragement, not only from the major European vendors but also from major US players and Japanese companies. Important technical input has also been provided by the Independent European Programme Group, a nine-nation consortium within NATO, which has mounted a programme to validate the PCTE standard in terms of its suitability for defence needs. The Group will use the results of the validation activity to help with the further evolution of the standard.

An additional important contribution of this work has been a reference model for CASE (computer-aided software engineering) tools, which was also adopted by ECMA. The quality of this work has been confirmed by requests from the US National Institute of Standards and Technology to collaborate on the development of the ECMA model as the basis for their own work on reference models in this area.

The emergence of a standard and the progressive agreements on a CASE reference model are important steps in improving the market for CASE tools and environments. They provide the user with wider freedom to mix and match individual tools to suit particular requirements, and offer vendors the possibility of lower development costs as they can increasingly work to accepted interface standards. PCTE environments are now commercially available on workstations from Bull, DEC, HP, IBM and Sun. Software environments and PCTE-compliant tools are now being offered by a range of software suppliers such as SFGL, Syseca, GIE Emeraude and IPSYS.

Systems design: key contributions to software assessment

Given the significant role that software now plays, the development of objective methods of assessment is increasingly seen as an important further step in developing the market for software products. Well-founded assessment processes are seen as contributing to a more open and better relationship between customer and supplier.

After only two years of work, SCOPE (project 2151) has already delivered a number of key recommendations to European standards bodies on this important issue. The tools and process being developed within SCOPE are continuing to be applied to a wide range of case studies to give further authority and confidence to the recommendations made and to extend the range of assessment approaches and the number of products that can be assessed.

Reliability issues and safety-critical systems are topics of special importance in the field of software assessment, and these have been addressed by REQUEST (project 300) and MUSE (project 1257), respectively.

REQUEST has provided improved and validated techniques for measuring and modelling software quality and reliability, and has exchanged tools with the Alvey software library, with further agreements under negotiation. REQUEST metrics are in use in ICL (UK) to define software quality environments, in Elektronik Centralen (DK) who provide services to other Danish companies, and in other ESPRIT projects.

MUSE has progressed the state of the art in the assessment of safety-critical systems. Partners are now providing expert services, incorporating results into their own internal procedures, organizing technology transfer to wider groups, and have produced technology prototypes aimed at supporting the assessment of important classes of system. SAMSON, a prototype expert system developed by the project to help assess the quality of safety-critical systems, has already been requested for use by companies outside the consortium. ATHENA, a tool for complexity measurement and maintenance assistance, and DEMETER and MODECON, for calculating design metrics based on two simple description languages, are other important outputs from the project.

Transferring results into the marketplace has been a focus of attention in IPS, and an early achievement in this field has come from METKIT (project 2384), which has already provided enhanced tools for teaching software metrics to managers, software engineers and students. The main features include a modular course structure, computer-aided-learning (CAL) techniques, and the use of video. Future developments of the work may include the use of CD-I.

Systems design: contributions to products

In addition to the extensive range of products stemming from the PCTE actions noted above, the work on system design, especially on object orientation and software reuse, has contributed to further product offerings which are now coming on to the market. ESI (F) have used results from KNOSOS (project 974) to further consolidate their world market lead in crash simulation software. The KNOSOS techniques for software reuse are now incorporated in CRASHSTATION, a support tool for the PAM-CRASH system, used by the great majority of car manufacturers world-wide.

GSI Tecsi (F) and TXT (I) are both exploiting results from DRAGON (project 1550). GSI Tecsi is marketing the job supervisor that was explored within the project and which supports the execution of multiple Ada programmes on target systems. The improved experience with multiprocessors has served as the basis for a new real-time craft multiprocessor product. TXT is pursuing the industrial exploitation of the object-oriented language and the preprocessor developed in the project. A number of companies and consortia have indicated interest in acting as beta test-sites, and evaluation copies of the preprocessor are currently in use both in Europe and the USA.

Knowledge engineering

Knowledge engineering has been of increasing importance in the field of advanced information processing systems and is making significant contributions to systems design and engineering.

Knowledge-based systems: developing the market

A significant set of projects were established in the earlier phase of the programme to demonstrate the practical application of knowledge-based systems (KBS) to problems on a scale found in real-world applications. The aim was to demonstrate that the technology was mature enough to begin to offer solutions to a broad class of systems problems. Successful applications of the technology have now been demonstrated in areas as diverse as process control, manufacturing, diagnosis, banking, intelligent interfaces, and medicine. Using the technology is

now almost routine in many computer-integrated manufacturing (CIM) and advanced business and home systems — Peripherals (ABHS-P) ESPRIT projects. Knowledge-based systems have gained widespread acceptance.

Application demonstrators within the Knowledge engineering area of IPS have made a major contribution to the development of this market, leading to products such as SPIRITS from Syseca (F), and ESB 96, an expert system shell developed by Plessey (UK) and sold by Siemens (D). These products support the development of intelligent interfaces and are derived from earlier work done in ESB (project 96). CARMEN, a user interface builder and rapid prototyping tool sold by BIM (B), is a result of LOKI (project 107). An expert system shell based on EMG (project 599) is commercially available from the start-up company Hugin, and SPIRAL, a Prolog program environment for safety-critical application areas based on work in ALPES (project 973), is available from CRIL (F).

The need for an engineering approach

With the rapid acceptance of knowledge-based systems (KBS) technology as a significant source of adding value to more traditional software systems, the development of methods and tools to support the building of well-founded knowledge-based systems has become an R&D priority. Several IPS projects have made important contributions to this end.

A methodology for the critical knowledge acquisition phase of knowledge engineering has been provided by KADS (project 1098). This methodology, now marketed by the commercial partners, has attracted the attention of other companies such as Arthur Anderson and IBM, both of which are adopting KADS as a standard methodology. Academic partners have established broad-based technology transfer actions and supporting tools, including the object-oriented graphical language, PCE, developed by Universiteit van Amsterdam (NL), and the Shelley workbench. These are now on the market both in Europe and the USA. The KADS results have also been used by two projects led by CAP Gemini (F). ACKNOWLEDGE (project 2576) is aimed at the construction of a knowledge engineering workbench to provide an integrated environment for knowledge elicitation and acquisition, and KADS II (project 5248) aims to extend methods to support the full life-cycle of KBS projects and will examine the issues of integration with software engineering tools and techniques.

Engineering specific applications

Work has also been directed at the engineering of more specific KBS systems, such as those that are distributed or have to meet real-time constraints.

KBS-SHIP (project 1074) is concerned with engineering distributed, cooperating systems. Coordinated by the Danish Maritime Institute, it aims to help bridge and engine-room officers carry out duties ranging from voyage planning to alarm-handling by providing a decision-support system and a standard framework for integrating shipboard data communication and information systems.

The novel KBS-SHIP approach is to combine artificial intelligence techniques with operational analysis methods to help with drawing up plans for voyages, alarm diagnosis and handling, and in preparing maintenance schedules and loading plans. A computer-based systems manager supervises the communication and collaboration of the individual systems, drawing on the support of individual expert systems, which include one storing all the relevant regulations governing the operation of a complex ship. Other subsystems include the expert voyage pilot (EVP) and expert loading system (ELS). The voyage planner has been demonstrated, is currently on sea trials, and is being commercialized by Krupp (D). An expert system product for machinery operation, stemming from the same project, will be available from Søren (DK).

Real-time issues are being addressed in AITRAS (project 2167), which is building a system shell and design tools for the real-time analysis of instrumentation signals. Prototype system components have been completed and are being tested on a number of safety-critical applications, including the non-destructive diagnosis of faults in nuclear steam generator turbines. Project partners Laborec (B) and Tecnatom (E) have exploitation plans for both the industrial applications and the tools and techniques with which the applications can be built, while partners Cognitec (F) and AI Systems (B) are using the techniques in other products.

Developments in constraint logic programming (CLP)

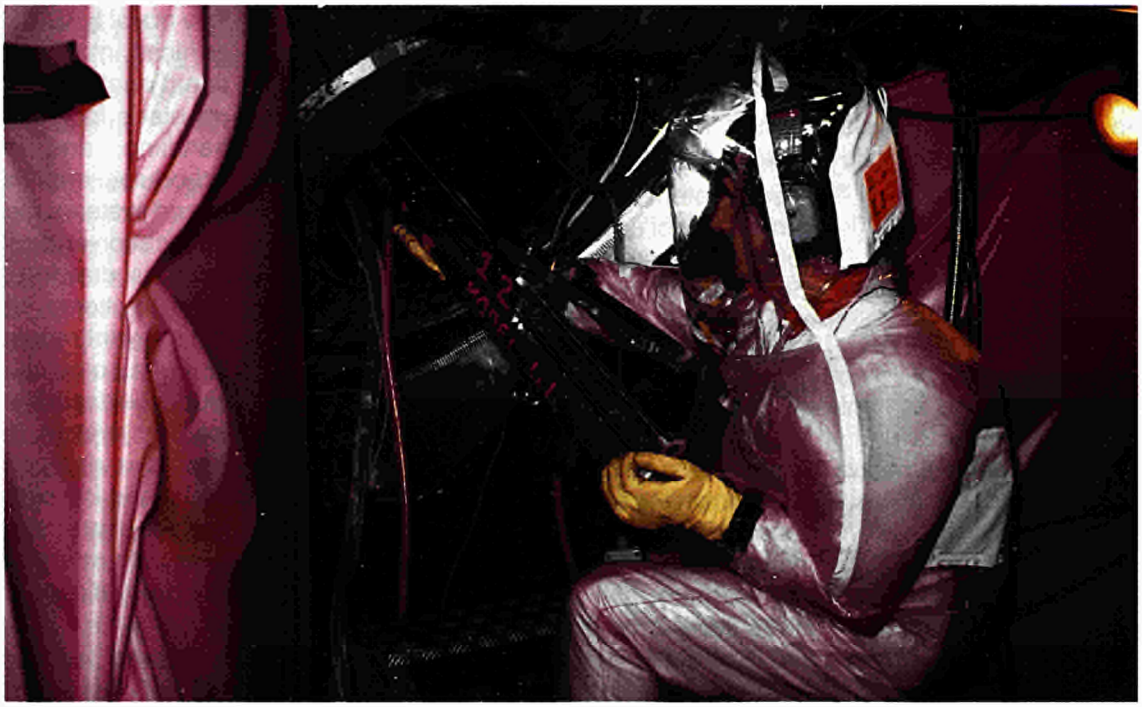
In addition to the advanced engineering concerns discussed above, other R&D in IPS ensures continued support for the further development of technology in areas of broad potential and wide application. Constraint satisfaction is one example, where the close integration between numeric and symbolic processing has already provided manageable solutions to problems that have hitherto presented major combinatorial difficulties. Application domains as diverse as production planning, VLSI design, diagnosis, financial systems, logistics and network management have all been shown as areas where the application of CLP has the potential to offer significant benefits.

ESPRIT has contributed substantially to establishing Europe as a source of leading-edge competence in the CLP domain. The Prolog III product from Prologia, derived from the work on PROLOG III (project 1106), incorporates strong constraint resolution capabilities. It is currently the most widely-used CLP tool available world-wide, with more than 300 licences already sold. Furthermore, the user partners in the project, Daimler-Benz (D) and Robert Bosch (D), now plan to continue to exploit CLP techniques internally for diagnosis and testing and for CAD. The application domains are being further developed in CHIC (project 5291) and the supporting technology in PRINCE (project 5246).

Further moves towards systems engineering

A significant step towards defining a common systems engineering model suitable for a wide range of applications has been made with the completion of the definition stage of ATMOSPHERE (project 2565). This major project extends the concepts and approaches developed within software engineering to embrace the full set of systems engineering requirements. It aims to integrate key aspects of CAD, CAE and CASE support, using existing technologies (such as PCTE) where appropriate, and to establish an architectural framework and supporting integration technologies to ensure that the ATMOSPHERE tools and environments are open and well integrated. The project brings together many of Europe's leading CASE and system engineering players. 'Proof of concept' demonstrators have already been developed, and the major partners aim to build well-engineered environment demonstrators addressing four important application areas:

- aerospace systems and distributed systems, using a framework integration approach;



Signal analysis: *an operator installs a remote-controlled manipulator to inspect a steam generator tube in the DOEL-II nuclear reactor in Belgium. The signals delivered by the manipulator will be analysed by a system stemming from AITRAS (project 2167).*

- digital computer network systems, again with a framework integration approach,
- communications systems, with a toolset-driven integration approach,
- process control systems, with a combination of toolset- and framework-driven integration.

The environments will all be piloted and evaluated through the involvement of systems engineers in selected partners' products divisions. Environments and toolsets resulting from the project are planned for subsequent commercialization by partners, as is a substantial programme of technology transfer.

The progressive intersection of system design with knowledge-based systems engineering has reached a point where it is beneficial to treat further developments as a joint set of actions. The focus in future will be on systems engineering techniques.

Signal processing systems

This sub-area of IPS R&D exemplifies, above all, the need for a true systems engineering approach. Signal processing projects draw extensively on the technologies of knowledge engineering and advanced architectures, build complex software and hardware components, and engineer their overall integration into major IT systems.

The work is concerned with systems where large quantities of complex, external-world data have to be recorded and handled in real-time, and focuses on the provision of 'automatic' interfaces that enable a computer system to respond promptly to external stimuli. Such systems are the critical components of applications involving speech recognition and vision applications, and they are finding their place not only in industrial applications, such as robotics and inspection, but also in medical imaging, environment monitoring, and systems to aid the handicapped.

Two major application areas are covered in IPS signal-processing work: vision and speech understanding.

Vision systems: 'open architecture' standards

Computer vision systems are increasingly becoming the high-value component in systems that address applications such as surface inspection, parts recognition, quality control, testing and measurement, and tracking. As the more rapid deployment of such systems is greatly impeded by comparatively high system and development costs, it makes economic sense to aim for the establishment of more cost-efficient standard interfaces and components. ARVISA (project 5225), launched as a result of the last Call, brings together major European vision systems organizations committed to achieving practical standards for the interfaces, protocols and software components that will comprise the vision systems likely to be on the market over the latter part of the decade. ARVISA is seen as a project of strategic importance.

Scene understanding: technical challenge and major market opportunity

A current major weakness in systems designed to understand scenes is the comparative lack of machine-readable knowledge concerning the information needed to process images. MUSIP (project 2316) has built a prototype image database combined with a knowledge-based scene-understanding workstation and powerful data-handling facilities. The prototype is currently being validated on a medical imaging system and a remote sensing application concerned with flood and deforestation monitoring.

In this same area, SKIDS (project 1560) has demonstrated a system that can merge numeric and symbolic data and is able to reason about the scene under observation. SKIDS has developed the principles of a generic architecture for multisensor integration, with particular emphasis on two classes of application: mobile robots, where the sensors are grouped together but the environment is unknown, and wide-area surveillance systems, where the sensors are distributed but fixed. The latter can be used for monitoring offshore oil-fields, nuclear plants and airports.

The results of the work are now being integrated into a surveillance system in VIEWS (project 2152), which will extend the 'understanding' capability to encompass moving scenes, with applications at airports and in motorway traffic control.

Speech: excellent progress in setting quality assessment standards

Many of the key European speech organizations have come together in SAM (project 2589) to define standards for the assessment of speech synthesis and recognition systems. Until recently, access to a systematically recorded set of data has been highly restricted, and this has inhibited the development of quality speech system components. In 1991 SAM established the first multilingual database, consisting of a set of 16 CD-ROMs containing speech recordings in eight European languages, along with recognizer tests and scoring protocols. This database now represents a major European asset. Standardized hardware definitions and software support packages have been developed, providing uniform facilities for database acquisition, annotation and management. The SAM standards are already in use in Europe and North America, and the SESAM workstation has been accepted as a reference.

Future speech products

The provision of a common testbed for speech technology applications is a key component in the progress towards the achievement of an increased volume of speech applications. This is one of the aims of SUNSTAR (project 2094), which has developed an operational dialogue design tool. SUNSTAR focuses on the development of human/computer interfaces based on speech input and output, and is aimed at the professional office and public telephone network environments. The project concentrates on the integration of existing technologies, with the tools currently in use for developing three major application demonstrators combining both speech understanding and synthesis. SUNDIAL (project 2218) is also concerned with methods of using speech in the human/computer interface, and is developing the technologies of continuous speech recognition and understanding. The application prototypes planned are interactive information services, including a hotel vacancy database (Italian), and a flight enquiry and reservation system (English and French).

A multilingual dimension is contributed by POLYGLOT (project 2104) through the provision of a text-to-speech/speech-to-text system for six European languages. An automatic language identifier for five of these languages has already been demonstrated, and two medical dictation systems developed, for radiology (in Italian) and pathology (English).

Awareness activities

Parallel computing action (PCA)

IPS has made a considerable investment in technology transfer in the parallel computing area. Following a competitive call for proposals, the Parallel computing action (PCA) has now established systems in 55 academic and research establishments throughout the Community. An additional 20 institutions are invited to participate in twice-yearly information workshops. The Inmos (UK) T800 transputer is the basis of most of the research vehicles in the selected projects. As a result, some 300 researchers per year are now given exposure to, and training on, parallel systems. This is a considerable contribution to widening the European skill-base necessary to push forward development in this area.

ESSI: European systems and software initiative

Considerable attention has also been devoted to the planning of a major European systems and software initiative (ESSI) that aims to secure a sharp increase in the productivity and capabilities of system and software engineers by encouraging the take-up and use of modern system design and production techniques. SMEs will receive particular attention.

The background to ESSI lies in the continuing trend for European companies to become more and more dependent on information technology to achieve and maintain internal efficiency, quality of service and competitive edge. Information technology systems are extremely software-intensive, yet the complex software needed is difficult to specify and design, costly and time-consuming to develop, and are not easily tested before use nor subsequently maintained. Moreover, most system designers and programmers employ tools and methods developed some time ago, though more recently developed techniques can provide significant gains in productivity and quality. These factors have led to an acute crisis of supply, which ESSI will address in three main ways:

- *Application experiments,* by supporting the critical testing and evaluation of advanced methods and tools. The intention is to reach system and software project leaders, opinion-formers in a position to introduce and foster the use of new techniques.
- *Training,* with activities aimed at establishing the better understanding and acceptance of the best methods and tools available, underpinning this with provision for the upgrading of existing skills.
- *Dissemination,* with Community-wide awareness and dissemination activities to link communities of developers and assist the rapid transfer of new and proven tools, methods and services into the marketplace.

A pilot phase will be launched as part of the new phase of ESPRIT, beginning later in 1991 with the selection by open competitive tender of an ESSI service organization responsible under contract to the Commission for the day-to-day administration of the initiative.

Special interest groups (SIGs)

IPS has encouraged the formation of a number of Special interest groups (SIGs) among partners of IPS projects. Current SIGs are active in:

- LISP,
- Vienna development method (VDM) and formal methods,
- Metrics,
- European Languages Standards Group for MIMD computers,
- Software maintenance.

Advanced business and home systems — Peripherals

Overview

Objectives

The products and services of the IT industry have become essential elements in improving productivity, flexibility and competitiveness throughout business and public administration. In industrial and commercial enterprises IT investments are instrumental in generating revenue. The IT user industries rely on advanced business systems to implement timely solutions and address the business opportunities in an ever more competitive marketplace. The Advanced business and home systems — Peripherals area (ABHS-P) of ESPRIT is developing key technologies, applications and services for this very broad market, which had a global turnover of ECU 700 billion in 1990, ECU 175 billion of which was within the European Community. By the year 2000 this is expected to reach 10% of Community GDP.

ABHS-P brings together the major IT companies, leading-edge users and small and medium-sized companies (SMEs) to create IT system solutions based on the concept of open systems. The aim is to enhance the competitive strength and efficiency of the European Community through the provision of easily implementable multivendor systems based on the ISO standard for Open distributed processing (ODP) and the support of multimedia (sound, text, graphics and images) through a European family of advanced workstations and peripherals. Work in ABHS-P has significantly influenced the relevant international standards and is helping to ensure reliable, affordable and customizable systems for all types of business users.

An additional and complementary area of work is that of open systems for homes and 'intelligent' buildings. In this area, too, a major impact has been made on standardization. Home automation lags behind business automation by several years, but it is expected to be a major market for IT companies in the future. ABHS-P aims to put European IT companies in a position to exploit this trend through the provision of systems and services that will bring an improved quality of life for Europeans both at work and at home.

The work carried out has received strong support from the major IT companies in Europe, and has also been successful in involving a wide range of other enterprises, including public administrations, private user organizations and academic research groups. Particular encouragement is being given to SMEs to participate in and benefit from the research. In connection with this, SMESPRIT (exploratory action 5639) was set up in 1990 to investigate the feasibility of an integrated computer-based system for supporting IT planning in SMEs.

133 projects and exploratory actions have been launched within ABHS-P to date, focused on three main themes providing:

- integrated systems for business,
- integrated systems for homes and intelligent buildings,
- advanced peripheral subsystems.

In addition to these, a major new initiative has been launched in open microprocessor systems.

Integrated systems for business

Integration with flexibility has become a key customer requirement in information

technology world-wide, particularly in Europe. User organizations are actively seeking solutions to the problems created in the past by building systems based on incompatible products supplied by different vendors. Users need to protect their existing investments while moving towards more advanced systems that better integrate the functions of different parts of the organization. R&D in ABHS-P is making significant contributions to affordable, reliable European solutions. Major European IT companies and user organizations are involved in projects which are exerting a strong influence on international standards and laying the basis for competitive European products.

During the past 18 months advances have been made in several key areas including distributed systems, the exploitation of ISDN, information management technologies, CD-ROM, and workstations. Significant results have been achieved in integrating the various technologies required in advanced business applications, and in developing the necessary environments and tools for building advanced applications including multimedia applications. Finally, several projects have made contributions towards facilitating the uptake of IT in organizations and to ensuring that the development and use of IT systems is consistent with improving the quality of life as well as the efficiency of business.

Integrated systems for homes and intelligent buildings

During the 1990s, the impact of IT will extend well beyond the boundaries of business applications. IT promises to revolutionize the home and public buildings. Home appliances, linked under the control of microprocessors and connected to the outside world, will be able to provide an entire range of new services and perform at levels never before possible. Buildings will incorporate sophisticated networks capable of providing a broad spectrum of services such as personal security, energy management, heating, lighting, control of appliances, health monitoring, entertainment systems, educational facilities and working from home. IT components will be incorporated into both brown and white goods (for example, music systems and dishwashers) so that these can become integrated into the home electronic system. Companies manufacturing such goods will need to adapt to these changes in order to remain competitive. Until recently, the USA and Japan were leading this field, positioning their industries ready for the new markets that are already opening up. However, the R&D undertaken in ABHS-P has now put European industry firmly in the lead by fostering collaborative research amongst European companies to define, validate and promote European standards for the interoperability of home systems products.

Advanced peripheral subsystems

Peripheral subsystems are essential in a wide range of IT domains, including systems for businesses, homes and intelligent buildings. In order to concentrate funding on a closely coordinated set of key projects, peripherals R&D, previously divided between the areas of Microelectronics and Office and business systems, was consolidated in 1990 into ABHS-P.

The European IT industry faces very strong competition in regard to peripherals but has particular strengths on which it can build; R&D in ESPRIT needs to be highly focused on the key trends in this field. The past year and a half has seen the first consolidation of work on peripheral devices and the start of work on peripheral subsystems. Significant results have been achieved, including products based on the work done in the field of flat-panel displays. In addition, building on earlier results, several projects dealing mainly with materials for recording devices and liquid crystal displays (LCDs) have reached a stage of development where it is possible to build prototypes for demonstration in 1992. Exploratory actions have also been launched in memory and printer subsystems to define the profiles and characteristics of further key European initiatives in these fields.

Building strength in open microprocessor systems

Microprocessors have become very widely used in many areas, and in order to facilitate the building of competitive European IT systems around them, a new initiative has been launched, the Open microprocessor systems initiative (OMI).

Integrated business systems

The last year and a half has seen major product announcements from the European IT in-

dustry based on ESPRIT R&D results achieved in integrated business systems and their underlying technologies. A key element in this success has been the strong emphasis on open systems.

Leading the way in distributed systems

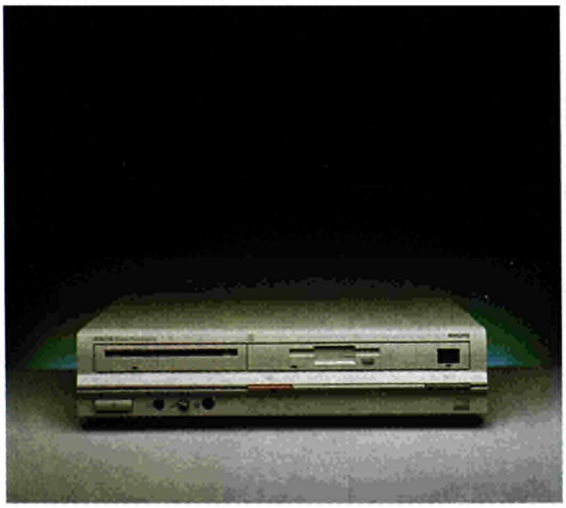
The value of ESPRIT's strategic orientation towards open systems was exemplified by Bull's major product announcement, in March 1991, of its Distributed Computing Model. This incorporates the commercial exploitation of results from eight different ESPRIT projects, six of which are in the ABHS-P area, including COMANDOS (projects 834 and 2071). In addition to its contributions to the Distributed Computing Model, COMANDOS has also enabled Bull to play an influential role in industry standardization bodies such as the Open Software Foundation and the Object Management Group.

ISA (project 2267) has also made significant contributions to standardization, having provided more than half of the text of the current ISO draft standard on Open distributed processing. It has also led to the development of the very successful ANSAware suite, giving Europe a world lead in the field of heterogeneous distributed systems. ANSAware is available on licence through APM (UK), and has been adopted by NASA to support its distributed astrophysics data system, the largest distributed system in the world, with around 600 nodes, 50 databases and 10 000 users. A demonstration at the 1990 ESPRIT Conference exhibition showed the system working with five different makes of computers online in Brussels and via satellite links to the NASA system in the USA.

The market for distributed systems is forecast to grow tenfold to reach ECU 73 billion worldwide by 1995. The work done under ESPRIT has reinforced the excellent reputation which European companies and research institutes (such as Trinity College Dublin) have in this field, helping to ensure that European industry will be in a good position to compete for a significant share of this rapidly emerging market in Europe and world-wide.

Exploiting the communications infrastructure

Value-added services are an important IT market, and work in ABHS-P is helping to provide a competitive base for European companies. Results from MIAC and MIAS (projects 1057 and 2684) represent a European breakthrough in developing a framework of standards for controlling and using the Integrated Services Digital Network (ISDN). ISDN is one of the most important developments in telecommunications, enabling voice, data and video signals to be efficiently transmitted using the existing telephone cables, making high-quality communications widely available to business. The results of MIAC and MIAS will help European companies to exploit the potential of this new infrastructure to the full. A demonstration at the 1990 ESPRIT Conference exhibition showed people in different offices working cooperatively on a common task using moving video images to see one another on screen while exchanging fax messages, accessing databases and editing text.



'Interactive' CD: *Philips's single-unit CD-I system for professional applications; the CDI 602, is pictured left. A European launch for the mass market version, shown on the right, is scheduled for 1992, following its introduction in the USA and Japan this year. The CD-I concept was developed in DOMESDAY (project 901).*

The workstation of the 1990s: *producing multimedia products requires so-called 'authoring' workstations, such as the Olivetti CP 486, here pictured on the left, while users need a low-cost 'delivery' workstation, such as Acorn's R260, shown on the right. Both were developed in MULTIWORKS (project 2105). The CD-ROM, centre, is the publishing medium. The aim of MULTIWORKS is to develop an office workstation that allows the manipulation of video, graphics, voice, sound, and text, and their combination in one multimedia document with facilities comparable to those now available in desk-top text-plus-graphics publishing systems.*

In a complementary line of R&D, DAMS (projects 1059 and 2146) has made significant progress towards a prototype distributed PBX capable of integrating circuit-switched and packet-switched services within the business environment.

Multimedia concepts

New concepts which combine direct user interaction with multimedia storage, based on CD-ROM technologies, are finding their way to the consumer electronics area. CD-Interactive (CD-I), to be introduced by Philips in the USA at the end of 1991, offers people the possibility of hypermedia-type interaction through their television sets with text, graphics, audio and video information. Although the product looks quite different from the DOMESDAY prototype, the concepts (i.e. putting the multimedia data and the access program required on the same CD) were developed in DOMESDAY (project 901). CD-I uses ISO standard 11172 developed by the ISO MPEG group drawing on the work done in COMIS (project 2102).

CD-ROM looks set to become a widely used storage medium during the 1990s. Work in project 2499, CDR, is developing an advanced, flexible workbench for fast and cost-effective development of multimedia CD-ROM applications. A first complete version of the workbench was demonstrated at the ESPRIT 1990 Conference exhibition, with the first commercial release scheduled for 1991.

Supporting document exchange

In the past, when a document created using one word-processor has been passed to another, its format was lost or disrupted. What is needed is a document standard to which different document creation packages all adhere, so that each package can recognize the structure of documents created by another. ESPRIT has helped to fund development of the Open document architecture (ODA), which is now a member of the OSI family of standards and has been adopted by leading European IT companies. ODA products are now available from many leading European companies including Bull, Siemens, ICL and British Telecommunications.

A number of these were shown during the 1990 ESPRIT exhibition and the first ODA

Symposium, which took place simultaneously in Paris. A joint demonstration showed the exchange of ODA multimedia documents (incorporating both graphics and text) among six different sites in four countries.

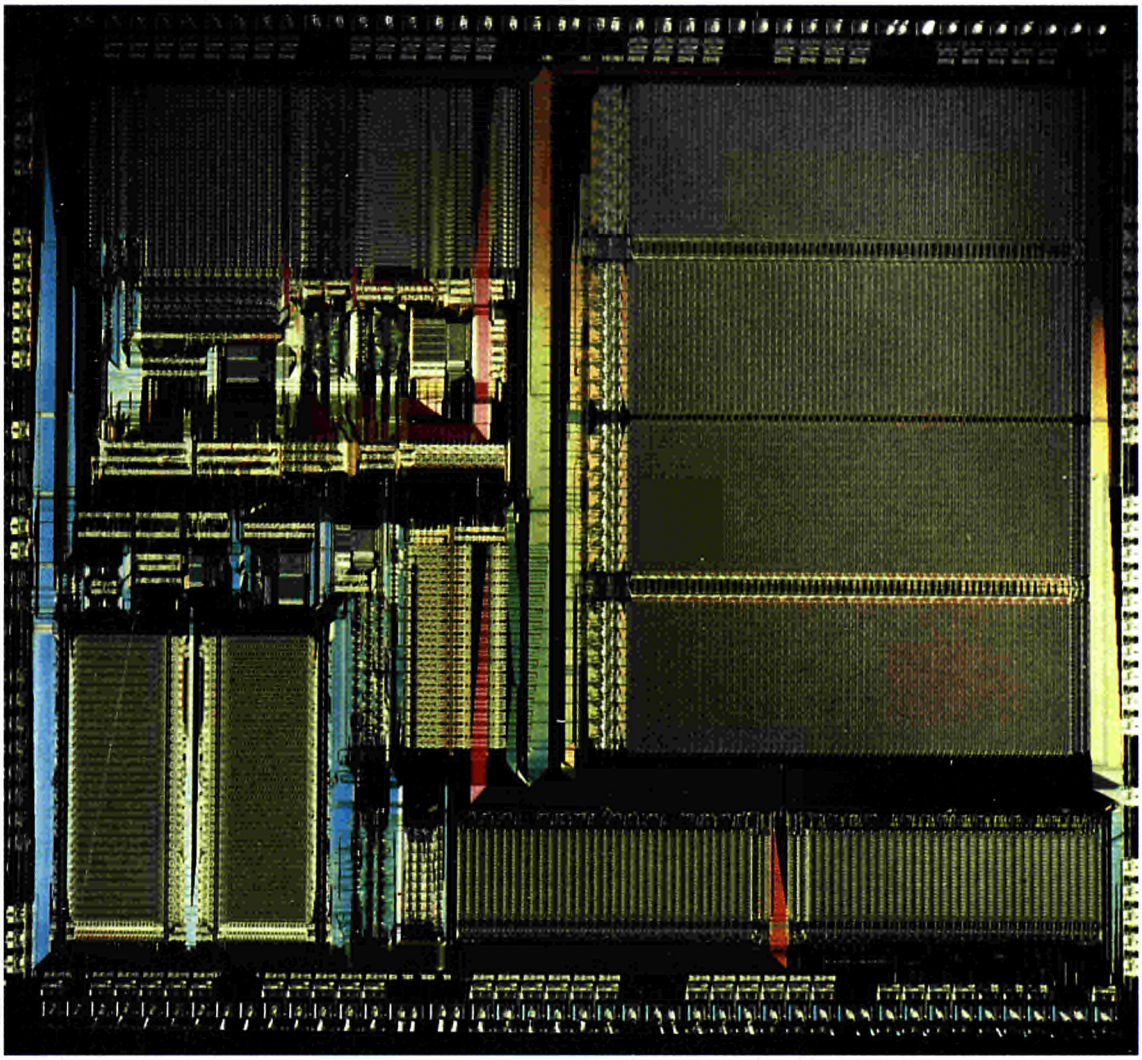
Providing powerful, user-friendly workstations

Workstations are the end-user's key to open systems and the principal interface for advanced applications, including multimedia and support for cooperative working. The market for workstations has been steadily rising, and is expected to reach ECU 9 billion in 1994 in Europe alone. To date it has been dominated by American products, but the research done in ESPRIT is now putting European industry in a strong competitive position. Significant results have been achieved across a range of workstation types, notably multimedia workstations for the general office (MULTIWORKS, project 2105), scientific workstations (EWS, project 2569) and very high performance technical workstations (SPIRIT, project 2484).

MULTIWORKS provides high bandwidth at all levels so that the workstations can handle video, voice and sound as easily as today's systems handle text and graphics. Users are able to interact with the system using traditional methods such as keyboard and mouse, and newer methods including handwriting and speech. The project is producing two types of workstation: one intended for applications development, and another for the end-user. Prototypes of these were shown at the 1990 ESPRIT Conference exhibition.

Some products have already benefited from the work, with major product developments scheduled for 1992 and beyond. The Acorn R260 workstation uses technologies developed under the project, including the MEMC2 memory controller which significantly improves memory handling. A high-end knowledge engineering development system has been completed and is being commercialized through an agreement to market it with Lispworks. An enhanced multimedia editor based on the earlier Raphael and Balzac developments has been completed. An ISDN bit-rate adapter component developed under the project is now offered as a standard component by SGS-Thomson, and interest in it has been expressed by telecom-

Multimedia production: *a screen from Olivetti's IM-AGE upgrade kit for Olivetti PCs, stemming from work in the MULTOS and MULTIWORKS projects. Full-motion video, photographs, animations, and stereo sound can be combined to produce, for example, business presentations, interactive training packages, and point-of-sale displays. Features include the control of multimedia peripherals such as video disc players and cassette recorders, the capture and editing of still images from video sources, and editing streams of video images.*



High processing power: *the latest version of Acorn's RISC microprocessor, the ARM3, pictured here, has high (15 Mips) processing power and low (0.4 watt) power requirements, making it an ideal choice for mobile equipment. This microprocessor was developed in MULTIWORKS (project 2105) and forms the CPU for Acorn's R260 machine. TELESTATION (project 5233) is using a version of the ARM3 in its work on portable workstations.*

munications companies. In addition, the YUV-to-RGB colour-space converter chip developed under the project is now offered as a standard component by Philips.

The project has also contributed to the establishment of a new company, Advanced RISC Machines Ltd, a joint commercial venture involving several IT companies (including Acorn and Apple) in exploiting key results from MULTIWORKS, including the ARM RISC processor. In addition to supporting extremely high performance desktop machines, the ARM architecture is well-suited to hand-held and low-power applications. The ARM3 chip was funded through MULTIWORKS and forms the CPU for the Acorn R260 and A540. Thousands of these machines have been sold since their launch in 1990, complementing the large installed base of over 130 000 Archimedes computers already in use. An upgrade card containing the ARM3 for R140 owners has also proved popular, and besides Acorn, the chip has been used by Radius, an American company, for their graphics accelerator card, which plugs into Apple computers. Overall, more than 150 000 ARM processor units have been sold to date.

TELESTATION (project 5233), which uses the ARM microprocessor, is integrating and extending developments in portable workstation design, including multimedia user-interfaces and application architectures, to provide a prototype portable workstation with integrated communications. Results are expected to be used in commercial products announced before the end of 1991.

While general office workstations are of increasing importance in business, scientific workstations play a major role in enhancing the productivity of engineers and scientists. Results achieved under EWS (project 2569) are helping European companies to offer a range of competitive products. The first workstation product shipments based on EWS

are expected in early 1992. The project has already formed the basis for both hardware and software products including an object-oriented database running under the distributed operating system CHORUS, an innovative geometric modelling system, and a multiprocessor system for use in electronic simulation accelerators.

Very high performance technical workstations are needed for use in technical and engineering offices and other environments where performance is of paramount importance. SPIRIT (project 2484) has been working on producing a platform for a European technical workstation based on a tightly-coupled shared-memory multiprocessor system with Futurebus+ as the central standard. Some versions of the hardware and software components have been implemented on the industry standard VME bus and are now marketed by the industry partners.

Further exploitation of the results of both EWS and SPIRIT is planned by a consortium of companies formed from the projects. The initial products will be derivatives of the basic workstation (BWS) developed by GIPSI under the EWS project. The companies currently involved include GIPSI (F), Grupo APD (E) and Kontron (D).

In order that users may find the European 'family' of workstations attractive to work with, special emphasis has been put on advanced user interfaces. These exploit the human factors results of several ESPRIT projects, particularly HUFIT (project 385). HUFIT's results are also being used directly in various commercial developments: for example, the Dialogue Manager, a development tool for building multimedia user-interfaces, has been developed by a spin-off company, ICIA GmbH, and licensed to several major IT companies, including Hewlett-Packard.

Meeting the application needs of enterprises in the 1990s

Work in ABHS-P is providing European application solutions across a diverse range of domains and in so doing has generated generic models and prototype solutions that can form the basis for applications in many market sectors.

Managing paper-flow. The results achieved by ASTRA (project 831) and PROMINAND (project 878) on managing the flow of paper through organizations have led to commercial product developments which have now begun to appear on the market. The Olivetti IBIS family has made significant use of the research results. User organizations will also benefit from a manual of IT uptake guidelines. In addition, the work has laid the ground for further developments within PANDA (project 5432). Developments similarly linked to case handling made in IWS (project 82) are being exploited by Bull (F) in their IMAGE WORK system.

Improving access to information. There is a pressing need for systems that can reduce information overload by guiding users to the items most relevant to them. Three projects have produced particularly notable results during the past 18 months. Nokia Telecommunications is using results from SIMPR (project 2083) to enhance the efficiency of access to technical information about their digital telephone exchanges. KIM (project 5638) has been applying knowledge-based systems technology to enable users to retrieve information from different systems without having to learn different query languages. Results are being exploited in ESA (European Space Agency), and other agreements with industrial organizations in Europe have been completed. MULTOS (project 28) has developed an automatic classification system for retrieving multimedia documents according to their semantic content. Results from this project are being used in a range of Olivetti's products.

Managing responses to emergencies. It is essential that emergencies are managed as effectively as possible with the resources and management techniques available. ISEM (project 2322) is developing a prototype toolbox as part of an overall methodology for developing distributed systems capable of handling international emergencies such as nuclear emergencies, major oil spillages and natural disasters, and during 1990 produced two prototype components, now being integrated into a full emergency management system. A prototype for the nuclear industry is being installed at Tecnatom in Spain, and one for the chemical industry at Kommunekemi in Denmark. The results of ISEM work are also being commercialized in a product marketed in the USA.

Overcoming language barriers. Both in business and in public administration, language barriers are obstacles hindering effective cooperation among organizations in

the different Member States. One aspect of the problem concerns the sharing of technical information. Here TWB (project 2315) has developed a leading-edge translator's workbench, designed to meet the needs of professional translators.

TWB has been effective in stimulating several important commercial developments. Triumph-Adler is releasing a PC-based translation support system running under MS Windows. This product is expected to be launched in 1992. Siemens-Nixdorf is commercializing a workstation version of TWB that integrates several tools using the FrameMaker environment running on Unix, and several organizations have expressed an active interest in the commercial possibilities of the MATE system, which consists of an integrated set of tools for helping develop and use the large term-banks needed in specialized fields. Several other commercially exploitable stand-alone systems have

Handling emergencies: *the system developed in the ISEM project can handle the automatic call-out of fire, police and ambulance services, while a structured dialogue takes the user through the decisions that must be handled by a responsible human agent.*

emerged from the project, including spelling-verification products and a document converter handling MS Word, WordPerfect and the METAL automatic translation system.

Patient care. Health care throughout the European Community would benefit from a European information and communication network based on a comprehensive set of accepted standards and agreed rules for data protection. This is the focus for RICHE (project 2221). The purpose of the project is to integrate the results derived from ESPRIT, AIM and other Community programmes into a system characterized by an emphasis on basing medical care and nursing on the patient's record. The work is expected to pave the way for setting up a new company at the end of the project for the commercial development, marketing, installation and maintenance throughout Europe of a hospital information system. A prototype system based on the project is being installed in the Ospedale San Andrea. In addition, 14 hospitals in Rome have cooperated in defining their requirements and a model for a standard information system.

Vehicle scheduling applications. Efficiency in scheduling vehicles is important in containing costs while still delivering a high quality of service. PONTIFEX (project 2111) has developed a prototype scheduling system to help airlines deal with this problem. Systems previously available have dealt with only one or a few aspects of the total problem in an unintegrated way. PONTIFEX is the first system to solve all aspects within a single integrated system using a novel combination of operations research and artificial intelligence techniques. Versions of the prototype are being evaluated by Alitalia and Iberia for airline scheduling. The benefits of the PONTIFEX research extend beyond aircraft scheduling to many other transport applications (such as road freight and mass transit), where systems can be built by customizing the generic system.

Very high-fidelity colour image processing. Image processing systems used for general office applications, even those used in current desktop publishing systems, are not adequate for applications where very precise colour calibration and high-quality reproduction are required. VASARI (project 2649) fills this gap and provides the European IT industry with a means of achieving a dominant market position in the field. The VASARI system shows promise in a wide range of applications where high-resolution image capture and the faithful reproduction of colours is of critical importance, such as in the paint and textile industries and in the field of medicine.

The VASARI system includes innovative image-processing software and a leading-edge digital acquisition system based on a high-resolution camera mounted on a precision-engineered three-dimensional positioning system. A prototype of the system has been installed in the National Gallery in London to help establish a high-fidelity archive of paintings that can then be used to keep track of subtle changes in the collection over time. The archive will also provide a set of digital master images from which copies can be made for educational and home entertainment use. As a demonstration of the latter, a prototype CD-ROM has been produced for use in computer-aided learning.

The uptake challenge

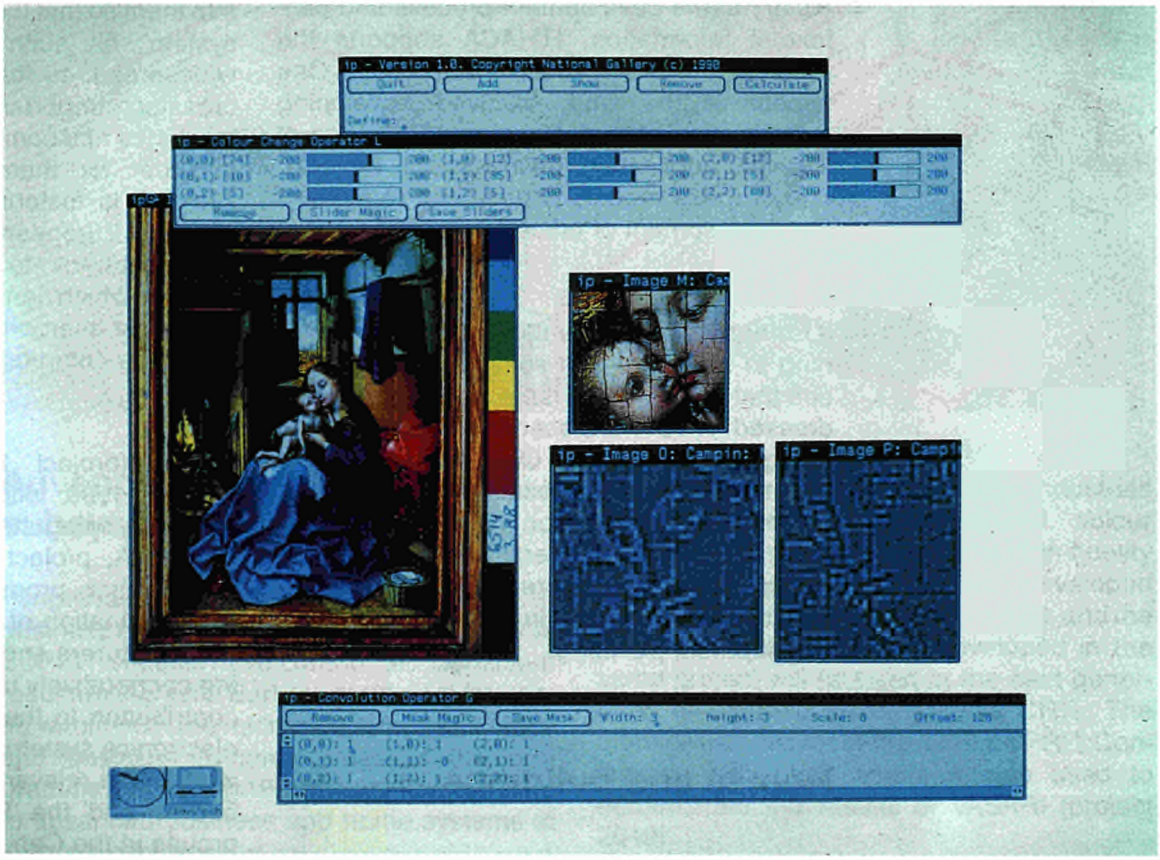
A recurring problem in the development of IT has been the relative lack of communication between suppliers and users. The work in ABHS-P has contributed to changing this situation by demonstrating the benefits of greater user involvement in IT projects. In many of the projects mentioned above a strong user orientation is apparent. For example, in TWB, Daimler-Benz is a user organization with a major technical translation requirement. In PONTIFEX, Alitalia is a partner and Iberia an associate. In RICHE, representatives from government and hospitals from all the Member States belong to a special interest group. And in VASARI, the National Gallery in London is a partner and the Direction des Musées de France an associate. In this way the Community's ESPRIT programme is fostering closer liaisons between IT providers and user organizations.

Beyond user involvement in R&D, attention to organizational factors can be an important element in the practical success of IT in an organization. Building on earlier work and integrating results from other fields, IT-USE (project 2144) is developing an IT awareness aid for high-level decision-makers, helping them to develop an appropriate organizational strategy for exploiting IT. A prototype embodying a large proportion of the high-level knowledge-base was demonstrated at the 1990 ESPRIT Conference exhibition.

Definition of an overall IT strategy leads on to the process of system development. Here HECTOR (project 2082), building on several earlier projects, aims to develop concepts and tools for building organizational information systems. OISEAU, a prototype HECTOR system linking a system developer to a database of methods and tools, was demonstrated at the 1990 ESPRIT Conference exhibition. One partner is now developing this further for commercial exploitation, and another is developing a training tool based on the HECTOR reference framework.

An important part of the process of system definition and development is the analysis of the information flows that need to be supported and the system resources these require. A number of leading companies are now using OrgSolution, a commercial product developed from work in OSSAD (project 285).

Building the software required for an application is a complex and potentially costly activity. The process can be made more efficient if ap-



Great paintings live on screen: *the VASARI system can capture images of delicate paintings (still in their frames) using a robotic scanner, and then analyse the* craquelure, *the network of fine cracks caused by the deterioration of pigment or varnish. The VASARI system is being used to monitor changes in works of art as they age or are subject to the rigours of exhibitions, and to apply computer-aided learning techniques to the field of art history, which requires the accurate reproduction of paintings on-screen. Applications foreseen in industry include paint manufacturing and food processing, where accurate colour-matching is important.*

propriate tools and generic models are available, with support for reusing concepts and software used in other application developments. A prototype software environment for building applications has been developed by ITHACA (projects 2121 and 2705), using an object-oriented approach, and is available on licence for evaluation purposes. Previous object-oriented approaches have supported the reusability of code, but ITHACA goes further: by providing easy access to objects together with information about the relationships among them, plus the history of the development process and contextual information, ITHACA supports the reusability of expertise as well as of code. One aspect of the work involved developing generic models that can support a range of specific application development projects; one of these models is designed to support the development of office applications.

It is important at all levels from strategic planning to hardware and software implementation that quality-of-life issues are properly addressed. A software scenario support tool is being developed within QLIS (project 5374) to help the IT industry forecast the likely impact of new IT applications on the quality of life at work and at home. Several large commercial organizations have already expressed interest in using this tool in their future product development planning.

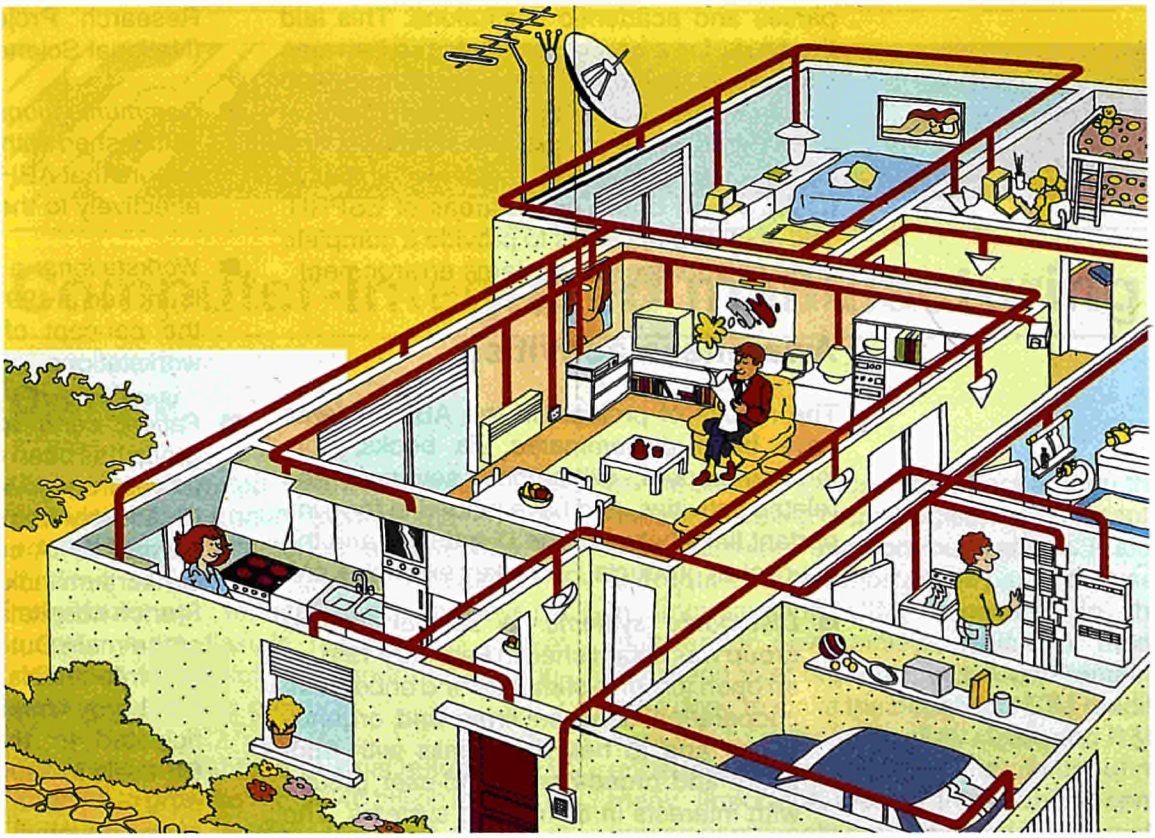
Homes and buildings

IT will extend beyond the boundaries of businesses and public administrations into homes and intelligent buildings. The market in Europe and world-wide is enormous, taking account of both new homes and buildings and the retrofitting of those already built. Developments in Japan and the USA bear testimony to the interest which Europe's competitors have in taking a major share of this market. If European companies are to be able to compete effectively, they need to be taking action now to develop an agreed framework of standards within which competitive product developments can take place. The important advances made in ABHS-P have meant that European industry has moved in the past few years from lagging behind developments in Japan and the USA to its current leading position. The European approach is compatible with the Japanese D2B standard but is more complete and 'future-proof', providing a comprehensive standard for home systems now and in the future.

The European approach to home systems envisages a system in which intelligence is distributed throughout the home in areas of most concern to users, such as safety, comfort and entertainment. In such a system, many common household appliances and consumer products will have IT components built into them so that they can be connected to the system. As such systems become more widespread, so manufacturers will find it increasingly important to build the necessary intelligence and connectivity into their products in order for them to remain competitive. ABHS-P is fostering collaborative research amongst European companies that will allow manufacturers to develop products and systems which can be sold separately and yet can all be interconnected and work together through a common home system.

HOME (project 2431) was launched in January 1989, following earlier work on the EUREKA Integrated home systems project (EUREKA, project 84). The home systems specification, produced in HOME, represents the culmination of work involving 11 leading manufacturers and service companies working cooperatively under ESPRIT. It is a major contribution to the definition of world home electronics systems standards, including the work of the relevant ISO/IEC standardization bodies and the European standardization groups in the Cenelec organization.

Two complementary projects have been launched to carry the work further. These are Integrated interactive home (IIH, project 5448) and Home interactive environment (HIVE, project 5140). IIH consolidates the results of HOME and develops a media-independent architecture for the home network which takes into account the need to interwork with other systems. The project also addresses the conformance-testing and standards-validation aspects. HIVE provides the enabling technologies required to integrate products from different companies into a common system with an appropriate human interface. Other projects are researching related topics, such as electronic shopping (EUROSHOP, project 5346).



The integrated home: *the home systems specification developed by HOME (project 2431) will enable many common household appliances and consumer products to be connected to a common communications system, as visualized here. Members of the HOME consortium have recently founded the European Home Systems Association (EHSA) to promote the harmonization and use of standards for homes and other buildings throughout the world.*

Advanced peripheral subsystems

Peripherals are essential subsystems in business and home systems, and a number of ESPRIT projects have contributed significant results in this field. Early projects were launched within both the microelectronics and office and business systems areas of the programme, but during 1990 the work was moved to advanced business and home systems to improve coordination.

A topic of particular strategic importance for European R&D has been flat-panel displays. The projects FELICITA (2360) and MATRIX-LCD (2283) are currently working on this topic, whose significance arises from developments in HDTV and the growing market for low-cost, lightweight screens for aerospace and automotive applications. The first year's work in MATRIX-LCD has already led to a product announcement from Thomson LCD of full-colour liquid crystal displays for avionics. An interesting spin-off from FELICITA has been equipment for use in manufacturing layers of thin-film transistors in silicon.

Completed ESPRIT projects continue to influence the development of innovative European peripherals products. Barco Industries recently launched an advanced colour monitor, Calibrator, that uses the high-fidelity colour correction techniques developed within MODEL-DISPLAY (project 612), and the very high speed amplifier developed in the same project will be used in the next generation of high-resolution graphic CRTs. The monitor was shown at the 1990 ESPRIT Conference exhibition, where it was used to demonstrate the results of VASARI (project 2649).

Building strength in open microprocessor systems

Microprocessors form an essential and integral part of IT applications in areas ranging from cars to office workstations. As both the range and complexity of such applications increase, the need is growing for greater interoperability among the processors concerned and easier migration paths from one processor to another.

In recognition of this, a workshop on the theme of developing a competitive microprocessor systems environment for computers and embedded control was held in 1989, attended by representatives from more than 70 com-

panies and academic institutions. This laid the basis for a continuing dialogue between suppliers and potential users, and during 1990 a series of workshops defined the requirements for a major new initiative, the Open microprocessor systems initiative (OMI), which draws on all areas of ESPRIT. The objective of OMI is to provide a complete open microprocessor systems environment.

Awareness activities

The results of projects in the ABHS-P area have been disseminated via books, conference papers, exhibitions, seminars and related activities, and have helped to form important links between the IT industry and the users of its products. Some key examples are:

- *Distributed systems:* a special interest group was established in February 1991 as an open forum to stimulate and encourage cooperation between firms and organizations and to help form links with end-users and broad-based end-user groups with interests in distributed systems. The group operates on a programme which includes plenary meetings two or three times a year and meetings of topic-oriented workgroups.

  As part of this initiative, and in response to interest from both European and US organizations, workshops were held in Brussels and Washington DC to discuss the technical achievements and industrial implications of the work on distributed systems, especially the achievements of ISA (project 2267) and COMANDOS (projects 834 and 2071). The workshops helped to identify areas in which collaboration between European and US organizations could be mutually beneficial, and established a basis for more detailed discussions with particular organizations, including DARPA (Defense Advanced Research Projects Agency) and NSF (National Science Foundation).

- *Communications:* links have been established with the RACE programme to ensure that ABHS-P's work can contribute effectively to the goals of RACE.

- *Workstations:* a series of workshops was launched in 1991 to discuss and elaborate the concept of a 'family' of European workstations.

- *Patient care:* a RICHE special interest group has been established with representatives from government, hospitals and the IT industry from each Member State and several EFTA countries. Members of the consortium include STAF (representing 75 French hospitals), BAZIS (representing 35 of the main Dutch hospitals) and Lombardia Informatica (representing the main Lombardy hospitals). Over 80 people participated in the last meeting held in Brussels in 1990.

- *Home systems:* work done in ESPRIT has been a major stimulus to the formation of the new European Home Systems Association (EHSA) which aims to promote cooperation, standardization and harmonization and to ensure that standards are properly applied. The results of HOME (project 2431) were presented to the industry at a special conference in Amsterdam held in January 1991. A model home system covering 100 square metres (including four rooms) was demonstrated, and the full specification for a system complying with the home systems standard made available. Over 600 copies of this specification have been distributed to interested parties around Europe, and in the light of the interest expressed, it is now available as a book (published by Springer-Verlag).

Computer-integrated manufacturing

Overview

Computer-integrated manufacturing (CIM) provides the information technology (IT) needed by the manufacturing and service industries to achieve greater efficiency in manufacturing, reduce costs, achieve a quicker, more flexible response to market demands and exploit new opportunities for incorporating IT into products.

The world market for industrial automation is forecast to grow from ECU 46 billion in 1989 to ECU 79 billion in 1995. The R&D in CIM is helping European industry to achieve a significant share of that market, including the developing markets for products incorporating IT components and for the CIM hardware and software technologies themselves.

The manufacturing sector, supported by engineering industry, is the second-largest sector in the Community economy after the service sector, to which manufacturing operations make a substantial contribution. The cycle time from design to product, especially in the electronics sector, has become a key factor in the battle for markets. Together with the need for greater efficiency and a more flexible response to market requirements, demand has induced a steep rise in the IT-related portion of the unit cost of most products and capital goods. R&D carried out in CIM is helping European companies to compete effectively with American manufacturers, with their economies of scale, and with the Japanese and the newly industrialized countries of the Asian rim, whose capacity for innovation in the techniques and organization of manufacturing has put them in a strong position.

Computer-integrated manufacturing is typical of many engineering applications. It provides a stringent test-bed for the real-time control of physical processes. It places heavy demands on the skills of system integrators and on the generic enabling technologies, including software, hardware and communications. It also still requires much effort on the part of the user in implementing CIM, especially in the multivendor environments typical of many European user organizations. Much remains to be done to make the benefits of CIM readily available to companies of all sizes, and R&D undertaken within ESPRIT is contributing many important results from which companies can benefit both now and in the years to come.

Opening up the manufacturing environment

In Western Europe and the USA, manufacturing companies spend considerable time and effort on integrating components from different suppliers. 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 users' needs has been limited by incompatibilities of languages, data formats, protocols and communication methods between the products of different vendors. This area of integration is being approached through a number of major projects involving major Community equipment vendors and users. These projects exert a strong influence on international standardization, and lead to the provision of economical, customized multivendor systems that can be progressively implemented by enterprises of all sizes.

Improving competitiveness and productivity

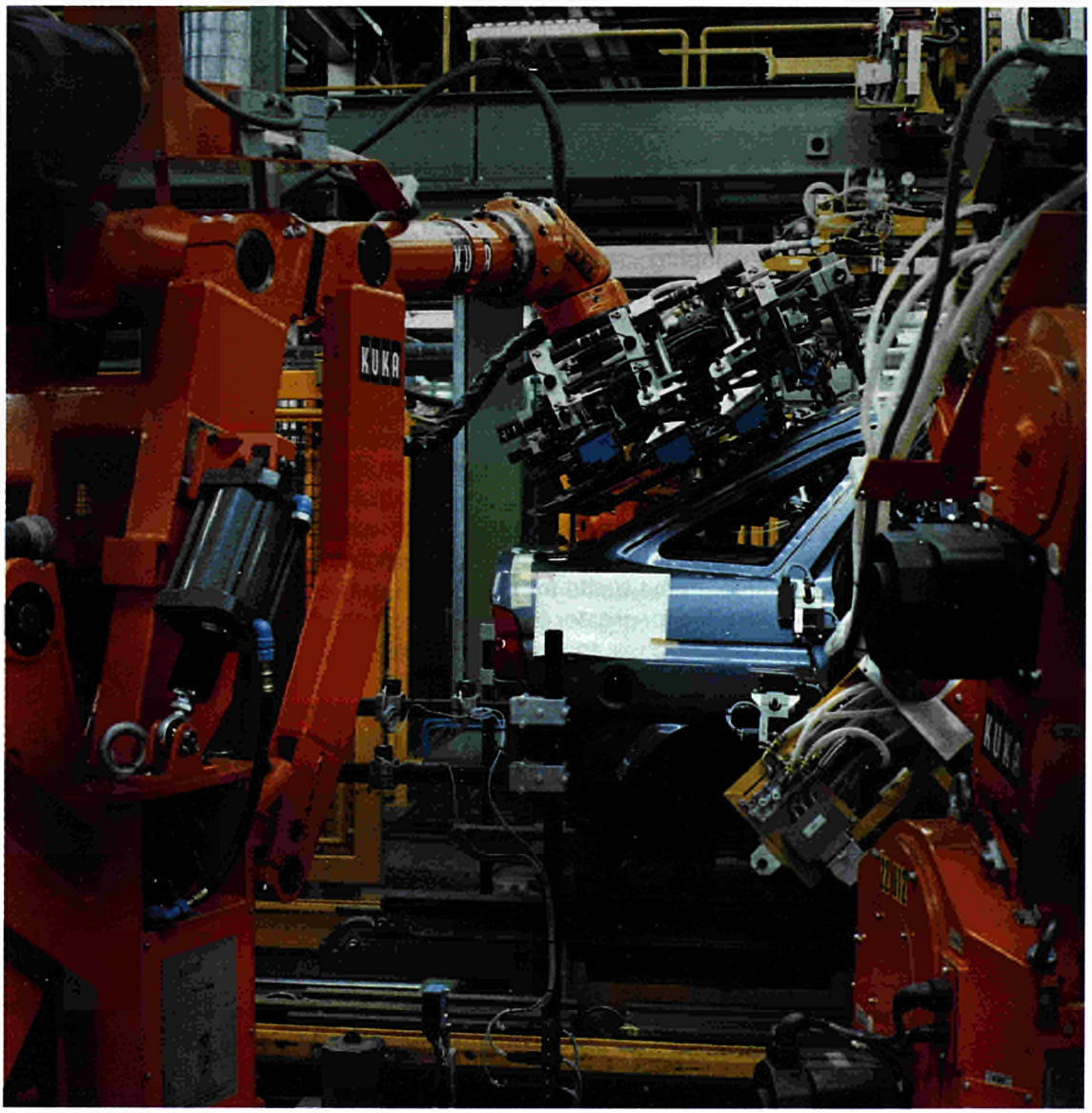
Work in this area covers the design and validation of complete manufacturing systems in the

discrete parts, batch and process industries. The factors regarded as crucial to success differ from one industrial sector to another. In some cases it is the product innovation rate, while in others it may be plant productivity, total quality, process flexibility, or efficiency of supply or distribution channels which is considered the most important.

The objectives are to shorten the time needed to bring products to market, to improve quality, and to reduce costs. The IT components developed must be of an easily manageable size so that they can be assimilated into the integration strategy of a company and so that smaller companies are able to invest in the available technology in a step-by-step fashion. They must also conform to widely accepted architectural constraints as well as existing and emerging standards so that system integrators can use them to assemble customized solutions meeting the requirements of particular users. As many of these technological developments have significant effects on the way people work and the skills they require, projects in this area give high priority to human and organizational factors.

Improving the end product

The engineering design process can be regarded as comprising requirements capture, design specification, analysis, evaluation and synthesis. The process needs to take account of external constraints such as those from production and marketing. It is iterative, draws on engineering judgement and experience, and is validated by testing. Infor-



Accurate calibration: *shown here is a car moving along a factory assembly line, while a robot fits its rear window into place. Requiring the ability to position components precisely and reliably within tight space constraints, this kind of task requires robots to be recalibrated throughout their working life after any repairs or modification of the work-space. CAR (project 5220) and CIM SEARCH (project 5272) are developing the calibration tools and methods required.*

mation technology today is applied most widely in the design specification activity, i.e. computer-aided design (CAD).

The other elements of the design process do not yet take full advantage of emerging IT. General modelling tools are required to integrate the information flow between the various levels of an engineering system. Apart from CAD applied to product design, this includes computer-aided engineering (CAE) for product analysis and evaluation, and process description techniques required for computer-aided manufacturing (CAM). There is also the need for subsets of information to be transferred from one activity to another. For example, the final results of a finite element analysis (an aspect of CAE) often need to be transferred to the user of a CAD system. The resultant design changes then often need to be transferred back to CAE for an iterative re-analysis. This can happen, for example, in car manufacturing, where a finite element analysis may show unacceptable stresses or strains on parts of the body, requiring that the design be modified. It is essential that this information transfer takes place rapidly if effective benefits are to be derived from the integration process. Modelling tools are required to enable information in the form of data, knowledge and procedures to be readily transferred between various distributed databases in the CIM system. This in turn requires attention to all aspects of standardization related to data transfer and communication.

Effective control of resources

To meet the changes in market demands and customer requirements, a manufacturing enterprise, be it large or small, must be able to respond and adapt quickly. Production planning, control and scheduling systems under development within ESPRIT, including quality control tools and systems for collecting and analysing process control statistics, allow the necessary flexibility by predicting manufacturing system throughput and highlighting potential problems. Effective use of such systems can reduce production lead-times, thus improving the economies of manufacture by reducing the amount of capital bound up in stocks and work in progress and allowing the accurate prediction of delivery dates.

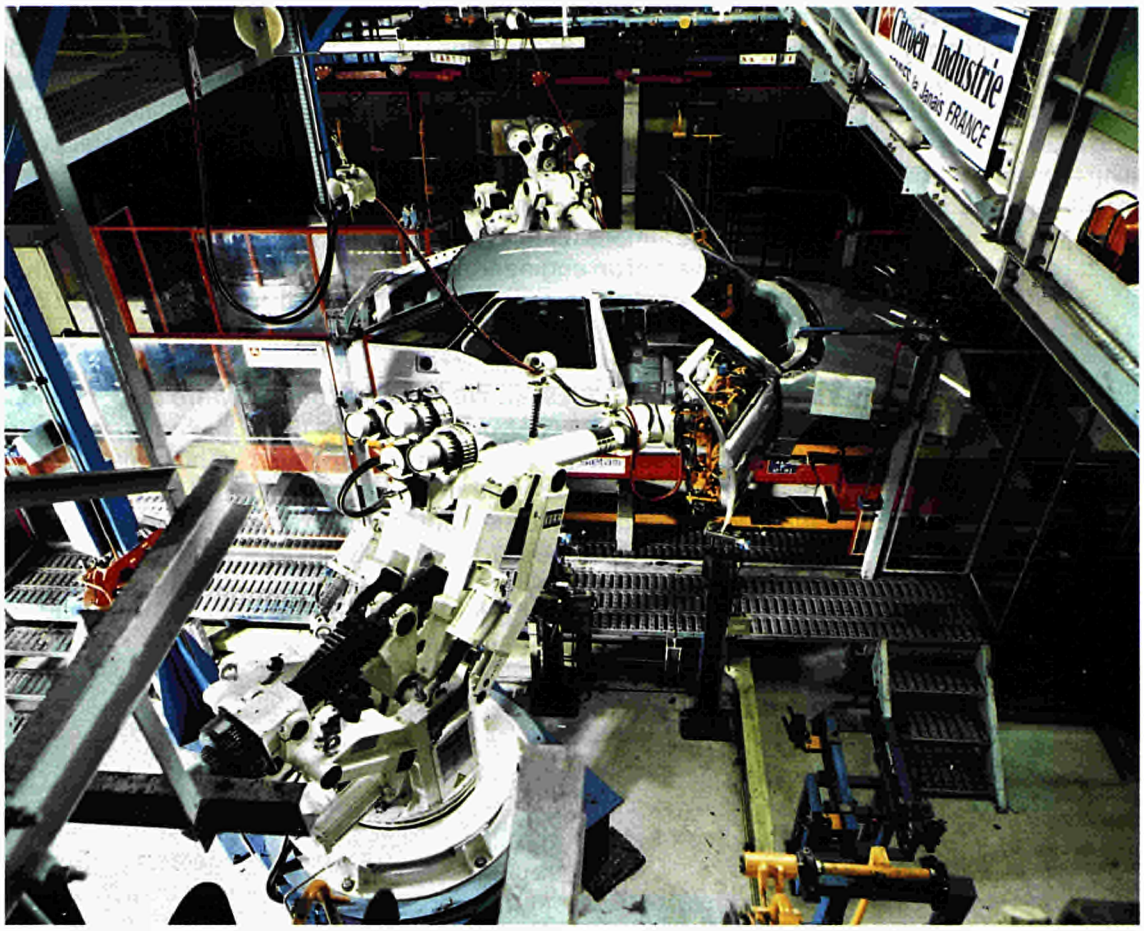
Many manufacturing plants are already using early project results and show the power of advances in this area, such as developments in just-in-time (JIT) manufacture and optimized production technology (OPT) techniques. Improved control structures enable increased flexibility, allowing, for example, a production line to be quickly and smoothly diverted to the production of a small batch of units with a particular variation (a higher-performance component, for example) and just as quickly and smoothly switched back to producing the standard product. IT systems can also help in tracking the life-history of product components, identifying where and when they were built, serviced, modified or repaired, so providing the information required for a high-quality after-sales service to customers during the lifetime of the product. R&D in CIM is also moving towards IT components which can help manufacturers achieve tighter coordination of multi-site, multi-supplier operations.

Making the product

Every manufacturing enterprise depends for its productivity not only on the skills of its workforce, but also on the supply of efficient equipment such as machine tools, robots, materials handling equipment, and sensors and actuators for process control. A common thread linking projects in this field is the multidisciplinary development approach, combining elements of control theory, mechanical engineering, the development of fast digital processors and the associated embedded software, and 'intelligent' sensors and actuators. This work has led to advances in machine and robot control, including fault diagnosis, and has improved the efficiency of robots on the factory floor for such applications as assembly, welding, paint-spraying and materials handling. It has also extended the use of robots into new application areas. For example, the ability to cope with unstructured and hazardous environments has led to projects which open the way to automating the transport of materials on building sites and in forestry and agricultural locations, open quarries, docks and warehouses. These areas need new intelligent machinery, such as harvesters, rock-drilling machines, construction equipment and large-area cleaning machines.

Architectures and communications

A prerequisite to enable full integration in a manufacturing environment is the ready



Advanced manipulation: *the new generation of robots, off-line programming tools and a sensor-based robot controller developed in ARMS (project 2637) enables European industry to tackle the most sophisticated assembly operations, such as attaching the interior panel of a car door, shown here. The ARMS project has targeted several applications in the automotive and domestic appliance industries, including subcomponent assembly (doors, dashboards, front-ends), assembly of these components into vehicles, and the assembly of washing-machines, refrigerators and cookers.*

availability of open systems with a functionality that gives maximum flexibility to users. In order to achieve this a number of projects have been supported that have contributed to both standardization and product development.

CIM architecture: European pre-standard established

In the consortium for AMICE (project 5288), 20 European organizations, research institutes, systems suppliers and system users are cooperating to define a CIM open systems architecture, CIM-OSA, building on earlier work in projects 688 and 2422. CIM-OSA aims to provide the infrastructure that will facilitate the increased use of IT industry-wide, and consists of a modelling framework for describing an enterprise's functionality, behaviour, information resources and organization in a consistent way. Emphasis is placed on providing the means for expressing the contents of a particular enterprise model in a user-oriented language. A key part of the implementation model is the Integrating infrastructure, dealing with the definition of the integrating services, such as communications, information, machine and human front-ends, and the business process. In 1990/91 the validation of the basic concept was performed through case studies in the aerospace, automotive and electronics industries, a limited prototype demonstrating the use of the basic CIM-OSA construct has been developed, and a European pre-standard 'Enterprise modelling framework' (ENV 40 003) has been established and accepted as the current basis for standardization work by ISO TC 184.

Business communication for manufacturing chains

Where AMICE concentrates on modelling the inner workings of an industrial enterprise, CMSO (project 2277) focuses on inter-enterprise operations with the aim of developing methods, tools, interfaces and architectures that facilitate the exchange of technical and commercial data between independent organizations working together in a manufacturing or distribution environment. Particular emphasis is placed on solving the logistics problems that occur in the automotive industry. The project has developed an integrated EDI architecture and the CMSO-

BOX, which allows intelligent servers to be configured to handle the communication needs occurring in a logistics chain.

No manufacturing integration would be possible without a robust and reliable communications system based on standardized communications protocols. Following on from pilot installations at British Aerospace, BMW and Aeritalia, CNMA (project 2617), the flagship project in the field of factory communications, has successfully commissioned and demonstrated the use of CNMA communication in an automated manufacturing demonstration site at Universität Stuttgart. This links CAD, CAM and computer-aided planning (CAP) systems and equipment on the shop floor, and demonstrates network management and directory services. In parallel with the AMB machine-tool trade fair (Internationale Austellung für Metallbearbeitung), a conference was held in Stuttgart in September 1990 on communications in manufacturing, incorporating tutorials on Manufacturing message specification (MMS) and Network management and covering wider technical and business issues. A large number of visitors to the AMB fair took advantage of the opportunity to visit the CNMA demonstrator.

CNMA commissioned two further industrial pilots during 1990. The Aerospatiale pilot is a prototype defence manufacturing facility, and the one at Renault a test laboratory and demonstrator for network management which is being used to develop and refine techniques for the use of artificial intelligence in Network management technology (NMT). Two conferences were held at the Renault pilot site in January 1991. Many presentations were given on CNMA Open systems interconnection (OSI) and Renault's Open systems approach. A conference was held in April 1991 by Magneti Marelli in Italy at which CNMA and Open systems were presented to an influential audience from the automobile industry. A further pilot at Magneti Marelli's alternator manufacturing facility in San Salvo is being commissioned. 1990 also saw the issue of a new implementation guide for CNMA (IG 4.1) replacing the previous IG 4.0 issued in 1989.

The market penetration of products based on CNMA will be largely dependent on the extent to which they conform to the emerging standards. The major activity of TT-CNMA (project 2292) in 1990 was the provision of test services at Universität Stuttgart to the partners of the CNMA project. This activity provided a proving ground for exercising and evaluating the test technologies being developed by the TT-CNMA project partners. The justification for investing in test technology is to enable the efficient building of application systems components from different vendors which adhere to agreed open standards. The availability of test systems is a prerequisite for the establishment of an open systems world where both developers produce and users buy open systems products because they are both economically and technically superior to alternatives. The prototype test systems used at the university were interoperability test systems for Manufacturing message specification (MMS) and Network management (NM), and conformance test systems for MMS application interface (MMSI), MS, NM, and directory services.

As open systems technology develops, two further requirements are emerging: the need for computer assistance in producing test systems from protocol and profile specifications, and the need to make the test tools easy to use. The project has addressed both these needs, and TNC and Fraunhofer-IITB, the developers of lower and upper layer test tools respectively, have worked with Swedish Telecom to demonstrate that the process of producing and executing test suites for a particular protocol can be automated to a large degree. TNC, Fraunhofer and SPAG have begun specifying and implementing an improved human-interface to the test tools to make operation and assessment of test results easier.

As a response to the requirement for products with response times appropriate to the factory environment, ACERLI and Alcatel-TITN have initiated work on performance measurement. This is being followed up in the successor project to TT-CNMA, TT-CNMA II (project 5392).

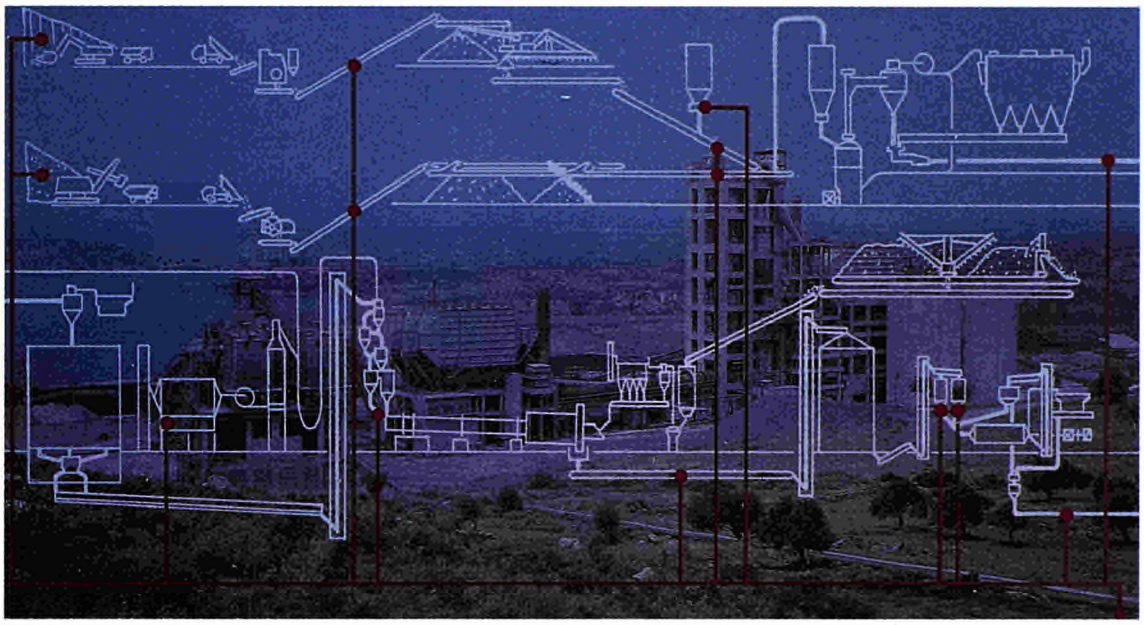
Recognizing the wider use of a number of communications technologies, including token ring, Ethernet, X.25 and token bus, TNC have developed Router and MAC Bridge test systems to support the testing of interconnections among different kinds of network.

The activities associated with the pilot site at Universität Stuttgart have been followed by further enhancements. Where possible, the test suites have been enlarged and aligned with developing international standards. Experience and understanding of the testing of systems working together has been further

enlarged by the development of a second interoperability test system.

Mobile communications for manufacturing

The goal of FCPN (project 2198) is to specify, develop and test a prototype multi-service communication system based on mobile infra-red-linked terminals for indoor industrial applications. The system will particularly address the need for mobility and for reliable communications in all kinds of factories and for a wide variety of tasks. Specifications have led to an architecture description on which further developments will be based. As infra-red radiation and the appropriate link protocols have not yet been standardized, effort will be put into proposals for a universal infra-red interface compatible with existing communication protocols.



Plant control: *monitoring and controlling the Heracles Milaky cement plant in Greece is done via a schematic (the overlay) built up from the plant-wide signals of programmable logic controllers (PLCs). The PLCs sense material flows, temperature, pressure, etc., and can actuate processes and operations. Designing such distributed control systems needs general-purpose design tools, such as those developed in DSDIC (project 2588).*

Design and implementation of manufacturing systems

Traditionally, work on the application of IT in manufacturing has focused primarily on applications in factories producing discrete parts, and the effort has been driven by the needs of the people who design the end product and those who design and manage the manufacturing plant, including the supply of raw materials, subcomponents and other items. A considerable amount of work is now going on in other application areas, such as the process industries.

Many large and complex plants such as those dealing with cement, food-processing, car manufacturing, steelworks and tyre manufacturing, are controlled by distributed networks of programmable logic controllers. In such plants the operators exert control via interactive schematic diagrams. The design of the control system is a very labour-intensive engineering process and at present there is little scope for the reuse of standardized subsystems. In addition, the designers are frequently forced to switch from one target controller to another in order to comply with the purchasing policy of their clients. DSCDIC (project 2588) is overcoming these difficulties by providing design engineers with a common platform for developing distributed programmable logic control (PLC) systems for different target machines. In close collaboration with FL Smidth (DK), one of the world's largest manufacturers of cement plants, AEG (D) and GEC (UK), together with Procos (DK) have agreed on the specification of a new development system to support work both in the design office and when commissioning on site. The user interface is complete, and a communication link to one of the target controllers (GEM 80) has been implemented under X11/UNIX. The other components of the design system are in progress and some of them are building on the reuse concepts and design reuse support facilities developed under the earlier ASPIS project (401).

Improved process control

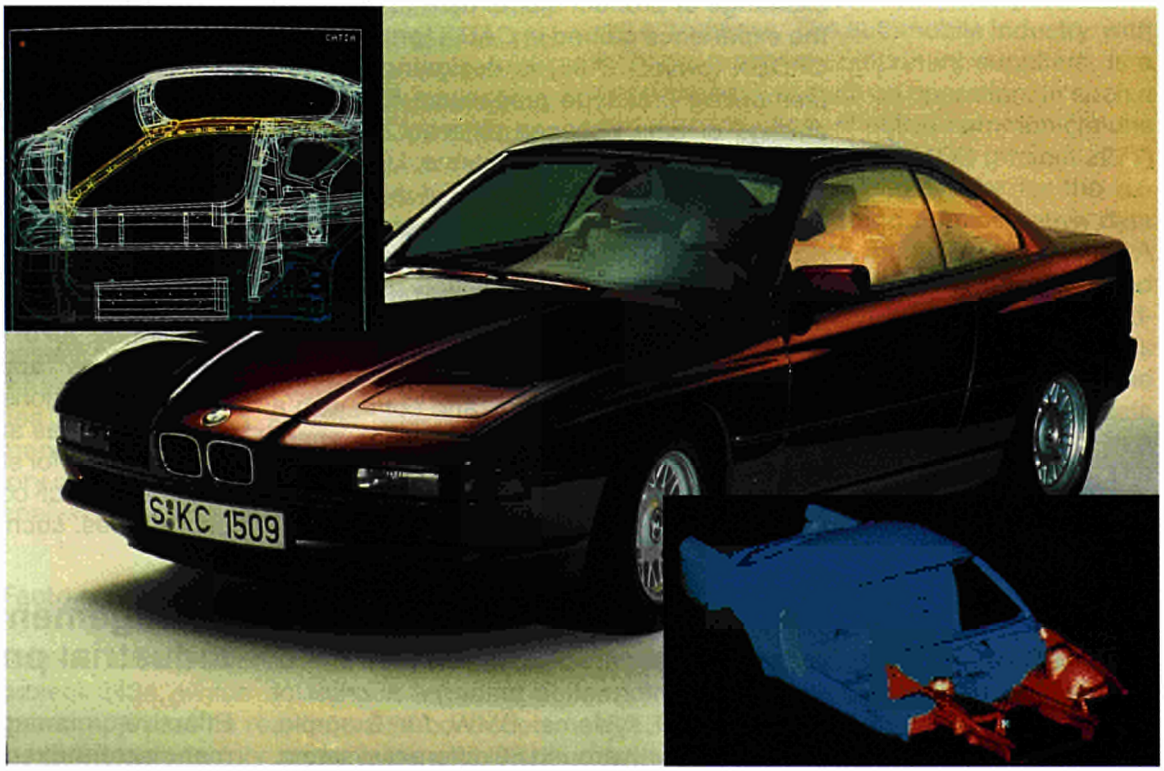
Throughout the process industries there are increasingly heavy demands on the control systems employed. These must not only guarantee a high level of plant availability and profitability but also minimize environmental damage through controlling effluents and conserving energy. A major contribution to this effort is being made by DIAS (project 2172), which is developing new intelligent sensors and actuators, integrating them with a fast communications network and providing advanced tools for plant control, management and maintenance. A pre-industrial series of intelligent sensors is being manufactured for use in the project. Software for the specific applications and the field bus has been developed by Hartmann & Braun (D) and Bailey Esacontrol (I). The work is being validated at selected sections of three different plants. The engineering and installation at the nuclear power plant auxiliary steam generator at Electricité de France (EDF) at Le Havre is complete, and commissioning is in progress. Installation has begun at the ENEL fossil-fuel power plant, where the system is concerned with a high-pressure part of a regenerative cycle, and has also begun at three industrial polymerization reactors at the Montefibre chemical plant. The systems being installed have resulted from close collaboration between the users (EDF, EDP, and Montefibre), instrumentation vendors (Hartmann & Braun, Bailey Esacontrol) and software companies (SEMA, MENTEC) involved.

New applications

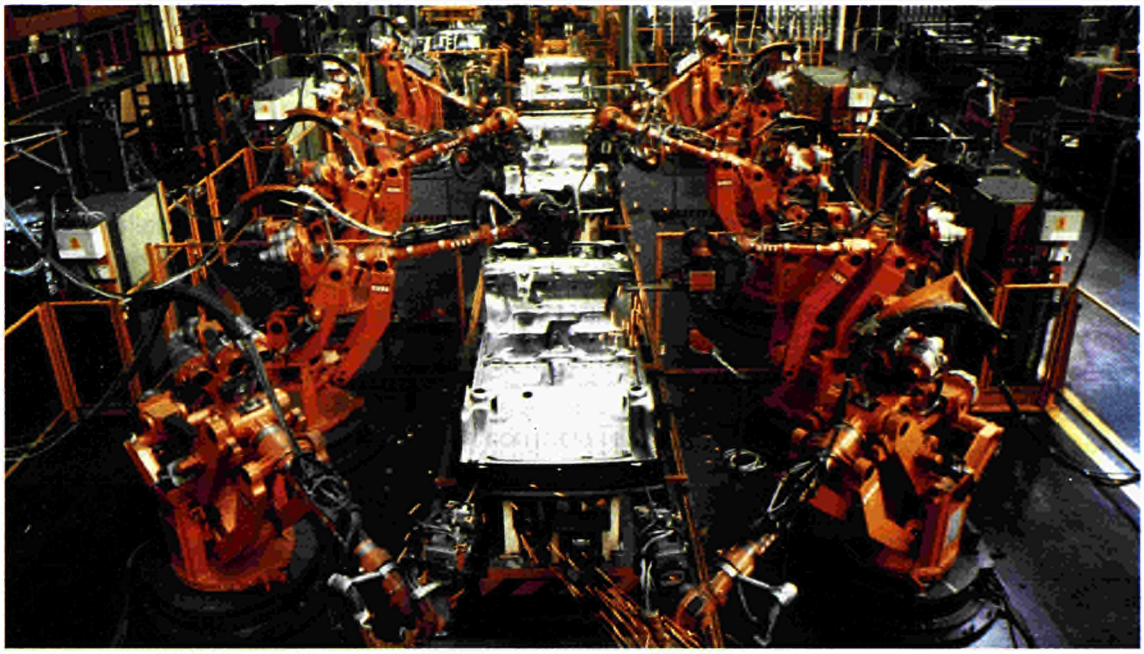
The building industry, in spite of its present complexity, fragmentation and sensitivity to economic conditions, is a prime target for applying IT as the best possible means of improving quality/cost ratios in the fields of building design and construction, maintenance and change of use. This can be achieved by using IT as the enabling technology which integrates the activities of those involved in building projects, including the client, the design and engineering unit, the supplier network and the construction site management. CIB, an exploratory action on computer-integrated building (action 5604), consisting of a coordinated set of 11 teams, has been established to examine requirements in this field. A working report has been produced which discusses the potential benefits of IT-based integration and defines possible lines of future action.

Engineering design

IT-based tools used by engineers for the design of products and manufacturing pro-



Design tasks: *the car's wire-frame representation (top left of picture) is used for stress analysis; the solid model (bottom right) for analysing interior spaces. CADEX (project 2195) has developed standards and protocols to enable the exchange of data between different representations of products and different modelling systems — for example, the data from the solid model describing the space available for headlights can be sent directly to the headlight supplier's own CAD system.*



Cooperating robots: *shown are robots carrying out welding tasks in a car factory. Simulating the layout and job sequence for such robotized car-assembly lines allows a check to be made on whether a particular robot can carry out its programmed task. The main objective of CIM-PLATO (project 2202) is to develop the tools and components for planning the manufacturing process.*

cesses are subject to two strong pressures. First, there is an ever-increasing demand to exchange electronically designed specifications and the data required for performing analysis and simulation. Second, there is a demand for more sophisticated tools which incorporate in their internal models a wide range of information on manufacturing, material properties and other aspects of the design context, far beyond that contained in simple CAD systems.

Based on the emerging ISO standard for the exchange of product model data (STEP) and the experience gained in CAD*I (project 322), CADEX (project 2195) is designing and implementing prototype processors for the exchange of data between different CAD and finite element modelling systems. Using well-defined STEP subsets, CADEX has developed application protocols for the exchange of the boundary representation and sculptured surface model descriptions widely used in the automotive and aerospace industries.

All CADEX processors are based on the same intermediate data structure, and come with a software toolbox that allows users to share independently developed software. The first STEP-based processor has been scheduled for launch on the European market before the end of 1991, and the CADEX project has already demonstrated prototypes at BMW and Fiat, where they are being used to help these consortium partners deal with the problems of exchanging information among a number of different CAD systems. BMW, for example, need to deal with around 60 different systems, including those used by their approximately 350 suppliers. This type of problem is very common in the CAD world, and represents a major market opportunity. The world market for CAD/CAM software is forecast to grow from ECU 2 550 million in 1989 to ECU 5 160 million in 1993.

Within IMPPACT (project 2165), integration is based on a new approach using 'features' at all stages of the manufacturing process. This allows semantic integration at the level of application software. This approach required the development of a global reference model, which is now under consideration for adoption by other ESPRIT projects. A further requirement was the development of a data manager system and a data manager interface, both of which have achieved international recognition. Improved functionality has been provided through two new combined solid and surface modellers, and also a new process planning system based on knowledge-based techniques. All of these have been based on the 'features' approach, and a number of small applications are now coming on the market, such as automatic numerical control programming for sheet-metal parts and for the manufacture of components with very complex shapes, such as a ship's propeller.

Management and control of industrial processes

Effective management and control of manufacturing resources can range from the

real-time monitoring of the behaviour of a single piece of machinery through to the scheduling of operations and logistics of a multi-site multi-supplier network of interconnected manufacturers.

Integrated sensors

Integration of intelligent sensors and advanced control techniques is the objective of KB-MUSICA (project 2671). In addition to the development of new sensors, work on signal processing enables the extraction of more information about the process and the performance of the sensor itself. The technical and economic merits of using digital communication through a field bus are being evaluated, and knowledge-based systems for the process industry are being developed which reduce the down-time resulting from process defects and perform online fault detection, thus reducing costs resulting from damage to the plant as well as reducing the risks of accidents which might affect human life and the environment.

Different aspects of the project are being demonstrated at four sites: an ICI chemical plant, a Krupp plastic mould injection machine, an ENASA robot deburring system, and a Stephens glass-manufacturing furnace.

Special-purpose sensors have been developed for the Krupp demonstrator which measure the wall-thickness of plastic bottles and the temperature profile in the mould. The ICI demonstrator is using new sensors to detect atmospheric pollution. Mathematical models relying on multi-variable control have been developed for all demonstrators, and for the glass manufacturing application a prototype of a new furnace temperature controller has been designed and installed. Knowledge-based systems of varying degrees of complexity are now in use, including one which suggests process modifications based on measurement of the quality of the plastic bottles produced, and another which recommends to the plant operator in the glass factory optimal operating set points based on an analysis of online data from the factory floor.

Factory management

Control, but of a different nature, is the topic of project 2434, which is taking a knowledge-based approach to real-time CIM controllers for distributed factory supervision and is addressing manufacturing in small, medium and large batch sizes. The work has been validated by factory implementations in plants manufacturing products as diverse as car tyres and car radios. The large consortium, led by Philips Research Laboratory in Hamburg, has successfully completed a programme of work which is now resulting in products such as workcell and shop-floor controllers for dynamic scheduling, maintenance planning, quality management, a portable knowledge-acquisition module for factory use and a relative expert system shell specially designed for CIM applications. This latter development is being commercialized by ARS under the product name RES-D2, and a knowledge-based quality assurance package (Total quality assurance — TQA) together with the knowledge acquisition tool required for its maintenance (Knowledge acquisition quality — KAQ) are being commercialized by Pirelli Informatica.

Reducing production costs

The main objective of much of the effort in CIM is to provide IT-based components that can be used to reduce production costs by lowering stock levels, predicting and shortening lead times, and increasing the level of service. In several fields of manufacturing the end-product appears at the end of a complex supply chain that can also be regarded as a logistics network of independent but closely interworking enterprises. The automobile industry, with its huge range of component suppliers, is a good example of such an operation. In such a complex structure, effective communications are crucial for success. CMSO (project 2277) is providing the building blocks for the exchange of technical and administrative data throughout multi-site, multi-supplier chains. A logistics chain simulator has been completed and an implementation guide for the standardized tools and interfaces is available. Work is continuing on improved functionality of the management system for the exchange of data such as that required for quality control in a heterogeneous product development. The prototype installed at automobile component manufacturers Karmann and Lucas, partners in the consortium, is based on a generalized Electronic data interchange (EDI) communication system. The work is in line with the development of standards such as ODETTE and EDIFACT for administrative data and IGES and STEP for technical and product description data.

Robotics and shop-floor systems

The use of robotics in manufacturing has been steadily rising during the last decade. Work in CIM is helping European companies to develop a competitive edge in robotics in several key areas.

Calibration

Quality control in robot production, application of off-line programming techniques and demands for high accuracy of robots need robot calibration procedures (model-based parameter-identification methods using advanced measuring procedures). Using these procedures, internal parameters of the robot can be determined which cannot be measured directly. For example, where a robot is used for welding, the exact position of the tip of the tool used for welding (and therefore the spot that will actually be welded) has to be calculated from data concerning such matters as the angle and length of the robot's arm, the angle of rotation of the robot, and so on. Theoretically, the welding spot is exactly determined by such data. In practice, slight variations during the manufacture of each robot, combined with changes over time as the arm bends slightly or gears become worn, mean that the robot has to be calibrated. This calibration needs to be repeated from time-to-time if inferences are to remain accurate.

CAR (project 5220) is aimed at developing a prototype of an automatic system for robot calibration with the ability to identify the values of all the parameters that make a significant contribution to a robot's stationary accuracy, such as geometric-kinematic parameters, joint elasticity, backlash and eccentricity, and beam elasticity. The aim is to provide sufficient flexibility to allow calibration of various types of robots, and permit recalibration after robot repair and installation using a low-cost measuring system.

An industrial experimental set-up for calibration has already been assembled at KUKA and first trials performed. This is the first industrial installation of its kind in the world that gives a complete and accurate identification of both geometrical and mechanical features of a robot. The Leica company is preparing to market the calibration system. It has been presented to major companies in the German automotive industry, where it has generated great interest.

Interoperability in robotics

Closely linked to the project on data exchange between CAD systems, NIRO (projects 2614 and 5109) is developing a set of processors and software tools which will enable the configuration of multi-vendor robotic systems. Work done in the project will lead to improved and extended standards for kinematics, inclusion of robot-specific technological information, a robot-programming language and intermediate code for robot control units. The project has already contributed directly to the developing international standard STEP in the field of robot kinematics and has provided the draft proposal ISO DP 10303 Part 105.

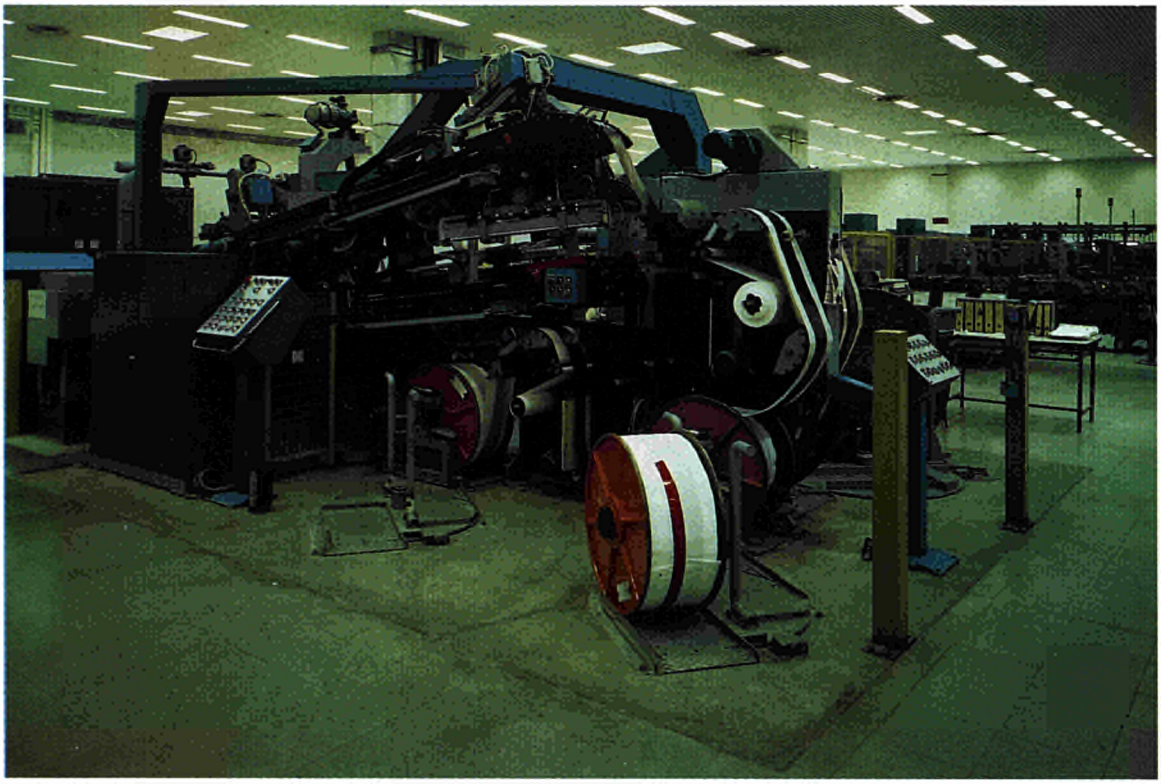
Robot finishing: a niche market

While competition for more efficient and cheaper robots increases, new robot applications emerge and create niche markets. Robot finishing is considered to be a very attractive field because of the tremendous industrial needs and the numerous technological questions demanding urgent solutions. ICI (project 2640) was initiated by Zenon, a Greek engineering company specializing in industrial robot applications. The main objective of the project is to develop a robot cell capable of providing perfect finishing for castings and efficient visual inspection of their surfaces.

The project is addressing the two major problems encountered in the manufacture of casting-based products: the grinding process, which is extremely demanding in terms of dexterity and power, and the need for the inspection for post-polishing defects to be 100% reliable.

The replacement of manual work by robots has already been attempted by other machine tool manufacturers, and some robot-based systems are starting to appear on the market. However, the solutions are only partially satisfactory because of the limited range of shapes that can be handled and associated programming and operational difficulties. Inspection constitutes a serious production bottleneck for several manufacturers, and has not been dealt with satisfactorily until now.

The ICI project has undertaken a very thorough approach to finishing, polishing and inspection. The mathematical modelling of the grinding process led to strict definitions of the requirements for the tools. Combined with sophisticated parts surface analysis and off-



Factory supervision: *Pirelli's Bollate car-tyre factory requires a reliable quality assurance and inspection system to monitor the performance of equipment such as the tyre cord machine pictured here, and to automatically supply, 'just-in-time', the components and raw materials needed throughout the factory. Project 2434 (on knowledge-based techniques for factory supervision) has enabled development of an expert system that could easily be tailored to this application.*

line programming techniques, this permitted the design of a prototype (for Metalworks of Attika SA) for polishing and finishing bathroom taps and sanitary fittings that is scheduled to be operational by September 1991.

Coupling robot grinding with automated visual inspection is an innovative step which, after two years of intensive research, has led to successful results. Advanced image-processing filters implemented on powerful specially designed parallel computing hardware today offer the possibility of visually inspecting a complete surface of a tap in less than a minute and of detecting defects as small as 0.1 mm. Project 2640 has made an important step towards opening up the difficult robot application area of finishing.

Autonomous robots

Situations often arise where it is necessary to carry out work in hazardous environments. Forestry, quarrying and mining provide examples. Such situations can also arise as a result of natural disasters (such as when transporting medical supplies or equipment to rescue teams after an earthquake). In these kinds of circumstances it would often be useful to be able to send in an unmanned vehicle that could find its own way across the terrain to where it was needed, avoiding obstacles and hazards on the way, and perform the necessary work when it arrived without risk to human life. Such autonomous machines would allow work do be done faster and with less human risk.

PANORAMA (project 2483) has made a significant contribution to this area by producing a prototype autonomous vehicle fully equipped with actuators, perception and navigation sensors and computing hardware and software. This vehicle is now used as a project test-bed for tasks that need to be carried out in unstructured or hazardous environments. To date, the first versions of the following functions have been successfully tested: visual beacons detection, attention focusing, environment modelling, local path planning, localization, and piloting. The vehicle's features include the controlled actuation of steering, throttle and brakes, and it is also able to navigate autonomously outdoors on an industrial site while 'blind'.

The first integration of the on-board part of the PANORAMA system in the test-bed vehicle is planned for the end of 1991, and it is foreseen that the vehicle will perform autonomously in a complex environment by the beginning of 1992. This work lays the necessary basis for tackling more complicated scenarios, leading up to forest and open-mine environments by the end of 1993.

Another issue in the project is the computing hardware architecture which combines ad-

vantages of the well-known VME-based systems (for interfaces with sensors and actuators) and the high computing power potentialities of transputer-based architectures (parallelization of high-level processing for modelling, planning and decision-making processes), enabling the easy upgrading of system performance and a high degree of flexibility in development. This task involves particularly close collaboration among project partners.

Shop-floor vision systems

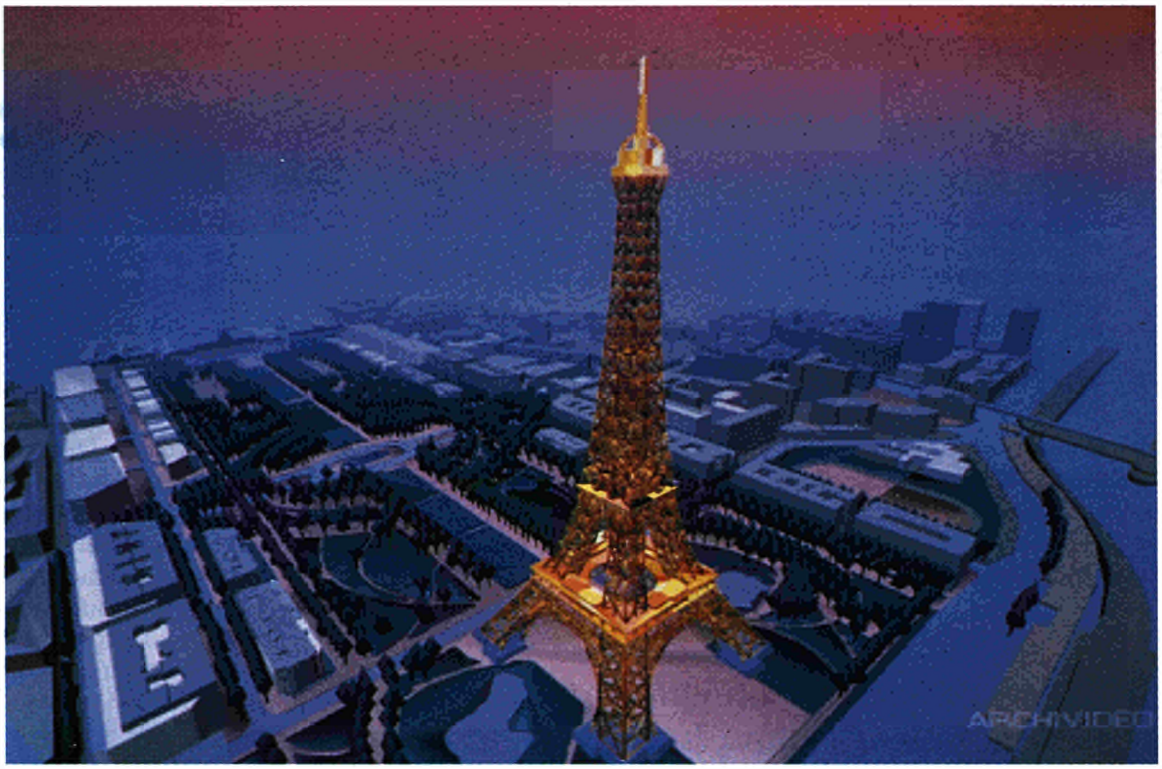
Sophisticated vision systems are not only required for guiding autonomous vehicles and robot grippers, but are also needed in other shop-floor operations. They form the link between CAD/CAM and automated inspection and assembly systems. This is well demonstrated in two projects. In the field of printed-circuit board manufacturing, TRIOS (project 2017), led by Siemens, uses advanced laser technology to solve the problem of achieving fast, 3D high-resolution high-speed data acquisition that is independent of the surface condition of the work-piece. One of the first and outstanding results of the project was a ranking filter for real-time 3D data processing on a single chip. Its use has been validated in test-beds for the inspection of patterns on high-density printed-circuit boards and for the assembly of populated boards. In the field of complex mechanical parts, VIMP (project 2091) compares images from an online vision system with those derived from a CAD system to provide a much more reliable and faster assessment of quality than can be achieved with conventional methods using mechanical measurements.

Materials tracking

The tracking of goods and materials in an industrial environment is the aim of HIDCIM (project 2127). The system is based on computer-generated holographic tags which can store up to 1 kbit of information on a 3 x 3 mm tag that is easily attached to equipment or work-pieces. Compared with available techniques this represents a very high density of information.

The tags, which are small pieces of the 'digital paper' developed by the chemical company ICI (UK), are coated to protect them from dirt and scratches. The optical read/write process makes them immune to electrical interference. They can be attached to the components of a product (for example, the parts of

Autonomous robots: *this unmanned car is a test-bed for the integrated sensors and scene-recognition systems developed in PANORAMA (project 2483). Navigational decisions are made by the knowledge-based processing of various sensorial inputs and by using a satellite-based global positioning system. The results of the project are expected to be incorporated into vehicles capable of carrying out a range of hazardous mining, quarrying, forestry, agricultural and inspection tasks in an autonomous fashion.*



Transputer power: *the transputer-based system employed by Caption, a partner in VIMP (project 2091), can generate sophisticated simulations such as the one shown here. The VIMP approach to inspecting manufactured parts involves comparing an online image of the workpiece with an image generated from data stored in the manufacturer's CAD system. The 3-D data stored is transformed into a 2-D projection corresponding to the angle of view of the image sensor.*

a car, refrigerator or television set) or to a machine tool in order to provide a history of its manufacture and servicing. The tags can only be written to once, but as they are very inexpensive, it is entirely feasible to update a tag by simply replacing it with an updated version.

The 'digital paper' medium consists of an optically active dye polymer which is coated onto a metallized polyester base. The data points are recorded by a focused infra-red laser beam without any chemical post-processing. Information retrieval is done by illuminating the 'holotag' with a laser diode and reconstructing the 2D bit-pattern with a Fourier transform lens.

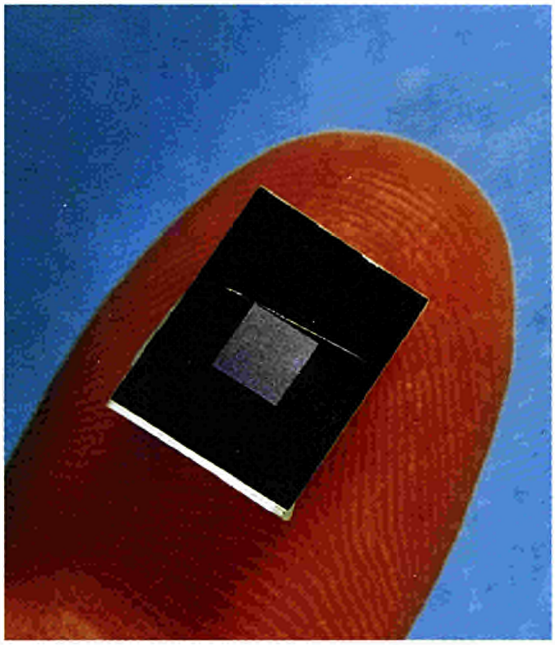
The reading station is very simple, based on a standard charge-coupled device camera connected to a computer. The camera can read a tag from up to 50 cm away, and the reading process is tolerant of mechanical vibration and largely unaffected by dust and scratches, due to the coating on the tag and the redundancy of the holographic storage technique.

At present, tags are written to under laboratory conditions, and work is in progress on developing a writing station that can be used in normal factory or other environments. A prototype demonstration has been set up at the machine tool manufacturer, Mandelli, where alpha-numeric information used to tag tool carriers is supplied by a CIM network. The tags ensure that the correct tools are used for the applications concerned.

Application awareness and technology transfer

Under the banner of CIM-Europe, a wide range of activities are carried out each year in order to familiarize workers in the area of CIM with developments outside their own projects, and to disseminate to a wider audience information on results which have been achieved, particularly potential end-users of the new technologies. The largest of these events is the annual CIM Conference, the sixth of which was held in May 1990 in Lisbon and the seventh, in May 1991, in Turin. Changing the venue stimulates the active participation of local industry, and the site visits to manufacturing plants have become a popular and enlightening feature of the conference programme.

In addition, there are regular meetings of special interest groups on topics such as human factors, field bus, and model-based predictive control. Workshops are also held which focus either on the main topic of interest of a project, such as the IMPPACT (project 2165) workshop on 'Product modelling', or concentrate on a subject, such as 'CIM in Pro-



Digital paper: *a holographic image is stored on this cheap, disposable 'digital paper' tag, 3 mm square, developed in HIDCIM (project 2127) for tracking equipment and workpieces. The information on a tag is read by a special camera connected to a decoding computer, and is unaffected by factory dirt or electrical interference.*

cess industries' or 'Mechatronics and robotics', which serves as a link between several projects. The conference and workshop proceedings are published in order to disseminate information on the progress reported to as wide an audience as possible.

A more basic form of technology transfer is under way in MICIM (project 2706). The MICIM team are applying a number of ESPRIT CIM results in real factory environments ranging from the manufacture of electronic components (Philips PCB manufacturing plant) to electromechanical components (Carlo Gavazzi). The experience gained is being packaged as a training methodology for provision to other teams finding themselves in similar situations. Along with a number of other issues, they are addressing the application of the CIM-OSA methodology and implementation of data-exchange mechanisms between previously incompatible CAD systems.

Basic research

Overview

Continual technological innovation is essential to maintain and strengthen the global competitiveness of Europe's IT industry, and the ESPRIT Basic research actions have been instrumental in providing the underlying knowledge and expertise needed to create future breakthroughs. A Europe-wide community of advanced research in IT has been established, and closer collaboration fostered between the academic community and advanced industrial research centres.

Actions in Basic research aim to promote collaborative research in areas with the potential to produce future advances and breakthroughs relevant to the long-term goals of the European IT industry and its users. The areas selected are upstream of industrial R&D and clearly capable of benefiting from collaborative fundamental research on a European scale. These selection criteria are particularly applicable to large-scale research efforts, often interdisciplinary, that would be too ambitious for individual teams to undertake.

As a result of the original call for proposals in 1989, 61 actions and 13 working groups were selected that focus on a range of key areas including superconductivity, optical computing, design methodology for integrated circuits, logic programming, concurrency, databases, knowledge representation, computer vision, neural networks and robotics. About 75% of participants in Basic research actions are newcomers to the ESPRIT programme and represent a net gain in the contribution made by the fundamental research community to the European IT industry's overall R&D effort. The transfer and uptake of results is being ensured by links to industry sector activities (through open workshops and the involvement of industrial participants in reviewing Basic research actions) and by direct involvement (over a quarter of the actions have industrial participants, and the proportion is rising as the work undertaken matures). In addition, 'Networks of excellence' have been conceived and set up to reinforce and further develop the strong patterns of cooperation that have been emerging between teams of researchers.

Networks of excellence foster collaborative research

A Network of excellence is a grouping of research teams sharing common long-term technological goals and closely coordinating their research and training activities. In principle, a Network of excellence is open to all organizations working towards the same goals, wherever in Europe they may be, though the research teams constituting the 'nodes' of a network (based in a research centre, academic department or industrial laboratory) must collectively possess a critical mass of top-level experts, skills in all the disciplines required to attain the objectives set, and state-of-the-art facilities.

Three Networks of excellence were launched early in 1991 in exploratory one-year phases. These three pilot networks have clear technological goals in the areas of Language and speech (Network 3701), Distributed computer systems architectures (Network 3702) and Computational logic (Network 3703). They are expanding rapidly from a limited base of founder-members — the Computational logic network alone now has over 50 participants. It is expected that valuable insights will be gained during this exploratory period into the best way of operating future networks.

Typically, the participating institutions define a strategy for the achievement of their common technological goals and devise a framework within which projects undertaken by different

members can fit. In addition, Networks of excellence take measures such as promoting the mobility of researchers, designing curricula and interdisciplinary course material, acting as clearing houses for research results, and promoting exchanges of staff with industry so as to foster training and technology transfer. All these contribute to their goals.

The close links between the nodes of a Network of excellence mean that access to any one node gives access to the resources of the entire network — interdisciplinary know-how, special skills, or material resources. Such accessibility has favourable implications for human resource development, the cohesion of Europe, and, in particular, for technology transfer and industrial innovation: instead of having to develop a working relationship with several research centres, a firm need only contact one node of the network to gain access to the expertise of them all.

The distributed nature of Networks of excellence also helps ensure that 'excellence' is not drained away from regions with less well-established technological traditions. In such regions viable nodes of European networks can be found, even if establishing self-sustained 'centres of excellence' would be unrealistic. Local industry can easily obtain the most advanced research results, and the local research community gains access to wider industrial markets.

The collective strength of a Network of excellence is expected to attract doctoral and post-doctoral students to spend part of their research time in different nodes. This will help provide the interdisciplinary skills that Europe needs. The majority of researchers trained in this way are expected to find a future in industry as sorely needed systems engineers — people with a complete view of a technology's development from conception through to implementation.

Another Basic research initiative, the VLSI design action, has made excellent progress in remedying a particular skills shortage: the ability to design VLSI circuits.

VLSI design action exceeds training targets

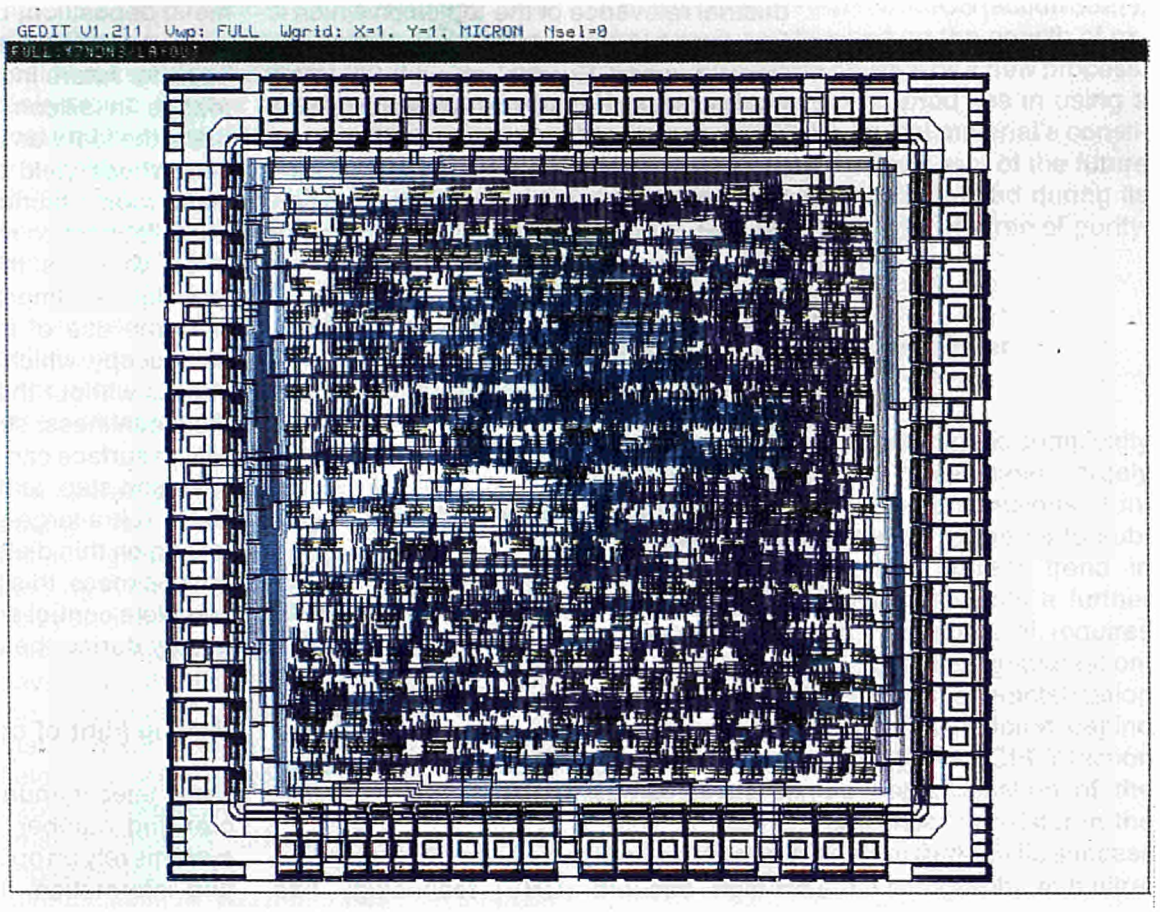
During 1990, EUROCHIP, the service organization for the ESPRIT VLSI design action (3700), entered its first full year of operation. The launch of the action was prompted by an acute shortage of VLSI designers within the Community, a shortage that has limited the use of advanced microelectronic technologies in a number of industrial sectors and particularly their take-up by SMEs (small and medium-sized enterprises). On current estimates at least an additional 3 000 students a year, besides the present 1 500, need to be trained in the necessary skills. The main obstacle to training which the action addresses is access to silicon and the resources and facilities required to make good use of this (such as workstations, computer-aided design (CAD) software, testers and trainers). 200 academic institutions are now involved: 60 receive support for their own design training facilities (including lecturer posts, CAD software and access to industrial fabrication facilities); a further 60 have been provided with free access to fabrication facilities, and, attracted by the advantages of the service, an additional 80 institutions are taking part at their own expense.

These participating institutions are supported by the central service organization, EUROCHIP, composed of five eminent research institutes from different Member States, that handles negotiations on their behalf with the suppliers of hardware, software and fabrication facilities. Strategic guidance is provided by a steering board drawn from industry and academia.

To date, 900 CAD software packages have been installed under the EUROCHIP agreement, and training in the use of CAD software has been completed for around 320 academic instructors. Some 80 workstations and IC (integrated circuit) testers have been provided to selected participating institutions, and a further 300 workstations have been bought by institutions at their own expense.

Fabrication contracts with five European foundries are now in place, and several fabrication routes (particular set-ups of manufacturing procedures) are in regular service. These include digital and analogue CMOS, advanced CMOS for complex digital designs, GaAs for monolithic microwave integrated circuits, and BiCMOS technologies on chips, wafers and ICs.

The VLSI design action has already enabled approximately 300 courses to be held, providing a total of around 700 000 student course-hours and resulting in the design of more than 350 VLSI chips, of which 200 have



VLSI design training: *a graphical representation of the design layout for a microelectronic circuit, as seen by the designer on a workstation. The design shown contains the control and processing units, the interface control and the memory manager for an asynchronous digital neural network. Created by a student of the Universidad Autonoma de Barcelona participating in the VLSI design training action (3700), the chip was manufactured by ES2 as part of the second EUROCHIP fabrication run.*

been fabricated and 120 tested. More than 5 000 students have been trained in the first full year of operation, a total which actually exceeds the action's original objective of tripling the number of trainees from 1 500 to 4 500 per year.

Research actions contribute to industrial innovation

All research actions have now completed their first 18 months of activity, and there is already evidence of their impact on the European IT research scene:

- ESPRIT Basic research has quickly gained momentum and generated considerable enthusiasm in the IT research community. One indication of this is the increasing number of researchers applying to join or become associated with existing actions, often without requesting additional funding.
- In addition to a large number of joint publications by researchers, it is becoming increasingly evident that strong cooperation mechanisms (in addition to the Networks of excellence described above) have been put in place throughout Europe to tackle difficult problems, integrate related approaches and bring together the different disciplines required.
- Evaluations by independent reviewers have identified a number of developments and results with clear industrial significance. Indeed, several industrial projects have already incorporated ideas and approaches consolidated during the first year of the ESPRIT Basic research activity.
- A survey of the current state of research actions shows the effect on training. An estimated 30% of Basic research funds (excluding the VLSI design training action described earlier) go to support doctoral and post-doctoral researchers, while at the same time putting their training to immediately useful ends. Moreover, it is estimated that about 1 000 doctoral theses are currently being prepared that are directly related to Basic research actions.
- The enthusiasm generated by ESPRIT Basic research, as well as the perceived in-

dustrial relevance of the topics on which it focuses, has stimulated very active interest outside Europe as well. A good number of researchers who were pursuing careers in the USA, Japan and other parts of the world have been recruited by participants in Basic research actions, reversing part of the 'brain-drain' from Europe of researchers in IT R&D.

Several significant results have already been produced by Basic research actions, and highlights from the main areas of activity are described below.

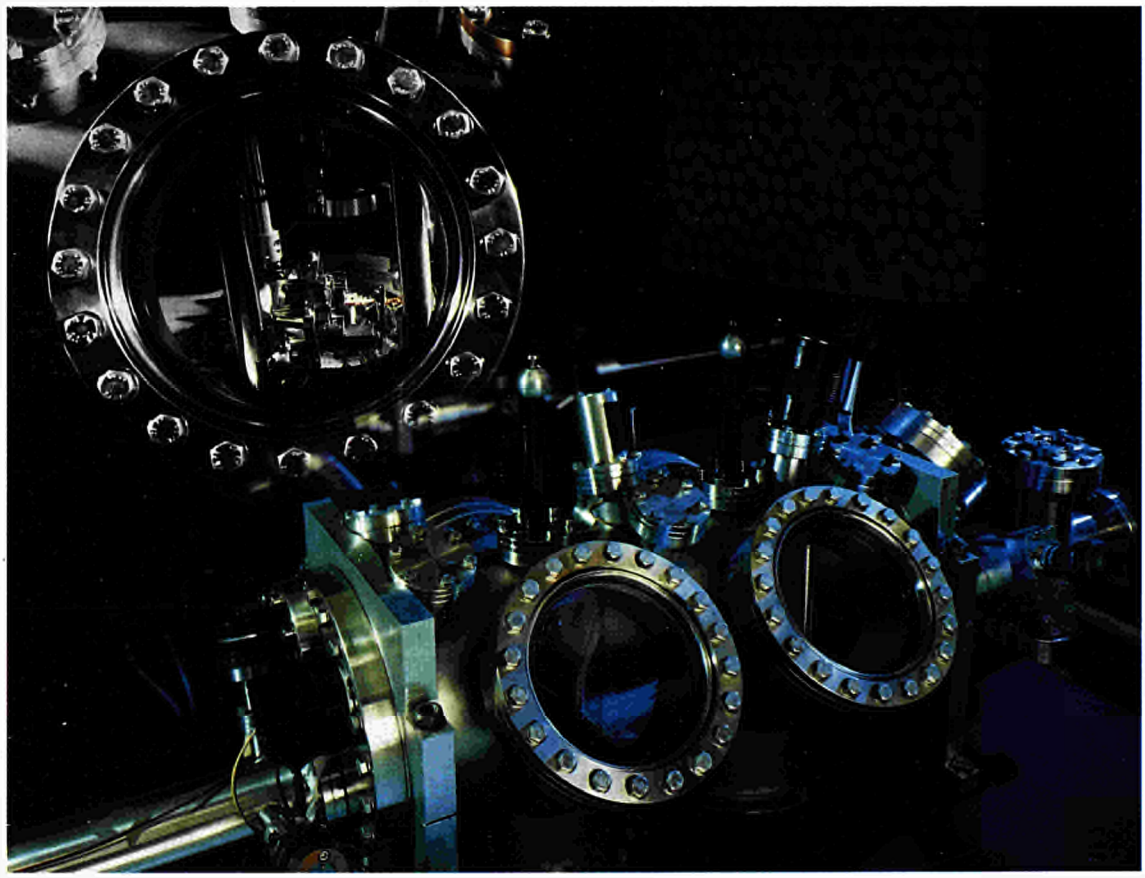
Novel techniques improve device performance

The research carried out in advanced materials processing and basic device characteristics is aimed at the realization of novel materials with electronic and optical characteristics that increase the yield and enhance the performance of integrated circuits and other components.

A research-scale linear cluster tool based on ultra-high vacuum (UHV) technology has been built by the members of PROMPT (Action 3109). This contains a station for UHV metal deposition, ultra-dry oxidation and ion-beam sputtering, and promises to provide a basis for future increases in yield and performance in silicon fabrication. During initial trials, the tool was used to fabricate MOS test-sets whose yield equals that of established clean-room fabrication methods (conventional fabrication techniques are optimized at 90%, which is the starting point for UHV techniques). Improved quality has resulted from the use of *in situ* scanning tunnelling microscopy, which permits a range of quality checks without the vacuum being broken — the cleanliness, structure and flatness of the silicon surface can now be verified, prior to the oxidation step, at the atomic level. For future ULSI (ultra-large-scale integrated) devices relying on thin dielectric layers of less than 10 nm thickness, this kind of processing will give complete control and hence a higher assured quality during the crucial oxidation process.

Making light of communications

Many telecommunication systems and an increasing number of information processing systems rely on optical processes for transmitting information. To date, no optoelectronic components have been devised that can be manufactured using silicon technology. New



MOS structures: *a research-scale linear cluster tool for ultra-high vacuum (UHV) semiconductor processing has been built by PROMPT (action 3109). The ion beam scattering, residual gas analysis and scanning tunnelling microscopy (STM) facilities fitted allow all stages of the oxidation step to be controlled. Shown is part of the apparatus, the integrated STM, and a clean silicon surface prepared for UHV processing.*

materials with optical characteristics that allow the direct coupling of silicon chips to optical fibres would enable the production of optoelectronic devices of better quality, lower cost and higher performance, and enormously simplify the wider use of optical devices. HESSILSIL (action 3026) has developed a new material in thin-film form ($FeSi_2$ in its semiconducting phase) with the necessary characteristics plus the ability to produce luminescence of the wavelength required. A collaboration with Philips Research Laboratories was arranged to transfer the research results to an industrial environment.

The overall goal of research in optical computing is to develop concepts and technologies for improving information processing in areas, such as electromagnetically noisy environments, which pose difficulties for electronic systems. With the specific aim of developing the field of optical logic processing, new parallel non-linear optical processing methods for coding information into laser fields are being researched in TOPP (action 3260). A prototype system for recognizing small numbers of patterns has recently been implemented in collaboration with Aliena/Alitalia (I). Research has also focused on the reduction of quantum noise in light beams. NOROS (action 3186) aims to use optoelectronic and non-linear optical devices to reduce the noise caused by the corpuscular nature of light. Before the action started, the best results achieved — noise reduction factors of up to 60% — were not good enough for practical applications. NOROS has achieved a world-record 90% noise reduction, making possible applications in the area of secure optical communications, as recently demonstrated by the Defence Research Agency (UK), a partner in the consortium.

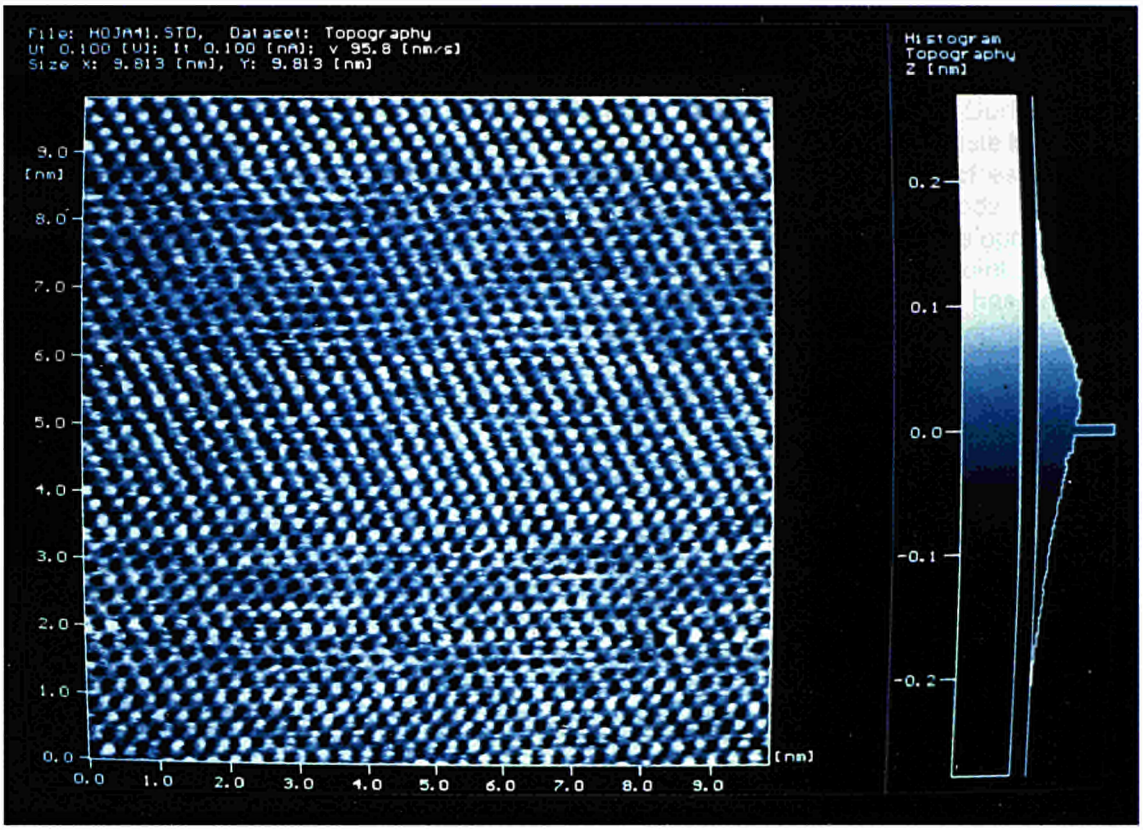
Superconductivity

The discovery of high-temperature superconductivity in oxide compounds has led to the formulation of a large number of theories to explain the mechanism involved, though none of the models that have so far emerged has become a commonly accepted basis for explaining the phenomenon. The problem largely stems from a lack of experimental data (inelastic neutron scattering data in particular), and here research into materials preparation and characterization is a key issue. Good progress in this area has been achieved in SUPRADYNAMICS (action 3327), where work has focused on the growth of extremely pure single crystals by a new process. The originality of the method lies in using a container to melt the crystal material's constituents that is itself a component of the future crystal and is therefore consumed during its growth. This ensures a high degree of purity.

Nanotechnology and molecular electronics

Increased levels of integration and complexity in integrated circuits have been largely achieved by shrinking the dimensions of individual semiconductor components to submicron dimensions. The current trend in microelectronics, pointing towards a further scaling-down to the nanometre level, requires new advances in growth, implantation, lithography, etching and characterization techniques, and is the driving-force behind the new 'nanotechnology'. NANOFET (action 3042) has achieved the fabrication of the smallest working field-effect transistor in the world (25 nm gate-length) through its success in using electron-beam lithography with ultra-submicron precision. By applying the same technique, the fastest pseudomorphic transistors ever made in Europe have been manufactured on pseudomorphic delta-doped AlGaAs/InGaAs epitaxial layers with current gain cut-off frequencies exceeding 170 GHz at room temperature.

The molecular electronics approach to fabricating ultra-small electronic components is to synthesize molecules that can be reliably switched between different states and then be assembled into structures that can store data and process it in predictable ways. A variety of such molecules have been designed and synthesized in the past 18 months by MOLSWITCH (action 3314) and OLDS (action 3200). Outstanding work has also been carried out on the modelling, synthesis and physical characteristics of conducting molecular crystals by MOLCOM (action 3121). In addition, a new technique, scanning near-field optical microscopy, has been developed in the OLDS action to enable the characterization of the thin-film molecular assemblies designed and prepared by this consortium. The technology is being commercially developed by a consortium partner, Helmut Hund GmbH (D).



Molecular electronics: *OLDS (action 3200) has developed scanning near-field optical microscopy and scanning tunnelling microscopy (STM) as new tools for storing and retrieving information at the nanometre scale. Shown is the atomically resolved structure of a Langmuir-Blodgett film and, on the right of the screen, an analysis of its topography. OLDS is studying two kinds of organic molecules: conjugated (i.e. those with electron transport properties) to be used for molecular 'wiring', and lipid molecules (i.e. those with defined dipole moments) for representing information.*

The reliability of circuits fabricated with submicron devices is an important problem-area for designers of advanced microelectronics components. The limitations in the performance of submicron devices caused by noise are under investigation by NOISE (action 3017). It had been assumed that the performance of circuits could be improved by cooling them to very low temperatures. However, an important result from NOISE is the discovery that the ageing of transistors is accelerated at such temperatures: designers will now be able to trade-off performance enhancement against degradation time.

Towards convivial software: more readily designed, easier to use

Moving away from components and hardware, a number of fundamental problems in computer science are being addressed by several Basic research actions. These cover both software design and evaluation methods, and aim both to reduce programming effort through improving design methods and to facilitate the development of more flexible, user-friendly systems. A further goal is to foster the development of programming languages that are far more expressive than any now in common industrial use, and to provide them with environments supporting high-level concepts.

Basic research actions have progressed towards these goals by addressing a range of key issues such as program semantics and parallel computing, logic and meta-logic reasoning, new models for programming, and complete systems based on graph grammars.

The latest results of COMPULOG (action 3012) were the focus of a symposium on computational logic held in conjunction with the ESPRIT Conference in November 1990. One of the results of this action has been the development of a new declarative logic programming language, GÖDEL, which has strong typing, modules and facilities for use in meta-programming. Besides making software engineering easier, the declarative nature of GÖDEL opens up possibilities for exploiting the parallelism of future systems with substantial gains in efficiency over other less declarative logic programming languages. Also developed within COMPULOG have been novel techniques, notably in the area of program transformation, that will reinforce the efficiency gains.

Flexible systems often encounter performance problems. These can be addressed through systems that enhance the performance of compilers and by employing better

algorithms. The latter approach is exemplified by the work of ALCOM (action 3075), which has succeeded in designing over 60 algorithms that are very much more efficient than those previously in use. These include routing techniques for networks of processors, recently adopted by industry in the development of the Inmos C104 routing chip, which is being used in conjunction with the new Inmos T9000 transputer. A library of tested algorithms has been made accessible to the computer science community.

New computing paradigms are expected to provide the environments necessary for resolving many long-standing problems in software development. One new paradigm is exemplified by the research on 'graphs' in COMPUGRAPH (working group 3299). Graphs are mathematical structures used in computer science to represent concepts ranging from the abstract syntax of a program to schemas of object databases, and specialized techniques for manipulating graphs more efficiently are needed. COMPUGRAPH's research has focused on the practical and theoretical aspects of hyper-edge replacement, which is one approach to graph transformation, and has led to a new generation of highly efficient rule-based inference mechanisms.

Paradigms are adopted by computer scientists to define both languages and software development environments. Central to the success of these environments is the assistance they provide the development team in 'proving' the correctness of a system under development without the need for testing — which in practice can rarely, if ever, be exhaustive. PROCOS (action 3104) has produced a method for capturing requirements for real-time, embedded, safety-critical systems. This is now being tested in collaboration with Danish National Railways.

The integration of paradigms to combine their various advantages is the focal point of several actions. One example is INTEGRATION (action 3020) which is integrating object-oriented, functional and logic programming and has already developed a new parallel object-oriented language whose functional characteristics address fundamental problems identified in earlier ESPRIT projects.

In the complementary field of operating systems, CONCUR (action 3006) has developed a concurrency workbench (CWB) for the analysis of practical distributed and concurrent systems. The adoption of a performance verification algorithm within CONCUR allows the properties of systems modelled using the CWB to be checked more rapidly than hitherto, a feature which is already being applied in practice.

An important research theme in the information and database systems areas is the integration of a full set of technologies — from object stores to user interfaces — to allow a total application to be built within an integrated environment. For instance, FIDE (action 3070) has succeeded in defining integration rules and tests: these were demonstrated by having the Galileo database programming language running with data provided independently by the Napier 88 persistent store.

Measuring software reliability

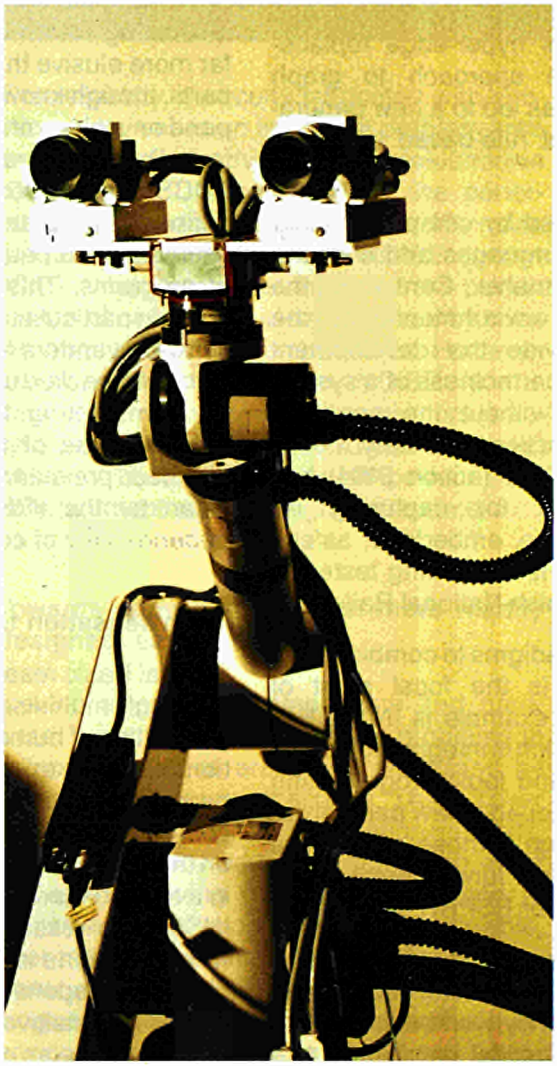
Despite advances in the manufacture of hardware, the reliability of computer software is especially difficult to measure. Techniques for building reliable software and techniques for evaluating what has been built have proved far more elusive than their hardware counterparts, though knowing how much one can depend on a piece of software is crucially important. Partly as a result of work carried out in PDCS (action 3092), methods have been defined for obtaining accurate reliability estimates and predictions for certain classes of programs. This has far-reaching implications. In particular, it now makes it possible for software vendors to use the reliability of their products, backed up by a scientific evaluation, as a marketing feature. Furthermore, the achievements of PDCS form the basis for planned pre-standardization efforts undertaken by the IFIP Working Group on the dependability of concepts and definitions.

From sensation to perception

Several Basic research actions have adopted a strongly multidisciplinary approach to the investigation of human cognition. INSIGHT (action 3001), for example, has brought together neuroscientists, cognitive psychologists and computer vision experts to pioneer new ideas on the functioning of vision systems operating in a three-dimensional dynamic environment. INSIGHT's research has demonstrated that when someone looks at a moving image, the neuronal response in the higher-level visual cortex is sensitive to information about the moving scene as a whole. Moreover, if part of

the image is momentarily occluded, the neuronal response at the higher cortical level fills in the missing information. This complementing of sensory information with implicit knowledge had been postulated and partially achieved in artificial vision systems, but has never been directly demonstrated before. INSIGHT's achievement represents an important step forward in the understanding of natural vision, and is expected to pave the way for the development of artificial vision systems able to operate in a changing three-dimensional world.

Vision as process (VAP) (action 3038) is developing techniques for the control of perception in a continuously operating artificial vision system. The VAP system integrates real-time processes for binocular camera control, image description, 3D scene modelling and symbolic scene interpretation. The consortium is developing control mechanisms which exploit observed temporal context and goal-oriented user instructions to direct vision processing for the continuous operation of the integrated system. Early results have confirmed that a number of vision problems are substantially simplified by the use of an active controllable sensor and continuous processing. The consortium has constructed three prototype binocular camera heads as well as a set of computer boards for real-time multi-resolution image description and tracking. Arrangements have recently been concluded for the image description boards to be commercialized by ITMI, a leading French supplier of machine vision systems.

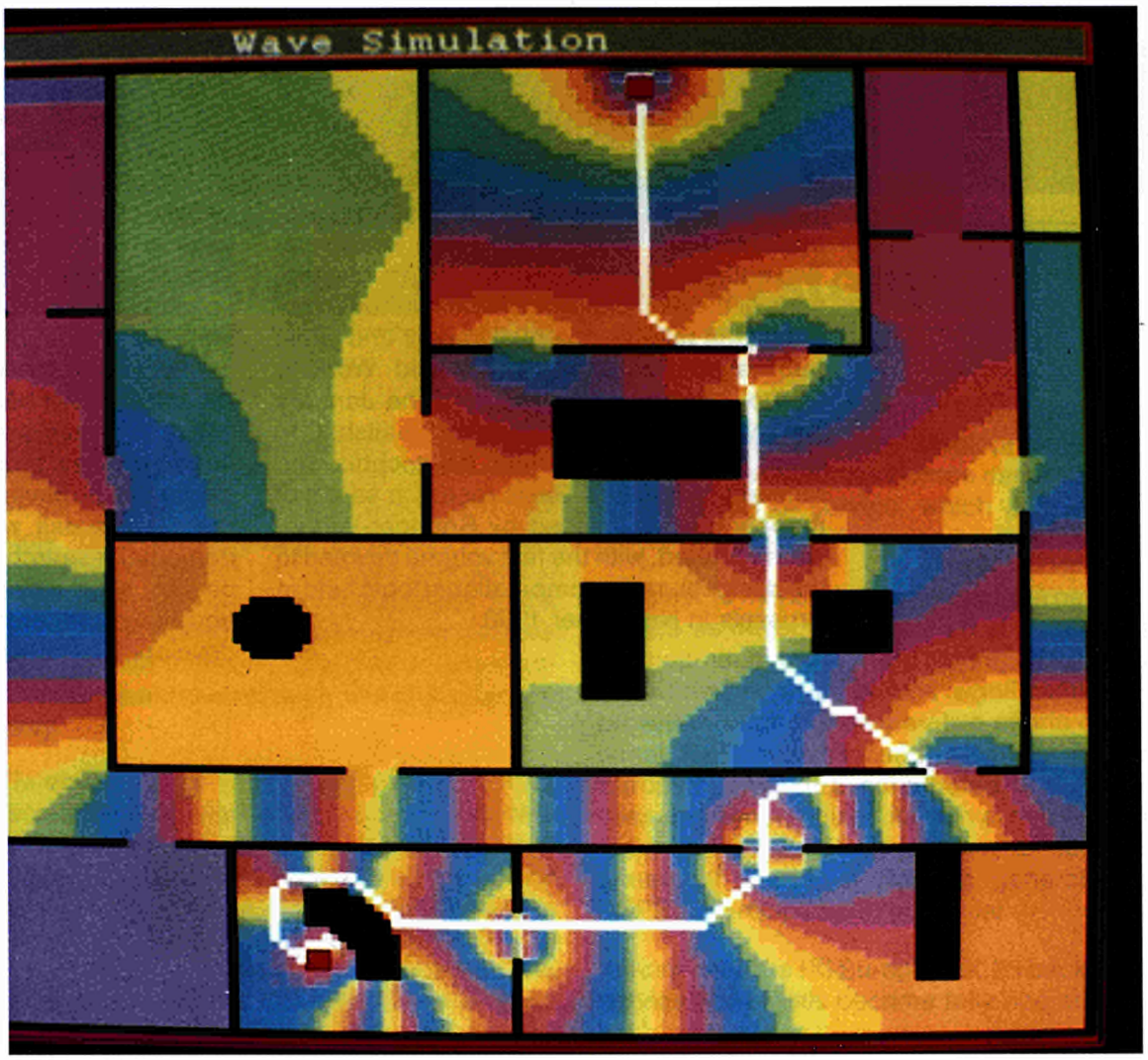


In vision: *VAP (action 3038) has developed this prototype of a vision robot which is able to keep its focus of attention on moving scenes. It can recognize dynamic patterns, and can continuously coordinate the aiming and focusing of its eyes with its movements, employing advanced real-time computing and sensing to do so. The dedicated hardware boards developed in the course of the work are being commercialized by ITMI of Grenoble, France.*

In conventional robotics, 'motion' generally takes place once a sequence of investigative interactions has established the parameters for movement. In contrast, SUBSYM (action 3234) is experimenting with direct vision-to-motion planning systems that eliminate the need for this stage. By storing a visual representation in an analogue buffer also containing predictive information on the scene in question, sensorimotor actions (such as hand-eye coordination between a video camera and a robot arm) can be planned and monitored. In the course of the action a powerful technique that can be used for robot navigation has been developed. Its ability to adapt in real time to topological changes, and to simultaneously compute the paths of multiple robots, is unmatched by any other method.

Speech recognition

Communication through sound and speech is less well understood than communication through vision. Fundamental research is essential if the long-term goal of direct speech communication with information processing systems is to be achieved. ACCOR (action 3279) studies human speech production in several languages with two main objectives: to recognize the invariants among these different languages, and to minimize the number of parameters necessary when modelling speech production. The research is vital for improving the efficiency of speech recognizers by simplifying their acoustic preprocessors. In the course of its work, the ACCOR consortium has developed a unique multisensor speech-data acquisition system which is already attracting interest from speech therapists, phoneticians, and scientists investigating the human speech production process. The system will be commercially



Finding the way: *a computational metaphor for path generation gleaned from fluid dynamics has been developed in SUBSYM (action 3234). This powerful technique finds the optimal path for a robot to navigate through any maze, no matter how complex. Its abilities to adapt in real time to topological changes in the maze and to compute, simultaneously, the paths for additional robots are unmatched. The picture represents the interior of a building with walls, doors and desks. The white line is the path found from the red square (in the room at the top) to the destination behind the desk at bottom left. The colours represent intermediate stages in the generation of the path.*

released in August 1991 by Phonologia, a company set up by the consortium.

At the other end of the speech processing and recognition continuum, ACTS (action 3207) has modelled auditory processing with such high resolution that the 'formants' of speech (the frequency bands that give a sound its particular quality, timbre or tone colour) can be resolved. The model provides a better representation of our auditory sensations than the activity observed in the auditory nerve, and has already allowed artificial speech recognizers to work more efficiently than with traditional sonograph front-end processors, especially in noisy conditions.

In Europe, with nine major languages in the countries of the Community alone, there is a strong motivation to develop multilingual human-computer interfaces, which can be considered as intermediate steps towards the goal of fully automated translation systems. DYANA (action 3175) is carrying out research that will help in the development of a computational and cognitively motivated model of how spoken language is understood, and is addressing fundamental issues in computational linguistics, speech understanding, syntax, semantic representation and reasoning, and the interfaces between all these areas. One important focus of work during the second year of the action was that of bridging the gap between computational linguistics and speech technology. A system was demonstrated which automatically labels intonation contours, and foundations for a theory of computational phonology were developed. Substantial progress was also made on the development of a comprehensive unification formalism for linguistic description. Both strands of work are moving the consortium — and the Community — towards the forefront of this highly competitive and rapidly evolving field.

Awareness activities

During 1990/91 the Basic research actions published a large number of papers in leading scientific journals. Many presentations were made in international conferences, and over 100 workshops were organized involving participants from both industry and academia. Two editions of synopses — succinct descriptions of the aims, approach and methods, progress and results, potential impact and latest publications of each Action and Working Group — were published, and the January 1991 version sent, in a targeted mailshot, to every European university, polytechnic and research institute. A Basic research series of monographs, published by Springer-Verlag, was launched, with the first volume devoted to the symposium on computational logic held in Brussels in November 1990.

Outlook

The activities comprising Basic research have begun to provide the necessary foundation for a broad range of new industries, with the results of any one action expected to feed into several other ESPRIT projects and areas of industrial R&D. Results, such as the demonstration of the way the brain handles certain cognitive processes, have long-term implications for fields of research as diverse as medicine and robotics, and the discovery of the unexpected behaviour of microcircuits at low temperatures will have an immediate influence on new product development. Just as important, however, is the demonstration that there are areas where the route from fundamental research to applied technology can be very short indeed, especially when small and lively companies take up the challenge of developing and exploiting new ideas.

Information exchange system

Overview

The international cooperation that characterizes ESPRIT requires that project participants communicate with each other not only by the traditional methods of conferences, seminars, workshops and special interest groups, but also via communications services that enable them to make immediate contact with their partners in other organizations or countries in an easy and cost-effective way.

To encourage the cross-fertilization of ideas, scientists and engineers should also be able to readily identify and contact participants in ESPRIT projects other than their own, and to access the Commission's scientific databases (hosted on the DG XIII sponsored 'ECHO' host computer in Luxembourg). It is also desirable that participants in other Community programmes, and indeed European scientists generally, should have high-quality, cost-effective communications tools and network facilities. To this end, three lines of activities are pursued within the Information exchange system (IES):

- The provision of communication services to ESPRIT participants.
- Projects aiming to accelerate the availability of OSI-conformant computer communications software.
- Harmonization of the implementation of inter-computer communication protocols, to be achieved by providing strong encouragement for the adoption of the ISO-OSI model. Particular support is given to Europe-wide networking activities such as the EUREKA COSINE project in order to enable interworking between researchers and their computers located in all participating countries.

These three types of activity are closely related: the communications services improve as new technical developments take place, and users across Europe demand even higher levels of service, which accelerates harmonization activities.

The past 18 months have ushered in a new era for IES as major, long-planned changes and developments took place. During this period R&D networking in Europe significantly improved through the cooperative efforts of national R&D networks and initiatives at the European level. IES contributed to this process and synchronized its own activities with major international developments for the benefit of European R&D in general and ESPRIT participants in particular.

In April 1990 the IXI European X.25 backbone service at 64 kbit/s became fully operational.

The progression of the EUREKA COSINE activity reached important milestones with the award of contracts for several COSINE subprojects.

Usage of the EuroKom system continued to increase, paving the way for its launch as a service independent of Community funding.

Activities supported

The most important activities supported by ESPRIT IES are:

EuroKom

Throughout 1990, EuroKom continued to make good progress in increasing its number of customers, with some 2 200 registered users reading an average of over 200 000 messages per month. As a direct result of the sustained improvements in the use of EuroKom, 1991 marked an important turning point for the service when it became fully self-supporting at the beginning of the year.

EuroKom will continue to provide services to the IT R&D community as its primary market. These services, especially its conferencing facility, are expected to remain an important and attractive complement to the other OSI-based services now emerging.

IXI

IXI, the international X.25 infrastructure backbone service for R&D, connects 20 public and private X.25 networks in 17 European countries. It also provides direct connections for several specific users (such as the JRC, CERN, EuroKom and the CEC). The major portion of funding provided by ESPRIT enabled the IXI pilot service to be launched in 1989 with the aim of constructing a high capacity, reliable network service providing links between national research networks at higher speeds (64 kbit/s), greater reliability and lower cost than those available from public services.

The service commenced regular operation in April 1990. Since then traffic volume has steadily increased, reaching about 16 Gbit/month in the spring of 1991. IXI will also provide the interconnections for the Y-NET service (see below).

Plans for upgrading to a 2 Mbit/s European backbone service were developed. In October 1990 the Y-NET project was launched. By the end of 1991, the pilot IXI service will have been replaced by a full-scale service.

Y-NET

Y-NET, a new ESPRIT pilot OSI action, was launched at the 1990 ESPRIT conference and exhibition by Teleo SpA, who have been contracted to implement the project via the Y-NET Management Unit (located in Brussels) in conjunction with a group of European manufacturers, who are also donating equipment for the project. The operational and management costs will be met by the IES.

Y-NET aims to provide communication services to all researchers participating in ESPRIT and other Community-supported R&D programmes using OSI-conformant systems. Particular emphasis is being placed on the needs of SMEs, who have hitherto experienced difficulties in accessing pan-European research networks.

The OSI-based network services to be provided during the 48-month project initially comprise X.400 mail services and FTAM (file transfer access and management), with X.500 directory services and ODA (office document architecture) available in a later phase. These facilities are intended to complement and facilitate access to services which have been launched or are currently in the process of being established under COSINE.

COSINE

The EUREKA COSINE project is dedicated to furthering the use of OSI-based communications by the European research community. The approach is to federate national OSI networking in the R&D domain through a set of specific activities (COSINE sub-projects) at the European level. Support for this project is provided by the Commission, including the provision of the project officer and secretariat functions.

COSINE has now launched several sub-projects, amongst them two aiming to improve specific aspects of European OSI interworking:

(i) a message-handling project (MHS) to coordinate X.400 traffic at European level originating from national MHS projects;

(ii) a gateway service for message-handling and file transfer to connect European R&D networks with those in the USA.

Other COSINE activities, such as a pilot international directory service and pilot support and information services, are coming on stream, with initial availability to users planned for the second half of 1991.

Subsequent COSINE activities have recently embarked on their implementation plans: pilots for FTAM interworking testing, virtual terminal and connectionless network services, and the support of international user-groups.

RARE

The work of the RARE (Réseaux associés pour la recherche européenne) association, through which national and international R&D networks cooperate in order to harmonize their different technical approaches, has continued to receive support from ESPRIT. This involved support both to specific RARE work-

ing groups and to the RARE X.400 MHS (message-handling system) pilot project which aims to encourage researchers to migrate to OSI-based electronic mail services.

Cooperation with R&D networks in the USA

The first steps have been taken to improve data communications between researchers in ESPRIT and those in programmes and projects funded under the National Science Foundation (NSF) and DARPA. Two working group meetings on R&D networking (in Brussels and Washington) were held as part of a major workshop involving ESPRIT and NSF/DARPA devoted to R&D collaboration in a number of specific areas. The proceedings of this workshop have been published.

Information dissemination

A major source of information dissemination has been the *IES Newsletter,* published every two months since it was launched in autumn 1985. During 1990 six editions of the Newsletter were published, containing information of specific interest to specialists in research networking as well as special sections provided by CEN-Cenelec and other IT standards bodies. A COSINE section was introduced in August 1987. In the first quarter of 1991 the Newsletter, after 31 issues, was merged with the *News Review Supplement* of the new *XIII Magazine,* published by DG XIII. Former readers of the *IES Newsletter* can continue to follow the activities of IES in the 'Programmes in action' section under the heading 'ESPRIT News'.

Outlook

The provision of standards-based communication services to European research remains the goal of IES. This is not only a technical issue, but is also closely connected to the introduction of suitable organizational concepts for R&D networking at the European level. Preliminary discussions with major European participants in R&D networking are under way, and include talks with the US authorities on transatlantic cooperation.

Awareness activities

Encouraging participation

DG XIII plays a very active role in alerting European academia and industry to forthcoming calls for proposals and in assisting potential participants to prepare proposals that stand the best chance of success. During 1990/91:

- The 1991 **work programme** and complementary background material were prepared after consultations involving the convening of industrial working groups and experts' workshops and on the basis of guidance and advice from the ESPRIT Advisory Board and Management Committee. An **information package** was prepared containing an overview of the programme, specifications of the form proposals should take, the evaluation and selection criteria employed, detailed notes on contract conditions, and descriptions of consortia-forming mechanisms. In mid-1991 over 25 000 copies were mailed or otherwise distributed, together with the work programme and background material.

- Fifteen **national information days,** with around 2 500 attendees in total, were held during 1991 in Community and EFTA Member States to help make potential participants aware of the rationale and content of the work programme and the call for proposals. Four **international information days** were organized in Brussels, where over 1 500 participants were given detailed information on each work area and provided with every opportunity to identify potential partners via posters, noticeboards, the use of the Eurocontact 'matchmaker' database, and the provision of venues for formal and informal meetings. A particular aim of these events was to ensure that information about ESPRIT was efficiently transmitted to the more outlying regions of the Community in order to give them an equal opportunity of participating in the programme.

- As in previous years, DG XIII was greatly assisted in disseminating information about ESPRIT by the **National contact points** (NCPs) established in every Community and EFTA Member State to provide a permanent and visible local presence for ESPRIT. NCPs maintain stocks of ESPRIT publications, provide early notice of calls for proposals, assist potential and actual participants, participate in information days, and administer local versions of the Eurocontact database. The Euroguichets, established to promote access, especially for smaller companies, to Community programmes in general, are another important source of ESPRIT information. **ESPRIT Clubs** were set up in Belgium, France, Spain, Greece, Italy, Denmark, Germany, Portugal and the United Kingdom, under the auspices of local trade, professional or governmental bodies, to further disseminate information about the programme.

- Potential programme participants were also reached by numerous **articles** and **information notes** written for a wide range of specialist journals, and the launching, in April 1991, of the Commission's quarterly *XIII Magazine* and *XIII News Review.*

Promoting contacts and disseminating results

DG XIII also takes an active part in promoting contact between ESPRIT participants. Now that such communications have been established for several years, a European IT community has become firmly established.

One outcome of this effort is that a great deal of communication now takes place within this community without the Commission's explicit involvement, as shown by the increasing number of European conferences and interest groups set up in the last few years.

The transfer of R&D results into actual use is of prime importance to ESPRIT participants and the European IT industry, and the Commission has made a special effort in the past 18 months to provide a supportive framework for technology transfer. The basis for both fostering contacts between participants and publicizing results was provided by the events and services described below.

The annual conference and exhibition, the major public event of the ESPRIT programme, was held in Brussels from 12 to 15 November 1990 and attracted more than 3 000 participants.

The ESPRIT Conference *provides many opportunities, both formal and informal, for people representing political, industrial and scientific interests within the European IT community to meet and discuss results, achievements and issues of common concern.*

As in former years, the conference addressed both policy and technical issues. Policy was covered in the day-long **IT Forum**. In the morning session, chaired by Mr F. M. Pandolfi, the Commission Vice-President responsible for information technology and telecommunications, leading politicians and industrialists joined Mr Pandolfi and Mr J.-M. Cadiou, director of ESPRIT, in discussing a range of broad strategic issues of importance to the future of IT in Europe. Prof. A. Ruberti, Italian research and higher education minister then chairing the Research Council, and Mr T. von der Vring, chairman of the European Parliament's Committee on Budgets, took part, as well as Prof. P. Aigrain, scientific advisor to the chairman of the Thomson Group, Mr F. D. Maier, AEG board-member, Prof. H. G. Danielmeyer, Siemens board-member, and Mr P. Hughes, director and former chairman of Logica.

The afternoon session, chaired by Mr Carpentier, Director-General of DG XIII, tackled the theme of 'The impact of information technology on society', with speakers addressing the topics of health, privacy, education, the workplace and the natural environment.

1990 IT Forum (morning session)

Professor A. RUBERTI, chairman of the Research Council, opened the proceedings by providing an overview of the commercial environment in which European companies were now operating. With the advent of the single market, he said, there would be explosive growth in the demand for and development of services. In order that these opportunities could be exploited to their best possible advantage by European companies, it was essential that there be a cooperative approach by organizations, and in many cases vertical integration might be desirable or even necessary. Cooperation was vital at all stages in the development of new products and services, and the success of the ESPRIT programme in encouraging primary research had shown what could be achieved.

Mr T. VON DER VRING, chairman of the European Parliament's Committee on Budgets, painted a bleak picture of the state of the European IT industry, which, he said, had lost its sense of direction and was suffering as a result of squabbling between vested interest groups and Member States. The recent takeover of ICL by Fujitsu was a vivid manifestation of these problems, he felt, and represented a low point for the European IT industry; a revision of Community IT strategy was desperately needed. There was no doubt that political

and economic support was necessary for industry to compete on equal terms with the Japanese. The problem, however, was in defining priorities. The questions which needed to be asked were as follows:

- Was a Community strategy needed?
- Which sectors should benefit from the available resources?
- Was the funding approach correct?
- To what extent should there be a social dimension to research?

To date, Mr von der Vring said, the Community had taken the view that cooperation in precompetitive research would solve all the IT industry's problems. It had been naïve in making this assumption. What was required was a redefinition of what was understood by competition and a better understanding of how it shaped the IT industry. At present the problems presented by competition were solved by takeovers. Not only was a European policy on mergers needed, but also a facility for providing a European solution for companies in difficulties. In addition, more thought should be given to strategic support for European industry, involving the three interrelated areas of research, social and regional policy.

Mr P. AIGRAIN, Thomson Electronics, considered that the situation in Europe was not as bleak as other speakers had suggested. The top five companies in Europe in both the computer and software industries were all gaining a market share in Europe. Europe was still strong in electronics, which boded well for the future; for example, in 10 years' time, 25% of a car's value would be its electronics — more than that constituted by the sheet steel industry. Where difficulties did exist, Mr Aigrain concluded, this was despite the ESPRIT programme, not because of it.

Mr F. D. MAIER, AEG, regretted the fact that the availability of money for R&D in Europe was limited. This was a disaster when it was considered that present high growth-rates were accompanied by a lowering of barriers to Eastern Europe, combined with economic stagnation in North America. The shortage of funding would almost certainly leave the IT sector in the same position as the Swiss watch industry, which had bought components from foreign suppliers only to see them start making their own products, putting the Swiss manufacturers out of business. The answer was to follow the Japanese example, where companies were well resourced as part of large integrated groups. In a European context this might be achieved in the form of close cooperation between organizations in the form of 'vertical integration alliances' between users and producers, with particular emphasis on the needs of SMEs. Mr H. G. DANIELMEYER, Siemens, expressed similar views.

Mr P. HUGHES, Logica, drew attention to the growing importance of the software services market in Europe, and appealed for a more appropriate level of attention to this sector from both the media and national administration. With software and services rapidly becoming the dominant component of the IT industry, ESPRIT and national administrations should in future:

- strive for a better understanding of the admittedly very disaggregated software industry;
- ensure much greater involvement by users at the earliest stages of research;
- place more emphasis on advanced software engineering.

Mr J-M. CADIOU, Director of ESPRIT, addressed the question of the competitiveness of the European IT industry. He pointed out that over the 1984-89 period more than 13 000 companies in this sector had increased their share of the European market by 8 percentage points (from 47 to 55%) and more than doubled their total R&D investment, despite falling profit margins and rising costs.

Mr Cadiou did not minimize the severity of the slow-down in demand for information technology nor the structural difficulties affecting the sector, and also drew attention to the much higher long-term R&D capital costs suffered by European IT companies compared to their Japanese equivalents. However, the catalytic effect of the ESPRIT programme had had a significant influence on the industry, bringing together organizations from all over Europe and resulting in more than 300 major technology results so far. He cited three examples of important technology developments: in lithography (wafer-stepper oper-

ating in the deep ultraviolet frequency range to produce 0.25 micron chip circuit geometries); parallel computer systems (T800 Transputer); and systems integration. Looking into the future, Mr Cadiou said that the necessity of ever-higher investment in R&D, together with the lowering of profit-margins, pointed to an increasing need for cooperation on the basis pioneered by ESPRIT. The proposed next phase of the programme would be characterized by an increased level of user involvement; a new initiative in technology transfer and acquisition, especially in the software area, to improve the take-up of the latest technologies; an emphasis on critical microelectronics components; and a doubling of the Basic research part of the programme.

Mr F. M. PANDOLFI, Commission Vice-President responsible for information technology and related industries, said that a Commission policy document would be available in the near future. Its main points would be as follows:

- concentration on a smaller number of strategic issues,
- on the supply side, an emphasis on new types of integrated projects,
- on the demand side, encouragement for public sector services in Member States to link up databases.

The specific areas to be addressed would include:

- Extension of the European nervous system (ENS) programme, which had already been formally incorporated into the third framework programme.
- 'Le Grand Réseau' — building up the necessary infrastructure to enable all the new services to be available across the Community.
- Improving the mobility of young researchers through the Human capital and mobility programme.

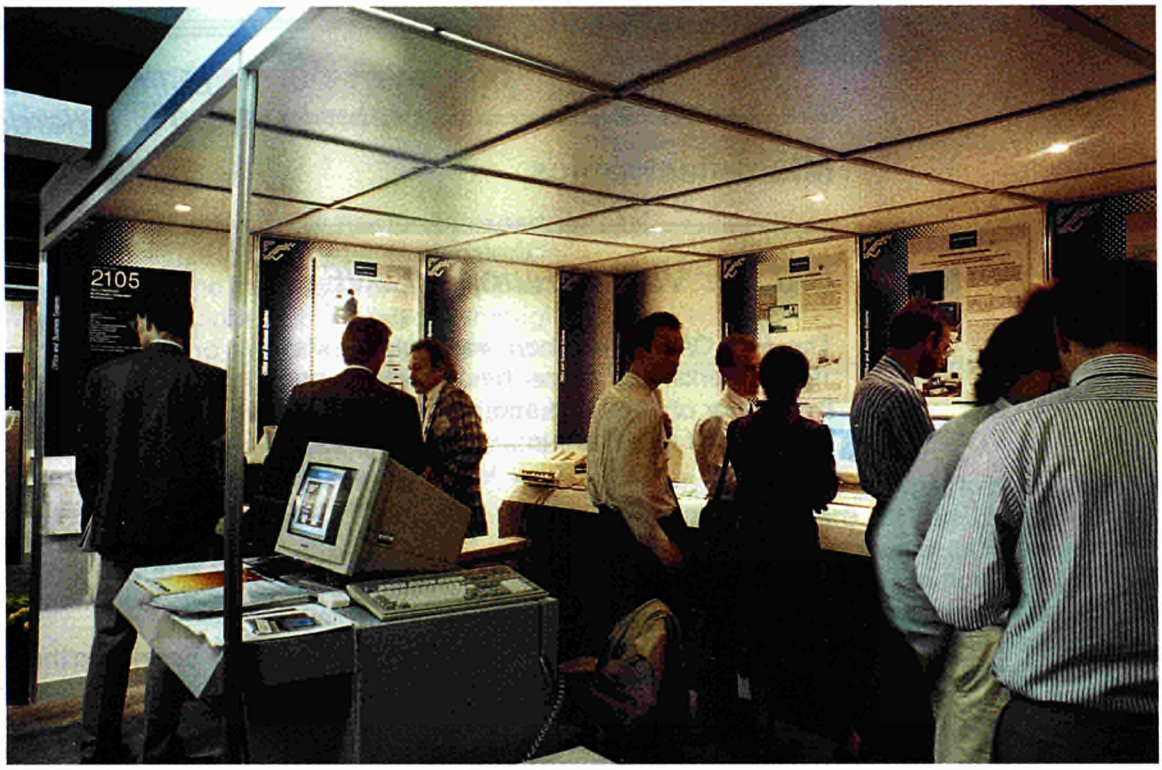
The first three days of the conference were devoted to technical sessions, with 130 presentations including descriptions of important results, panels discussing topics of general interest, and workshops on specific issues. A special session took place on information technology and the environment. A major part of the conference was the **exhibition** of ESPRIT results, which featured 100 projects involving more than 300 companies. The demonstrations ranged from intermediate findings through to industrial prototypes and included impressive results from all areas of the programme. Following on from an initial seminar held in the 1989 conference week on the **technology transfer** of results, where several case-studies of successful technology transfer out of ESPRIT projects were presented, a seminar took place during the 1990 conference on **technology acquisition:** several conclusions were reached, including the importance of nominating a 'project champion', responsible for technology transfer, from the outset of a project.

In addition, the ESPRIT programme was presented at numerous **conferences, workshops** and **seminars** throughout the Community and abroad. With the programme's high profile in the IT community, presentations on ESPRIT are invited for most of the relevant conferences world-wide, and it is common for contributions from ESPRIT project participants to dominate European events. The Commission has exhibited ESPRIT at numerous technology conferences in the past 18 months, held in most of the Community Member States and also in several EFTA countries. The Commission has also encouraged and sponsored presentations at technical conferences by project representatives. In addition, a seminar for ESPRIT contractors on **project management** was held in June 1991, where participants had the opportunity to identify, and suggest solutions for, the typical management problems that arise in the course of an ESPRIT project.

Special interest groups (SIGs) continue to provide an important communications medium between projects with common interests and between projects and industry. The current groups are briefly described, together with their contact points, at the end of this chapter.

ESPRIT information

The most general and widely used description of ESPRIT projects and their results is contained in the **project synopses.** The eight-volume set contains summary descriptions covering, in each case, a project's objectives, progress, results, and commercial prospects, and giving details of participating organiza-



The 1990 Conference exhibition *featured 100 projects involving more than 300 companies.*

tions, contact points, start date and duration. A master index and list of participants is included. The synopses were completely revised for the September 1990 edition to include the 107 new projects and 43 exploratory actions selected for funding that year. Over 100 000 volumes were distributed at various events, by direct mailshot and in response to enquiries. An interim update was issued in June 1991, and the next full edition will be available in autumn 1991. The synopses are also available as an electronic database via the EuroKom service. **Technical factsheets** were prepared for over 100 projects for distribution at exhibitions and other events.

Major reports of the final results of ESPRIT projects are increasingly disseminated in the form of **monographs**, and in the past 18 months a dozen have been published by Springer-Verlag (see bibliography). The proceedings of the 1990 ESPRIT Conference were published by Kluwer. In addition, a series of **occasional papers** was started in 1991, under the aegis of the Commission, to improve the interim reports emanating from projects. Information is also provided via *XIII News Review,* the supplement to the recently launched *XIII Magazine,* which covers the activities and programmes supported by DG XIII. This ESPRIT **Progress and results report** itself makes available an overview of the programme's status to the interested layperson as well as acting as a reference document.

The **ESPRIT Information Desk** provides institutions, participants (potential and actual), the media and interested individuals from both within and outside the Community with information about the ESPRIT programme. The type of information requested ranges from the very general (on Community R&D policy) to the very specific (concerning particular projects and participants). As well as dealing with requests for information, the information desk supports ESPRIT at exhibitions, conferences and other public events. In a typical month several hundred requests for documents are received and several thousand documents sent out.

Press-releases and **information sheets** are regularly mailed out or distributed at press briefings and conferences to several hundred periodicals, journalists, companies and institutions. They cover calls for proposals, selection of projects to be funded, announcements of conferences and other notable events or news items.

Special interest groups

Microelectronics

CAD for VLSI in Europe (CAVE)

The first CAVE workshop was held in May 1983. Workshops were held in May and December of 1990 and another in May 1991. The aims of CAVE are to:

— disseminate the results of ESPRIT CAD projects

— ensure the rapid and consistent exploitation of new research ideas by means of selected tutorials

— maintain the strong sense of identity of the existing community of CAD researchers in Europe

— encourage strategic thinking and debate on critical issues and draw up recommendations for future action in this field.

Contact: Mike Newman — CEC, DG XIII-A3
✆ +32/2-236-8039 Fax: +32/2-236-8389

Lithography

This group has the following objectives:

— exchanging views in the field of optical, E-beam and X-ray lithography

— promoting the standardization of metrology procedures.

The group meets once or twice a year. The core participants are partners in ESPRIT and EUREKA projects, but others may participate in certain events. A workshop was held in Brussels in November 1990 during the annual ESPRIT Conference.

Contact: Leo Karapiperis — CEC, DG XIII-A3
✆ +32/2-236-8034 Fax: +32/2-236-8389

VLSI manufacturing automation and standards

This group has the following objectives:

— exchanging views and experience about the implementation of standards and recommending changes and additions to them

— promoting future industrial cooperative actions for tackling VLSI automation-related problems

— collating semiconductor manufacturing requirements for automation and reliability in order to provide informal recommendations to manufacturers and users

— promoting the use of and disseminating information about a uniform set of standards.

The group meets at least twice a year. The core participants are partners in ESPRIT and EUREKA projects; others may participate by invitation. Two workshops were held in Brussels in 1990.

Contact: Leo Karapiperis — CEC, DG XIII-A3
✆ +32/2-236-8034 Fax: +32/2-236-8389

Integrated circuit (IC) reliability

The main objectives of the group are to:

— establish a framework for coordinating current and new activities within ESPRIT in this area

— provide a forum for the dissemination of results and for stimulating their take-up and use in other projects

— prepare surveys on the state of the art of major reliability issues.

The first workshop was held in April 1990, when relevant results from all ESPRIT projects covering the topic of IC reliability were presented and discussed.

Contact: H. Maes
IMEC vzw
Kapeldreef 75
B-3030 Leuven
✆ +32/16-281-211 Fax: +32/16-22-9400

Electronic Materials Research Society/Electronic materials network

More than 10 networks of European experts have been active in various fields of materials science under the framework of the European Materials Research Society which, through conferences and symposia, maintains contacts with over 2 000 researchers. These ESPRIT-funded networks offer both industrial and university researchers open forums for assessing the potential of a variety of new materials.

Contact: Aziz M'Baye — CEC, DG XIII-A3
✆ +32/2-236-8037 Fax: +32/2-236-8389

Analogue circuit design

The broad aims of this new group are to create a network of analogue researchers; provide a forum for the exchange of ideas; debate and establish research activity priorities; enable the rapid dissemination of relevant ESPRIT project results; obtain and provide updates on new trends in the analogue domain; and to enable the formation of new international working relationships in the area of analogue circuit design.

The first workshop took place in Milan in September 1991; two a year are planned, together with a bi-annual newsletter for members.

Contact: Dave Broster — CEC, DG XIII-A3
✆ +32/2-236-8021 Fax: +32/2-236-8389

Information processing systems

Graphics and interaction

The objective is to encourage information exchange in the computer graphics field. A workshop on user interface management and design was held in Lisbon in June 1990. Its proceedings (edited by J. Lee *et al.*) have been published by Springer-Verlag in the Eurographic Seminars series.

Contact: D. A. Duce
Rutherford Appleton Laboratory
Chilcot, Didcot
OX11 0QX
United Kingdom
✆ +44/235-445-511 Fax: +44/235-445-831

LISP

The objective of this group is to prepare an international standard for the LISP programming language. It is open to all European parties interested in the definition and use of a standardized LISP. Four meetings have been held up to the middle of 1991 to prepare 'The EULISP definition'.

Contact: Jérôme Chailloux / Greg Nuyens
ILOG
2, avenue Galiéni
F-94253 Gentilly
✆ +33/1-466-366-315-66
Fax: +33/1-466-315-82

VDM-Europe/Formal methods Europe

VDM-Europe was formed in 1985 with the aim of increasing the awareness, use, development and standardization of the Vienna development method (VDM). A major change is taking place in 1991: VDM-Europe is becoming Formal methods Europe, a forum for any formal method user. Industrial use will be a major focus of attention.

Contact: Alejandro Moya — CEC, DG XIII-A4
✆ +32/2-236-8098 Fax: +32/2-236-8364

Software maintenance

This SIG acts as a communication forum for its members, who are drawn from industry and research institutes across Europe. The main aim is to establish and publish information on the practice of software maintenance. This brings benefits to the practitioners them-

selves, who can compare their operations with those of others, and to researchers, who can learn of the problems that truly concern people, and so guide their research accordingly.

Contact: Mrs Hilary Calow
FI Group plc
Sapphire West, Streetsbrook Road
Solihull B91 1QY
United Kingdom
✆ +44/21-711-4242 Fax: +44/21-711-4200

European Languages Standards Group for MIMD computers

This working group concentrates on standardizing parallel constructs in Fortran 90 and C. Regular meetings are held to write the draft standards. Collaboration is being sought with similar groups in the USA to ensure there is no duplication. Final drafts will be distributed for public comment.

Contact: Rolf Hempel
GMD Institut F1/T
Schloß Birlinghoven
D-5205 Sankt Augustin 1
✆+49/2241-142-575 Fax:+49/2241-142-889

Metrics

The objective of this group is the promotion of software metrics and certification. Coordinated by PYRAMID (project 5425), it organizes various events throughout the Community, some of which are devoted to specific metrics application areas such as banking, telecommunications, the health sector, etc.

Contact: Frédéric Copigneaux
Veriditas
Aeropole Bat. A
F-31700 Blagnac
✆ +33/61-719161 Fax: +33/61-718867

Advanced business and home systems — Peripherals

Open microprocessor systems initiative (OMI)

OMI aims to provide a complete competitive microprocessor capability for both computer systems and embedded control, ranging from very high performance (over 1 000 Mips) to very low power (down to 0.01 watt). The initiative will build on European strengths in advanced RISC microprocessors, and will be both technically and institutionally 'Open'. The new family of OMI microprocessors will be provided as macrocells in a standard design library of microelectronic components. Users will be involved at all stages of the initiative. Universities will obtain early access to developments under a technology transfer scheme so that the next generation of young hardware, software and applications engineers is trained in using the OMI technology.

Contact: Rosalie Zobel — CEC, DG XIII-A5
✆ +32/2-236-8168 Fax: +32/2-236-8387

RICHE (Réseau d'information et de communication hospitalier européen)

The RICHE (project 2221) special interest group aims to inform hospital managers, decision-makers in health-care ministries, representatives of health organizations, etc., about the RICHE project in order to raise awareness and stimulate comment and discussion.

Contact: Prof. Van der Werff
SIG Services Ltd
Maliebaan 50
Postbus 14066
3508 SC Utrecht
The Netherlands
✆ +31/30-345-611 Fax: +31/30-313-149

Distributed systems (SIGDIS)

Established in February 1991, this SIG aims to stimulate and encourage cooperation between firms and organizations and to help form links with end-users and broad-based end-user groups with interests in distributed systems. The group operates on a six-month rolling programme which includes plenary meetings two or three times a year and meetings of topic-oriented workgroups. Workshops have been held in Brussels and Washington DC to discuss the technical achievements and industrial implications of the work on distributed systems, especially the achievements of ISA (project 2267) and COMANDOS (projects 834 and 2071). The workshops helped to identify areas in which collaboration between European and US organizations could be mutually beneficial, and established a basis for more detailed discussions with particular US organizations, including DARPA and NSF.

Contact: Mr M. Eyre
Architecture Projects Management Ltd
Poseidon House
Castle Park
Cambridge CB3 02D
United Kingdom
✆ +44/223-323-010 Fax: +44/223-359-779

European Home Systems Association (EHSA)

The European Home Systems Association (EHSA) has been founded by members of the HOME (project 2431) consortium. Membership or associate membership of the Association is open to organizations, companies or individuals, both in Europe and beyond, who support the following aim: to enable the introduction of integrated applications in homes and buildings by supporting and promoting activities that lead to the harmonization and use of standards for homes and buildings throughout the world.

Contact: Mr Leo E. Zegers
Philips Consumer Electronics BV
Glaslaan 218, Building SWA
5600 MD Eindhoven
The Netherlands
✆ +31/ 40-734311 Fax: +31/ 40-732037

Peripherals

The objectives of this SIG are to:

— form a group of experts in the field of peripherals with a common interest in establishing a strong European R&D base

— propose actions to fill gaps in the overall European peripherals activity

— ensure that studies include an analysis of the evolution of the technology with respect to market opportunities

— redefine the notion of 'peripherals' with respect to newly emerging functionalities, manufacturing techniques and market approaches.

The group will meet at least three times a year. It is open to participants in Europe working in the field of peripherals technologies and subsystems.

Contact: Régis Langlet — CEC, DG XIII-A5
✆ +32/2-236-8155 Fax: +32/2-236-8387

Computer-integrated manufacturing

CIM-Europe

CIM-Europe, now in its seventh year, continued to expand its role in disseminating information about the progress, achievements and results of the Computer-integrated manufacturing (CIM) part of the ESPRIT programme both to the CIM R&D community and to manufacturing industry. 1990/91 was characterized by a continued emphasis on public events (the annual conferences and many workshops), and by an internal assessment of CIM-Europe's structure and operations, which resulted in the formulation of an action plan for the development of CIM-Europe's interest groups.

Two types of interest group are now distinguished: the first aims to bring related CIM project teams together, while the second type is centred around particular topics, and includes members of the wider CIM community as participants. Interest groups cover topics

Quality control: *The inspection of complex surfaces, such as the fan-blades pictured here, requires the intelligent processing of information derived from sensors and its comparison with CAD data about the product. CIM-Europe helps bring together members of the ESPRIT CIM and wider CIM community interested in this and many other topics.*

such as model-based predictive control, human and organizational factors in CIM, advanced robotics and intelligent sensors, and CIM architecture and communications. Over 20 technical and discussion meetings were organized in 1990/91. Special topic workshops were held on robotics (in Genoa), open systems architecture (Brussels), project 477 (Dublin, Turin and Eindhoven), project 623 (Berlin), model-based predictive control (Paris), project 809 (Twente), communications for manufacturing (a congress in Stuttgart), 'Implementing CIM' (Saarbrücken), and on project 2165, IMPPACT (Berlin). In addition, sessions on ESPRIT CIM were held at the EuropIA (Liège) and Robotics (Copenhagen) conferences.

The highlight of 1990 was the sixth annual conference, hosted by the Portuguese Ministry of Industry and Energy in Lisbon from 15 to 17 May. Over 300 delegates attended over 40 presentations. The seventh conference, with around 350 delegates, was held in Turin from 28 to 31 May 1991 and was co-hosted by Fiat.

Contact: Heather Bell — CEC, DG XIII-A6
✆ +32/2-236-8112 Fax: +32/2-236-8365

Basic research

High-temperature superconductivity (HTSC)

A high-level advisory panel composed of 12 European scientists and industry experts and chaired by Nobel Prize-winner K. A. Müller is advising the Commission on matters related to HTSC activities. In 1990 the panel met twice. In its first session a workplan for low-current applications was discussed and endorsed. The second session, which took place on 26 and 27 November in Strasbourg, was organized in tandem with a workshop where Community-funded HTSC projects presented their research work and results. The panel also advised the Commission on the preparation of a brochure on superconductivity.

Contact: Manuela Pinheiro — CEC, DG XIII-A7
✆ +32/2-236-8078 Fax: +32/2-236-8390

Bibliography

General information
(in all Community languages unless otherwise indicated)

Update to 1990 project synopses
June 1991 (English only)

Project synopses (8 volumes)
October 1991 (English only)

Information package
July 1991

Work programme and background material
July 1991

Report of the ESPRIT Review Board
(executive version) May 1989 (English only)

ESPRIT: key to the technological awakening of Europe
November 1989

XIII Magazine (quarterly)
(English, French, German, Italian, Spanish)

XIII News Review (quarterly)
(English only)

Information and communication technologies in Europe
April 1991 (all Community languages plus Czech, Hungarian and Polish)

Official documents
(in all Community languages unless otherwise indicated)

Council Decision
Adopting the third phase of ESPRIT
Official Journal L 218, 6.8.1991

Communication from the Commission to the Council
The European electronics and information technology industry: state of play, issues at stake and proposals for action
CES(91) 565 final, 3.4.1991

Proposal for a Council Decision
Concerning a specific programme of research and technological development in the field of information technology (1990-94)
COM(90) 153 final, 23.5.1990

Communication from the Commission to the Council and the Parliament
Concerning a review to assess the performance and results of the ESPRIT programme
CES(89) 1348 final, 7.9.1989

Council Decision
Adopting the second phase of ESPRIT
Official Journal L 118, 6.5.1988

Communication from the Commission to the Council and the Parliament
Concerning the final assessment of the microelectronics programme
COM(88) 173 final, 5.4.1988

Communication from the Commission to the Council
Revised proposal for a Council decision concerning ESPRIT
COM(88) 102 final, 29.2.1988

Communication from the Commission to the Council
ESPRIT — The first phase: progress and results
COM(86) 667 final, 8.12.1986

Communication from the Commission to the Council
The second phase of ESPRIT
COM(86) 269 final, 21.5.1986 (not in Spanish or Portuguese)

Communication from the Commission to the Council and the Parliament
Concerning a review to assess the initial results of the ESPRIT programme
COM(85) 616 final, 19.11.1985 (not in Spanish or Portuguese)

The above are available from:
ESPRIT Information Desk
Commission of the European Communities
BA29 1/28
200 rue de la Loi
B-1049 Brussels

Project results monographs

ESPRIT research reports series

AMICE Consortium (ed)
Open system architecture for CIM
1989. IX, 212 pp. (project 688, AMICE, Vol. 1) ISBN 3-540-52058-9

Badham, M., Becker, K., Langsford, A., Möller, M., Nennast, K., Xie, Y.
Establishing management requirements for distributed systems
in press (project 5165, DOMAINS)

Balter, R., Cahill, V., Harris, N., Horn, C.
The COMANDOS distributed application platform
in press (project 2071, COMANDOS)

Banâtre, J.-P., Jones, S.B., Le Métayer, D.
Prospects for functional programming in software engineering
1991. IX, 210 pp. (project 302, Vol. 1) ISBN 3-540-53852-6

Bösser, T.
Learning in man-computer interaction
1987. XI, 218 pp., 6 figs (project 385, HUFIT, Vol. 1) ISBN 3-540-18391-4

Goult, R.J., Sherar, P.A. (eds)
Improving the performance of neutral file data transfers
1990. IX, 138 pp. (project 322, CAD*I, Vol. 6) ISBN 3-540-53427-X

Grabowski, H.
Advanced modelling for CAD/CAM systems
in press 1991 (project 322, CAD*I, Vol. 7)

Habraken, F. H.
LPCVD silicon oxynitride films
in press 1991 (project 369, Vol. 1)

Home Systems Consortium (ed)
The Home Systems specification
in press 1991 (project 2431, HOME)

Jüptner, W., Kreis, T. (eds)
An external interface for processing 3-D holographic and X-ray images
1989. IX, 147 pp., numerous figs, 13 in colour (project 898, PHOX, Vol. 1)
ISBN 3-540-50822-8

Kersken, M.
Strategies for the achievement and assessment of fault-tolerant software
in press 1991 (project 300)

Pernici, B., Rolland, C. (ed)
Automatic tools for designing office information systems
1990. IX, 321 pp. (project 813, TODOS, Vol. 1) ISBN 3-540-53284-6

Pirani, G. (ed)
Advanced algorithms and architectures for speech understanding
1991. XIV, 274 pp. (project 26, SIP, Vol. 1) ISBN 3-540-53402-4

Puccetti, A. (ed)
The programming and proof system ATES
1991. VIII, 341 pp. (project 1158, Vol. 1) ISBN 3-540-54188-8

Raflik, M., Pätzold, B (eds)
An approach to an engineering database. Version 4.0
1990. X, 174 pp. (project 322, CAD*I, Vol. 5) ISBN 3-540-53383-4

Schlechtendahl, E. G. (ed)
CAD data transfer for solid models
1989. XVIII, 325 pp. (project 322, CAD*I, Vol. 3) ISBN 3-540-51826-6

Schlechtendahl, E. G. (ed)
Specification of a CAD*I neutral file for CAD geometry. Wireframes, surfaces, solids. Version 3.3
3rd rev. ed. 1988. XV, 242 pp. (project 322, CAD*I, Vol. 1) ISBN 3-540-50392-7

Schlechtendahl, E. G. (ed)
Specification of a CAD*I neutral file for CAD geometry. Version 3.2
2nd rev. and enlarged ed. 1987. XIV, 255 pp. (project 322, CAD*I, Vol. 1)
ISBN 3-540-18397-3

Schlechtendahl, E. G. (ed)
Specification of a CAD*I neutral file for solids. Version 2.1
1986. XII, 149 pp. (project 322, CAD*I, Vol. 1) ISBN 3-540-16927-X

Schuster, R., Trippner, D., Endres, M.
CAD*I drafting model
1990. XII, 233 pp. (project 322, CAD*I, Vol. 4) ISBN 3-540-52051-1

Thomas, D., Van Maanen, J., Mead, M. (eds)
Specification for exchange of product analysis data
1989. XVI, 146 pp. (project 322, CAD*I, Vol. 2) ISBN 3-540-51579-8

Ullrich, C., Wolff von Gudenberg, J. (eds)
Accurate numerical algorithms
1989. IX, 234 pp. (project 1072, DIAMOND, Vol. 1) ISBN 3-540-51477-5

ESPRIT Basic research series

Kassing, R. (ed)
Scanning microscopy
Proceedings of IMO symposium, October 1990
in press 1991

Lloyd, J. (ed)
Computational logic
Symposium proceedings, Brussels, 13 and 14 November 1990
1990. XI, 211 pp., 2 figs., ISBN 3-540-53437-7

Radig, R., Pfleger, S. (eds)
Advanced matching in vision and artificial intelligence
Workshop proceedings
in press 1991

The above two series are available from:
Springer-Verlag
Postfach 10-52-80
Tiergartenstr. 17
D-6900 Heidelberg

Other project reports

Aslett, M. (ed)
A knowledge-based approach to software development
1991. XIV, 249 pp. (project 401, ASPIS) ISBN 0-444-88886-1

Christie, B. (ed)
Human factors of the user-system interface
1985, ISBN 0-444-87832-2

Diaz, M., Ansart, J-P., Azema, P., Chari, V.
Results of the ESPRIT SEDOS project (project 410)
1989, ISBN 0-444-87132-2

Hirsch, B., Actis-Dato, M. (eds)
ESPRIT CIM. Design, engineering, management and control of production systems
Proceedings of European working conference, Bremen, 27 to 29 May 1986
1987, ISBN 0-444-70300-4

Van Eijk, P. H. J., Vissers, C. A., Diaz, M. (eds)
The formal description technique LOTOS. Results of the SEDOS project
1989 (project 410, SEDOS)

Yeomans, R. W., Choudry, A., Ten Hagen, P. J. W. (eds)
Design rules for a CIM system
1985 (reprinted 1987), ISBN 0-444-87812-2

The above are available from:
Elsevier Science Publishers BV
Sara Burgerhartstraat 25
PO Box 211
1000 AE Amsterdam
The Netherlands

Breuker, J. (ed)
EUROHELP: Developing intelligent help systems
1990. XI, 409 pp., 84 figs (project 280, EUROHELP)

Available from:
University of Amsterdam
Department of Social Science Informatics
Roetersstraat 13
1018 WB Amsterdam
The Netherlands

Dumas, P., Charbonnel, G.
La méthode OSSAD: Principes pour maîtriser les technologies de l'information
1990, 168 pp. (project 285, OSSAD, Vol. 1)

Charbonnel, G., Calmes, F., Dumas, P.
La méthode OSSAD: Guide pratique
1990, 280 pp. (project 285, OSSAD, Vol. 2)

The above are available from:
Les Editions d'Organisation
26, av. Emile Zola
F-75015 Paris

Krämer, B.
Concepts, Syntax and Semantics of SEGRAS, a specification language for distributed systems
1989. VI, 180 pp., 23 figs (project 125, GRASPIN) ISBN 3-486-21438-1

Krämer, B.
Specification and correct implementation of non-sequential systems combining abstract data types and petri-nets
1988. IX, 206 pp. (project 125, GRASPIN) ISBN 3-486-21292-3

The above are available from:
GMD mbH
Postfach 1240, Schloß Birlinghoven
D-5205 Sankt Augustin 1

Bauer, A. *et al.*
Shop-floor control systems: from design to implementation
1991. XX, 344 pp., 94 figs (project 477, COSIMA) ISBN 0-412-36040-2

Bernhardt, R. *et al.* (eds)
Integration of robots into CIM
in press 1991, c. 360 pp. (project 623)
ISBN 0-412-37140-5

Fenton, N.
Software metrics — A rigorous approach
1991. 337 pp., numerous figs (project 2384, METKIT) ISBN 0-412-40440-0

The above are available from:
Chapman & Hall
2-6 Boundary Row
London SE1 8HN
United Kingdom

Bakker, J. de (ed)
Languages for parallel architectures: design semantics, implementation models
1989. XV, 273 pp., numerous figs (project 415, PALAVDA) ISBN 0-471-92177-7

Gardiner, M., Christie, B. (eds)
Applying cognitive psychology to user interface design
1987 (project 234, COGNISM)
ISBN 0-471-91184-4

Huws, U., Korte, W., Robinson, S.
Telework: towards the elusive office
1990 (project 2382, ELO)

Treleaven, P. (ed)
Parallel computers: object-oriented, functional, logic
1990. XVI, 297 pp., numerous figs (project 415, PALAVDA)

The above are available from:
John Wiley & Sons Ltd
Baffins Lane
Chichester PO19 1UD
United Kingdom

ESPRIT Annual Conference proceedings

ESPRIT '84, status report
Roukens, J., Renuart, J. F. (eds)
1985, ISBN 0-444-87740-1

ESPRIT '85, status report
1986, ISBN 0-444-87915-3

ESPRIT '86, results and achievements
Third ESPRIT Conference proceedings, 29 September to 1 October 1986
1987, ISBN 0-444-70160-5

ESPRIT '87, achievements and impact
Fourth ESPRIT Conference proceedings, Brussels, 28 and 29 September 1987
1987, ISBN 0-444-70333-0

ESPRIT '88, putting the technology to use
Fifth ESPRIT Conference proceedings, Brussels, 14 to 17 November 1988
1988, ISBN 0-444-87145-4

The above are available from:
Elsevier Science Publishers BV
Sara Burgerhartstraat 25
PO Box 211
1000 AE Amsterdam
The Netherlands

ESPRIT '89
Sixth ESPRIT Conference proceedings, Brussels, 27 November to 1 December 1989
1989, ISBN 0-7923-0592-2

ESPRIT '90
Seventh ESPRIT Conference proceedings, Brussels, 12 to 15 November 1990
1990, ISBN 0-7923-1039-X (also on CD-ROM)

The above are available from:
Kluwer Academic Publishers
PO Box 322
3300 AH Dordrecht
The Netherlands

ESPRIT '91
Eighth ESPRIT Conference proceedings, Brussels, 25 to 29 November 1991
in press November 1991 (also on CD-ROM)

Available from:
Office for Official Publications of the European Communities
2, rue Mercier
L-2985 Luxembourg

CIM-Europe: conference proceedings

Rathmill, K., MacConaill, P. (eds)
Computer-integrated manufacturing
Third International Conference proceedings, Knutsford (UK)
1987, ISBN 0-9485007-67-5

Puente, E., MacConaill, P. (eds)
Computer-integrated manufacturing
Fourth International Conference proceedings, Madrid
1988, ISBN 0-948507-67-5

Halatis, C., Torres, J. (eds)
Computer-integrated manufacturing
Fifth International Conference proceedings, Athens
1989, ISBN 1-854423-040-9

Faria, L., Van Puymbroeck, W. (eds)
Computer-integrated manufacturing
Sixth CIM-Europe Conference proceedings, Lisbon, 15 to 17 May 1990
1990, ISBN 0-387-19616-1

Vio, R., Van Puymbroeck, W. (eds)
Computer-integrated manufacturing
Seventh CIM-Europe Conference proceedings, Turin, 29 to 31 May 1991
1991, ISBN 3-540-19695-1

Withnell, S., Van Puymbroeck, W. (eds)
Communications for manufacturing
Open Congress proceedings, Stuttgart, 4 to 7 September 1990
1990, ISBN 3-540-19642-0

The above are available from:
Springer-Verlag
Postfach 10-52-80
Tiergartenstr. 17
D-6900 Heidelberg

CIM-Europe: workshop proceedings

MacConaill, P., Drews, P., Robrock, K-H. (eds)
Mechatronics and robotics, I
CIM-Europe workshop proceedings, Aachen, 8 to 10 July 1991
1991, ISBN 90-5199-057X

Available from:
IOS-Press
Van Diemenstraat 94
1013 CN Amsterdam
The Netherlands

CIM-Europe SIG on advanced information processing (eds)
Advanced information processing in CIM
CIM-Europe workshop proceedings, Bremen, 20 to 22 September 1989

CIM-Europe SIG on human factors in CIM (eds)
Human-centred CIM
CIM-Europe workshop proceedings, Bremen, 20 to 22 September 1989

Richalet, J., Tzafestas, S. (eds)
Computer-integrated design of controlled industrial systems
CIM-Europe workshop proceedings, Paris, 26 to 27 April 1990

Scheer, A-W. (ed)
Implementing CIM
CIM-Europe workshop proceedings, Saarbrücken, 3 to 4 December 1990

CIM in the process industry
CIM-Europe workshop proceedings, Athens, 20 to 21 June 1991

CNMA implementation guide, Rev. 4.1
July 1990 (project 2617, CNMA)

Computer-integrated manufacturing open systems architecture
CIM-Europe workshop proceedings, Brussels, 7 to 8 March 1990

Open systems architectures and communications: preparing the enterprise for CIM
CIM-Europe workshop proceedings, Aachen, 13 and 14 June 1991

The above are available from:
CIM-Europe Secretariat
CEC - DG XIII/A6
BA31 1/82
200 rue de la Loi
B-1049 Brussels

Projects and participants

Microelectronics

10
High-level CAD for interactive layout and design
Bull, Daimler Benz, GEC, Plessey Company

14
Advanced interconnect for VLSI
GEC, Plessey Company, Telefunken Electronic, Thomson-CSF

97 **CATHEDRAL**
Advanced algorithms, architecture and layout techniques for VLSI dedicated digital signal processing chips
Bell Telephone, IMEC, Philips, Ruhr-Universität Bochum, Siemens

232
Compound semiconductor materials and integrated circuits - I
Philips, Plessey Company, Siemens, Thomson-CSF

243
Submicron bipolar technology - I
Cemota, Plessey Company, Technische Universität Berlin, Telefunken Electronic, Thomson-CSF

244 **HYETI**
High-yield, high-reliability ULSI system
British Telecommunications, Bull, CEA, Cirrus Computer, IMAG-LGI, INPG, SGS-Thomson Microelectronics, Technische Hochschule Darmstadt, University of Brunel

245
Silicon-on-insulator (SOI) materials and processing: towards 3-D integration
CEA, CNET, GEC, National Microelectronics Research Centre, SGS-Thomson Microelectronics, University of Cambridge

255
CAD methods for analogue and GaAs monolithic ICs
CISE, Politecnico di Torino, Siemens, Telettra

263
Integrated optoelectronics on InP
Alcatel, Alsthom Recherche, CNET, CSELT, GEC Research, Marconi Research, Heinrich-Herz, Standard Elektrik Lorenz, STC-ICL, Thomson-CSF

271 **ADVICE**
Automatic design validation of integrated circuits using E-beam
British Telecommunications, CNET, CSELT, IMAG-LGI, Trinity College Dublin

281
Submicron bipolar technology - II
RTC, Siemens

305
Assessment of silicon MBE layers
Daimler Benz, GEC, ISA Riber

334
Plasma deposition technology for magnetic recording thin-film media
BASF, Leybold Heraeus, SAGEM

369
Physical-chemical characterization of silicon oxynitrides in relation to their electronic properties
IMEC, Matra-MHS, Philips, UKAEA, Universiteit van Utrecht

370
Silicon-on-insulator systems combined with low-temperature silicon epitaxy
GEC, IMEC, Mietec

380
Optical interconnect for VLSI and high bit-rate ICs
GEC Research, Marconi Research, Telettra, University of Southampton

412 **BiCMOS**
A high-performance CMOS bipolar process for VLSI circuits
Philips, Siemens

443
Molecular engineering for optoelectronics
CNET, ICI, Imagedata, Thomson-CSF, université Notre-Dame de la Paix

456
Improvement of yield and performance of ICs by design centring
AEG, SGS-Thomson Microelectronics, Telefunken Electronic, Universität Stuttgart

491
Materials and technologies for high mobility TFTs for LC display-bus drivers
AEG, CNET, CSEE, Thomson-CSF

509
Substrates for CMOS VLSI technology
IMEC, Matra-MHS, SGS-Thomson Microelectronics

514
Quantum semiconductor devices
GEC, Thomson-CSF

519

Dopant profiling for submicron structures

Daimler Benz, GEC, IMEC

522

Compound semiconductor materials and integrated circuits - II

Bell Telephone, CNET, Farran Technology, GEC, STC-ICL, Telefunken Electronic

544

Investigation of all aspects of interconnection of high pincount ICs

BPA-Technology and Management, British Aerospace, Lucas, National Microelectronics Research Centre

554 **SPECTRE**

Submicron CMOS technology

Århus Universitet, British Telecommunications, Bull, CNET, CNR-Istituto Lamel, IMEC, Matra-MHS, SGS-Thomson Microelectronics, Telettra, UKAEA, université catholique de Louvain

574

High-resolution plasma etching in semiconductor technology: fundamentals, processing and equipment

Fraunhofer IM, Johnson Matthey Chemical, Leybold Heraeus, Mono Light Instruments, UKAEA

802 **CVS**

CAD for VLSI systems

Alcatel, British Telecommunications, CNET, CSELT, Daimler-Benz Elektronik Centralen, GMD, Italtel Telematica, Matra-MHS, SGS-Thomson Microelectronics

824

Wafer-scale integration

British Telecommunications, CEA, INPG, National Microelectronics Research Centre, SGS-Thomson Microelectronics, Technische Hochschule Darmstadt

830

Packages for high-speed digital GaAs integrated circuits

Mo Valve Company, Thomson-CSF

833

Large-area complex LCDs addressed by thin-film silicon transistors

AEG, Aristoteles University of Thessaloniki, CNET, GEC, Modulex, Thomson-CSF, Università di Bologna

843

Compound semiconductor ICs

Farran Technology, GEC, Philips, Plessey Company, Siemens, STC-ICL, Thomson-CSF

887 **ECIP**

European CAD integration project

Alcatel, Bull, Philips, SGS-Thomson Microelectronics, Siemens, STC-ICL

888 **AIDA**

Advanced IC design aids

SGS-Thomson Microelectronics, Siemens, STC-ICL

927

Basic technologies for GaInAs MISFETs

Aixtron, Philips, RWTH Aachen, Wacker-Chemie

957

High-density mass storage memories for knowledge and information storage

Bull, BASF, CEA/LETI, Thomson-CSF, Simulog, Glaverbel, Bogen Electronic

958

High-performance VLSI packaging for complex electronic systems

British Telecommunications, Bull, GEC Research, Marconi Research

962 **EVEREST**

Three-dimensional algorithms for robust and efficient semiconductor simulator

Analog Devices, GEC, IMEC, National Microelectronics Research Centre, Philips, Rutherford Appleton Laboratory, SGS-Thomson Microelectronics, STC-ICL, Trinity College Dublin, Università di Bologna, University College Swansea

971

Technology of GaAs-GaAlAs bipolar integrated circuits

CNET, Farran Technology, GEC, Plasma Technology, Plessey Company

986

Optical interconnect for VLSI and high bit-rate ICs

GEC Research, Marconi Research, Telettra, University of Southampton

991

Multiview VLSI-design system ICD

British Telecommunications, ICS, INESC, PCS Computersysteme, 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, King's College London, SGS-Thomson Microelectronics, Thomson-CSF

1043

Advanced mask and reticle technology for VLSI submicron microelectronics devices

BMP Plasmatechnologie, British Telecommunications, Ferranti, IMEC, Siemens, Valvo Unternehmensbereich

1056

Ultrasensitive impurity analysis for semiconductor structures and materials

Cameca, IMEC, Philips Research Laboratories UK, Siemens

1058

Knowledge-based design assistant for modular VLSI design

IMEC, INESC, Philips

1128

Large diameter semi-insulating GaAs substrates suitable for LSI circuits

Philips, université catholique de Louvain, Wacker-Chemie

1270

Advanced processing technology for GaAs modulation doped transistors and lasers

CNET, Elltec, Forth Research Centre, Plessey, University of Wales

1551 **AMS**

Advanced manufacturing system

Marconi, SGS-Thomson Microelectronics

1563 **ACAFS**

Automatic control of an ASIC fabrication sequence as demonstrated in the plasma etch area

Bertin & Cie, European Silicon Structures, Leybold Heraeus, Mietec, Plasma Technology

2016 **BASE**

Bipolar advanced silicon for Europe

IMEC, Philips Gloeilampenfabrieken, Plessey, Ruhr-Universität Bochum, SGS-Thomson Microelectronics, Siemens Semiconductors, Technische Hochschule Darmstadt, Technische Universität Berlin, Telefunken Electronic, Trinity College Dublin, Università di Catania, Swindon Silicon Systems, DRA, National Technical University of Athinai

2035

Advanced GaInAs-based transistors for high-speed integrated circuits

Farran Technology, Forth Research Centre, Philips, Picogiga, Plessey, STC-ICL, Thomson-CSF, Universidad Politécnica de Madrid, université de Lille

2039 **APBB**

Advanced PROM building blocks

Deister Electronic, Eurosil Electronic, Gemplus Card International, IMEC, INESC, INPG, Plessey, SGS-Thomson Microelectronics, Università di Bologna, University College Cork

2048

Deep UV lithography

ASM-Lithography, CEA/LETI, Carl Zeiss, Fraunhofer-IPA, Hoechst, Nederlandse Philips Bedrijven, Siemens, Siemens Semiconductors, University of Edinburgh

2072 **ECIP**

European CAD integration project

Bull, INESC, INPG, Institut méditerranéen de technologie, Nederlandse Philips Bedrijven, SGS-Thomson Microelectronics, Siemens, Siemens-Nixdorf , ICL, Universität Paderborn, Thomson-CSF, Thomson-CSF/SINTRA-ASM, UCI microélectronique, Rutherford Appleton Laboratories, University of Manchester, GMD

2075 **APACHIP**

Advanced packaging for high performance

Bull, GEC Research, Hoechst Ceramtec, MCTS, National Microelectronics Research Centre, Siemens-Nixdorf, Souriau & Cie, Technische Universität Berlin

2193 **ADCIS**

Analogue/digital CMOS ICs

Anacad-Computer Systems, CNM, CNET, Instituto Superior Técnico, Matra-MHS, Mietec, National Microelectronics Research Centre, Universidad de Sevilla

2197 **STORM**

Process modelling and device optimization for submicron technologies

CNET, CNR-Istituto Lamel, Fraunhofer IM, IMEC, National Microelectronics Research Centre, Plessey, SGS-Thomson Microelectronics, Università di Bologna

2260 **SPRITE**

Interactive silicon compilation for high-performance integrated systems

CGED, IMEC, INESC, Philips, Racal Research, DRA, Siemens

2265 **DRYDEL**

Dry develop optical lithography for ULSI

CEA, Farran Technology, IMEC, Philips, Plessey, Siemens, UCB Electronics

2268 **CANDI**

Combined analogue/digital integration

AEG, Alcatel, Standard Electrica, Dosis, Fraunhofer-IMSS, Plessey, SGS-Thomson Microelectronics, Telefunken Electronic, Thomson-CSF, Universität Dortmund, université Pierre et Marie Curie

2270 **IDPS**

Integrated design and production system

Bell Telephone, CNET, INMOS, Plessey, SGS-Thomson Microelectronics, Siemens, Siemens-Nixdorf , STC-ICL, Thomson-CSF

2272 **SMILE**

Technological feasibility of high-voltage smart-power ICs for lighting applications

Alcatel Standard Electrica, CNM, Elektronik Centralen, National Microelectronics Research Centre, Philips, SGS-Thomson Microelectronics, Università di Genova, Università di Pisa

2281 **UNITED**

High-T_c superconducting thin films and tunnel junction devices

CNRS, Philips, Thomson-CSF, université de Paris-VII, Universiteit Van Twente, University of Cambridge

2284

Optoelectronics with active organic molecules

CEA, CNET, ICI Imagedata, Thomson-CSF, université Notre-Dame de la Paix

2289 **OLIVES**

Optical interconnections for VLSI and electronic systems

AKZO International Research, CNM, Forth Research Centre, IMEC, Plessey, Siemens, STC-ICL, Swiss Federal Institute of Technology, Thomson-CSF, University College London

2318 **EVEREST**

European vanguard efforts on research and engineering of systems for testing

Bennetts Associates, Bull, Elektronik Centralen, Herie, IMEC, INESC, Philips, Scantest System, Siemens, Technische Universiteit Eindhoven, Telefónica, Universidad de Cantabria, Universidad Politécnica de Cataluña, Universidad Politécnica de Madrid, Universität Duisburg, Universität Gesamthochschule Siegen, université de Montpellier, University College Dublin, University Brunel, RE Technology

2319

ASIC multichamber rapid thermal processing with microwave enhancement

CEA, CNRS-LAAS, SGS-Thomson Microelectronics, Sitesa, Addax, STC-ICL, University of Edinburgh

2394 **ASAC**

Application-specific architecture compilation

Bull, Hitec, INESC, Ing. C. Olivetti, SGS-Thomson Microelectronics, Siemens, STC-ICL, UMIST

2403 **MCBRIDE**

Development of a multichamber batch reactor for the production of multilayer interpoly dielectrics

AMTC, CEA/LETI, SGS-Thomson Microelectronics

2426 **IDPS**

Very fast implementation of complex systems on silicon

Bull Italia, Bull, ES2, IMEC, Marconi, Philips, Robert Bosch Silicon & Software Systems, University of Strathclyde

2430 **BiCMOS**

A high-performance CMOS/bipolar process for VLSI circuits

Entwicklungszentrum für Mikroelektronik, INESC, Nederlandse Philips Bedrijven, Phoenix, VLSI Consultants, Siemens Semiconductors, Trinity College Dublin, Universität Stuttgart

2437 **ICARE**

Industrial characterization of an advanced resonant etcher

Alcatel, CEA-LETI, CNM, CNET, Nederlandse Philips Bedrijven, STC-ICL, Trinity College Dublin

2478

Research into boundary scan test implementation

Elektronik Centralen, INESC, Matra, Philips, SGS-Thomson Microelectronics, Siemens, Silicon & Software Systems, Thomson-CSF

2518

Wafer and epilayer improvement correlated with device performances for InP-based optoelectronics

Aixtron, ICI Wafer Technology, Philips-LEP, RWTH Aachen

5002

New generation DUV-stepper optics

ASM-Lithography, Carl Zeiss, Heraeus Quarzschmelze

5003 PLANET

Multiwafer planet MOVPE reactor

Nederlandse Philips Bedrijven, Aixtron, Polyflow, Telefónica

5004 SEDESES

Selective deposition of silicides and epitaxial silicon

Advanced Semiconductor Materials International, Alcatel, CNET, IMEC, National Microelectronics Research Centre, Siemens

5005 ESD

Protection for submicron technologies

IMEC, Philips, Siemens, Technische Universität München

5014

Mask and reticle technology for advanced high-density and ASIC devices

Balzers, BMP, Plasmatechnologie, Compugraphics International, IMEC, Polymer Laboratories, Semisystems, Siemens, Valvo Unternehmensbereich, Wild Leitz Instruments

5018 COSMIC

GaAs monolithic analogue circuits for microwave communication systems up to 23 GHz

Argumens, CNET, Forth Research Centre, Fraunhofer-IIS, Ingenieurbüro für IMHT, Philips, Picogiga, Plessey, DRA, Siemens, Telefónica, Telettra, Università di Roma-La Sapienza

5020 PATRICIA

Proving and testability for reliability improvement of complex integrated architectures

Abstract Hardware, GEC, Italtel Telematica, Politecnico di Milano, University of Bristol

5026 METRICS

High precision automated CD metrology station

Nederlandse Philips Bedrijven, IMEC, Integrated Circuit Testing, Rutherford Appleton Laboratory, SGS-Thomson Microelectronics, Siemens, University of Edinburgh

5029 SUBSOITEC

High-performance submicron SOI/CMOS technologies

CEA, CNRS-LPCS, Fraunhofer, Marconi, National Microelectronics Research Centre, Sextant Avionique, SGS-Thomson Microelectronics, Telefunken Systemtechnik, Thomson-CSF, University of Sheffield

5030 FREE

Fast reticle equipment for Europe

ELISA, Cambridge Instruments, SGS-Thomson Microelectronics, Valvo Unternehmungsbereich, University of Cambridge, Technische Universiteit Delft, National Research Centre 'Demokritos'

5031 MOSDT

Metal-organic research for semiconductor epitaxy

Forth Research Centre, ISA Riber, DRA, RWTH Aachen, Thomson-CSF, CNET, Universität Stuttgart, CNR, Metaleurop Preussag Pure Metals, SMI Organometallic Division

5032 AIMS

Advanced integrated millimetre-wave subassemblies

Alcatel, Daimler-Benz, Elektronik Centralen, Telefunken Electronic, Telefunken Systemtechnik, Thomson-CSF, université de Lille

5033 PLASIC

Performance and reliability of plastic encapsulated CMOS ASICs

Elektronik Centralen, Mietec, National Microelectronics Research Centre, SGS-Thomson Microelectronics, Standard Elektrik Lorenz

5041 PROMIMPS

Process module integration for a multichamber production system

Alcatel, AST Elektronik, Balzers, CEA, CSIC, Fraunhofer-IFT, Philips, Plasmos, SGS-Thomson Microelectronics, Siemens

5047 QUICKCHIPS

A very quick turnaround system for ASIC design and manufacturing supporting multiple design tools and implementation technologies

INESC, CPRM, Milano Research Centre

5048 ACCES

ASIC 0.5 micron CMOS

British Telecommunications, CNET, European Silicon Structures, IMEC, Matra-MHS, Mietec, Plessey, Standard Elektrik Lorenz, STC-ICL, Telefónica, Telefunken Electronic

5051 MORECO

Integrated circuits for mobile reader and communicator for ISO-standard smart-cards

Telefónica Sistemas, Bull, Philips Composants, Telesincro, Sinory, ELGEIEC

5052 MONOFAST

Monolithic integration beyond 26.5 GHz

Alcatel, Farran Technology, GAAS Code, National Microelectronics Research Centre, University of Cambridge, University of Glasgow

5056 AD 2000

Advanced CMOS analogue/digital and digital/analogue converters

Instituto Superior Técnico, Italtel SIT, Universidad de Sevilla (AICIA), Università di Pavia, Fujitsu Spain

5075 IDPS

Integrated design and production system

Philips International, Robert Bosch, ES2, SGS-Thomson Microelectronics, Siemens, Plessey, STC-ICL, Bull

5080 JPL

Joint logic project

Philips International, ES2, Plessey, Siemens-Nixdorf, Telefunken Electronic, SGS-Thomson Microelectronic, Mietec, Matra-MHS

5081

Manufacturing science and technology

Siemens-Nixdorf, ES2, Mietec, Plessey, SGS-Thomson Microelectronics, Telefunken Electronic, STC, Philips International, Matra-MHS

5082

JESSI CAD-frame

Siemens-Nixdorf, Technische Universiteit Delft, ICL, Swedish Telecom, Siemens, SGS-Thomson Microelectronics, Nederlandse Philips Bedrijven, Bell Telephone, University of Manchester, Universität Paderborn, Fernuniversität Gesamthochschule Hagen, Swedish Institute of Microelectronics, Plessey, Forschungszentrum Informatik an der Universität Karlsruhe, IMEC, GMD, CNET, Robert Bosch

5083 GAME

Special action in microelectronics for Spain

By mid-1991 over 30 projects had been proposed to the GAME committee for support under this action

5084 CTA-SME

Concerted technology access for small and medium-sized enterprises

5691 **AICI**

Special action in microelectronics for Portugal

INESC, Animee, Tecmic, Challenge

5692 **VLSI-DPE**

Special action in microelectronics for Greece: Hellenic VLSI design and prototyping environment

Intracom, Ergon, Zenon, University of Patras, National Technical University of Athinai, Computer Technology Institute, Forth Research Centre, University of Thrace Demokritus, NCSR Demokritos, L-Cube

Information processing systems

26

Advanced algorithms and architectures for speech and image processing

AEG, CSELT, GEC, Thomson-CSF, université Louis Pasteur de Strasbourg

32 **PCTE**

A basis for a portable common tool environment

Bull, GEC Research, Marconi Research, Ing. C. Olivetti, Siemens-Nixdorf, STC-ICL

96 **ESB**

Expert system builder

CIMSA, CSELT, Plessey, Søren T. Lyngsø, Tecsiel

107 **LOKI**

A logic-oriented approach to knowledge and databases supporting natural user interaction

BIM, Cretan Computer Institute, Fraunhofer-IAO, Scicon, SCS Informationstechnik

112

Knowledge integration and management systems

Alcatel, Alsthom Recherche, Bull, Siemens

125 **GRASPIN**

Personal workstation for incremental graphical specification and formal implementation of non-sequential systems

ALGMD, Ing. C. Olivetti, Siemens, Tecsiel

256

Time dependency and system modelling in KBS design for industrial process applications

CISE, Framentec

266 **PEACOCK**

Software development using concurrently executable modules

Eurosoft Systems, Hatfield Polytechnic, Roke Manor Research, Universität Dortmund, Universität Karlsruhe

267 **ASSET**

Automated support for software engineering technology

GPP, Plessey

280 **EUROHELP**

Intelligent help for information systems users

Courseware Europe, CRI, DDC/CRI, STC-ICL, University of Leeds

282 **SPMMS**

Software production and maintenance management support

Data Management, GSI Tecsi Software, Sema Metra Group, Siemens, Alcatel, Sofemasa, STC-ICL

283 **FOR-ME-TOO**

Formalisms, methods and tools

Bull, CSELT, Siemens, Syseca

300 **REQUEST**

Reliability and quality of European software

AEG, CISI, Elektronik Centralen, Esacontrol, GRS, BNR-Europe, Thomson-CSF, UKAEA

302

Investigation of performance achievable with highly concurrent interpretations of functional programs

CAP, Sogeti Innovation, INRIA, STC-ICL, University of Stirling

304

Design of techniques and tools to aid in the analysis and design of knowledge-based systems

Scicon, SCS Informationstechnik, South Bank Polytechnic, STC-ICL, Universiteit van Amsterdam

311 **ADKMS**

Advanced data and knowledge management systems

Bull, Ing. C. Olivetti, Siemens-Nixdorf, Technische Universität Berlin

315 **RAISE**

Rigorous approach to industrial software engineering

Brown Boveri & Cie, CRI, STC-ICL

316 **ESTEAM**

An architecture for interactive problem solving by cooperating data and knowledge bases

CAP Sogeti Innovation, CSELT, ONERA-Centre, Philips, Politecnico di Milano

348 **GIPE**

Generation of interactive programming environments

BSO, CWI, INRIA, Sema Metra Group

387 **KRITIC**

Knowledge representation and inference techniques in industrial control

British Telecommunications, Framentec, Krupp, Queen Mary College

390 **PROSPECTRA**

Program development by specification and transformation

Alcatel Standard Eléctrica, CRI, Syseca, Systeam, Universität Bremen, Universität des Saarlandes, Universität Dortmund, Universität Passau, University of Strathclyde

393 **ACORD**

Construction and interrogation of knowledge bases using natural language text and graphics

Alcatel, Alsthom Recherche, Bull, Triumph Adler

401 **ASPIS**

Application software prototype implementation system

CAP, Sogeti Innovation, GEC Research, Marconi Research, Ing. C. Olivetti, Tecsiel, université Joseph Fourier (Grenoble)

410 **SEDOS**

Software environment for the design of open distributed systems

Agence de l'informatique, Bull, CNRS-LAAS, Politecnico di Milano, STC-ICL

415 **PALAVDA**

Parallel architectures and languages for AIP: a VLSI-directed approach

CSELT, Daimler-Benz, GEC, Philips, Siemens-Nixdorf, Bull

419 **IMU**

Image and movement understanding

Captec, Katholieke Universiteit Nijmegen, Trinity College Dublin, Università di Genova, Video Display Systems

432 **METEOR**

An integrated formal approach to industrial software development

Alcatel, Alsthom Recherche, ATT Telecommunication, COPS, CWI, Philips, TXT, Universität Passau, université de Paris-Sud

440 **MADS**

Message-passing architectures and description systems

Alcatel, Alsthom Recherche, Bell Telephone, Delphi, Vrije Universiteit Brussel

510 **TOOL-USE**

An advanced support environment for method-driven development and evolution of packaged software

CISI, Generics Software, GMD, Onera-CERT, université catholique de Louvain

527 **CFID**

Communication failure in dialogue: techniques for detection and repair

Alcatel-ESC, Linguistics Institute of Ireland, Memory Computer, St Patrick's College, Università di Pisa, University of Leeds

530 **EPSILON**

Advanced knowledge-based management system

CRISS, Bense, INSA, Systems & Management, Università di Pisa, Universität Dortmund

532 **GENEDIS**

Real-time generation and display of 25-D sketches for moving scenes

Barr & Stroud, University of Strathclyde, Zeltron

599 **EMG**

Knowledge-based assistant for electromyography

CRI, Judex Datasystemer, Logica, NUC, University of London

814 **PIMS**

Project integrated management system

BSO, CAP Gemini Sogeti, PA Consulting Group, Turing Institute

818 **DELTA-4**

Definition and design of an open dependable distributed computer system architecture

Bull, CNR-IEI, CNRS-LAAS, Ferranti Computer Systems, Fraunhofer Institut für Information, IMAG-IGI, INESC, J-S Telecom, Mari Group, Telettra, Università di Bologna

820 **QUIC**

Design and experimentation of a KBS development tool-kit for real-time process control applications

Aérospatiale, Ansaldo Impianti, CAP Gemini Sogeti, CISE, Framentec, FL Smidth, University of Heriot-Watt

835 **PROSPECTRA-D**

Demonstration of PROSPECTRA methodology and system

Alcatel Standard Eléctrica, Syseca

857 **GRADIENT**

Graphics and knowledge-based dialogue for dynamic systems

ABB Asea Brown Boveri, CRI, Katholieke Universiteit Leuven, Universität Kassel, University of Strathclyde

865 **MUMP**

Non-monotonic reasoning techniques for industrial planning applications

Aeritalia, Battelle Institut, ELSAG

866 **COUSTO**

Integrated optical technologies for real-time wideband optical signal processing

GEC Research, Marconi Research, Selenia, University College London

867 **ARTS-IP**

Adaptive real-time strategies for image processing: a case for satellite data

Dornier System, ESIEE, GEC Research, Marconi Research, Hunting Technical Services, Politecnico di Milano, Polytechnic of Central London, Selenia, Thomson-CSF

874 **CONCORDIA**

Integrated environment for reliable systems

J-S Telecommunications, Mari Group, Telettra, Università di Bologna

881 **FORFUN**

Formal description of arbitrary systems by means of functional languages

Bell Telephone, Katholieke Universiteit Nijmegen, Sagantec, Technische Universiteit Delft

891

Development of an efficient functional programming system for the support of prototyping

Non-standard Logics, STC-ICL, Universiteit van Twente, University of St Andrews

892 **DAIDA**

Advanced interactive development of data-intensive applications

Forth Research Centre, BIM, GFI, SCS Informationstechnik, Universität Frankfurt, Universität Passau

898 **PHOX**

External interface for processing of 3-D holographic and X-ray images for analysis and control

BIAS, GEC, IRAM, Scanray, Universität Dortmund

928 **RUBRIC**

A rule-based approach to information systems development

BIM, James Martin Associates, Micro Focus, UMIST

937 **DESCARTES**

Debugging and specification of Ada real-time embedded systems

Électronique Serge Dassault, Dassault-Breguet-Aviation, Foxboro Nederland, GSI, Systeam, Technische Universiteit Eindhoven, University of Stirling

938 **IMPW**

Integrated management process workbench

CETE Méditerranée, NIHE, STC-ICL, Imperial College of Science, Technology & Medicine, Verilog

940 **DMA**

Depth and motion analysis

ELSAG, GEC, INRIA, ITMI, Matra, Noesis, Università di Genova, University of Cambridge

951 **PACT**

PCTE-added common tools

Bull, Eurosoft Systems, GEC Software, Ing. C. Olivetti, Siemens, STC-ICL, Syseca, Systems and Management

967 **PADMAVATI**

Parallel associative development machine as a vehicle for artificial intelligence

CSELT, GEC, Thomson-CSF, First International

973 **ALPES**

Advanced logical programming environments support

Bull, CRIL, Enidata, Technische Universität München, Universidade Nova de Lisboa, université de Paris-Sud

974 **KNOSOS**

A knowledge-based environment for software system configuration reusing components

Alcatel, CNET, Dornier System, ESI, Matra, Yard Software Systems

1005 **MUST**

Next-generation database management system

ABSY, Syseca, Universität Kaiserslautern

1015 **PALABRE**

Integration of artificial intelligence, vocal input/output and natural language dialogue: application to directory services

British Telecommunications, CNET, CNRS, Sarin, Telematica, SESA

1033 **FORMAST**

Formal methods for asynchronous system technology

Advanced System Architectures, ERNO Raumfahrttechnik, Loughborough University of Technology, Imperial College of Science, Technology & Medicine, Universität Kaiserslautern

1035 **COOP**

2-D coherent optical dynamic processor

GEC, Thomson-CSF, université libre de Bruxelles

1041 **GENESIS**

A general environment for formal systems development

Imperial Software Technology, Philips, Imperial College of Science, Technology & Medicine

1063 **INSTIL**

Integration of symbolic and numeric learning techniques

Cognitech, GEC Research, Marconi Research, université de Paris-Sud

1072 **DIAMOND**

Development and integration of accurate operations in numerical data processing

CWI, Numerical Algorithms Group, Siemens, Universität Karlsruhe

1074

Shipboard installation of knowledge-based systems: conceptual design

Danish Maritime Institute, Krupp, Lloyd's Register of Shipping, Soft International, Søren T. Lyngsø, The East Asiatic Company, University of Athinai

1085 **SUPERNODE**

Development and application of a low-cost, high-performance multiprocessor machine

APSIS, IMAG, INMOS, DRA, Thorn EMI, University of Southampton

1094 **PRACTITIONER**

Support system for pragmatic reuse of software concepts

Asea Brown Boveri, CRI, PCS Computersysteme, University of Brunel

1098 **KADS**

A methodology for the development of knowledge-based systems

CAP Gemini Innovation, Scicon, SCS Informationstechnik, South Bank Polytechnic, STC-ICL, Universiteit van Amsterdam

1106 **Prolog III**

Further development of Prolog and its validation by KBS in technical areas

Daimler-Benz, GIT, Prologia, Robert Bosch, université d'Aix-Marseille

1117 **KIWI**

Knowledge-based user-friendly system for the utilization of information bases

CRAI, DDC/CRI, Enidata, INRIA, Philips, Università di Roma-La Sapienza, Universitaire Instelling Antwerpen

1133 **ISIDE**

Advanced model for integration of DB and KB management systems

Agusta, ARS, CRIL, INRIA, SAGEM, Simulog

1158 **ATES**

Advanced techniques integration into efficient scientific application software

CISI, Philips

1252 **AMADEUS**

A multi-method approach for developing universal specifications

BIM, HITEC, Interprogram, Telefónica CTNE, UMIST

1256 **CHAMELEON**

Dynamic software migration between cooperating environments

Delphi, Harlequin, Non-standard Logics

1257 **MUSE**

Software quality and reliability metrics for selected domains: safety management and clerical systems

Brameur, CRIL, EBO, TÜV

1258 **TRUST**

Testing and consequent reliability estimation for real-time embedded software

Centre for Software Reliability, John Bell Technical Systems, LDRA, SES Software Engineering Services, University of Liverpool

1261 **HTDS**

Host-target development system

Logica, Marconi, SFGL, Softlab

1262 **SFINX**

Software factory integration and experimentation

CRI, ERIA, Sema Group, SFGL, Tecnopolis Csata Novus Ortus

1265 **SEDOS-D**

SEDOS Estelle demonstrator

E2S, Marben, Verilog

1271 **SED**

SETL experimentation and demonstrator

CNAM, Enidata, Thomson-CSF, Universität Hildesheim, University of Patras

1277 **SAPPHIRE**

PCTE portability

GIE-Émeraude, Sema Group UK, Software Sciences

1282 **PAVE**

PCTE and VMS environment

GEC Software, Syseca

1283 **VIP**

VDM interfaces for PCTE

Praxis Systems, CWI, OCE-Nederland

1520 **ALF**

Advanced software engineering environment logistics framework/Accueil de logiciel futur

Cerilor, Computer Technologies, CRIN/ADILOR, GIE-Émeraude, Grupo de Mecánica del Vuelo, STC-ICL, Universität Dortmund, université catholique de Louvain

1527 **SPEM**

Software productivity evaluation model

CERCI, Fuigi Italiana, O Dati Española, Sofemasa, UKAEA

1532

A preliminary study of a vector processing-oriented parallel architecture

Bull, Siemens

1535 **APHRODITE**

A PCTE host-target distributed testing environment

Bull, Chorus Systèmes, Delphi, Ferranti Computer Systems, Philips, université de Liège

1542 **INDOC**

Intelligent documents production demonstrator

ARG, Epsilon Software, INESC

1550 **DRAGON**

Distribution and reusability of Ada real-time applications through graceful and online operations

Dornier System, GSI, University College Wales Aberystwyth, University of Lancaster

1558 **EQUUS**

Efficient qualitative and quantitative use of knowledge-based systems in financial management

Citymax, Riada & Co, University College London

1560 **SKIDS**

Signal and knowledge integration with decisional control for multisensory systems

British Aerospace, CNRS-LAAS, Krupp, Maps Informática Industrial, Matra Rovsing, Universidad Politécnica de Cataluña, University of Oxford

1570 **ESCA**

Application of expert systems to industrial chemical analysis

Katholieke Universiteit Nijmegen, Organon International, Philips Scientific, Vrije Universiteit Brussel

1588 **SPAN**

Parallel computer systems for integrated numeric and symbolic processing

Computer Technology Institute, INESC, PCS Computersysteme, Thomson-CSF, Thorn EMI, University College London

1592 **TAO**

Therapy adviser for oncology

CITSA, Medimatica, University of Leeds

1598 **REPLAY**

Replay and evaluation of software development plans using higher-order meta-systems

Alpha SAI, CISI, CRI, E2S, Onera-CERT

1609 **SMART**

System measurement and architectures techniques

CCS, CEA, CRI, Matra, Paisley College of Technology

1613 **ITS**

Evaluation of an intelligent tutoring system for industrial and office training

Shell, Datamat Ingegneria dei Sistemi, Education Technology Institute

2025 **EDS**

European declarative system

Bull, CCIP, Chorus Systèmes, Computer Technology Institute, European Computer Industry Research Centre, INESC, Infosys, INRIA, Siemens-Nixdorf, STC-ICL, Swedish Institute of Computer Science, Systems & Management, Telefónica, Imperial College of Science, Technology & Medicine, Universidad Politécnica de Cataluña, University of Athinai, University of Bristol, University of East Anglia, University of Heriot-Watt, University of Manchester

2046 **MERMAID**

Metrication and resource modelling aid

Data Management, NCC, City University London, University College Cork, Volmac Software Groep

2059 **PYGMALION**

Neurocomputing

Alcatel, Alsthom recherche, CEA-LETI, Computer Technology Institute, CSELT, École normale supérieure, INESC, INRIA, IRIAC, Philips, Politecnico di Torino, SGS-Thomson Microelectronics, Standard Elektrik Lorenz, Thomson-CSF, Universidad Politécnica de Madrid, université Joseph Fourier de Grenoble-I, University College London

2080 **REX**

Reconfigurable and extensible parallel and distributed systems

2I Industrial Informatics, GMD, GSI, Intracom, Siemens-Nixdorf, Stollmann, Technische Universität Berlin, Imperial College of Science, Technology & Medicine, Universität Karlsruhe, University of Oxford

2092 **ANNIE**

Application of neural networks for industry in Europe

Alpha SAI, Artificial Intelligence, British Aerospace, CETIM, IBP Pietzsch, Peat Marwick Consultants, Siemens, Technische Hochschule Darmstadt, UKAEA, University of Athinai

2094 **SUNSTAR**

Integration and design of speech understanding interfaces

AEG Olympia, Alcatel Face Standard, Daimler-Benz, Fraunhofer-IPA, INESC, Jydsk Telefon, Telefónica, Universität Stuttgart

2101 **ARS**

Adverse environment recognition of speech

CSELT, Logica, Matra, Page Iberica, Politecnico di Torino, Telecom Paris, Universidad Politécnica de Madrid, University of Cambridge, University of Keele

2104 **POLYGLOT**

Multi-language speech-to-text and text-to-speech system

Bull, CNRS-LIMSI, Katholieke Universiteit Nijmegen, Philips, Ruhr-Universität Bochum, Syntax Software Sistemi, Triumph Adler, Universidad Nacional de Educación, Universidad Politécnica de Madrid, University of Edinburgh, University of Patras, CRAI

2143 **IMSE**

An integrated modelling support environment

Fraunhofer, INRIA, Simulog, SINTEF Group, BNR Europe, Thomson-CSF (LCR), Thomson-CSF (CIM), Università degli Studi di Milano, Università degli Studi di Pavia, Università di Torino, Universität Dortmund, University of Edinburgh

2148 **VALID**

Validation methods and tools for knowledge-based systems

Centre d'Estudis Avançes de Blanes, Cognitech, CRI, Universidad Politécnica de Madrid

2151 **SCOPE**

Software certification on program in Europe

Cabinet Bensoussan, CEA, City University London, Elektronik Centralen, ERIA, Etnoteam, Glasgow College, GMD, GRS, NIHE, Technical Research Centre of Finland, TÜV Bayern, UKAEA, University of Strathclyde, Veridatas, Verilog

2152 **VIEWS**

Visual inspection and evaluation of wide-area scenes

Framentec, Fraunhofer Institut für Information, GEC Research, Marconi Research, Krupp Atlas Elektronik, Thomson-CSF, Queen Mary & Westfield College, University of Reading

2154 **MLT**

Machine learning toolbox

Alcatel, Alsthom Recherche, British Aerospace, Forth Research Centre, GMD, INRIA, I-Soft, Siemens-Nixdorf, Turing Institute, Universidade de Coimbra, université de Paris-Sud, University of Aberdeen

2163 **KBS-SHIP**

Shipboard installation of knowledge-based systems: design and installation

Cambridge Consultants, Danish Maritime Institute, Danmarks Tekniske Højskole, Instituto Superior Técnico, Krupp, Lloyd's Register of Shipping, Soft International, Søren T. Lyngsø, The East Asiatic Company, University of Athinai

2167 **AITRAS**

An intelligent real-time coupled system for signal understanding

Artificial Intelligence Systems, Cognitech, CRIN, Laborelec, Tecnatom

2177 **GIPE II**

Generation of interactive programming environments II

ADV/ORGA FA Meyer, Bull, CWI, GIPSI, INRIA, Planet, PTT Research, Neher Laboratories, Sema Metra Group, Technische Universität Darmstadt, Universiteit van Amsterdam

2218 **SUNDIAL**

Speech understanding and dialogue

CAP Gemini Innovation, CNET, CSELT, Daimler-Benz, IRISA, Logica, Politecnico di Torino, Saritel-Sarin, Telematica, Siemens-Nixdorf, Universität Erlangen-Nürnberg, University of Surrey

2252 **DELTA-4**

Definition and design of an open dependable distributed system architecture

Bull, CNR-IEI, CNRS-LAAS, Ferranti Computer Systems, Fraunhofer Institut für Information, INESC, Mari Group, Renault Automation, Sema Metra Group, UKAEA, Unibanque, université Joseph Fourier de Grenoble-I, University of Newcastle

2255 **TOPMUSS**

Tools for processing multi-sensorial signals for plant monitoring and control

Alcatel, Audi, Cegelec Projects, Danmarks Tekniske Højskole (IAL), DISEL, Bailey Esacontrol, Fraunhofer IITB, Krupp Atlas Elektronik, Stewart Hughes, Universität Hannover (IFW), University of Brunel, Ruston Gas Turbines Engineering Research Centre

2256 **ARCHON**

Architecture for cooperative heterogenous online systems

Amber, CEC-JRC Ispra Establishment, CERN, Electricity Association Services, Framentec, Iberduero, Krupp Atlas Elektronik, LABEIN, Queen Mary & Westfield College, Universidade do Porto, université libre de Bruxelles, Universiteit van Amsterdam, University of Athinai, Volmac Nederland

2288 **NAOPIA**

New architectures for optical processing in industrial applications

Krupp, Risø National Laboratory, Thomson-CSF, Universität Erlangen-Nürnberg

2301 **ORDIT**

Development of a methodology for specifying non-functional requirements

Algotech, Husat Research Centre, Mari Group, University of Newcastle, Work Research Centre

2304 **LOTOSPHERE**

Lotosphere

Alcatel, Standard Electrica, Ascom Holding, British Telecommunications, CNR-IEI, CNRS-LAAS, CPR, GMD, INRIA, OCE-Nederland, PTT Research, Neher Laboratories, Syseca, Technische Universität Berlin, Tecsiel, Universidad Politécnica de Madrid, Universiteit van Twente, University of Stirling

2316 **MUSIP**

Multisensor image processor

GEC Research, Marconi Research, Hunting Technical Services, Marconi, MBB, Thomson-CSF, Università di Genova, University of Reading

2354 **DARTS**

Demonstration of advanced reliability techniques

CEGB, Ceselsa, DSMC, EDF, GRS, UKAEA

2384 **METKIT**

Metrics education tool kit

Brameur, British Telecommunications, CAP, DIDA*EL, GMD, SES, South Bank Polytechnic, Verilog

2397 **PROMISE**

Process operator's multimedia intelligent support environment

Algotech, Dow Benelux, IDS, Katholieke Universiteit Leuven, Realace Scottish Power, Tecsiel, University College Dublin, University of Strathclyde, Work Research Centre

2409 **EQUATOR**

Environment for qualitative temporal reasoning

CENA, CISE, École polytechnique fédérale de Lausanne, Eria, ETRA, Ferranti Computer Systems, PTT Switzerland, Laben, Politecnico di Milano, SWIFT, Syseca, Imperial College of Science, Technology & Medicine, University College London

2424 **KIWIS**

Advanced knowledge-based environments for large database systems

Alcatel, Bell Telephone, Craienidata, Origin/International Business Consultants, Philips, Swedish Institute of Computer Science, Università dell'Aquila, Università della Calabria, Universitaire Instelling Antwerpen, University of Kreta

2427 **TROPICS**

Transparent object-oriented parallel information computing system

CAP Sogeti Innovation, CWI, Delphi, Infosys, Ing. C. Olivetti, Katholieke Universiteit Nijmegen, Philips, Siemens-Nixdorf, Stollmann, Thomson-CSF, Universiteit van Twente

2443 **STRETCH**

Extensible KBMS for large knowledge-based application

Agusta, Alcatel Alsthom Recherche, Infosys, INRIA, MBP Software & Systems, Politecnico di Milano, STZ, TXT, Fernuniversität Gesamthochschule Hagen

2447 **GENESIS**

A European, distributed memory, parallel supercomputer for numerical applications

Bull, Chorus Systèmes, GMD, DRA, Siemens, Syseca, University of Liverpool, University of Southampton

2469 **TEMPORA**

Integrating database technology, rule-based systems and temporal reasoning for effective software

BIM, Hitec, Logic Programming Associates, Sintef, Swedish Institute of Computer Science, Sybase, Imperial College of Science, Technology & Medicine, université de Liège, University of Manchester

2471 **PEPMA**

Parallel execution of Prolog on multiprocessor architectures

BIM, Katholieke Universiteit Leuven, Meiko, Swedish Institute of Computer Science, Universidad Politécnica de Madrid, University of Bristol

2474 MMI2

A multi-modal interface for man-machine interaction with knowledge-based systems

ADR-CRISS, BIM, École des mines de Saint-Étienne, INRIA, INSOS, Rutherford Appleton Laboratory, University of Leeds

2487 REDO

Maintenance, validation and documentation of software systems

Centrisa, Computer Technologies, Delft Hydraulics, Dr Jens Grumann Daten-Kommunikation, EDF, ITS, Lloyd's Register of Shipping, Marconi, NIHE, University of Oxford

2502 VOILA

Variable object identification, location and acquisition

ELSAG, GEC, INRIA, Matra, Roke Manor Research, Università di Genova (DIST), Università di Genova (FISICA), University of Oxford, University of Sheffield

2528 SUPERNODE II

Operating systems and programming environments for parallel computers

Aptor, Danish Parsim Consortium, Grupo APD, INPG, IPSYS Software, Numerical Algorithms Group, Ove Arup & Partners, DRA, Syseca, Telmat Informatique, Thorn EMI, Universidad Politécnica de Cataluña, University of Liverpool

2537 ICARUS

Incremental construction and reuse of requirements specifications

Alcatel, Alsthom Recherche, Alcatel Standard Eléctrica, INRIA, Sema Metra Group, Teice Control, université Notre-Dame de la Paix, Universidad Politécnica de Cataluña

2565 ATMOSPHERE

Advanced techniques and models of system production in a heterogeneous, extensible and rigorous environment

CAP Gemini Innovation, Bull, Siemens-Nixdorf, Nederlandse Philips Bedrijven, Siemens, GMD, 2I Industrial Informatics, Bull Italia, SERC, University of Strathclyde, Universität Dortmund, Universität Paderborn, Telesoft, SFGL, Sema Group, Nokia, Intecs Sistemi, GIE-Emeraude, Generics Software, GEI, Computer Technologies

2570 MACS

Maintenance capability for software

Centro de Cálculo de Sabadell, CISI, SESA, Tecnopolis Csata Novus Ortus, Universität Bremen, Universiteit van Limburg

2576 ACKNOWLEDGE

Acquisition of knowledge

CAP Gemini Innovation, Computas Expert Systems, GEC Research Marconi, Sintef, Group Telefónica, Universidad Politécnica de Madrid, Universiteit van Amsterdam, University of Nottingham

2589 SAM

Multi-lingual speech input/output: assessment, methodology and standardization

CNR, CRIN/Adilor, CSELT, Daimler-Benz, ELAB, Jydsk Telefon, Logica, National Physical Laboratory, PTT Research, Neher Laboratories, DRA, Ruhr-Universität Bochum, Smiths Industries Aerospace & Defence Systems, Televerket, The Royal Institute of Technology, TNO, Universität Bielefeld, University College London

2592 VIDIMUS

A generic vision system for industrial applications

British Aerospace, CEA-LETI, Daimler-Benz, Deutsche System-Technik, Ibermatica, Philips, Thomson-CSF, University of Strathclyde, Valvo Unternehmensbereich

2615 ITSIE

Intelligent training systems in industrial environments

Alcatel, Alsthom Recherche, CRI, CISE, Iberduero, LABEIN, Marconi, Universidad del País Vasco, University of Heriot-Watt

2620 FOCUS

Front-ends for open and closed user systems

Indecon, Loughborough University of Technology, Metek, Numerical Algorithms Group, Philips, Solvay, Imperial College of Science, Technology & Medicine, Universidad Politécnica de Cataluña, Universität Münster

2686 COSMOS

Cost management with metrics of specification

Alcatel Austria — Elin, British Telecommunications, Nijenrode Universiteit voor Bedrijfskund, Techforce, Telefónica, University of London Goldsmith's College

2701 PUMA

Universal message-passing architectures

Bull, Chorus Systèmes, École normale supérieure, GMD, Inmos, DRA, Siemens, Syseca, University of Liverpool, University of Southampton

2702 GENESIS II

Development of a distributed memory MIMD system for very high performance numerical computing

Pallas, GMD, Krupp Atlas Elektronik, Stollmann, University of Southampton, University of Liverpool, Meiko Scientific, CHAM, TNO, Universität Wien, Universidad Politécnica de Cataluña, University of Jyvaskyla, Tritech, Simulog, NA Software, European Centre for Medium-Range Weather Forecasts, INRIA, First International, Dornier Luftfahrt

2703 HSSC

High-speed scientific computer

ACRI

2716 AMUS

A multiscalar supercomputer

ACRI, Forth Research Centre, EUCAD, SEKAS, Siemens Semiconductors, University of Manchester

5111 DOCKET

Document and code knowledge elicitation toolset

Computer Logic R&D, CRIAI, Software Engineering Service, SOGEI, UMIST, Universidade Portucalense

5143 ARTIST

Advanced reasoning tool for model-based diagnosis of industrial systems

CEPSA, CISE, Delphi, Heriot-Watt University, LABEIN, Siemens

5146 REAKT

Environment and methodology for real-time knowledge-based systems

Comptas Expert Systems, CRIN, Etnoteam, Grupo de Mecánica del Vuelo, Marconi, Syseca, Thomson-CSF, Universidad Politécnica de Valencia

5170 STATLOG

Comparative testing and evaluation of statistical and logical learning algorithms on large-scale applications for classification, prediction and control

Brainware, Daimler-Benz, Isoft, MBB, Turing Institute, Universidad de Granada, Universidade do Porto, Universität Lübeck, University of Strathclyde

5184 LOCOMOTI

Low-cost moving symbols recognition through intelligent vision engineering

Elliop, Katholieke Universiteit Leuven, Robert Bosch, Universidad Politécnica de Madrid

5192 SPELL

Interactive system for spoken European language training

Alcatel Face Standard, Oros, Tecnopolis Csata Novus Ortus, Università di Roma-La Sapienza, University of Edinburgh

5204 PAPYRUS

Pen and paper input recognition using script

Active Book Company, CAPTEC, Katholieke Universiteit Nijmegen, Nottingham Polytechnic, Olivetti Systems & Networks, Pacer Systems, Università di Genova

5210 AIMS

Advanced information management system

Datamont Feruzzi Group, Deutsches Herzzentrum Berlin, ERIA, Non-standard Logics, ONERA-CERT, Quinary, Technische Universität Berlin, Universidad del País Vasco

5212 FASST

Fault-tolerant architecture with stable storage technology

August Systems, Bull, ETRA Electronic Trafic, INRIA, Stollmann, Tolsys, Trinity College Dublin, Universidad Politécnica de Madrid, Universidad Politécnica de Valencia, University of Newcastle

5225 ARVISA

Advanced real-time vision system and architecture

Carl Zeiss, CEA, ELSAG, FIM-FGAN, Fraunhofer-ISI, INPG, Kontron Elektronik, Krupp Atlas Elektronik, Matra, Philips, Signum Computer, Thomson-CSF, Universidad Politécnica de Cataluña, VTE

5246 PRINCE

Prolog integrated with constraints and environment for industrial and financial applications

Banque La Henin, BIM, Daimler-Benz, FAW, Katholieke Universiteit Leuven, Prologia, Robert Bosch, Universidad Politécnica de Madrid, université d'Aix-Marseille, University of Bristol

5248 KADS-II

An advanced and comprehensive methodology for integrated KBS development

CAP Gemini Logic, CAP Sogeti Innovation, ECN, Entel, IBM France, Lloyd's Register of Shipping, Siemens, Swedish Institute of Computer Science, Touche Ross Management Consultants, Universiteit van Amsterdam, Vrije Universiteit Brussel

5254 PLUS

A pragmatic-based language understanding system

CAP Gemini Innovation, CNRS-LIMSI, ITK, Omega Generation, CAP Gemini SCS Becom, UMIST, Università di Pisa, University of Bristol, University of Göteborg, Katholieke Universiteit Brabant (ITK)

5291 CHIC

Constraint handling in industry and commerce

AIS, Avions Marcel Dassault, Braghenti, Bull, CMSU, ECRC, ETRA, Iberia Lineas Aéreas de España, Onera-Cert, Renault RNUR, Siemens, STC-ICL, Imperial College of Science, Technology & Medicine

5293 GALATEA

Neurocomputing

Computer Technology Institute, CRAM, INESC Informatica Sistemi, INPG, Philips, SGS-Thomson Microelectronics, Siemens, Thomson-CSF, University College London

5304 MULTILEX

A multi-functional standardized lexicon

CAP Gemini Innovation, Fraunhofer-IAO, GETA, L-Cube Information Systems, Lexicon, Philips, Ruhr-Universität Bochum, Siemens-Nixdorf Informationssystem, Siemens-Nixdorf Sistemas de Información, Triumph Adler, Università di Pisa, université de Paris-VII, Vrije Universiteit Amsterdam, University of Manchester, University of Surrey

5311 BUSINESS

Business class

Applied Logic Research, Datamont, Feruzzi Group, ERIA, Etnoteam, Société des outils du logiciel, TAO, Télésystèmes, université de Nice

5312 EMIR

European multilingual information retrieval

CEA, Systex, Transmodul, université de Liège

5327 REBOOT

Reuse bases on object-oriented techniques

Bull, CAP Sogeti Innovation, INPG, Sema Group, Siemens, Sintef, Televerket, TXT

5330 NOMOS

Knowledge acquisition for normative reasoning systems

Axon, CNR-IDG, Hellaslex, INESC, IRETIJ, SOGEI, STEP-Informatique, Tecsiel

5342 PROOFS

Promotion of formal methods in the European software industry

Entel, France câbles et radio, Prisma Informatica, Sligos, Technische Universiteit Eindhoven, TNO

5345 DIMUS

Data integration in multisensor systems

Ansaldo, ELSAG, Istituto Trentino di Cultura, Signum Computer, Technische Universität München, Thomson-CSF, Università di Genova

5362 IMAGINE

Integrated multi-agent interactive environment

Intrasoft, Rijksuniversiteit Leiden, Roke Manor Research, Siemens, Steria, Imperial College of Science, Technology & Medicine, University of Keele

5363 GLAD-IN-ART

Glove-like advanced interface for the control of manipulative and exploratory procedures in artificial realities

AITEK, Eeidetics, Scuola Superiore, Technology Applications Group, Trinity College Dublin, Video Display Systems

5365 VITAL

A methodology-based workbench for KBS life-cycle support

Andersen Consulting, Bull, Koninklijke PTT Nederland, Nokia Research Centre, Onera-Cert, Open University, Syseca, University of Nottingham

5375 ISSS

Intelligent signals, sensors and surveillance

Academisch Ziekenhuis Rotterdam, Aristoteles University of Thessaloniki, Daltek, IBC-DANICA, Philips, Scaitech

5383 LACOS

Large-scale correct systems using formal methods

Bull, CRI, INISEL, Lloyd's Register of Shipping, Matra, Space Software Italia, STC-ICL, Sypro København, Technisystems

5390 RTGC

Real-time gaze control

GEC, INRIA, SAGEM, University of Oxford

5398 SHAPE

Second-generation hypermedia application project environment

Alcatel, Bureau Marcel van Dijk, Datamont Feruzzi Group, Transtools, University of Glasgow

5399 COMPARE

Compiler generation for parallel machines

ACE, CWI, GMD, Harlequin, INRIA, Steria, Universität des Saarlandes

5404 GP MIMD

General-purpose MIMD machines

CERN, Grupo Apd, INESC, Inmos, IRISA, Meiko Scientific, Parsys, Parsytec, Siemens, Swedish Institute of Computer Science, University of Southampton

5409 COMPLEMENT

Comprehensive large-scale engineering methodologies and training

British Aerospace, CEGELEC, GEI, HCS Industrial Automation, Intrasoft, Ipsys Software, IRIT, Matra, RWTH Aachen, SAS, Software Ireland, Syseca, Systems Designers Europe, Universidad de Murcia, University of Southampton, University of Ulster, Veridatas

5425 PYRAMID

Promotion of metrics

Brameur, Desisco, Euroexpert & Partners, Siemens, Veridatas

5429 **MUSIC**

Metrics for usability standards in computing

Veriditas-Brameur, Data Management, Ergonomic Institut, Husat Research Centre, National Physical Laboratory, SEMA Group, Technische Universiteit Delft, Universität Münster, University College Cork

5433 **NEUFODI**

Neural networks for forecasting and diagnosis applications

Austrian Research Institute of Artificial Intelligence, BIKIT, EYS, KTAS, LABEIN, Société lyonnaise des eaux

5441 **BOOTSTRAP**

Bootstrap

2I Industrial Informatics, E2S, Etnoteam, Robert Bosch, Technische Universität Graz

5473 **PAYDIRT**

Processing architecture yielding deductions in real time

Krupp, Atlas Elektronik Bremen, Lloyd's Register of Shipping, SINAPSE, Société lyonnaise des eaux

5477 **CONSTRUCT**

Computer-aided knowledge engineering for construction tasks

Renault automation, Siscog, Vrije Universiteit Brussel

5494 **AMI**

Applications of metrics in industry

Advanced Software Technology, Alcatel Austria — ELIN, Bull, Corelis Technologie, GEC Alsthom, GEC Marconi, ITS, RWTÜV, South Bank Polytechnic

5516 **ROARS**

Robust analytical speech recognition system

CRIN, ENA Telecomunicaciones, Thomson-CSF, Universidad Politécnica de Valencia

5570 **IPTES**

Incremental prototyping technology for embedded real-time systems

CEA, ENEA, IFAD, Mari Group, Politecnico di Milano, Technical Research Centre of Finland, Telefónica, Universidad Politécnica de Madrid

5661 **STANDARDIZATION**

Standardization for object-oriented systems

D-Tech, INTECS International, Teclab

5662 **SOFTWARE TOOLS**

Software tools: intercommunications

Dr Jens Grumann, Daten-Kommunikation, Software España, Systems & Management, Techforce

5663 **REAL-TIME**

Real-time systems

Autograph International, CSC, Diseño y Metodología, Intron, Katholieke Universiteit Leuven, Systeam

5664

Multimedia systems and human-computer interface

Envirotech International, Epsilon Software, Selisa, Silvertech

5665

Trends in operating systems for parallel computing

GPP, Standard International Consulting

5666

Massively parallel platform

Active Memory Technology, Dancomp (Decanter, Richter & Rosenstand), PCS Computersysteme, Pliroforiki, TECMIC

5667

Parallelizing tools

AIIT, Elabodater, Parseq, TNO, Tritech

5668

Neural computing

ARITEX, DIDA*EL, IBP Pietzsch, Jenni-International User Group, Software de Base

5669

Measurement of advanced architecture

Algotech, First International, Mental Images, Simulog

5670

Fault-tolerant systems

SEPA, Software Cientifico y Técnico, Verilog

5671

Improvement of complex systems using KB techniques

Corelis Technologie, Ingegneria Informatica, Knossos Technologies, Søren T. Lyngsø, Vision Computing

5672

Vision systems

Athinai Technology Centre, INTECS International, Maptel

5673

Multisensor systems

AIIT, And Software, Universidade de Coimbra, Zenon

5674

Quality assessment in KBS

AITEC, Cetena, IGC, LDRA

5675 **AMKBS**

Applications of multi-agent KBS

Artificial Intelligence Systems, Elabodater, Indecon, Advanced Technology, Instituto Superior Técnico, PROSS

5676 **PCTE**

PCTE policy options

Elios informatique, Generics Software, GMD, OVUM

5677 **ROBUST**

Robust speech understanding

ENA Telecomunicaciones, Knowledge, Lernout & Hauspie Speech Products

PARALLEL COMPUTING ACTION PCA

LRI Lab. de Recherche Vidal-Naquet en Informatique, Universidad Politécnica de Madrid, Technische Universität Berlin, University of Thessaloniki, Technische Hochschule Darmstadt, University of Athinai, Universität Erlangen-Nürnberg, Johann Wolfgang von Goethe Universität Frankfurt, Odense Universitet, Università di Bologna, université de L'État à Mons, Polytechnic of Central London, Politecnico di Milano, Universität Karlsruhe, Universität Köln, National Technical University of Athinai, Technische Universiteit Eindhoven, Università di Bari, Katholieke Universiteit Leuven, Universität Paderborn, Rijksuniversiteit Gent, TNO, Onera-CERT, Vrije Universiteit Brussel, University of Sheffield, CNR, University College London, Trinity College Dublin, Università di Genova, University of London (Birkbeck College), University College of North Wales, IFISIC-Rennes, University of Bristol, Katholieke Universiteit Nijmegen, University of Reading, Universität Bremen, INESC, Universiteit Twente, Universiteit Kaiserslautern, Universidade do Porto, Universidade Nova de Lisboa, université Louis Pasteur (Strasbourg), Universidad Politécnica de Cataluña, University of Ulster, Università di Torino, CSIC, INT, université de Bourgogne, Ålborg Universitet, Università di Roma II, université de Franche-Comté, université Pierre et Marie Curie

Advanced business and home systems — Peripherals

28 **MULTOS**

A multimedia filing system

Battelle Institut, CNR-IEI, Cretan Computer Institute, Epsilon Software, ERIA, Ing. C. Olivetti, Philips, Triumph Adler

43 **E-INTERFACE**

Standardization of integrated LAN services and service access protocols

Alcatel, British Telecommunications, Bull, CAP Gemini, Sogeti, CSELT, GEC Research, Marconi Research, OCE-Nederland, Philips International, Plessey, RCE, Roke Manor Research, Siemens-Nixdorf, Universiteit van Twente

56 **FAOR**

Functional analysis of office requirements

GMD, STC-ICL, The East Asiatic Company, Universität Köln-BIFOA

59 **MINSTREL**

New information models for office filing and retrieval

DDC/CRI, GN, National Software Centre, University College Dublin

64 **SPIN**

Speech interface at office workstation

Alcatel, Alsthom Recherche, CEA, CMSU, CSELT, Daimler-Benz, Oros, CAP-SESA, Siemens-Nixdorf, SNS Pisa, Universiteit van Amsterdam

73 **BWN**

Broad-site local wideband communication system

CEC, Bell Telephone, CISI, CMSU, France câbles et radio, SG2, Informatique Stollmann, université de Liège

82 **IWS**

Intelligent workstation

Bull, Forth Research Centre, INRIA, Katholieke Universiteit Nijmegen, OCE-Nederland, Vrije Universiteit Brussel

121 **HERODE**

Handling mixed text/image/voice documents based on a standardized office document architecture

Alcatel, CRIN, Siemens

169 **LION**

Local integrated optical network

Alcatel, British Telecommunications, CSELT, Politecnico di Milano, université de Paris, université Paul Batier de Toulouse, University of Patras

231 **DOEOIS**

Design and operational evaluation of office information servers

Bull, STC-ICL, Trinity College Dublin, Universität Stuttgart

234

Cognitive simulator for user interface design

Alcatel-ESC, GEC, Logos Progetti, Medical Research Council

237 **CSA**

Communications systems architecture

ITK, Mari Group, Philips, Roke Manor Research, SYD

249 **UCOL-1**

Ultra-wideband optical coherent LAN

Alcatel, Face Standard, GEC Research, Marconi Research, Politecnico di Milano

285 **OSSAD**

Office support systems analysis and design

Centre d'études du management, IOT, CRI, Università degli Studi di Milano

291 **LING-ANALYSIS**

Linguistic analysis of the European languages

Acorn Computers, CNRS-LIMSI, Ing. C. Olivetti, Katholieke Universiteit Nijmegen, Ruhr-Universität Bochum, Tecnopolis Csata Novus Ortus, Universidad Nacional de Educaciône, University of Patras

295 **PAPER**

The paper interface

AEG Electrocom, Ing. C. Olivetti, Philips, Plessey

367 **SOMIW**

Secure, open, multimedia integrated workstation

AEG Electrocom, Bull, CSELT, INESC, INRIA, Italtel Telematica, RITEL, SCK-CEN, Sema Group Belgium

385 **HUFIT**

Human factors laboratories in information technologies

Bull, Fraunhofer-IAO, Husat Research Centre, Ing. C. Olivetti, Philips, Piraeus Graduate School, Siemens, STC-ICL, Universidade do Minho, Universität Münster, University College Cork

395 **INCA**

An integrated network architecture for office communications

GEC, Ing. C. Olivetti, Modcomp, Siemens-Nixdorf, Systems Wizards, University College London

449 **SPEECH**

Investigation into the effective use of speech at the human-machine interface

British Maritime Technology, Cortec, Fincantieri, STC-ICL, Voice Input

563 **PICA**

A high compression picture-coding algorithm for videotex

British Telecommunications, CCETT, CSELT, IBA, KTAS, PTT Research, Siemens-Nixdorf

612 **MODEL-DISPLAY**

Modelling and simulation of the visual characteristics of modern display technologies under office work conditions

Barco Industries, GEC, MYFRA, OCE-Nederland, Thomson-CSF, université de Paris, Universiteit van Twente

813 **TODOS**

Tools for designing office systems

CNR-IEI, Dornier System, Italtel Telematica, OCE, Politecnico di Milano, Sema Metra Group, Systems & Management, Thomson-CSF, Universität Köln-BIFOA, université de Paris-I

831 **ASTRA**

Advanced and integrated office systems prototypes for European public administrations

Bull, Cesia, CRIAI Datacentral, Datenzentrale Schleswig-Holstein, GSI, Ing. C. Olivetti, MC2, Silogia, Sogei

834 **COMANDOS**

Construction and management of distributed office systems

ARG, Bull, CNR-IEI, Fraunhofer IM, IMAG, INESC, Ing. C. Olivetti, Siemens-Nixdorf, STC-ICL, Trinity College Dublin, Universität Stuttgart

853 **TRUE-COLOUR**

Acquisition, compression and reproduction of true-colour image documents

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

855 TYPEWRITERS

European typewriters and other workstations integration

AEG Olympia, Ing. C. Olivetti, Politecnico di Torino, Triumph Adler

870 TALON

Testing and analysis of local area optical networks

Cossor Electronics, NKT Elektronik

878 PROMINAND

Extended office process migration with interactive panel displays

IAB, Modulex, Risø National Laboratory, Scaitech, Technische Universität München

890 PANGLOSS

Parallel architecture for networking gateways linking OSI systems

7-Technologies, CAP, PCS Computersysteme, université de Liège, Universiteit van Twente, University of Reading

901 DOMESDAY

An intelligent general public data, voice and picture storage retrieval system

BBC, Bureau van Dijk, CRIN, Logica, Philips Gloelampenfabrieken

925 CODING-256

Coding for moving pictures and still pictures at 256 Kbit/s and 64 Kbit/s

Alcatel, GEC, Philips, Société anonyme de télécommunication, Sepa, Telefónica

954 IKAROS

Intelligence and knowledge-aided recognition of speech

Alcatel, Alsthom Recherche, Fraunhofer-IAO, GEC, Universität Stuttgart

956 COCOS

Components for future computing systems

Bull, Ing. C. Olivetti, INRIA, SGS-Thomson Microelectronics, Siemens-Nixdorf, STC-ICL

998 MARS

Highly secure office information systems

Bertin & Cie, COPS, Protexarms Rovsing, Universität Köln-BIFOA, University of East Anglia

1024 PODA

Piloting the office document architecture

Alcatel, Bull, Ing. C. Olivetti, OCE-Nederland, Siemens, Siemens-Nixdorf, STC-ICL, Syntax Software Sistemi, Queen Mary & Westfield College, University College London

1030 IT-UPTAKE

Human and economic factors in IT uptake processes

Empirica, Irish Medical Systems, STC-ICL, Work Research Centre

1051 A-Si IMAGER

Amorphous silicon contact imager for office and graphic applications

Agfa Gevaert, CNRS-Lepsi, IMEC, MBB

1057 MIAC

Multipoint interactive audiovisual communication

Alcatel, Face Standard, British Telecommunications, CNET, CSELT, PTT Research, Neher Laboratories, STC-ICL, Telefónica, Thomson-CSF

1059 DAMS-1

Dynamically adaptable multi-service switch

J-S Telecom, Roke Manor Research, TN Telenorma

1533 MIS

Multilingual information system

Bull, Ing. C. Olivetti, Siemens-Nixdorf, STC-ICL

1541 MULTILINGUA

Multilingual speech input-output assessment, methodology and standardization

CNET, CSELT, Jydsk Telefon, Universiteit van Amsterdam, University College London

1573 IBASS

Intelligent business application support system

Bull, Datamont, Feruzzi Group, Langton, Siemens-Nixdorf, South Bank Polytechnic

2001 SPRITE

Storage, processing and retrieval of information in a technical environment

ADV/ORGA FA Meyer, AEG Electrocom, Alcatel, Armines, Katholieke Universiteit Brabant, OCE-Nederland, Trinity College Dublin, Universität Hamburg, Daimler-Benz, Akademie der Wissenschaft

2013 MAGNOPTIC

Development of European magneto-optical drives

CEA, Coventry Polytechnic, NIHE, GEM, Olivetti Systems & Networks, Philips Nederland, Philips Dupont Optical

2054 UCOL-2

Ultra-wideband coherent optical LAN

Alcatel, Alsthom Recherche, Face Standard, COSI, Daimler-Benz, IDATE-Yves Gassot, INESC, PTT Research, Neher Laboratories, Standard Elektrik Lorenz, STC-ICL, Telettra España, University of Southampton

2058 ICI

Intelligent communication interface

British Telecommunications, SAIT Electronics, Universidad Politécnica de Cataluña, Universidad Politécnica de Madrid

2071 COMANDOS-2

Construction and management of distributed open systems

Bull, Chorus Systèmes, Fraunhofer-ITW, IMAG-LGI, INESC, Siemens-Nixdorf, Trinity College Dublin, Universidad Politécnica de Cataluña, Universität Stuttgart, University of Glasgow

2082 HECTOR

Harmonized European concepts and tools for organizational information systems

CAP Sogeti Innovation, CRAI, Delga International, Dornier Systems, Fraunhofer-IPA, IOT, KPMG-Peat Marwick McLintock, PA Consulting Group, Universität Köln-BIFOA

2083 SIMPR

Structured information management: processing and retrieval

CAP Gemini Europe, CRI, Dublin City University, Nokia, Research Unit for Computational Linguistics, Universidade Católica Portuguesa, Universiteit van Amsterdam, University College Dublin, University of Strathclyde

2100 MAX

Metropolitan area communication system

3IT, Alcatel, CSELT, Hewlett-Packard, KTAS, L-Cube Information Systems, NKT, Sirti, université de Paris-VI, University of Patras

2102 COMIS

Standard for coding moving images on digital storage media

British Telecommunications, CNET, CSELT, Deutsche Thomson-Brandt, Eikon, Inmos, Halbleiterwerk der Deutsche, Philips Research Laboratories UK, PTT Research, Neher Laboratories, Sidac, Thomson-CSF, TN Telenorma, Universität Hannover

2103 MASCOT

Multi-environment advanced system for colour treatment

Computer Logic R&D, Hitec, ICI, Ing. C. Olivetti, Katholieke Universiteit Leuven, Kern & Co, OIS, Syntax Software Sistemi, Thomson-CSF

2105 **MULTIWORKS**

Multimedia integrated workstations

Acorn Computers, AEG Olympia, Bull, Chorus Systèmes, Daimler-Benz, GMD, Harlequin, Ing. C. Olivetti, INPG, INRIA, Philips, Polytechnic of Kreta, SGS-Thomson Microelectronics, Triumph-Adler, Tecnopolis Csata Novus Ortus, Télésystèmes

2109 **TOOTSI**

Telematic object-oriented tools for services interfaces

Algotech, ARG, Centro di Cultura Scientifica — A. Volta, Desarrollo de Software, Infotap, Politecnico di Milano, Saritel, Sophiatec, Télésystèmes, université de Nice-Lisan, System & Management

2111 **PONTIFEX**

Planning of non-specific transportation by an intelligent fleet expert

Aeritalia, CAP Gemini Europe, CNR-IASI, Iberia Lineas Aéreas de España, Siemens-Nixdorf, O Dati Española SL, Sipe Optimation, TAP Air Portugal, Trademco Trut — Kykloforiaki

2114 **LSVI**

Large-size visual interface design for multimedia workstation terminals

Pilkington, Standard Elektrik Lorenz, Thomson-CSF

2121 **ITHACA 1**

Integrated toolkit for highly advanced computer applications

Bull, CAP Sogeti Innovation, CNRS-LADL, Communication and Management System Unit, D-TECH, Datamont Feruzzi Group, Delphi, E2S, Forth Research Centre, INRIA, Politecnico di Milano, Siemens-Nixdorf, TAO, Trinity College Dublin, Università degli Studi di Milano, Universität Karlsruhe, université de Genève

2125 **ETR**

Electrothermal ribbon

AEG Olympia, Baltea, Ing. C. Olivetti, Manchester Polytechnic

2144 **IT-USE**

Information technology uptake support environment

Datacentralen, Futurmedia, Groningen University, Handelshøjskolen i København, Irish Medical Systems, Memory Computer, Work Research Centre

2146 **DAMS-2**

Dynamically adaptable multiservice system

INESC, J-S Telecom, RWTH Aachen, STC-ICL, TN Telenorma, Universidad Politécnica de Madrid, Universität Kaiserslautern, Universität Stuttgart, University of Patras

2170 **SUPERDOC**

A set of software tools for a document workstation

Addax, Bull Italia, Epsilon Software, INESC, Lombardia Informatica, Politecnico di Milano, Selisa, Sistemas Multiposto e Distribuidos, Strategic International, Teseo

2221 **RICHE**

Health services information and communication network for Europe

Actir-Sante, Bazisleid, Bull, GESI, IRIAM Irish Medical Systems, Lombardia Informatica, SIG Services, STAF-Conseil de Filière, Università Cattolica del Sacro Cuore, NHS Management Information Centre

2239 **SESEFA**

Self-service facilities architecture

ERIA, IKOSS-Software Service, Prisma Informatica, Silogia, Università di Firenze, ERITEL

2267 **ISA**

Integrated systems architecture for ODP

British Telecommunications, CASEG, Chorus Systèmes, CNET, Computer Technology Institute, Deutsche Thomson-Brandt, Daimler-Benz, Digital Equipment, GEC Marconi, GEC Plessey Telecommunications, GESI, Hewlett-Packard, Modcomp, Philips International, Siemens, STC-ICL, Syseca, Televerket

2283 **MATRIX-LCD**

Active matrix LCD for TV and office systems

AEG, Aristoteles University of Thessaloniki, GEC, IMEC, Rytrak Seleco, Thomson-CSF, Thomson-LCD

2294 **TOBIAS**

Tools for object-based integrated administration systems

GIE-Émeraude, Intecs International, Intrasoft Planet, University of Newcastle

2315 **TWB**

Translator's workbench

Mercedes Benz, Fraunhofer-IPA, L-Cube Information Systems, Siemens-Nixdorf, SPAI, Triumph Adler, Universidad Politécnica de Cataluña, SNI CDS

2322 **ISEM**

IT support for emergency management

ADV/ORGA FA Meyer, ENEA, GRS, IGC, Jydsk Telefon, Risø National Laboratory, SCK-CEN, Studsvik Nuclear Technical Research Centre Finland, Tecnatom, Técnicas Reunidas, Uitesa

2360 **FELICITA**

Development of ferroelectric liquid crystal devices for information technology applications

BDH, GEC, Lagerwall RL, Merck, OCE-Nederland, Robert Bosch, DRA, Seleco, Thomson-CSF, Thorn EMI, Universidad Politécnica de Madrid, Università di Bari, University of Hull

2374 **PODA-2**

Piloting of the office document architecture

ICL, British Telecommunications, Siemens-Nixdorf, Olivetti Information Services, Alcatel TITN, OCE-Nederland, IBM Deutschland, Bull, University College London, SSI

2382 **ELO**

Elusive office

Bonnscript, CLS Computer Lernsysteme, Empirica, Fraunhofer-ISI, Heptacon Neptune Freight, OEVA-Versicherungen, Otter Online, Rutherford Appleton Laboratory, Standard Elektrik Lorenz

2404 **PROOF**

Primary rate ISDN OSI office facilities

3 Net, Systems Wizards, University College London

2431 **HOME**

Home systems

AEG, Alcatel Standard Eléctrica, Asea Brown Boveri, Bang & Olufsen, Bassani Ticino, British Telecommunications, Busch-Jäger-Elektro Centre, GEC, Honeywell Europe, Ikerlan

2455 **LTI**

Large-image terminals

Nokia Grätz, Standard Elektrik Lorenz, Thorn EMI, University of Heriot-Watt

2463 **ARGOSI**

Applications-related graphics and OSI standards integration

COSI, Fraunhofer Graphische Datenverarbeitung, GESI, GMD, INRIA, Laser-Scan Laboratories, Rutherford Appleton Laboratory, Tecsiel, Thomson-CSF, University of East Anglia

2466 **KWICK**

Knowledge workers intelligently collecting, coordinating and consulting knowledge

ADV/ORGA FA Meyer, Artificial Intelligence Systems, Bull, CEC, ISPRA Establishment, CMSU, CNRS, Elsa Software, Elsevier Science Publishers, Espasa-Calpe, IRIAM, Maatschappij Voor Informatica Diensten, Office Workstations, Tecograf Software, Università degli Studi di Milano, University of Glasgow

2476 **BANK '92**

Bank '92

Banco de Sabadell, Banco Herrero, Bull España, Caja de Ahorros del Mediterráneo, Caja Insular de Ahorros de Canarias, CAP Gemini Sogeti, Computer Logic R&D, Credito Italiano, Entel, Ikoss, INESC, CRI, Prisma Informatica, Silogia, STC-ICL, Thomson-CSF, Unibanque

2484 **SPIRIT**

High-performance technical workstation

ACE, British Aerospace, Caption, GIPSI, Kontron Elektronik, Telmat informatique, Queen Mary & Westfield College, Universität Tübingen, University of Sussex, École polytechnique fédérale de Lausanne

2499 **CDR**

CD-ROM workbench

ACT, Clarinet Systems, Elektroson, Katholieke Universiteit Nijmegen, Textware

2512 **IACIS**

Intelligent area communication and information system

Administração do Porto de Lisboa, Port Autónom de Barcelona, Bull Italia, CSELT, Entel, INESC, Ositel, Prisma Informatica, SECRE, SEGET, SIRTI, SISMET, Porto di Genova, Stollmann, SYD, Synergia, Tecno T&G, Telefónica, Televas, Universidad Politécnica de Madrid, Universität Stuttgart

2563 **GAUCHO**

General distributed architecture for unified communication in heterogeneous OSI-environments

ADVORGA FA Meyer, Dannet, Fischer & Lorenz, Project Management Consultants, RC-Computer Telefónica, Universidad Politécnica de Madrid

2569 **EWS**

European workstation

Bull, Chorus Systèmes, Fraunhofer Graphische Datenverarbeitung, GIPSI, Grupo Apd, INESC, INRIA, Rutherford Appleton Laboratory, Siemens-Nixdorf, University of Brunel

2633 **MAG-UHD**

Magnetic media for future ultra-high-density information storage

Agfa Gevaert, Aristoteles University Thessaloniki, BASF, CNRS-Mulhouse, Du Pont de Nemours de Luxembourg, Institut national polytechnique de Lorra, université de Bordeaux

2638 **ADOT**

Advanced display optimization tools

British Aerospace, City University (London), OCE-Nederland, Sogitec, TNO

2649 **VASARI**

Visual arts system for archiving and retrieval of images

Brameur, Direction des musées de France, Dörner Institut, Eikon, National Gallery, Syseca, Telecom Paris, Thomson-CSF, TÜV, University of London (Birkbeck College)

2684 **MIAS**

Multipoint interactive audiovisual system

Alcatel, Amper, British Telecommunications, CNET, CSELT, PTT Research, Neher Laboratories, Telefónica

2704 **CRYPTO-CARD**

Development of a dedicated microprocessor with a universal crypto processor and its integration into high-security IC-cards

Bull, Siemens

2705 **ITHACA**

Integrated toolkit for highly advanced computer applications

Bull, CNRS-LADL, CMSU, D-TECH, Datamont Feruzzi Group, Delphi, Forth Research Centre, PTT Research and Development, Gip Altair, IFATEC, INRIA, Politecnico di Milano, Siemens-Nixdorf, SQL Databanksysteme, TAO, Technische Universität Dresden, Trinity College Dublin, Università degli Studi di Milano, Universität Zürich-IRCHEL, université de Genève

5011 **JEPS**

Bootstrap project for joint European printer server

Bull, OCE-Nederland, Siemens-Nixdorf

5012 **PREJEEMI**

Bootstrap project for a multiple device file server

Bull, Philips, Rodime

5140 **HIVE**

Home interactive environment

Bang & Olufsen, Centra Burkle, Honeywell Europe, Jydsk Telefon, University of Bristol

5165 **DOMAINS**

Distributed open management architecture in networked systems

Harwell Laboratory, ITK, Mari Group, Philips, Roke Manor Research Limited, Siemens, université Pierre et Marie Curie, University of Athinai, Architecture Projects Management

5167 **EURORIP**

European raster image processor for common fonts and page description languages

Autograph International, Fraunhofer Graphische Datenverarbeitung, URW

5193 **MAXI**

Metropolitan area communication system

Alcatel, British Telecommunications, CSELT, Hewlett-Packard, IRIT, KTAS, L-Cube Information Systems, NKT, SIRTI, Telettra, université Pierre et Marie Curie, University of Athinai

5199 **ISA-DEMON**

A distributed environment monitor for the ISA architecture

Architecture Projects Management, Mari Group, Universidade de Aveiro

5203 **INTREPID**

Innovative techniques for recognition and processing of documents

AEG Electrocom, CTA, EWH Koblenz, Nottingham Polytechnic, Olivetti Systems & Networks, Pacer Systems, Università di Napoli

5233 **TELESTATION**

Telestation

Active Book Company, Alcatel, ARG, Daimler-Benz, Hewlett-Packard, Olivetti Systems & Networks, Perihelion Software

5252 **HYTEA**

Hypertext authoring

CEC-JRC Ispra Establishment, Epsilon Software, GMD, Ing. C. Olivetti, Politecnico di Milano, Siemens, Systems & Management

5279 **HARNESS**

European distributed system integration project

British Telecommunications, Bull, CAP Sogeti Innovation, CNRG, Datamont Feruzzi Group, Ensta-Liès Grupo, INESC, INRIA, Kapsch, Siemens, STC Technology, Trinity College Dublin, Universitaire Instelling Antwerpen, Volmac Nederland, Architecture Projects Management

5303 **EUROCOOP**

IT support for distributed cooperative work

Århus Universitet, Empirica, GMD, Jydsk Telefon, STC-ICL, Storebæltsforbindelsen-Great Belt, Triumph Adler, X-TEL Services

5320 **PODA-SAX**

Piloting ODA extensions and their applications in systems

Bull, IBM Deutschland, Olivetti Information Services, Siemens-Nixdorf, STC-ICL, Syntax Software Sistemi, University College London

5322 **CHALENGE**

Standardized EDI platform for applications using OSI

Bull HN Information Systems, EPEC, Epsilon Software, Ibermatica, Informabel, Irish Medical Systems, Siemens-Nixdorf, Pross

5341 **OSI 95**

High-performance OSI protocols with multimedia support on HSLANs and B-ISDN

Alcatel Austria — Elin, Bell Telephone, Bull, INRIA, Institut national des télécommunications, Intracom

5346 **EUROSHOP**

Distributed electronic shopping and integrated retail logistics for Europe

Corte Inglés, GIE-Recherche Haussmann, Littlewoods Organization, Siemens-Nixdorf, Sligos

5371 **PEMMON**

Performance management and monitoring of open networks in heterogeneous contexts

CSEE, Selenia, université Pierre et Marie Curie, University College Dublin

5374 **QLIS**

Software scenario models for quality of life in information society

Bang & Olufsen, BBC Productions, Open University, CAP Sogeti Innovation, Copenhagen Business School, Datamont Feruzzi Group, Fiat, Siemens-Nixdorf, Universität Marburg

5376 **ROCKI**

Raster to object conversion aided by knowledge-based image processing

Algotech, CNR, Fraunhofer-IPA, OCE-Nederland, TNO

5386 **OMIMAP**

Open microsystems initiative: microprocessor architecture project

Acorn Computers, Active Book Company, Bull, European Educational Software, IMEC, Inmos, Olivetti Systems & Networks, DRA, Siemens, Thomson-CSF, University of Manchester

5402 **FODATEC**

Feasibility demonstration of ODA for technical documents

Bureau van Dijk, Caption Kapsch, Universidad Politécnica de Cataluña, Universität Karlsruhe

5405 **HERMES**

Highly interactive environment resource management extendible system

Algotech Sistemi, Ayuntamiento de Sevilla, Azienda Servizi Municipali Comune di Brescia, CRI, Kommunedata, Novosoft, Paisley College Technology

5432 **PANDA**

Public administration demonstrator

Bull, Datacentralen, Grupo APD, IABG, SOGEI, Telefónica

5444 **ACIBS**

Architecture for computer-integrated business systems

CMSU, Norcontel (Ireland), Philips, Trinity College Dublin

5448 **IIH**

Integrated interactive home

British Telecommunications, Daimler-Benz, GEC Marconi, Legrand, Philips International, Siemens, Thomson-CSF, Thorn EMI, Zeltron

5469 **CITED**

Copyright in transmitted electronic documents

British Library, Bull, Bureau van Dijk, Charles Clark, Computer Industry Research Unit, Elsevier Science Publishers, Jaime Brull, NTE, Oxford University Press, Telematic Services, Télésystèmes

5470 **MORESYS**

Accreditation and access control for smart-card mobile reader and communications system

Bull, Elgelec, SINORG, Telefónica, Telesincro

5492 **PROVIDE**

Digital distribution of video

Desisco, Iselqui

5631 **WINS**

Wireless in-house network studies

Alcatel Portugal, Ergon, Maintenance & Automation, Ste Seferiades & Associates, Universidade de Aveiro, Universidad Politécnica de Madrid, NTUA Propagation Group, NTUA Microwave & Optics Group, Universidad de Las Palmas de Gran Canaria, University of Limerick, LEREA SNC

5633 **HYTECH**

Hypertextual and hypermedia documentation

Datamont, Ifatec, INESC, Magneti Marelli, Universität Münster, Etnoteam

5634 **AURA**

Adaptable user interfaces for reusable applications

Fraunhofer, ISA, Mari Group, Thomson-CSF, University of Leeds

5636 **ALDUS**

Artificial legal draftsman for use in sales

Machine Intelligence, BIKIT, Hellenic Information Systems, Universiteit van Amsterdam, Wolters Kluwer, Imperial College of Science, Technology & Medicine, DIDA*EL, CNR-IDG

5638 **KIM**

Knowledge-based information management

Consorzio Roma Ricerche, Futurmedia, GESI, Irish Medical Systems, Software Italia, Trinity College Dublin, Università di Roma-La Sapienza

5639 **SMESPRIT**

An SME expert support system for planning and reporting about information technology

Addax, Algosystems, Delphi, Experteam, Hellenic Management Association, LSE

5640 **PIA**

Public information access

Sistemas Modulares, Association Acropol, System & Management, INESC

5641 **INCH**

Intelligent charts

Bull, CMSU, Datenzentrale Schleswig-Holstein, IGN-France international, INESC, ISSI, Kommunedata, Magistratsdirektion Wien, Télésystèmes

5644 **EXPORT**

Extended X-protocol for office-related technology

CNRG, Framentec, Meterquest

5650 **ERWIN**

European railways wireless in-house network

Autophon, CER, Plessey, Trialog Informatique

5652 **HYPERDOCSY**

Automatic production of technical documentation

Alcatel, Alsthom Recherche, Avions Marcel Dassault-Breguet Aviation, OC Consulting Engineers & Planners, Siemens SI

5653 **FOES**

Front-office environment study

Banque nationale de Paris, Bull, Concept Logiciels Expert, Pliroforiki, SELISA, Thorn EMI, Time Sharing, University College London

5656 **OSMOSE**

Open standard for multimedia optical storage environments

Espasa-Calpe, Ing. C. Olivetti, Pergamon Compact Solution, Philips TDS

5660 **PECOS**

Perspectives on cooperative systems

AIS, BIKIT, EMMEPI, Industrias de Telecomunicazione Lombardia, Mari Group, Universidad Politécnica de Madrid

Computer-integrated manufacturing

9

Exploitation of real-time imaging for arc welding

Babcock Energy, Messer Griesheim, RWTH Aachen, Welding Institute of Cambridge

34

Design rules for computer-integrated manufacturing systems

ISTEL

75

Design rules for the integration of industrial robots into CIM systems

Fraunhofer IPK, University College Galway, Renault Automation, RPK der Universität Karlsruhe

92 **CIPI**

A computer-integrated production insula: design rules and standards

Logica

118

General-purpose sensory-controlled systems for parts production

Comau, IPA-Fraunhofer Gesellschaft, OCN-PPL, Siemens-Nixdorf, SINCON

179

Integrated electronic subsystems for plant automation

AEG, GEC Marconi Research

197

Computer-aided thermal image technique for real-time inspection of composite material

Barr & Stroud, CNR, University of Strathclyde

278

Integrated sensor-based robot system

IPA-Fraunhofer Gesellschaft, Joyce-Loebl, Mari Group, Robert Bosch, Universidade Nova de Lisboa, National Technical University of Athinai, University of Newcastle

293

Knowledge and decision support for material-handling systems

Alcatel, Alsthom Recherche, CGP, Fraunhofer-IPK, IBM Deutschland, Instituto Superior Tëcnico

319

Data transfer between CIM systems and management information systems

Computer Systems Development, Mentec International, Trinity College Dublin

322 **CAD-I**

CAD interfaces

BMW, Cisigraph, Cranfield Institute of Technology, Danmarks Tekniske Højskole, GFS, Katholieke Universiteit Leuven, Kernforschungszentrum Karlsruhe, Leuven Measurement & Systems, NEH Technology, Rutherford Appleton Laboratory, Universität Karlsruhe

338

Product design for automated manufacture and assembly

CIMAF, COMAU, Cranfield Institute of Technology, Renault automation

384

Integrated information processing for design planning and control of assembly

AEG, Fraunhofer-IPK, GEC Research, Marconi Research, Induyco/Investronica, Télémécanique

409

Development of an integrated process and operations planning system with the use of interactive 3-D modelling techniques

EXAPT-Systems Technology, Matra Datavision, Volkswagen

418

Open CAM system allowing modular integration into factory management of a workshop structured in functional cells with various levels of automation

CIG, Ing. C. Olivetti, Logica, Matra, Procos, RTM, RWTH Aachen, université de Bordeaux

477 **COSIMA**

Control systems for integrated manufacturing

COMAU, Digital Equipment, Renault automation

496 **PAPILLON**

Design and specification of configurable graphics subsystems for CIM

Generics Software, GTS, Trinity College Dublin

504 **PAQO**

Plant availability and quality optimization

ADERSA, AMTRI, Battelle Institut, Danobat Coop, GRS, Ikerlan, Stewart Hughes, Technische Hochschule Darmstadt

534

Development of a flexible automated assembly cell and associated human factors study

Dantec Elektronik, Medical Research Council, Risø National Laboratory, Vrije Universiteit Brussel, Westland

595

The application of CIM to welded fabrication

Ålborg Shipyard, Danish Welding Institute, Italsiel, Odense Steel Shipyard, Università di Genova, Welding Institute of Cambridge

623

Operational control for robot system integration into CIM

CNR-LADSEB, FIAR, Fraunhofer-IPK, Kuka Schweißanlagen & Roboter, Politecnico di Milano, PSI, Renault automation, Seram, Universidad Politécnica de Madrid, Universidade Nova de Lisboa, Universität Karlsruhe, université de Valenciennes, Universiteit van Amsterdam, University College Galway

688 **AMICE**

A European computer-integrated manufacturing architecture

AEG, Aérospatiale, Alcatel, AT&T Nederland, British Aerospace, Bull, CAP Gemini Innovation, Cegelec Projects, Digital Equipment, Dornier System, Fiat Aviazione, Hewlett-Packard France, IBM Deutschland, Italsiel, Philips, Procos, RWTH Aachen, SEIAF, Siemens, STC-ICL, Volkswagen

809

Advanced control real-time CIM systems and concepts for flexible automation

Krupp, STC-ICL, TDS Dextralog, Technische Universiteit Delft, Universiteit van Twente

812

Experimental centre for system integration in CIM

Aeritalia, ELSAG, Philips, Politecnico di Milano, RWTH Aachen, SESA

850

Predesign of FMS for small-batch production of electronic cards

CSEA, ERIA, Eurosoft Systems

909

Development of tools for economic evaluation of CIM in smaller manufacturing companies

AMTRI, BIBA-Bremen, Institute for Industrial Technologies, CIMAF, Danmarks Tekniske Højskole, Mentec International, WTCM/CRIF

932

Knowledge-based real-time supervision in CIM

AEG, ARS, BICC Technologies, CEA, Fiar, Fraunhofer IPA, Philips, Pirelli, Politecnico di Milano, SGN Graphael, SIS AV, Universität Karlsruhe, université de Savoie

955 CNMA

Communication network for manufacturing applications

Aeritalia, BMW, British Aerospace, Bull, CGE, Elf Aquitaine, Fraunhofer Institut, GEC, Olivetti IS, Ricerca SCPA, PSA, Siemens-Nixdorf, STC-ICL

975 TRACIT

Transponders for real-time activity control of manufacturing links to CIM information technology systems

Polydata, Redar NAH-Ortungstechnik, TMTED

1062 ACCORD

Computer-aided engineering software for advanced workstations in the CIM environment

Athinai School of Economics, Bertin & Cie, GEC Research, Marconi Research, Philips, Société générale de techniques et d'études, Trinity College Dublin, Università di Genova, Vector Fields

1136 DASIQ

Distributed automated system for inspection and quality control

CEA-LETI, Microtecnica, SAGEM, Universität Hannover, Visitec

1199

Human-centred CIM system

BICC Technologies, Danmarks Tekniske Højskole, Dansk Teknologisk Institut, Greater London Enterprise, Krupp, NEH Technology, Rolls Royce, Universität Bremen, University of Liverpool, University of Manchester

1556 VITAMIN

Visualization standard tools in manufacturing industry

Fraunhofer Institut für Industrieinformation, Politecnico di Milano, Syseca, Team, université de Valenciennes

1561 SACODY

A high-performance flexible manufacturing system robot with dynamic compensation

AEG, Bertin & Cie, Katholieke Universiteit Leuven, Kuka Schweißanlagen & Roboter, Leuven Measurement & Systems, University College Dublin

1572

Basic technologies for high-performance solid-state image sensors

Thomson-CSF, Valvo Unternehmensbereich

1653

Intelligent process control by means of expert systems

Centre d'Estudis Avançes de Blanes, CNRS-LAAS, Dornier System, Eltec Elektronik, Miniwatt, Philips Composants, Universidad Politécnica de Cataluña

2010 NEUTRABAS

Neutral product definition database for large multifunctional systems

BIBA, Bremer Vulkan, Chantiers de l'Atlantique, GEC Alsthom, Construnaves, Cotec Computing Services, Decision International, Gesellschaft zur Entwicklung von DV-Methoden, Howaldtswerke — Deutsche Werft, Institut de recherche de construction navale, ITS, Schiffko, Sener-Sistemas Marinos, Technische Universität Berlin, Universidad Politécnica de Madrid, université Paul Sabatier de Toulouse, University of Strathclyde

2017

Automated process and assembly inspection by 3-D vision

INISEL, Philips Robotiker, Siemens, Silicon & Software Systems, Universität Erlangen-Nürnberg, Zenon

2032 CIM ALIVE

Implementation addressing levels of integration in various environments

AEG, Carlo Gavazzi Impanti, CEC Electrical Projects, Philips, SNIA BPD — Fiat Group

2043 MARIE

Mobile autonomous robot in an industrial environment

Framatome Group, Framentec, Hitec, IAI, Metek, Robert Bosch, Universiteit van Amsterdam, University of Strathclyde, Volmac Nederland

2090 EPIC

Early process design integrated with controls

Info Systems, City University (London), Intrasoft, Metek Motor Oil, Planet, Special Analysis & Simulation Technology, TNO

2091 VIMP

Vision-based online inspection of manufactured parts

Caption, CCD and CAD Image Comparison, Fraunhofer Institut für Information, Speroni, Universität Karlsruhe, université Louis Pasteur de Strasbourg

2127 HIDCIM

Holographic labelling techniques for automatic identification in CIM environments

ICI Imagedata, King's College London, Krupp, Mandelli, Standard Elektrik Lorenz, Universidade do Porto

2165 IMPPACT

Integrated modelling of products and processes using advanced computer technologies

Games Ingenieri France, Hellenic Aerospace Industry, Krupp, Lips, Unibed, Norsk Data, PAFEC, RWTH Aachen, Centre for Industriforskning, Sintef Group, Technische Universität Berlin, TNO, Universität Karlsruhe

2172 DIAS

Distributed intelligent actuator and sensors

EDF, Electricidade de Portugal, Empresa Fabril de Máquinas Eléctricas, ENEL, Esacontrol, Hartmann & Braun / Schoppe & Fäser, Instituto Superior Técnico, Mentec International, Montefibre, Sema Group Belgium

2178 RA-IQSE

Revision advisor — an integrated quality support environment

Asociación de La Industria Navarra, Computer Technologies, CRI, HCS Industrial Automation, Paisley College of Technology

2189 BIPMS

Building industry project management system

Baan Info Systems, Centre scientifique et technique de la construction, UTI Services

2192 **AIMBURN**

Advanced intelligent multisensor system for control of boilers and furnaces

Electricidade de Portugal, Fábrica de Vidros Barbosa & Almeida, IDS, IGC, Instituto Superior Técnico, Mague, Servotrol, Imperial College of Science, Technology & Medicine, Trion Präzisionselektronik & Co, Unisoft

2195 **CADEX**

CAD geometry data exchange

BMW, Det Norske Veritas, Disel, FEGS, Fiat Aviazione, GFS, Hewlett-Packard, Isykon Software, Italcad Tecnologie e Sistemi, Norsk Data, Procad, Senter for Industriforskning, Siemens-Nixdorf, University of Leeds

2198 **FCPN**

Factory customer premises network

Compañia Sevillana de Electricidad, EDF, INPT/ENSEEIHT, National Research Centre, Polydata, Pross, Robert Bosch, Thomson-CSF, Universidad Politécnica de Madrid, University of Patras, University of Thrace 'Demokritus'

2202 **CIM-PLATO**

CIM system planning toolbox

Bull, CNR-LADSEB, Fiar, Fraunhofer-IPK, Induyco/Investronica, Kuka Schweißanlagen & Roboter, Politecnico di Milano, Psi, Renault Automation, Universidad Politécnica de Madrid, Universidade Nova de Lisboa, Universität Karlsruhe, Universiteit van Amsterdam, University College Galway

2277 **CMSO**

CIM for multi-supplier operations

Actis Zentrale Verwaltung, Afia, Alcatel, BIBA, Institute for Industrial Technologies, Catia Software Service, CMSU, DAF, Helsinki University of Technology, Instituto Superior Técnico, Lucas Automotive, OY Saab-Valmet, Technische Universiteit Delft, University of Warwick, Vegla Vereinigte Glaswerke, Wilhelm Karmann

2280 **LAMA**

Large manipulators for CIM

AEG, Bertin & Cie, CASA, Dansk Teknologisk Institut, Fraunhofer-IPA, Fraunhofer-IPK, HF Jensen, Moog Controls, Putzmeister-Werke

2292 **TT-CNMA**

Testing technology for communications networks for manufacturing applications

Acerli, Alcatel, BMW, Fraunhofer Institut für Informationstechnik, Siemens, SPAG-CCT, Swedish Telecom, TNC

2312 **CIRCE**

Application and enhancement of an experimental development centre

Aeritalia, Alcatel, Elsag, Philips, RWTH Aachen

2331 **ADEPT**

Advanced distributed environment for production technology

CMSU, Sema Group UK, Syntax Factory Automation, Teknecomp

2338 **IMPACS**

Integrated manufacturing planning and control system

Alcatel, Alsthom Recherche, Comau, Digital Equipment, PA Consulting Group, université de Bordeaux, University College Galway, CENTUNION

2349

Fault tolerance in the control and management of production systems

Adersa, AMTRI, Ikerlan, Mandelli, Pegaso/Enasa, PSA, Seram, Stewart Hughes

2415

Distributed manufacturing planning and control

Harmonic Drive Antriebstechnik, Krupp, RDP Technology, Technische Universiteit Delft, Imperial College of Science, Technology & Medicine

2422 **AMICE II**

Amice II/P — CIM-OSA releases

AEG Aerospatiale, British Aerospace, Alcatel, ATT Nederland, Bull, CAP Gemini, Sogeti, Cegelec Projects Digital Equipment, Dornier System, Fiat Aviazione, Hewlett-Packard France, IBM Deutschland, Italsiel, Philips, Procos, RWTH Aachen, SEIAF, Siemens-Nixdorf, STC-ICL, Volkswagen

2428 **IPCES**

Intelligent process control by means of expert systems

Centre d'Estudis Avançcas de Blanes, CNRS-LAAS, Dornier System, Eltec Elektronik, Philips Composants, Miniwatt, Solam-CAM, Universidad Politécnica de Cataluña

2434

Knowledge-based real-time controllers for distributed factory supervision

Alcatel Austria — Elin, ARS, BICC Technologies, CEA, CGE, Fiar, Fraunhofer-IPA, Games Ingenieri, Noratom, Philips, Pirelli, Politecnico di Milano, RWTH Aachen, SIS AV, Steria, Tecnicas Reunidas, Universität Hannover, Universität Karlsruhe, université de Savoie

2439 **ROCOCO**

Real-time monitoring and control of construction site manufacturing

Biba, Bremer Vulkan, British Maritime Technology, Cortec, CAP Gemini Europe, Chantiers de l'Atlantique, GEC Alsthom, Eleusis Shipyards, Fincantieri Helsinki, University of Technology, Magnemag, Masa-Yards, Microlog Team, Universiteit van Amsterdam

2457 **FLEXPLAN**

Knowledge-based planning and control in manufacturing environments

ADVORGA FA Meyer, Artificial Intelligence Systems, CIM-Fabrik Hannover, IDS, Katholieke Universiteit Leuven, LVD Company, Metek, NTE, Universität Hannover

2483 **PANORAMA**

Advanced perception and navigation system for autonomous mobile applications

British Aerospace, Mobile Robots, CEA, CRIF/WTCM, Easams, EID, Helsinki University of Technology, LNETI, Rauma-Repola, Sagem, Sepa, Tampelle Technical Research Centre of Finland, Universidad Politécnica de Madrid, University of Southampton

2486 **DYNAMO**

Integrated CAE techniques for dynamic analysis of structures

Fiat Aviazione, Katholieke Universiteit Leuven, Leuven Measurement & Systems International, NCODE International, Politecnico di Torino, Porsche, Straco, Tritech, Universität Karlsruhe, université de technologie de Compiègne

2527 **CIDAM**

System with distributed database and configurable modules

Digital Kienzle, Fiat Aviazione, Fichtel & Sachs, Mannesmann Hartmann & Braun, Sesam, Syseca, Trinity College Dublin, Universität des Saarlandes

2588 **DSDIC**

Design support for distributed industrial control

AEG, GEC Electrical Projects, F. L. Smidth & Co., GEC Research, Marconi Research, Procos

2590 **IPDES**

Integrated product design system

CETIM-Établissement de Senlis, Charmilles technologies, Coretech International, Deltacam Systems, École centrale de Lyon, Exapt-Systems, Gildemeister Automation, IDS, Kade-Tech, Matra, Mecánica de La Pena, Technische Hochschule Darmstadt

2614 **NIRO**

Neutral interfaces for robotics

Byg Systems, CASA, Danmarks Tekniske Højskole, Dansk Ingeniør System, Disel, Kernforschungszentrum Karlsruhe, PSI, Reis & Co Maschinenfabrik, Seeber

2617 **CNMA**

Communications network for manufacturing applications

Aeritalia, Aérospatiale, Alcatel, British Aerospace, Bull, CEGELEC Projects, Comconsult Communication Technologies, École polytechnique fédérale de Lausanne, Fraunhofer Institut für Information, Magneti Marelli, Olivetti IS, Ricerca SCPA, Renault, DiO Robotiker, Siemens-Nixdorf, Universidade do Porto, Universität Stuttgart

2623 **MAGIC**

Methods for advanced group technology integrated with CAD/CAM

CAP Gemini, Sogeti, CETIM-Établissement de Senlis, LVD Company, Michel van de Wiele, WTCM/CRIF

2626 **AUTOCODE**

Intelligent system for automatic processing of design codes of practice

Analyse de systèmes et informatique, Babcock & Wilcox Española, Ingeciber, CAE ISQ, Unisys España, Universidad Politécnica de Madrid

2637 **ARMS**

Advanced robotics manipulation system

CEA, Citroën-PSA, CRIF/WTCM Industrial Automation, Industrie Zanussi, INRIA, Kuka Schweißanlagen & Roboter, Sipa, Tecnomatix Europe, Télémécanique, UKAEA, Zeltron

2640 **ICI**

Integration of intelligent process control and inspection in robot finishing

Andenosa-Empresa Nacional de Óptica, Fraunhofer-IPK, Joyce-Loebl, Metalworks of Attika, University of Newcastle, Zenona

2656 **IDRIS**

Intelligent drive for shop-floor systems

Mari Group, Nada Consulting Group, Robert Bosch, University of Newcastle

2658 **ARTIFACTS**

Advanced robotics in flexible automation: components, tools and strategies

Fraunhofer-IPA, Intracom, Joyce-Loebl, Loughborough University of Components, Technology Mari Group, Robert Bosch, Siemens, Sincon, Universidade Nova de Lisboa, Universität Erlangen-Nürnberg, Universität Stuttgart, Zenon

2671 **KB-MUSICA**

Knowledge-based multi-sensors systems in CIM applications

ARS, British Maritime Technology, Cortec, Cambridge Control, CGE Drägerwerk, Fabrica Escola Irmaos, Stephens EP, Fraunhofer-IPK, ICI, Krupp, Pegaso/Enasa, Senter for Industriforskning, Tecnopolis, CSATA Novus Ortus, Turing Institute, université de Savoie

2706 **MICIM**

Methodology for the introduction of CIM

Carlo Gavazzi Systems, GEC Marconi, Philips International, TNO

2711 **MULTICON**

Multi-level shop-floor control

AEG, AEG Ibérica de Electricidad, Biba, Carlo Gavazzi Impianti, Compagnia Generale Contatori, Officine Galileo di Sicilia, Technische Universität Braunschweig, Tecnopolis Csata Novus Ortus

5104 **CNMA**

Communications network for manufacturing applications

Alcatel, British Aerospace, Bull, École polytechnique fédérale de Lausanne, Efacec, Fraunhofer-IITB, Magneti Marelli, Siemens-Nixdorf, Olivetti Information Services, Renault, Robotiker, Siemens, Syntax Software Sistemi, Télémécanique, Universidade do Porto, Universität Stuttgart

5109 **NIRO**

Neutral interfaces for robotics

Byg Systems, Construcciones Aeronauticas, Danmarks Tekniske Højskole, Dansk Ingeniør System, Disel Fiat, Kernforschungszentrum Karlsruhe, Odense Steel Shipyard, PSI, Reis & Co Maschinenfabrik, SEEBER

5114 **DIREK**

Knowledge-based real-time diagnosis and repair for a complete robotized handling and storage system

BMT Fluid Mechanics, Pirelli, Siemens, SNIA BPD — Fiat Group

5136 **LITE**

Links and interfaces for tool data exchange

Adepa, CIM-Centre NW F Technologie Transfer, Ikerlan, Kendu S Coop, RWTH Aachen, TOOL, Universität Karlsruhe

5161 **KBL**

Design, development and implementation of a knowledge-based leitstand

AHP Havermann und Partner, AIC Management, IDS, Institute of Product Development

5168 **CACID**

Computer-aided concurrent integral design

Albert Nestler Electronics, Association française de normalisation, BER Dessindus, Danobat Coop, Falko Standard EDV Software, Tecnation per l'Innovazione Tecnologica, Universität Karlsruhe

5172 **IDAM**

An integrated design and analysis environment for advanced magnetic devices

Ansaldo, Bertin & Cie, Electrotecnica Arteche, Labein, Polymotor, Rutherford Appleton Laboratory, Università di Genova, Vector Fields

5178 **DISCO**

Distributed management and coordination of scheduling system in a multisite production environment

AEG, Bull, Fraunhofer-IAO, ISA, Magneti Marelli, PROMIP

5194 **CIVIS**

CIM vision system

Adec Robot, Fraunhofer-IPA, I2S, IMEC, Kronimus, Optec, PSI Co Laboratories RCA

5206 **FICIM**

Fieldbus integration into CIM

AEG Automatisierungstechnik, Alcatel, Bull, École polytechnique fédérale de Lausanne, EDF, Endress & Hauser, Esacontrol, Fraunhofer-IITB, Gespac, Hartmann & Braun / Schoppe & Fäser, Namur, Nuovo Pignone, Philips Robotiker, Senter for Industriforskning, Siemens, Softing, Universidade do Porto, Universität Karlsruhe, Universität Stuttgart

5220 **CAR**

Calibration applied to quality control and maintenance in robot production

Fraunhofer-IPK, Kuka Schweißanlagen & Roboter, Leica, Taighdeclar Genesis Teoranta, Universiteit van Amsterdam

5272 **CIM-SEARCH**

Open sensor integrated architecture for managing manufacturing uncertainty

Prozeßsteuerung und Schweißtechnik, Renault automation, University of Surrey

5288 **AMICE**

Amice II/M — CIM-OSA releases

Aérospatiale, Alcatel, ATT Nederland, British Aerospace, Bull, CAP Gemini Europe, Daimler, Digital Equipment International, Ensidesa, Fiat Gepro, Hewlett-Packard France, IBM Deutschland, Italsiel, Philips, Procos, RWTH Aachen, Siemens, STC-ICL, Universidad de Valladolid

5292 **MOSAIC**

Modular open system architecture for industrial motion control

BMW, CEA, Fagor, Fraunhofer-IPA, Marben, Mari Group, Mikron, Odense Steel Shipyard, Philips, ROL, Tecniro, Universität Stuttgart-IFF

5338 **CIMPLIFY**

Computer-integrated manufacturing of PCBs by laser-induced photolithography

Electrónica Básica, ENS-DE chimie de Mulhouse, Philips, Rijksuniversiteit Gent, UCB Electronics, Universidad del País Vasco

5352 **PROFIT**

Process plant reliable operations facilitated and enhanced by information technology

City University, DSM Research, Intrasoft, Modcomp, Sast, Sintef Group, Statoil, TNO

5369 **HEPHAESTOS**

Intelligent robotic welding systems for unique fabrications

Algosystems, Centre de robotique intégrée, I & T Kalogeridis, IAI, Technische Universiteit Eindhoven, Torre, University of Goteborg, University of Lund, Welding Institute of Cambridge

5379 **FRUIT**

Fresh fruit tracking system

Bristol Polytechnic, Fomesa, Robotec, Syntax Factory Automation, Trademco

5391 **HYPERFACE**

A hypermedial user interface management system for industrial applications

CESI, CNR-IMU, Ensidesa, ERIA, Etnoteam, INESC, Non-standard Logics, Università degli Studi di Milano

5392 **TT-CNMA II**

Testing technology for CNMA — Phase II

Acerli, Alcatel, BMW, Bull, Fraunhofer-IITB, SPAG

5416 **CIMDATA**

A database for selection of CIM tools

Cambashi, Fordesi, Fraunhofer-IPK, GEPRO, Longman Cartermill, Teknologisk Institut, TNO, WTCM/CRIF

5417 **BECAUSE**

Benchmark of concurrent architectures for use in scientific engineering

Bertin & Cie, INRIA, Parsys, Rutherford Appleton Laboratory, University of Athinai, Vector Fields

5424 **CIMPLE**

User-driven and configurable tool set for CIM implementation in SMEs

Asociación de Investigación, Tekniker, BIBA-Bremen, Institute for Industrial Technologies, Blobis, Fordesi, IBK System- und Softwarehaus, Isardata, Kewill Systems, Nokia Research Centre

5467 **CIMSIM**

Integrated simulation for economic and technical evaluation of CIM implementation and management for SMEs

ABC Systems & Software, AMTRI, BIBA, Institut for Industrial Technologies, CAP Gemini Europe, CERN, Fordesi, Isomag, Teknologisk Institut, WTCM/CRIF

5471 **FAME**

Five-axis manufacturing

Fidia, Spalips Unibed, NEH Technology, Norsk Data, Norsk Jetmotor, Sintef Group, Technische Universität Berlin, Universität Stuttgart, Waldrich Siegen

5474 **COALA**

Computer-aided manufacturing layout design

CAP Gemini Europe, Ilog, INRIA, Orbis, Serete Productique, université libre de Bruxelles

5478 **SUB-CONTROL**

Modular framework for evolutionary implementation of shop-floor control

Asociación de la Industria Navarra, Fraunhofer-IPA, Hyperion Energy System, INESC, Picotron

5497 **PROCIC**

Process computer for computationally intensive control

Delta T, Instituto Superior Tëcnico, Microprocessor Engineering, THOT Informatique

5499 **CODE**

Computer-supported enterprise-wide data-engineering

Extech, Manager Software Products, Pilkington, RWE-DEA für Mineralöl und Chemie, Universität des Saarlandes

5510 **VOICE**

Validating OSA in industrial CIM environments

Fraunhofer-IPK, ISMCM, Kernforschungszentrum Karlsruhe, Prism Computer & Communication Systems, Renault automation, TNO, Traub, Zenon

5524 **MDS**

High-performance computing for multidisciplinary dynamic simulation of mechanism

ABB Robotics, Dansk Teknologisk Institut, Det Norske Veritas, Dornier System, FEMVIEW, Kernforschungszentrum Karlsruhe, Norsk Forsvarsteknologi, Sintef Group, Syntax Factory Automation

5532 **CIMPRES**

CIM model and implementation concept in precision and special tooling industry

CIM-Fabrik Hannover, EICAS Automazione, IBM Deutschland, OSI, RWT, Wilhem Fette

5564 **IDEAL-CIM**

Integrated design and evaluation of assembly lines within CIM

AEG, Delta Industrie Informatik, Fraunhofer-IAO, Intracom Intrasoft, Sema Metra Group

5601

Design and implementation of CNMA-based networks for CIM applications in SMEs

Intracom, Fraunhofer-IPK

5602 **KNOBA**

Knowledge-based real-time systems for fault diagnosis of flexible manufacturing systems

Asociación de Investigación, Teknikerdoimak, Fatronik System, GEPRO, LABEIN, Technische Universiteit Delft

5603 **CIM-SME**

Joint technical and organizational design of CIM systems for SMEs

BIBA, Cheshire Henbury Research & Consultancy, Danmarks Tekniske Højskole, EXTECH, GEPRO, Intervisie Strategie & Organisatie Advies

5604 **CIB**

Computer-integrated building

CSTB, D'Appolonia, Dialogic, Euroexpert & Partners, PCK & Associates, Scott Wilson Kirkpatrick & Partners, SOGEA, Taywood Engineering, Technische Universiteit Delft, université de Liège, Volmac Nederland

5605 **CIA**

Application of concepts, architectures and technology to computer-integrated agriculture

Big Dutchman, Danish Meat Research Institute, Fraunhofer-IAO, Hotrasoft, I & ME Gesellschaft für Informatik & Mikroelektronik, Land-Data

5606 **PRO-DATIS**

Analysis of car crash behaviour through simulation

Cranfield Institute of Technology, ESI-Engineering Systems, FEGS, Systex

5607 **FLEXICOM**

Multimedia communication system for the SME manufacturing environment

BICC Technologies, Globalsis Engenharia Sistemas, Greater London Enterprise, Solari Udine, TSI, University College Galway, University of Strathclyde

5608 **TRAMON**

Material flow transportation monitoring system

CLB Electronics, ORE, Polydata, Redar Nah-Ortungstechnik

5609 **SMART**

Yield improvement in SMD assembly

Fine Pitch, CSEA, University College Cork, Valtronic France, Weld-Equip

5610 **ASSAN**

Advanced sensor systems for autonomous navigation

Calabrese Engineering, CRIF/WTCM, Isra Systemtechnik, Robosoft, Sincon, Technische Hochschule Darmstadt, Tecnopolis Csata Novus Ortus, Università di Genova, Zenon

5611 **OFSES**

Fibre-optic sensor systems

Catsaros Automation, Leas Industrie, National Research Centre 'Demokritos', Imperial College of Science, Technology & Medicine

5620 **ADONIS**

Adaption of numerical hydrodynamic tools for integration into ship design systems

Astilleros Españoles, Cetena, Concentration Heat & Momentum, Danish Maritime Institute, DMT-Marinetechnik, EMIT

5630

AI for fashion design and manufacturing

ABC Tecniche Avanzate di Gestione, ECC Couture, Face, Investil, Pili Carrera, Universidad de Málaga, Zenon

Basic research

3001 **INSIGHT**

Vision systems for a natural human environment

Centre de mathématiques de l'École polytechnique, INRIA, Katholieke Universiteit Leuven, Royal Institute of Technology, Ruhr-Universität Bochum, Università di Genova, Universität Karlsruhe, Universiteit van Utrecht, University College London, University of Keele, University of Oxford, University of Sheffield, University of Stirling

3003 **CLICS**

Categorical logic in computer science

Århus Universitet, CNRS-ENS, GMD, INRIA, Imperial College of Science, Technology & Medicine, Università di Parma, University of Cambridge

3006 **CONCUR**

Theories of concurrency: unification and extension

CWI, INRIA, Swedish Institute of Computer Science, Universiteit van Amsterdam, University of Edinburgh, University of Oxford, University of Sussex

3011 **CEDISYS**

Models, languages and logics for concurrent distributed systems

Århus Universitet, INRIA, Università di Pisa, University of Sussex

3012 **COMPULOG**

Computational logic

ADER, European Computer Industry Research Centre, Katholieke Universiteit Leuven, RWTH Aachen, Imperial College of Science, Technology & Medicine, Uninova, Università di Pisa, Università di Roma, Universität Kaiserslautern, Universität Passau, Universität Tübingen, université d'Aix-Marseille, University of Bristol, University of Edinburgh, University of Uppsala

3014

High-temperature superconductivity: concepts, models and methods

ISI, Max-Planck-Gesellschaft für Festkörperforschung, Rutherford Appleton Laboratory

3017 **NOISE**

Electrical fluctuations and noise in advanced microelectronics: submicron, 2-D gas and low-temperature devices

CNET, IMEC, Plessey, Research Caswell, Technische Universiteit Eindhoven, Università di Modena, université de Lille, université de Montpellier, Universiteit van Utrecht

3020 **INTEGRATE**

Integrating the foundations of functional, logic and object-oriented programming

CNRS, CWI, Philips Research Laboratories, Imperial College of Science, Technology & Medicine, Universidade Nova de Lisboa, Università di Pisa

3023 **IS-CORE**

Information systems: correctness and reusability

INESC, Katholieke Universiteit Brabant, Technische Universität Braunschweig, Imperial College of Science, Technology & Medicine, Universität Dortmund

3026 **HESSILSIL**

Heterostructures of semiconducting silicides on silicon: applications to Si-compatible optoelectronic devices

CRMC2-CNRS, Universidad Autónoma de Madrid, Università di Roma II, universités de Paris-VI et de Paris-VII, IESS-CNR

3030 **ACQUILEX**

Acquisition of lexical knowledge for natural language processing systems

CNR, Universidad Politécnica de Cataluña, Università di Pisa, Universiteit van Amsterdam, University College Dublin, University of Cambridge

3038 **VAP**

Vision as process

Ålborg Universitet, INPG, Linköping University, Royal Institute of Technology, University of Surrey, LIFIA, LTIRF

3041 **MESH**

Possible mechanisms for high-T_c superconductivity and phenomenological approaches

CNRS-PMTM, Forth Research Centre, Universität Dortmund, Universität Karlsruhe, université de Paris-Sud, University of Oxford

3042 **NANOFET**

Performances and physical limits of heterostructure field-effect (HFET) transistors

ARMINES, CNRS, IMEC, University of Cambridge

3043 **LATMIC**

Lateral microstructures: fabrication, low dimensionality effects and applications to III-V devices

CNET, CNRS, National Microelectronics Research Centre, DRA, Universität Stuttgart, University of Cambridge, University of Exeter

3049 **NERVES**

Innovative architectures for neurocomputing machines and VLSI neural networks

CSEM, École polytechnique fédérale de Lausanne, INPG, Politecnico di Torino, St Patrick's College, Universität Dortmund, Universität Stuttgart, université catholique de Louvain, université Joseph Fourier de Grenoble-I, University of Edinburgh, University of Oxford

3059 **ECOLES**

Development of representation in machine learning

Turing Institute, Universidade do Porto, université de Paris-Sud, University of Bradford

3066 **AMODEUS**

Assimilating models of designers, users and systems

Københavns Universitet, Logica Cambridge Ltd, Medical Research Council, Rank Xerox, Standard Elektrik Lorenz, université Joseph Fourier de Grenoble-I, University of York

3070 **FIDE**

Formally integrated data environment

IEI-CNR, Gip Altair, Università di Pisa, Universität Hamburg, université de Paris-Sud, University of Glasgow, University of St Andrews

3074 **SEMAGRAPH**

The semantics and pragmatics of generalized graph rewriting

CNRS, CWI, Katholieke Universiteit Nijmegen, STC-ICL, Imperial College of Science, Technology & Medicine, University of East Anglia

3075 **ALCOM**

Algorithms and complexity

Århus Universitet, Computer Technology Institute, École des hautes études et sciences sociales, Freie Universität Berlin, INRIA, Trinity College Dublin, Universidad Politécnica de Cataluña, Università di Roma-La Sapienza, Universität des Saarlandes, Universiteit van Utrecht, University of Warwick, Rijksuniversiteit Utrecht

3085 **DRUMS**

Defeasible reasoning and uncertainty management systems

Centre d'Estudis Avançes de Blanes, CNRS-LRI, Imperial Cancer Research Fund, IRISA, Queen Mary College, Universidad de Granada, université d'Aix-Marseille, université libre de Bruxelles, université Paul Sabatier de Toulouse

3086 **LDS**

Low dimensionality structures for future quantum semiconductor devices

CNRS, École centrale de Lyon, LEAME/ISEN Lille, Forth Research Centre, INSA Lyon, Universidad de Barcelona, Universidad Politécnica de Madrid, université Blaise Pascal de Clermont-II, University College Cardiff

3092 **PDCS**

Predictably dependable computing systems

Centre for Software Reliability, CNR-LEI, CNRS, Technische Universität Wien, Universität Karlsruhe, University of Newcastle, University of York

3096 **SPEC**

Formal methods and tools for the development of distributed and real-time systems

Forth Research Centre, Katholieke Universiteit Nijmegen, Swedish Institute of Computer Science, Technische Universiteit Eindhoven, Imperial College of Science, Technology & Medicine, université de Grenoble, université de Liège, University of Manchester, University of Oxford

3104 **PROCOS**

Provably correct systems

Århus Universitet, Danmarks Tekniske Højskole, Royal Holloway & Bedford New College, Universität Kiel, University of Manchester, University of Oxford

3105 **MOHAWC**

Models of human-actions in work context

ISPRA, Risø National Laboratory, Roskilde Universitetse Center, Universität Bamberg Psychologie II, université de Liège, université de Paris-Nord, University of Manchester, University of Uppsala

3109 **PROMPT**

Programme for MOS processing technology

Harwell Laboratory, IMEC, University of Cambridge

3121 **MOLCOM**

Conducting organic materials as molecular components for microelectronics

CNRS, H. C. Ørsted Institute, ADIST-Instituto Superior Tècnico, LNETI

3124 **SEMANTIQUE**

Semantics-based program manipulation techniques

École Polytechnique, Københavns Universitet, Imperial College of Science, Technology & Medicine, University of Glasgow

3125 **MEDLAR**

Mechanizing deduction in the logics of practical reasoning

INPG, ONERA-CERT, Research Institute for Symbolic Computation, Imperial College of Science, Technology & Medicine, Universität Kaiserslautern, université Paul Sabatier de Toulouse, Universität München, University of Oslo

3133 **NANSDEV**

Nanostructures for semiconductor devices

CNM, IMEC, Ludwig Maximilian Universität, Philips Research Laboratories, Technische Universiteit Delft, Thomson-CSF, University of Glasgow

3143 **FOF**

Factory of the future production theory

Bremen Institute for Industrial Technologies, Danmarks Tekniske Højskole, Helsinki University of Technology, SINTEF Group, Technische Universiteit Eindhoven, université de Bordeaux, University College Galway

3146 **DIRTYSUPRA**

Study of the influence of impurities on the properties of high T_c superconductors

Max-Planck-Institut für Festkörperforschung, université de Paris-Sud, université libre de Bruxelles

3147 **PHOENIX**

Hierarchical integration of logic and functional paradigms: specifications, refinement and implementation

GMD, Katholieke Universiteit Nijmegen, Imperial College of Science, Technology & Medicine

3148 **DEMON**

Design methods based on nets

GMD, Rijksuniversiteit Leiden, Technische Universität München, Universidad de Zaragoza, Università degli Studi di Milano, Universität Passau, université de Paris-Sud, université libre de Bruxelles, University of Newcastle

3149 **MUCOM**

Multisensory control of movement

CNR, CNRS, Katholieke Universiteit Nijmegen, Ruhr-Universität Bochum, université catholique de Louvain, université de Genève, University of Zürich

3152

Foundations of legal reasoning

Imperial College of Science, Technology & Medicine, università di Pisa, Universität Kiel, Universität Tübingen, université d'Aix-Marseille, University College Cork, University of Edinburgh, University of London, University of Oxford, Bristol Polytechnic, Machine Intelligence Ltd

3160 **DIALOGUE**

Models for explanation and learning

City University, CNR — Istituto di Linguistica Computazionale, Queen Mary College, Università di Pisa, University of the Aegean

3166 **ASMICS**

Algebraic and syntactic methods in computer science

École normale supérieure de Lyon, INIC, LITP, Politecnico di Milano, Rijksuniversiteit Leiden, RWTH Aachen, Technische Universität Berlin, Technische Universität München, université de l'État à Mons, université de Lille, Università degli Studi di Milano, Università di Napoli, Università di Palermo, Universität des Saarlandes, université de Bordeaux, University College Dublin

3168 **DX CENTRES**

Limiting factors in III-V semiconductor devices due to donor-related deep states

CNRS, Universidad Politécnica de Madrid, Università di Pisa, Universität Paderborn, université de Paris-VII, University of Lund, University of Sheffield

3174 **Si/Ge SLS**

Ultrathin silicon/germanium superlattices

AEG, University of Lund, Universität München, University of Newcastle

3175 **DYANA**

Dynamic interpretation of natural language

Technische Universität München, Universität Stuttgart, Universität Tübingen, Universiteit van Amsterdam

3177 **EPIOPTICS**

European project: investigation of optical probe techniques for interface characterization

DRA, Technische Universität Berlin, Trinity College Dublin, Università di Messina, Università di Roma II, University College Cardiff, University of Liverpool

3178 **REFLECT**

Reflective expertise in knowledge-based systems

BSR Consulting, ECN-NETH Energy Research Foundation, GMD, Interface Concilium, Universiteit van Amsterdam

3180 **FOCUS**

Foundations of optoelectronic computers

IMEC, LEP Philips, Roke Manor Research, Trinity College Dublin, Universidad de Madrid — ETSI, Universidad Politécnica de Madrid, université de Paris-VII, University College London, University of Sheffield

3186 **NOROS**

Quantum noise reduction schemes in optical systems

CNRS, CNET, INFM, Universität Konstanz, Max-Planck-Institut für Quantenoptik, DRA

3191 **BASIC GOODS**

Basic research actions for a geographic object-oriented database system

Algotech, CNR-ISRDS, CNR-IASI, Fernuniversität Hagen, Universität Freiburg, INRIA, Università di Roma-La Sapienza

3199 **EOC**

ESPRIT optical computing

CERT, CNET-CNRS, CNRS-LAAS, Heriot-Watt University, IMEC, IOTA, Istituto Nazionale di Ottica, Johann Wolfgang von Goethe-Universität, King's College London, Odense Universitet, Politecnico di Milano, Technische Universität Braunschweig, université Louis Pasteur, université de Toulon, Universidad de Madrid, Universität Erlangen-Nürnberg, Universität Kaiserslautern, Universität Münster, Vrije Universiteit Brussel

3200 **OLDS**

Structure and transport properties of organic low-dimensional systems for application to information technology

Helmut Hund, Max-Planck-Institut für Festkörperforschung, Trinity College Dublin, Università di Genova, Universität Tübingen, University of Edinburgh, University of London (Queen Mary College)

3207 **ACTS**

High-resolution speech recognition: auditory connectionist technologies for speech

INESC, INPG, Medical Research Council, Università di Milano, University of Cambridge, University of Edinburgh

3215 **CHEOPS**

Higher order logic-supported design for complex data-processing systems

IMEC, Philips Research Laboratories, University of Cambridge

3216 **CHARME**

Correct hardware design methodology: towards formal design and verification for provably correct VLSI hardware

Politecnico di Torino, Technische Hochschule Darmstadt, IMEC, université de Provence, University of Strathclyde

3219 **KAUDYTE**

Knowledge acquisition and use in dynamic task environments

Institut für Informatik der Universität Bonn, Universität Bayreuth, Universität der Bundeswehr, université libre de Bruxelles, University of Oxford

3228 **SPRINT**

Speech processing and recognition using integrated neurocomputing techniques

CAP Gemini Innovation, École nationale supérieure des télécommunications, IRIAC, DRA, Standard Elektrik Lorenz, Universidad Politécnica de Madrid

3230

Common foundations of functional and logic programming

CNRS, Eidgenössische Technische Hochschule, Swedish Institute of Computer Science, Università di Roma, Universität Kaiserslautern, University College Swansea, University of Athinai

3234 **SELF**

Organization and analogical modelling using subsymbolic computing

CEAB-Blanes, Rolf Nevanlinna Institute, Universität Hamburg, université de Genève, université libre de Bruxelles, University of Lappeenranta, Vrije Universiteit Brussel

3237 **PATMOS**

Power and timing modelling, optimization and specification

Telecom Paris, Universidad Politécnica de Canarias, Universität Kaiserslautern

3245 **LF**

Logical frameworks: design, implementation and experiment

Chalmers University of Technology, INRIA, Università di Torino, université de Paris-VII, University of Cambridge, University of Edinburgh, University of Manchester, University of Oxford

3247 **DESON**

Disorder and electrical properties in silicon oxynitrides

CNRS-LEPES, IMEC, Universidad Autónoma de Madrid, université de Montpellier, Universiteit van Utrecht

3249 **WGQR**

European working group on qualitative reasoning

École polytechnique fédérale de Lausanne, Fraunhofer IITB, Heriot-Watt University, Siemens, Università degli Studi di Milano, University College London

3260 **TOPP**

Transverse optical patterns

INFM, Physikalisch-technische Bundesanstalt

3264 **COMPASS**

A comprehensive algebraic approach to system specification and development

Katholieke Universiteit Nijmegen, Technische Universität Berlin, CRI, Technische Universität Braunschweig, Universidad Politécnica de Cataluña, Università di Genova, Universität Bremen, Universität Dortmund, Universität Passau, université de Paris-Sud, University of Edinburgh

3267

Use of children's and teachers' explanations in the specification of systems of explanation for intelligent learning environments

Kingston Polytechnic, London Institute of Education, London Mental Models Group (King's College), Royal Danish School of Educational Studies, université de Paris-Sud

3274 **FIRST**

Fundamentals of intelligent reliable robot systems

INPG, Katholieke Universiteit Leuven, Università di Genova, Universität Karlsruhe, University of Oxford

3279 **ACCOR**

Articulatory-acoustic correlations in coarticulatory processes: a cross-language investigation

CNR-Consiglio Nazionale delle Ricerche, CNRS, Ludwig-Maximilians-Universität, Siemens, Trinity College Dublin, Universidad de Barcelona, Universidad Politécnica de Valencia, University of Reading, University of Stockholm

3280 **NANA**

Novel algorithms for new real-time VLSI architectures

IMEC, INPG, INRIA, Katholieke Universiteit Leuven, Technische Universiteit Delft

3281 **ASCIS**

Behavioural synthesis, partitioning and architectural optimization for complex systems on silicon

IMEC, INPG, Danmarks Tekniske Højskole, Technische Hochschule Darmstadt, Technische Universiteit Eindhoven, University of Patras

3299 **COMPUGRAPH**

Computing by graph transformations

Freie Universität Berlin, Rijksuniversiteit Leiden, Technische Universität Berlin, Università di Pisa, Universität Bremen, université de Bordeaux

3314 **MOLSWITCH**

Evaluation of molecular switch type devices: theory and experiment

Københavns Universitet, Max-Planck-Institut für Festkörperforschung, université de Strasbourg, University of Uppsala

3327 **SUPRADYNAMICS**

Lattice dynamics of high T_c single crystal superconductors

CNRS-CRPHT, Kernforschungszentrum Karlsruhe

3350 **COSTY**

Computers and optics study group

CNET, IMEC, Philips-LEP, Roke Manor Research, Trinity College Dublin, Universidad de Madrid — ETSI, Universidad Politécnica de Madrid, université de Besançon, université de Paris-VII, université libre de Bruxelles, University College London, University of Athinai, University of Sheffield

3351 **DANDI**

Dialogue and discourse

BIM, Copenhagen School of Economics & Business, École Polytechnique, IDSIA-Fondazione dalle Molle, Institiuid Teangeolaiochta Eireann, Institut für Deutsche Sprache, Katholieke Universiteit Brabant, Katholieke Universiteit Nijmegen, Max-Planck-Institut für Psycholinguistik, UMIST, Università di Milano, Università di Udine, Universität des Saarlandes, Universität Stuttgart, Universität Tübingen, Universitaire Instelling Antwerpen, université de Liège, Universiteit van Amsterdam, University of Cambridge, University of Essex, University of Oslo

3352

Working group on vision

Ålborg Universitet, City University London, CNRS-LAAS, Fraunhofer-IITB, INPG, Linköping University, Morpho-Systèmes, NIHE, Norwegian Institute of Technology, Philips, Royal Institute of Technology, Tampere University of Technology, Technische Universität Hamburg, Technische Universität München, Trinity College Dublin, Universidad Politécnica de Cataluña, Universidade de Aveiro, Universidade de Coimbra, Universidade do Minho, Universidade Nova de Lisboa, Università di Genova, Università di Torino, Università di Trento, Università di Udine, Universität Karlsruhe, université de Paris-VI, University College of North Wales (Bangor), University of Brunel, University of Kent, University of Surrey, University of Sussex

3700 **VLSI DESIGN**

VLSI design training action

Ålborg Universitet, Centre commun de micro-électronique, City University London, CMSU, CNRS, Danmarks Tekniske Højskole, Dorset Institute, École polytechnique fédérale de Lausanne, ENSEA, Fachhochschule Augsburg, Fachhochschule Ulm, Georg-Simon-Ohm Fachhochschule, GMD, Helsinki University of Technology, Heriot-Watt University, IMEC, INPG, INSA, Institute of Higher Professional Education, Instituto Superior Técnico, Johann Wolfgang von Goethe-Universität, Katholieke Industriële Hogeschool West-Vlaanderen, King's College London, LABEIN, Lancashire Polytechnic, Middlesex Polytechnic, Napier Polytechnic of Edinburgh, National Microelectronics Research Centre, Newcastle upon Tyne Polytechnic, NIHE, Plymouth Polytechnic, Pôle de formation en micro-électronique, Politecnico di Milano, Politecnico di Torino, Polytechnic of Central London, Portsmouth Polytechnic, Rijksuniversiteit Gent, Rutherford Appleton Laboratory, RWTH Aachen, Sheffield City Polytechnic, Staffordshire Polytechnic, Tampere University of Technology, Techdarm Technische Hochschule Darmstadt, Technische Universität Braunschweig, Technische Universität Graz, Technische Universität Hamburg, Technische Universität Wien, Technische Universiteit Delft, Teesside Polytechnic, Thames Polytechnic, Trent Polytechnic, Trinity College Dublin, université de Lille, Universidad de Barcelona, Universidad de Cantabria, Universidad de Las Islas Baleares, Universidad de Las Palmas, Universidad de Sevilla, Universidad Politécnica de Cataluña, Universidad Politécnica de Madrid, Universidad Politécnica de Valencia, Universidade de Aveiro, Universidade de Coimbra, Universidade do Porto, Università di Bologna, Università di Genova, Università di Parma, Università di Pisa, Università di Roma, Universität Bremen, Universität des Saarlandes, Universität Duisburg, Universität Hagen, Universität Hamburg, Universität Kaiserslautern, Universität Karlsruhe, Universität Oldenburg, Universität Passau, Universität Tübingen, université catholique de Louvain, université de Montpellier, université de Paris-VII, université Pierre et Marie Curie, Universiteit van Amsterdam, Universiteit van Twente, University College of North Wales, University of Aberdeen, University of Bath, University of Bradford, University of Bristol, University of Brunel, University of Cambridge, University of Kreta, University of Essex, University of Exeter, University of Hull, University of Kent, University of Liverpool, University of Manchester, University of Newcastle, University of Nottingham, University of Oulu, University of Patras, University of Reading, University of Sheffield, University of Strathclyde, University of Sussex, University of Thrace 'Demokritus', University of Ulster

3701

Network of excellence in speech and natural language

Roskilde Universitet, LIMSI/CNRS, Universität Stuttgart, University College Dublin, Instituto di Linguistica Computazionale/CNR, Universiteit Amsterdam, INESC, Ålborg Universitet, CNRS (Aix-en-Provence), National Technical University of Athinai, University of Cambridge, Københavns Universitet, Universität Hamburg, UMIST, Università di Pisa, Rijksuniversiteit Utrecht, Universiteit van Tilburg, Universität des Saarlandes

3702

Network of excellence in distributed computing systems architecture

Università di Bologna, Università di Pisa, University of Cambridge, INESC, INRIA/IRISA, Universität Kaiserslautern, LAAS/CNRS, Universitet van Twente, Technische Universität Wien, Architecture Project Management, Bull-IMAG, Chorus Systèmes, Computer Technology Institute, ETSIT, IEI del CNR, Itatel, GMD-Fokus, université de Liège, Trinity College Dublin, Rijksuniversiteit Utrecht, Vrije Universiteit Amsterdam

3703

Network of excellence in computational logic

Université d'Aix-Marseille-II, CWI, University of Bristol, University of Edinburgh, SLS CAP Gemini, Universität Kaiserslautern, Katholieke Universiteit Leuven, Universidade Nova de Lisboa, Universidad Politécnica de Madrid, ECRC, Universität Passau, Università di Pisa, Università di Roma I, Università di Roma II, IRST, University of Uppsala

Information exchange system

33 **ROSE**
Research open systems for Europe
Bull, GEC, Ing. C. Olivetti, Siemens, STC-ICL

130
The Unix-united aspects of the IES
Mari Group, SG2

700 **ELAN**
ESPRIT/European local area network
Bull, ICL Belgium, Olivetti, Siemens Data

706 **EUROKOM**
Computer conferencing and electronic mail
University College Dublin

710
Information exchange system (IES) support services
IEGI, Expertel, Noveau Medias, GRS, Longman-Cartermill, IOS

717 **HERMES**
Message-handling survey and trends for the IES user community
Fischer Madsen & Lorenz Petersen

718 **CARLOS**
Communications architecture for layered open systems
Fischer Madsen & Lorenz Petersen, RC International, Universidad Politécnica de Madrid, CASE Communications, INESC, PMC, Universidad Politécnica de Cataluña

719 **THORN**
The obviously required name-server
Bull, CERN, DFN, GEC, Ing. C. Olivetti, INRIA, Siemens, STC-ICL, Systems Wizards, University College London

5700 **Y-NET**
Y-Net
Teleo, Bull, Olivetti Systems and Networks, Siemens-Nixdorf Informationssysteme

Industry participants and sites

2I Industrial Informatics
Freiburg

3-Net
Basingstoke

7-Teknologi
København

A. T. Kearney
London

ABB Robotics
Vasteras

ABC
Milano

ABC Systems & Software
Athinai

Abstract Hardware
Uxbridge

ABSY
Bruxelles

ACE
Amsterdam

ACEC
Charleroi

Acerli
Fontenay-aux-Roses

Acorn Computers
Cambridge

Acropol Association
Nancy

ACT
Paris

Actir-Santé
Louveciennes

Actis Zentrale Verwaltung
Stuttgart

Active Book Company
Cambridge

Active Memory Technology
Reading

Addax
Athinai

Adec Robot
Schlieren

Adepa
Montrouge

Aderfrance
Marseille

Administração do Porto de Lisboa
Lisboa

ADR-CRISS
Grenoble

ADV/ORGA A. Meyer
Wilhelmshaven

Advanced Mechanics & Engineering
Guildford

Advanced Semiconductor Materials International
Bilthoven

Advanced Software Technology
Milano

Advanced System Architectures
Camberley

AEG
Berlin; Frankfurt; Ulm; Böfingen

AEG Automatisierungstechnik
Selinenstadt

AEG Electrocom
Konstanz

AEG Iberica de Electricidade
Rubi

AEG Olympia
Konstanz; Wilhelmshaven

Aeritalia
Napoli; Roma; Torino

Aérospatiale
Châtillon; Les Mureaux; Paris

Afia
Porto

Agence de l'informatique
Paris-la Défense

Agfa Gevaert
Edegem; München

Agusta
Milano

AHP Havermann und Partner
Planegg

AIC Management
Torino

AIIT
Gerrards Cross

AIS
Milano

AITEC
Milano

Aixtron
Aachen

Albert Nestler Electronics
Lahr

Ålborg Shipyard
Ålborg

Alcatel
Amsterdam; Chilly-Mazarin; Colombes; Évry; Harlow; La-Ville-du-Bois; Lannion; Les Ulis; Malakoff; Massy; Morangis; Paris; Puteaux; Toulouse

Alcatel Alsthom Recherche
Marcoussis

Alcatel Austria — Elin
Wien

Alcatel Bell Telephone
Antwerpen

Alcatel Face Standard
Milano; Pomezia

Alcatel Portugal
Cascais

Alcatel Standard Eléctrica
Madrid

Algosystems
Athinai

Algotech
Roma

Algotech Sistemi
Frosinone

Alpha
Athinai

Alsys
Henley-on-Thames

Amber
Lykovrisi

Amper
Madrid

Anacad Computer Systems
Bonn

Analog Devices
Limerick

Analyse de systèmes et informatique
Fontenay-sous-Bois

Andersen Consulting
Madrid

Ansaldo Impianti
Genova

Applied Logic Research
London

Applied Magnetics Belgium
Turnhout

Apsis
Meylan

Aptor
Meylan

Architecture Projects Management
Cambridge

ARG
Vimodrone; Milano

Argumens
Duisburg

Aritex
Badalona

ARS
Milano

Artificial Intelligence
Watford

Artificial Intelligence Systems
Bruxelles

Ascom Holding
Bern

Asea Brown Boveri
Heidelberg; Ladenburg

ASM-Lithography
Veldhoven

Asociación de la Industria Navarra
Cordovilla-Pamplona

Association francaise de normalisation
Paris-la Défense

AST Elektronik
Kirchheim

Astilleros Españoles
Madrid

Athinai Technology Centre
Athinai

ATT Nederland
Hilversum

ATT Télécommunication
Bruxelles

August Systems
Crawley

Autograph International
Lyngby

Port Autònom de Barcelona
Barcelona

Autophon
Levallois-Perret

Avions Marcel Dassault-Breguet-Aviation
Saint-Cloud; Vaucresson

Axion
Birkerød

AXON
Porto

Ayuntamiento de Sevilla
Sevilla

Azienda Servizi Municipali Comune di Brescia

Baan Info Systems
Barneveld

Babcock
Glasgow

Babcock & Wilcox Española
Bilbao

Baltea
Leini (Torino)

Balzers
Balzers

Banco de Sabadell
Barcelona

Banco Herrero
Asturias

Bang & Olufsen
Struer

Banque La Henin
Paris

Banque nationale de Paris
Paris

Barco Industries
Kortrijk

Barr & Stroud
Glasgow

BASF
Ludwigshafen

Bassani Ticino
Varese

Battelle Institut
Frankfurt am Main

BBC
London

BDH
Poole

Bell Telephone
Antwerpen

Bennetts Associates
Burridge

Bense
Coesfeld

BER Dessindus
Colmar

Bertin & Cie
Les Milles; Plaisir

Bias
Bremen

BICC Technologies
Hemel Hempstead

Big Dutchman
Vechta; BIKIT; Gent

BIM
Everberg

BLOBIS
Almassera

BMP Plasmatechnologie
Garching

BMW
München

Bogen Electronic
Berlin

Bonnscript
Bonn

BPA-Technology and Management
Dorking

Braghenti
Malnate

Brainware
Berlin

Brameur
Aldershot

Bremer Vulkan
Bremen

British Aerospace
Bracknell; Chester; Bristol; London; Preston; Stevenage

British Library
London

British Maritime Technology
Cortec Wallsend

British Telecommunications
Ipswich; London

Brown Boveri & Cie
København

BSO
Utrecht

BSR Consulting
München

Bull
Angers; Bruxelles; Échirolles; Hemel-Hempstead; Köln; Les-Clayes-sous-Bois; Louveciennes; Massy; Nanterre; Paris; Saint-Martin-d'Hères

Bull España
Madrid

Bull Italia
Milano

Bureau Marcel van Dijk
Bruxelles

Busch-Jäger-Elektro
Lüdenscheid

BYG Systems
Nottingham

Cabinet Bensoussan
Paris

Caja de Ahorros del Mediterráneo
Alicante

Caja Insular de Ahorros de Canarias
Las Palmas

Calabrese Engineering
Modugno

Cambashi
Cambridge

Cambridge Consultants
Cambridge

Cambridge Control
Cambridge

Cameca
Courbevoie

CAP
New Malden

CAP Gemini Europe
Bruxelles; Rijswijk

CAP Gemini Innovation
Meylan; Paris

CAP Gemini Logic
Stockholm

CAP Gemini Sogeti
Grenoble; Paris; Puteaux

CAP Sogeti Innovation
Meylan

Captec — Computer Applied Technics
Malahide

Caption
Chantepie

Carl Zeiss
Oberkochen

Carlo Gavazzi Impianti
Milano

CASA — Construcciones Aeronáuticas
Madrid

CASEG
Watford

Catia Software Service
Stuttgart

Catsaros Automation
Athinai

CCIP
Noisy-le-Grand

CCS
Madrid

CEA
Grenoble

CEGB
Leatherhead

Cegelec
Levallois-Perret

Cegelec Projects
Rugby

Centra Burkle Honeywell Europe
Schoenaich

Centrisa
Barcelona

Centro de Calculo de Sabadell
Barcelona

Centunión
Madrid

Cepsa
Madrid

CER
Bruxelles

Cerci
Fontenay-sous-Bois

Cerilor
Maxeville

Ceselsa
Madrid

CESI — Centro Elettrotecnico Sperimentale
Milano

Cesia
Marseille

Cetena
Genova

CGE
Chilly-Mazarin

CGED
Bath

CGP
Orléans

Chantiers de l'Atlantique Gec Alsthom
Paris

Charles Clark
London

Charmilles Technologies
Meyrin

Cheshire Henbury Research & Consultancy
Macclesfield

Chorus Systèmes
Saint-Quentin-en-Yvelines

CIG — Centre d'informatique générale
Bruxelles

CIM
Aachen; Hannover

CIMAF
Porto

CIMSA
Vélizy-Villacoublay

Cirrus Computer
Fareham

CISE
Milano

CISI
Rungis; Toulouse

Cisigraph
Vitrolles

Citroën
Neuilly-sur-Seine

CITSA
Santiago

Citymax
London

Clarinet Systems
Blackwater

CLB Electronics
Amsterdam

CLS Computer Lernsysteme
Bonn

COGECO
Milano

Cognitech
Paris

COMAU
Torino

Comconsult
Aachen

Compañía Sevillana de Electricidad
Sevilla

Compugraphics International
Glenrothes

Computas Expert Systems
Hovik

Computer Industry Research Unit
Norwich

Computer Logic R&D
Athinai

Computer Systems Development
London

Computer Technologies Co
Athinai

Concentration Heat and Momentum
London

Concept Logiciels Expert
Boulogne

Construcciones Aeronáuticas
Madrid

Construnaves
Madrid

COPS
Dublin

Corelis Technologie
Boulogne

Coretech International
Les Ulis

Correlative Systems International
Bruxelles

Corte Inglés
Madrid

COSI
Milano

Cossor Electronics
Harlow

Cotec Computing Services
Tyne and Wear

Courseware Europe
Zaandam

CPRM
Lisboa

CRAI
Rende

CRAM
Catania

Credito Italiano
Milano

CRI — Computer Resources International
Birkerød; København

CRIL
Colombes

CSC
Amstelveen; Bruxelles

CSEA
Torino

CSEE
Les Ulis; Toulon

CSELT
Torino

CTA
Barcelona

D-Tech
Athinai; Luxembourg

DAF
Eindhoven

Daimler-Benz
Berlin; Frankfurt; Stuttgart; Ulm

Daltek
Borlange

Dancomp (Decanter, Richter & Rosenstand)
København

Dannet
Birkerød

Danobat Coop
Elgoibar

Dansk Ingeniør System
Glostrup

Dansk Meat Research Institute
Danmark

Dansk Parsim Consortium
Charlottenlund

Dansk Teknologisk Institut
Tåstrup

Dansk Welding Institute
Brøndby

Dantec
Skovlunde

Data Management
Milano

Datacentral
Hvidovre; Valby

Datamat Ingegneria dei Sistemi
Roma

Datamont Ferruzzi Group
Milano

Datenzentrale Schleswig-Holstein
Kiel

Décision International
Toulouse

Deister Electronic
Barsinghausen

Delga International
Madrid

Delphi
Viareggio

Delta Industrie Informatik
Waiblingen

Delta T
Hamburg

Deltacam Systems
Birmingham

Desarrollo de Software
Barcelona

Desisco
Harrow

Det Norske Veritas
Hovik

Deutsche Thomson-Brandt
Villingen

Dialogic
Paris

Didatel
Milano

Digital Equipment
Galway; München; Kaufbeuren; Bruxelles

Digital Kienzle
Villingen

Disc
Gent

Disel
Madrid

Diseño y Metodología
Madrid

DMT Marinetechnik
Hamburg

Doimak
Elgoibar

Domino
Milano

Dornier System
Friedrichshafen

Dorset Institute
Dorset

Dosiss
Dortmund

Dow Benelux
Terneuzen

Dr Jens Grumann Daten-Kommunikation
Bad Homburg

Drägerwerk
Lübeck

DSM Research
Geleen

DST
Bremen

DT2I
Meylan

Dunaiturria y Estanconia
Durango

Du Pont de Nemours Luxembourg
Luxembourg

E2S
Gent

EASAMS
Camberley

EB Industry and Offshore
Oslo

EBO
Athinai

ECAT
Luxembourg

ECC Couture
Oldenzaal

EDC
Heverlee

EDF
Chatou

Eeidetics
Blackrock

EFACEC
Porto

Eicas Automazione
Torino

EIDE
Monte de Caparica

Eigner
Karlsruhe

Eikon
Roma

Elabodater
Caserta

Electricidade de Portugal
Sacavém

Electricity Association Services
Chester

Electrolux Mecatronik
Malmö

Electrónica Básica
Esparraguera

Electrotécnica Arteche
Munguía

Elektroson
Liempde

Eleusis Shipyards
Elefsina

Elf Aquitaine
Saint-Symphorien

Elgelec
Fontenay-les-Briis

Elios informatique
Lannion

ELISA
Bures-sur-Yvette

Ellemtel
Stockholm

Elliop
Madrid

Elltec
Athinai

Elsag
Genova

Elsa Software
Meudon-la-Forêt

Elsevier Science Publishers
Amsterdam

Eltec Elektronik
Mainz

Emit
Bremerhaven

Emmepi
Milano

Empirica
Bonn

Empresa Fabril de Máquinas Eléctricas
Guarderios

ENA Telecomunicaciones
Getafe

Endress & Hauser
Maulburg

Enel
Roma

Enidata
Bologna; Milano; Roma

ENOSA
Madrid

Ensidesa
Avilés

Entel
Madrid

Envirotech International
Athinai

EPEC
Bruxelles

Epsilon Software
Athinai

Ergon
Athinai

Eria
Madrid

Erno Raumfahrttechnik
Bremen

Erovi
Barcelona

Esacontrol
Genova

ESF
Bruxelles

ESI
Rungis

Espasa-Calpe
Madrid

Etnoteam
Milano

Etra Electronic Trafic
Valencia

Eucad
Cheltenham

Eurodisk Technologies
Deeside

Euroexpert & Partners
Aldershot; Paris

Europäisches Computer Industrie Forschungs Center
München

European Educational Software
Cambridge

European Silicon Structures
Rousset

Eurosil Electronic
Eching

Eurosoft Systems
Suresnes

EWH Koblenz
Koblenz

Exapt
Aachen

Experteam
Slough

Extech
Galway

EYS
Bilbao

F. L. Smidth & Co.
Valby

Fábrica de Vidros Barbosa & Almeida
Vila Nova de Gaia

Fábrica Escola Irmãos Stephens
Marinha Grande

Face
Veldhoven

Fachhochschule Augsburg
Augsburg

Fachhochschule Ulm
Ulm

Fagor
Mondragón

Falko Standard Edv Software
Wien

Farran Technology
Cork

Fatronik System
Elgoibar Guipúzcoa

FEGS
Cambridge

Femview
Leicester

Ferranti
Chadderton; Cwmbran; Wythenshawe

FIAR
Milano

Fiat Aviazione
Torino

Fichtel & Sachs
Schweinfurt

Fidia
San Mauro

Fincantieri
Trieste

First International
Patras

Fischer & Lorenz
Gentofte; Rickmansworth

Fomesa — Food Machinery Española
Valencia

Fondazione Ugo Bordoni
Roma

Fordesi
Lisboa

Foxboro Nederland
Soest

Framatome Group
Paris

Framentec
Paris

France câbles et radio
Paris

Fuigi Italiana
Milano

Futurmedia
Bognor Regis

Gaas Code
Cambridge

Game Ingenieri France
Saint-Quentin-en-Yvelines

GEC
Chelmsford; Coventry; London; Rochester; Wembley; Whetstone

GEC Alsthom
Saint-Ouen

GEC Marconi
Borehamwood; London; Stanmore

GEC Software
London

GEI
Aachen

Gemplus Card International
Aix-en-Provence

Generaldirektion PTT Forschung und Entwicklung
Bern

Generics Software
Dublin

Georg-Simon Fachhochschule Nürnberg
Nürnberg

Gepro
Aachen

Gesellschaft zur Entwicklung von DV-Methoden
München

Gesi
Roma

Gespac
Plan-les-Ouates

GFI
Paris

GfS — Gesellschaft für Strukturanalyse
Aachen

GIE-Émeraude
Suresnes

GIE-Recherche Haussmann
Paris

Gildemeister
Nordrhein-Westfalen

Gildemeister Automation
Hannover

Gipsi
Saint-Quentin-en-Yvelines

GIT — Gesellschaft für Ingenieurtechniken
Essen

Glaverbel
Jumet

Globalsis, Engenharia Sistemas
Lisboa

GN — Great Nordic
København

GPP
Oberhaching bei München

Greater London Enterprise
London

GRS — Gesellschaft für Reaktorsicherheit
Garching

Grupo Apd
Madrid

Grupo de mecánica del vuelo
Madrid

GSI
Charenton

GSI Tecsi Software
Paris

GTS
Darmstadt

Guehring Automation & Co
Stetton

H. F. Jensen
København

Harlequin
Barrington; Cambridge

Harmonic Drive Antriebstechnik
Limburg

Hartmann & Braun
Minden

HCS Industrial Automation
Apeldoorn

Hellaslex
Athinai

Hellenic Aerospace Industry
Schimatari

Hellenic Information Systems
Athinai — Marousi

Hellenic Management Association
Athinai

Helmut Hund
Wetzlar

Heptacon
London

Heraeus Quarzschmelze
Hanau

Hewlett-Packard
Böblingen; Bristol; Wokingham

Hewlett-Packard France
Villefontaine

Hitec Athinai
Kallithea

Hoechst
Wiesbaden

Hoechst Ceramtec
Marktredwitz

Honeywell Europe
Bruxelles

Hotrasoft
Horst

Howaldtswerke — Deutsche Werft
Kiel

Hunting Technical Services
Hemel Hempstead

Hyperion Energy System
Cork

I & T Kalogeridis
Piraeus

I&ME
Wolfenbüttel

I2S
Bordeaux

IABG
Ottobrunn

IBA
Winchester

IBC-Danica
Rødovre

Iberduero
Bilbao

Iberia Líneas Aéreas de España
Madrid

Ibermática
Madrid; San Sebastián

IBK System-und Softwarehaus
München

IBM Deutschland
Sindelfingen; Stuttgart

IBM France
Paris

IBP Pietzsch
Ettlingen

ICI
Manchester; Winnington, Northwich

ICI Imagedata
Welwyn Garden City

ICI Wafer Technology
Milton Keynes

ICL Belgium
Bruxelles

ICS
Enschede

Idate
Montpellier

IDS
Madrid

IEGI
Luxembourg

IFAD
Odense

Ifatec
Versailles

IGC — Inspección y Garantía de Calidad
Madrid

IGN
Paris

Ikoss — Software Service
Aachen

Ilford
Knutsford, Cheshire

Ilog
Gentilly

Imperial Software Technology
Cambridge

Indecon
Marousi

Indecon Advanced Technology
Athinai

Industrias de Telecomunicación
Madrid

Industrie Zanussi
Pordenone

Induyco/Investrónica
Madrid

Infoarbed
Bertrange

Informabel
Bruxelles

Informatica Sistemi (Fiat Group)
Milano

Infosys
Puteaux

Infotap
Luxembourg

Infratest Industria
München

Ing. C. Olivetti & C.
Ivrea; Pisa; Torino

Ingeciber Cae
Madrid

Ingegneria Informatica
Padova

Ingenieurbüro für IMHT
Ratingen

Inisel
Madrid

Inmos
Bristol

Insos — Intelligent Software Solutions
Barcelona

Institute of Higher Professional Education
Eindhoven

Institute of Product Development
Lyngby

Intecs International
Bruxelles

Intecs Sistemi
Pisa

Interface Concilium
München

Intergrated Circuit Testing
Heimstetten

Intermetall
Freiburg

Interprogram
Diemen

Intersys Graphic
Bruxelles

Intervisie Strategie & Organisatie Advies
Leiden

Intes
Stuttgart

Intracom
Peania

Intrasoft
Athinai

Intron
Sittard

Investil
Vigo

IOT
München

IPACRI
Roma

Ipsys Software
Macclesfield

IRI
Roma

IRIAM
Marseille

Iris
Paliano

Irish Medical Systems
Blackrock, Dublin

ISA
Stuttgart

ISA Riber
Rueil-Malmaison

Isardata
Wolfratshausen

Iselqui
Ancona

Isoft
Orsay

Isomag
München

Isomet Laser Systems
Cwbran, Gwent

Isra Systemtechnik
Darmstadt

Issi
Paris

Istel
Redditch

Isykon Software
Bochum

Italcad Tecnologie e Sistemi
Genova

Italsiel
Roma

Italtel Telematica
Milano; Santa Maria Capua Vetere

ITMI
Meylan

ITS — Ingeniería y Tecnología de Sistemas
Madrid

J-S Telecom
Puteaux

Jaime Brull
Madrid

James Martin Associates
Bruxelles

Jenni — International User Group
London

John Bell Technical Systems
Fleet

Johnson Matthey Chemical
Royston

Joyce-Loebl
Gateshead

Judex Datasystemer
Ålborg

Jydsk Telefon
Århus

Kade-Tech
Écully

Kapsch
Wien

Kendu S Coop
Segura

Kern & Co
Arrau

Kewill Systems
Walton-on-Thames

Knossos Technologies
Heraklion

Knowledge
Patras

Kommunedata
København

Koninklijke Ptt Nederland
Groningen

Kontron Elektronik
Eching

KPMG — Peat Marwick Consultants
Frankfurt am Main

KPMG — Peat Marwick McLintock
London

Kronimus
Iffezheim

Krupp
Essen

Krupp Atlas Elektronik
Bremen

KTAS — Københavns Telefon Aktieselskab
København

Kuka Schweißanlagen & Roboter
Augsburg

L-Cube Information Systems
Athinai

Laben
Vimodrone

Laborelec
Linkebeek

Lagerwall
Bandol

Land-Data
Visselhoevede

Langton
London

Laser-scan Laboratories
Cambridge

LCC
Courbevoie

LDRA — Liverpool Data Research Association
Liverpool

Leas Industrie
Saim-Issmier

Legrand
Limoges

Leica
Milton Keynes

Lerea
Illkirch

Lernout & Hauspie Speechproducts
Ieper

Leuven Measurement & Systems International
Herverlee

Lexikon
Ivrea

Leybold Heraeus
Hanau

LGMI
Ivry-sur-Seine

Lips Unibed
Drunen

Littlewoods Organization
Liverpool

Lloyd's Register of Shipping
Croydon, London

Logic Programming Associates
London

Logica
Cambridge; Cobham; London

Logimatic
Ålborg

Logos Progetti
Milano

Lombardia Informatica
Milano

Longman Cartermill
St Andrews

LPS
Torino

Lucus
Birmingham; Belfast

LVD Company
Wevelgem

Maatschappij voor Informatica Diensten
Zeist

Machine Intelligence
Cambridge

Magistratsdirektion Wien
Wien

Magnemag
Skovlunde

Magneti Marelli
Milano

Mague
Alverca

Maintenance & Automation
Liège

Manager Software Products
Pinneberg

Mandelli
Piacenza

Mannesmann Hartmann & Braun
Frankfurt

Mannesmann/Digital
Karlsruhe; Ratingen; Wetter

Maps Informática Industrial
Barcelona

Maptel
Madrid

Marben
Paris

Marconi
Camberley; Fife; Leicester; Lincoln; Portsmouth; St Albans

Mares
Barcelona

Mari Group
Gateshead

Masa-Yards
Turku

Matra
Bois-d'Arcy; Les Ulis; Montrouge; Saint-Quentin-en-Yvelines; Toulouse; Val-de-Reuil; Velizy-Villacoublay

Matra-MHS
Nantes

MBB — Messerschmitt-Bölkow-Blohm
München; Putzbrunn

MBP Software & Systems
Dortmund

MC2
Grenoble

MCTS — Micro-Connectique Technologies
Boulogne-Billancourt

Mecánica de La Pena
Bilbao

Medimatica
London

Meiko
Bristol

Memory Computer
Dublin

Mental Images
Berlin

Mentec International
Dublin; Dun Laoghaire

Merck
Darmstadt

Messer Griesheim
Frankfurt am Main

Metalworks of Attika
Athinai

Metek
Halandri

Meterquest
London

Michel van de Wiele
Kortrijk

Micro
Évry

Micro Focus
Newbury

Microin R&D
Montgat

Microlog
Bargteheide

Microprocessor Engineering
Southampton

Microtecnica
Torino

MID
Nürnberg

Mietec
Oudenaarde

Mikron
Eching

Milano Research Centre
Milano

Mimetics
Paris

Ministry of Defence
London

Miniwatt
Barcelona

MO Valve Company
London

Modular Computer
Konstanz

Modular Computer Services
Wokingham

Modulex
Billund

Mono Light Instruments
Weybridge

Monotype Corporation
Redhill

Montefibre
Porto Marghera

Moog Controls
Tewkesbury

Morpho-Systèmes
Avon

Motor Oil
Athinai

Myfra
Montrouge

NA Software
Liverpool

Nada Consulting Group
Gateshead

Namur
Leverkusen

National Software Centre
Dublin

NCC — National Computing Centre
Manchester

Ncode International
Sheffield

NEA-Lindberg
Ballerup

NEH Technology
København

Neptune Freight
Dublin

NHS
Birmingham

Nixdorf Computer
Milano

Nixdorf Computer Software
Dublin

NKT
Brøndby

Noesis
Versailles

Nokia Graetz
Esslingen

Nokia Head Office
Helsinki

Nokia Research Centre
Espoo

Non-standard Logics
Paris

Norcontel
Dublin

Norsk Data
Kongsberg; Mühlheim

Norsk Forsvarsteknologi
Kongsberg

Norsk Jetmotor
Kongsberg

Novabase — Sistemas Informação
Bases Dados
Lisboa

Novosoft
Madrid

NTE
Barcelona; München

Numerical Algorithms Group
Oxford

Nuovo Pignone
Bari

O Dati Española
Barcelona

OC Consulting Engineers and Planners
Birkerød

Océ-Nederland
Venlo

OCN-PPL
Torino

Odense Steel Shipyard
Odense

OEVA-Versicherungen
Mannheim

Office Workstations
Edinburgh

Officine Galileo di Sicilia
Milazzo

Olivetti
Milano

Olivetti
Bruxelles

Olivetti Information Services
Bari

Olivetti Research
Cambridge

Olivetti Systems and Networks
Torino

Omega Generation
Bologna

Onera-CERT
Toulouse

Optec
Rho

Orbis
Saarbrücken

Organon International
Oss

Origin
Veldhoven

Oros
Meylan

OSI — Officine Stampaggi Industriali
Torino

Ositel
Meudon-Bellevue

Otter Online
Mühlheim

Ove Arup & Partners
London

Ovum
London

Oy Saab-Valmet
Uusikaupunki

PA Consulting Group
London

Pacer Systems
Nottingham

Pafec
Nottingham

Page Ibérica
Madrid

Pallas
Bonn

Parseq
Chandlers Ford

Parsys
London

Parsytec
Aachen

PCK and Associates
Athinai

PCS Computersysteme
München

Pegaso/Enasa
Madrid

Pergamon Compact Solution
London

Perihelion Software
Shepton Mallet

Philips
Apeldoorn; Eindhoven; Hilversum; Aachen; Hamburg; Kassel; Nürnberg; Wien; Le Plessis-Robinson; Limeil-Brevannes; Nijmegen

Philips Composants
Dreux; Issy-les-Moulineaux; Bruxelles; Louvain-la-Neuve

Philips International
Nijmegen

Philips Research Laboratories
Redhill

Philips Scientific
London

Phoenix VLSI Consultants
Towcester

Picogiga
Les Ulis

Picotron
Aartselaar

Pili Carrera
Porrino

Pilkington
Lathom; Ormskirk; St Asaph

Piraeus Graduate School
Piraeus

Pirelli
Milano

Planet
Athinai

Plasma Technology
Bristol

Plasmos
München

Plessey
Beeston; Christchurch; Poole; Swindon; Towcester

Pliroforiki
Athinai

Polydata
Athinai

Polyflow
Louvain-la-Neuve

Polymer Laboratories
Church Stretton

Polymotor
Casella

Porsche
Weissach

Preussag Pure Metals
Langelsheim

Prism Computer & Communication Systems
Athinai

Prisma Informatica
Perugia

Procad
Karlsruhe

Procos
Birkerød

Project Management Consultants
Holte

Prologia
Marseille

Pross
Madrid

Protexarms
Paris

Prozeßsteuerung und Schweißtechnik
Aachen

PSA
Neuilly-sur-Seine

PSI
Berlin

Putzmeister-Werke, Maschinenfabrik
Aichtal

Quinary
Milano

Racal Research
Reading

Rauma-Repola
Tampere

RC Computer
Åbyhøj

RCE — Réseaux communication entreprise
Cergy-Pontoise

RDP Technology
London

RE Technology
København

Realace
Dublin

Redar Nah-Ortungstechnik
Darmstadt

Reis & Co Maschinenfabrik
Obernburg

Renault
Rueil-Malmaison

Renault Automation
Boulogne-Billancourt; Le Chesnay

Riada & Co
Dublin

Robert Bosch
Darmstadt; Gerlingen-Schillerhöhe; Erbach; Hildesheim; Reutlingen; Stuttgart

Robosoft
Asnières

Robotec
Bilbourough

Robotiker
Mungia

Rodime Europe
Glenrothes

Roke Manor Research
Romsey

Rol
Orsay

Rolls-Royce
Watford

Rovsing
København

RSO
Milano

RTC
Paris

RTM
Torino

Rutherford Appleton Laboratory
Didcot

RWE-DEA für Mineralöl und Chemie
Hamburg

RWT
Coventry

RWTUEV
Essen

Rytrak
Liverpool

Sagantec
Eindhoven

Sagem
Paris

SAIT Electronics
Bruxelles

Sandretto Industrie
Collegno

Saritel-Sarin Telematica
Pomezia

SAS — Space Applications Services
Bruxelles

SAST
Brentford

SAT
Paris

SCAITECH
Ballerup; Lyngby

Scanray
Hvidovre

Scantest System
Værløse

Schiffko
Hamburg

Scicon
London

Scott Wilson Kirkpatrick & Partners
Basingstoke

Scottish Power
Glasgow

Scs Informationstechnik
Hamburg

Secre
Paris

Seeber
Leifers

SEGET
Barcelona

SEIAF
Genova

Sekas
München

Seleco
Pordenone

Selenia
Roma

Selisa
Chilly-Mazarin; Wissous

Sema Group
Bruxelles; London; Madrid

Sema Metra Group
Fontenay-sous-Bois; Montrouge; Paris

Semisystems
Fruthwilen

SENER — Sistemas Marinos
Madrid

SEP
Puteaux

Sepa
Torino

Sept
Caen

Serete Productique
Paris

Servotrol
Lisboa

SES Software Engineering Services
Neubiberg

SESA
Puteaux; Rennes

Sesam
Torino

Sextant Avionique
Vélizy-Villacoublay

SFGL
Boulogne

SG2 Génie informatique
Paris

SGN Graphael
Saint-Quentin-en-Yvelines

SGS-Thomson Microelectronics
Gentilly; Grenoble; Milano

SIDAC
Pomezia

Siemens
Berlin; Erlangen; Gräfing; Karlsruhe; München; Paderborn; München; Regensburg; Unterschleißheim

Siemens Data
Bruxelles Siemens Nixdorf Information Systems (SNI)
Barcelona; München

SIG Services
Utrecht

Signum Computer
München

Silicon & Software Systems
Dublin

Silogia
Paris

Silvertech
Horsham

Simulog
Saint-Quentin-en-Yvelines

Sinapse
Paris

Sincon
Roma

Sinorg
Paris

Sipa
Vittorio Veneto

Sipe Optimation
Pratica di Mare

Sirti
Milano

SIS
Milano

Siscog
Lisboa

Sismet
Lisboa

Sistemas Multiposto e Distribuídos
Lisboa

Sistemi e Telematica Porto di Genova
Genova

Sitesa Addax
Montbonnot

Sligos
Paris

SMI Organometallic Division
Marseille

Smiths Industries Aerospace & Defence Systems
Cheltenham

SNIA BPD — Fiat Group
Milano

Société des outils du logiciel
Paris

Société générale de techniques et d'études
Puteaux

Société lyonnaise des eaux
Paris

Sofemasa
Madrid

Soft International
Den Haag

Softing
München

Softlab
München

Software Cientifico y Técnico
Madrid

Software de Base
Madrid

Software Engineering Service
Ottobrunn

Software España
Madrid

Software Ireland
Belfast

Software Italia
Milano

Software Sciences
Macclesfield; Cheshire

SOGEA Rueil
Malmaison

SOGEI
Roma

Sogitec
Boulogne-Billancourt

Solam-Cam
Barcelona

Solari
Udine

Solvay
Bruxelles

Sophiatec
Valbonne-Sophia Antipolis

Souriau
Boulogne-Billancourt

Space Software Italia
Taranto

SPAG
Bruxelles

Special Analysis and Simulation Technology
Brentford

Speroni Sostegno di Spessa
Po — Pavia

SQL Databanksysteme
Berlin

Staf — Conseil de filière Staf
Le Mans

Standard Elektrik Lorenz
Stuttgart

Standard International Consulting
Paris

Statoil
Trondheim

STC-ICL
Bracknell; Harlow; Herts; Kidsgrove; London; Manchester; Newcastle under Lyme; Paignton, Devon; Reading; Sidcup; Stevenage; Sunbury-on-Thames; West Gorton; Wokingham

STE Seferiades & Associates
Athinai

Step-informatique
Paris

Steria
Vélizy-Villacoublay

Stewart Hughes
Southampton

Stollmann
Hamburg

Storebæltsforbindelsen Great Belt
København

Straco
Compiègne

Strategic International
Athinai

STZ Gesellschaft
Dortmund

Suprenum
Bonn

Swedish Institute of Computer Science
Kista

SWIFT
La Hulpe

Sybase
Bracknell

SYD
Paris; Puteaux

Synergia
Milano

Syntax Factory Automation
Torino

Syntax Software Sistemi
Bari

Sypro København
København

Syseca
Rennes; Saint-Cloud

Systeam
Karlsruhe

System Software Factors
Reading

Systems & Management
Milano; Torino

Systems Designers Europe
Camberley

Systems Wizards
Torino

Systex
Gif-sur-Yvette

Sysware
København

Søren T. Lyngsø
Hørsholm

TA — Triumph Adler
Fürth; Nürnberg

Taighdeclar Genesis Teoranta
An Spideal

Tampelle
Tampere

TAO
Barcelona

TAP Air Portugal
Lisboa

Taywood Engineering
Southall

TDS Dextralog
Blackburn

Team
Ispra; Roma

Techforce
Leiden

Technisystems
Piraeus

Technology Applications Group
Alnwick

Teclab
Ceparana

Tecmic
Lisboa

Tecnation per l'Innovazione Tecnologica
Torino

Tecnatom
Madrid

Técnicas Reunidas
Madrid

Tecnirob
Alfragide

Tecno T&G
Madrid

Tecnomatix Europe
Antwerpen

Tecnopolis CSATA Novus Ortus
Valenzano

Tecograf Software
Milano

Tecsiel
Napoli; Pisa

Teice Control
Madrid

Teknecomp
Cavaglià

Teldat
Madrid

Telefónica
Madrid

Telefunken Electronic
Heilbronn

Telefunken Systemtechnik
Ulm

Telelogic
Farsta

Telematic Services
Berlin

Télémécanique
Nanterre; Rueil-Malmaison

Telesincro
Cerdanyola

Telesoft
Farsta

Télésystèmes
Paris

Telettra
Bologna; Cinisello Balsamo; Milano

Telettra España
Madrid

Televas
Milano

Telmat Informatique
Soultz

Teseo
Milano

Textware
Bagsværd

The East Asiatic Company
København

Thomson — CSF
Bagneux; Boulogne-Billancourt; Cagnes-sur-Mer; Cesson-Sévigné; Colombes; Courbevoie; Illkirch-Groffenstaden; Issy-les-Moulineaux; Orsay; Paris; Saint-Égrève; Toulon

Thomson — LCD
Moirans

Thorn EMI
Hayes

Thot Informatique
Angers

Time-sharing
Lisboa

TMTED
Dieren

TN Telenorma
Frankfurt am Main

TNC
Hemel Hempstead

TNO
Delft

TOC
Barcelona

Tolsys
Dublin

Tool
Annecy-le-Vieux

Torre
Navara

Touche Ross Management Consultants
London

Trademco
Athinai

Transmodul
Saarbrücken

Transtools
Madrid

Traub
Reichenbach

Trialog informatique
Paris

Trion Präzisionselektronik & Co
Berlin

Tritech
Dublin

Trut — Kykloforiaki
Thessaloniki

TSI
Roma

TÜV
Essen; München

TXT
Milano

UCB Electronics
Bruxelles

UITESA
Madrid

Unibanque
Paris

Unisoft
Lisboa

Unisys España
Madrid

URW
Hamburg

UTI — Services
Paris

UVA
Amsterdam

Valtronic France
Gif-sur-Yvette

Valvo Unternehmensbereich
Hamburg

Vdo Luftfahrtgeräte-Werk
Frankfurt am Main

Vector Fields
Oxford

Vegla Vereinigte Glaswerke
Aachen

Veridatas
Paris-la Défense

Verilog
Toulouse

Video Display Systems
Firenze

Vision Computing
Dublin

Visitec
Seraing

Voice Input
Cambridge

Volkswagen
Ingolstadt; Wolfsburg

Volmac Nederland
Utrecht

VTE — Videotechnik & Elektronik
Braunschweig

Wacker-Chemie
Burghausen

Waldrich Siegen
Siegen

Weld
Helmond

Welding Institute of Cambridge
Abington

Westland
Yeovil

Whitechapel Computer Works
London

Wild Leitz Instruments
Heidelberg

Wilhelm Karmann
Osnabrück

Wilhelm Fette
Schwarzenbek

Wolters Kluwer
Deventer

Work Research Centre
Dublin

X-Telephone Services
Nottingham

Yard Software Systems
Chippenham

Zeltron
Campoformido

Zenon
Athinai

University and research institute participants and sites

3IT
Toulouse

Academisch Ziekenhuis Rotterdam
Rotterdam

ACRI
Lyon

Adersa
Verrières-le-Buisson

AKZO International Research
Arnhem

Ålborg Universitet
Ålborg

AMTRI
Macclesfield

Århus Universitet
Århus

Aristotle University of Thessaloniki
Thessaloniki

Armines
Palaiseau; Paris

Artificial Intelligence Research Institute
Wien

Asociación de Investigación Tekniker
Eibar

Athinai School of Economics
Athinai

BAZIS
Leiden

BBC Productions (Open University)
Milton Keynes

BIBA
Bremen

BMT Fluid Mechanics
Teddington

Brighton Polytechnic
Brighton

Bristol Polytechnic
Bristol

CCETT
Cesson-Sévigné

CEA
Fontenay-aux-Roses; Grenoble; Paris

CEA-LETI
Grenoble

Cemota
Vernaison

CENA
Orly-Aérogare

Centre commun de micro-électronique de l'Ouest
Rennes

Centre d'Estudis Avançcas de Blanes
Blanes (Cataluña)

Centre d'études du management
Puyricard

Centre de mathématiques de l'École Polytechnique
Palaiseau

Centre de robotique intégrée
Paris

Centre for Software Reliability
London

Centre régional de technologie Électrique-Optique
Limoges

Centre scientifique et technique de la construction
Bruxelles

Centro di Cultura Scientifica
Como

Centro Nacional de Microelectrónica
Madrid

CERICS
Valbonne

CERN
Genève

CERT
Toulouse

CETE Méditerranée
Les Milles

CETIM
Senlis

Chalmers University of Technology
Gøteborg

City University
London

CMSU
Athinai

CNAM
Paris

CNET
Bagneux; Issy-les-Moulineaux; Lannion; Meylan

CNR
Padova; Pisa

CNR-IL
Bologna

CNR-IDG
Firenze

CNR-IEI
Pisa

CNR-IESS
Roma

CNR-IMU
Milano

CNRG
Athinai

CNRS
Aix-en-Provence; Bagneux; Marseille; Orléans; Toulouse; Paris; Grenoble; Strasbourg; Orsay; Valbonne; Sophia Antipolis; Écully; Mulhouse; Villetaneuse

Computer Technology Institute
Patras

Consorzio Roma Ricerche
Roma

Coventry Polytechnic
Coventry

CPR
Pisa

Cranfield Institute of Technology
Milton Keynes

Cretan Computer Institute
Iraklion

CRIAI
Napoli

CRIF/WTCM
Bruxelles

CRIN
Vandœuvre-lès-Nancy

CSELT
Torino

CSEM
Neuchâtel

CSIC
Madrid

CSTB
Paris

CWI
Amsterdam

Danmarks Maritime Institut
Lyngby

Danmarks Tekniske Højskole
Lyngby

Delft Hydraulics
Delft

Deutsches Herzzentrum Berlin
Berlin

Direction des musées de France
Paris

Dörner Institut
München

Dublin City University
Dublin

ECN
Petten

École centrale de Lyon
Écully

École des mines de Saint-Étienne
Saint-Étienne

École nationale supérieure d'électronique
Grenoble

École nationale supérieure
Fontainebleau

École normale supérieure
Lyon; Paris

École normale supérieure des
télécommunications
Paris

École Polytechnique
Palaiseau; Paris

École polytechnique fédérale de
Lausanne
Lausanne

École supérieure d'électricité
Cesson-Sévigné

Education Technology Institute
Milton Keynes

EHESS-CAMS
Paris

Eidgenössische Technische Hochschule
Zürich

ELAB
Trondheim

Elektronik Centralen
Hørsholm

ENEA
Roma

ENS
Mulhouse

ENSEA
Cergy

ENSTA-LIES
Paris

Entwicklungszentrum für
Mikroelektronik
Villach

EPFL
Lausanne

Ergonomic Institut
Berlin

ESIEE
Noisy-le-Grand

European Centre for Weather Forecasts
Reading

FAW
Ulm

Fernuniversität Hagen
Hagen

FIM-FGAN
Ettlingen

Forschungszentrum
Linz

FORTH Research Centre
Iraklion

Fraunhofer AIS
Erlangen; München

Fraunhofer Graphische
Datenverarbeitung
Darmstadt

Fraunhofer IAO
Stuttgart

Fraunhofer IFT
München

Fraunhofer IIS
Erlangen

Fraunhofer IITB
Karlsruhe

Fraunhofer IMS
Berlin

Fraunhofer IMSS
Duisburg

Fraunhofer Institut für Information
Karlsruhe

Fraunhofer IPA
Stuttgart

Fraunhofer IPK
Berlin

Fraunhofer ISI
Karlsruhe

Fraunhofer ITW
Dortmund

Freiburg Universität
Freiburg

Freie Universität Berlin
Berlin

GETA
Grenoble

GIP Altair
Le Chesnay

Glasgow College
Glasgow

GMD
Berlin; Darmstadt; Karlsruhe;
St. Augustin

Groningen University
Groningen

Handelshøjskolen i København
Frederiksberg

Harwell Laboratory
Didcot

Hatfield Polytechnic
Hatfield

H. C. Ørsted Institut
København

Heinrich Hertz Institut
Berlin

Helsinki University of Technology
Espoo

HERIE
Nîmes

Heriot-Watt University
Edinburgh

HUSAT Research Centre
Loughborough

IABG
Ottobrunn

IASI
Arganda del Rey

IDSIA
Lugano

IKERLAN
Mondragón

IMAG
Saint-Martin-d'Hères

IMEC
Heverlee (Leuven)

Imperial Cancer Research Fund
London

INESC
Lisboa; Porto

INFM
Genova

Informació Cartogràfica i de Base
Barcelona

INIC
Porto

INPG
Grenoble

INPT
Toulouse

INRIA
Le Chesnay; Rennes; Valbonne; Vandœuvre-lès-Nancy

INSA
Villeurbanne

Institiuid Teangeolaíochta Eireann
Dublin

Institut d'optique théorique et appliquée
Orsay

Institut de recherche de construction navale
Paris

Institut für Deutsche Sprache
Mannheim

Institut für Informatik der Universität
Bonn

Institut méditerranéen de technologie
Marseille

Institut national des télécommunications
Évry

Institut national polytechnique de Lorraine
Nancy

Institut supérieur d'électronique du Nord
Lille

Instituto Superior Técnico
Lisboa

IPA-Fraunhofer Gesellschaft
Stuttgart

IRAM
Saint-Martin-d'Hères

IRETIJ
Montpellier

IRIAC
Paris

IRISA
Rennes

IRIT
Toulouse

ISI
Torino

ISMCM
Saint-Ouen

Istituto Nazionale di Ottica
Firenze

Istituto Trentino di Cultura
Trento

ITK — Informations-Technologie Kiel
Kiel

ITK — Katholieke Universiteit Brabant
Tilburg

Johann Wolfgang von Goethe-Universität
Frankfurt am Main

Katholieke Industriële Hogeschool West-Vlaanderen
Oostende

Katholieke Industriële Hogeschool Antwerpen
Hoboken

Katholieke Universiteit Brabant
Tilburg

Katholieke Universiteit Leuven
Heverlee; Leuven

Katholieke Universiteit Nijmegen
Nijmegen

Kernforschungszentrum Karlsruhe
Karlsruhe

King's College
Kingston-upon-Thames, London

Kingston Polytechnic
London

Kongelige Danske Skole for Økonomi
København

Konstanzun
Konstanz

København Business School
København

Københavns Universitet
København

Labein
Bilbao

Lancashire Polytechnic
Preston

Linguistics Institute of Ireland
Dublin

Linköping University
Linköping

LITP
Paris

LNET
Lisboa

LNETI-ICEN
Sacavém

London Institute of Education
London

London Mental Models Group
London

Loughborough University of Technology
Loughborough

LSF
London

Ludwig-Maximilians-Universität
München

Manchester Polytechnic
Manchester

Max-Planck-Institut für Festkörperforschung
Stuttgart

Max-Planck-Institut für Festkörperforschung
Grenoble

Max-Planck-Institut für Quantenoptik
Garching

Max-Planck-Institut für Psycholinguistik
Nijmegen

Medical Research Council
Cambridge; London; Sheffield

Middlesex Polytechnic
London

NAEGL
Dublin

Napier Polytechnic
Edinburgh

National Gallery
London

National Microelectronics Research Centre
Cork

National Physical Laboratory
Teddington

National Research Centre
Athinai

National Research Centre 'Demokritos'
Athinai

Newcastle upon Tyne Polytechnic
Newcastle upon Tyne

NIHE
Dublin

Nijenrode Universiteit voor Bedrijfskunde
Breukelen

Norwegian Institute of Technology
Trondheim

Nottingham Polytechnic
Nottingham

NUC
Ålborg

Odense Universitet
Odense

Onera — CERT
Châtillon; Toulouse

Open University
Milton Keynes

ORE
Utrecht

Oxford University Press
Oxford

Paisley College of Technology
Paisley

Physikalisch-technische Bundesanstalt
Braunschweig

Plymouth Polytechnic
Plymouth

Pôle de formation en micro-électronique
Toulouse

Politecnico di Milano
Milano

Politecnico di Torino
Torino

Polytechnic of Central London
London

Polytechnic of Crete
Chania

Portsmouth Polytechnic
Portsmouth

Promip
Toulouse

PSI Co Laboratories RCA
Zürich

PTT Research Telematica Laboratories
Groningen; Leidschendam

Queen Mary College
London

Research Unit for Computational Linguistics
Helsinki

Ricerca SCPA
Bari

Rijksuniversiteit
Gent

Rijksuniversiteit
Leiden

Risø National Laboratory
Roskilde

Rof Nevanlinne Institute
Helsinki

Roskilde Universitetscenter
Roskilde

Royal Holloway & Bedford New College
Egham

Royal Institute of Technology
Stockholm

RSRE
Great Malvern

Ruhr-Universität
Bochum

Rutherford Appleton Laboratory
Didcot

RWTH
Aachen

SCK-CEN
Mol

Scuola Superiore S. Anna
Pisa

Senter for Industriforskning
Oslo

Seram
Paris

SERC
Utrecht

Sheffield City Polytechnic
Sheffield

Sintef
Trondheim

SNS
Pisa

South Bank Polytechnic
London

St Patrick's College
Kildare

Staffordshire Polytechnic
Stafford

Studsvik Nuclear
Nykoping

Swedish Institute of Computer Science
Kista

Swedish Institute of Microelectronics
Stockholm

Swedish Telecom
Farsta

Swiss Federal Institute of Technology
Zürich

Tampere University of Technology
Tampere

Technical Research Centre of Finland
Espoo; Oulu

Technische Hochschule Darmstadt
Darmstadt

Technische Universität Berlin
Berlin

Technische Universität Braunschweig
Braunschweig

Technische Universität Dresden
Dresden

Technische Universität Graz
Graz

Technische Universität Hamburg
Hamburg

Technische Universität München
München

Technische Universität Wien
Wien

Technische Universiteit Delft
Delft

Technische Universiteit Eindhoven
Eindhoven

Tecnopolis Csata Novus Ortus
Valenzano (Bari)

Teesside Polytechnic
Cleveland

Teknologisk Institut
Tåstrup

Telecom Paris
Paris

Televerket
Farsta

Thames Polytechnic
London

TNO
Apeldoorn; Delft; Den Haag; Eindhoven; Leiden; Utrecht

Trent Polytechnic
Nottingham

Trinity College Dublin
Dublin

Turing Institute
Glasgow

UKAEA
Didcot; Dorchester; Harwell; London; Warrington

UMIST
Manchester

UNINOVA
Monte di Caparica

UNIQUEE
Belfast

Universidad Autónoma de Madrid
Madrid

Universidad de Barcelona
Barcelona

Universidad de Cantabria
Santander

Universidad de Granada
Granada

Universidad de Las Islas Baleares
Palma

Universidad de Las Palmas
Las Palmas

Universidad de Madrid
Madrid

Universidad de Málaga
Málaga

Universidad de Murcia
Murcia

Universidad de Sevilla
Sevilla

Universidad de Valladolid
Valladolid

Universidad de Zaragoza
Zaragoza

Universidad del País Vasco
Bilbao; San Sebastián

Universidad Nacional de Educación a Distancia
Madrid

Universidad Politécnica de Canarias
Las Palmas

Universidad Politécnica de Cataluña
Barcelona

Universidad Politécnica de Madrid
Madrid

Universidad Politécnica de Valencia
Valencia

Universidade Católica Portuguesa
Lisboa

Universidade de Aveiro
Aveiro

Universidade de Coimbra
Coimbra

Universidade do Porto
Porto

Universidade do Minho
Braga

Universidade Nova de Lisboa
Monte da Caparica

Universidade Portucalense
Porto

Università Cattolica del Sacro Cuore
Roma

Università degli Studi di Milano
Milano

Università degli Studi di Pavia
Pavia

Università dell'Aquila
Poggio di Roio

Università della Calabria
Arcavacata (Cosenza)

Università di Bari
Bari

Università di Bologna
Bologna

Università di Firenze
Firenze

Università di Genova
Genova

Università di Messina
SantÀgata-Messina

Università di Milano
Milano

Università di Modena
Modena

Università di Napoli
Napoli

Università di Palermo
Palermo

Università di Parma
Parma

Università di Pavia
Pavia

Università di Pisa
Pisa

Università di Roma
Roma

Università di Roma - La Sapienza
Roma

Università di Torino
Torino

Università di Trento
Trento

Università di Udine
Udine

Università di Pavia
Pavia

Universitaire Instelling Antwerpen
Wilrijk

Universität Bamberg
Bamberg

Universität Bayreuth
Bayreuth

Universität Bielefeld
Bielefeld

Universität Bremen
Bremen

Universität der Bundeswehr
Hamburg

Universität des Saarlandes
Saarbrücken

Universität Dortmund
Dortmund

Universität Duisburg
Duisburg

Universität Erlangen-Nürnberg
Erlangen

Universität Frankfurt
Frankfurt am Main

Universität Gesamthochschule Siegen
Siegen

Universität Göttingen
Göttingen

Universität Hagen
Hagen

Universität Hamburg
Hamburg

Universität Hannover
Hannover

Universität Heidelberg
Heidelberg

Universität Hildesheim
Hildesheim

Universität Kaiserslautern
Kaiserslautern

Universität Karlsruhe
Karlsruhe

Universität Kassel
Kassel

Universität Kiel
Kiel

Universität Köln
Köln

Universität Lübeck
Neumünster

Universität Marburg
Marburg

Universität Münster
Münster

Universität Oldenburg
Oldenburg

Universität Paderborn
Paderborn

Universität Passau
Passau

Universität Stuttgart
Stuttgart

Universität Tübingen
Tübingen

Universität Wien
Wien

Universität Zürich
Zürich

Université Blaise Pascal de Clermont
Aubière

Université catholique de Louvain
Bruxelles; Louvain-la-Neuve

Université d'Aix-Marseille
Aix-en-Provence; Les Milles; Marseille

Université de Besançon
Besançon

Université de Bordeaux
Talence

Université de Genève
Genève

Université de Grenoble
Grenoble

Université de l'État à Mons — Informatique
Mons

Université de Liège
Liège

Université de Lille
Lille

Université de Lille
Villeneuve-d'Ascq

Université de Montpellier
Montpellier

Université de Nice
Sophia Antipolis

Université de Nice-Lisan
Valbonne-Sophia Antipolis

Université de Paris
Paris

Université de Paris-I
Paris

Université de Paris-V
Paris

Université de Paris-Nord
Villetaneuse

Université de Paris-Sud
Orsay

Université de Provence
Marseille

Université de Savoie
Chambéry

Université de Strasbourg
Strasbourg

Université de technologie de Compiègne
Compiègne

Université de Valenciennes
Valenciennes

Université Joseph Fourier de Grenoble-I
Grenoble; Saint-Martin-d'Hères

Université libre de Bruxelles
Bruxelles

Université Louis Pasteur de Strasbourg
Strasbourg

Université Louis Pasteur — Physique et chimie
Strasbourg

Université Notre-Dame de la Paix
Namur

Université Paul Sabatier de Toulouse
Toulouse

Université Pierre et Marie Curie
Paris; Versailles

Université Toulon-Gessy
Toulon

Universiteit van Amsterdam
Amsterdam

Universiteit van Limburg
Maastricht

Universiteit van Twente
Enschede

Universiteit van Utrecht
Utrecht

University College Cardiff
Cardiff

University College Cork
Cork

University College Dublin
Dublin

University College Galway
Galway

University College London
London

University College of North Wales
Aberystwyth; Bangor

University College Swansea
Swansea

University of Aberdeen
Aberdeen

University of Athinai
Athinai

University of Bath
Bath

University of Bradford
Bradford

University of Bristol
Bristol

University of Brunel
Uxbridge

University of Cambridge
Cambridge

University of East Anglia
Norwich

University of Edinburgh
Edinburgh

University of Essex
Colchester

University of Exeter
Exeter

University of Glasgow
Glasgow

University of Göteborg
Göteborg

University of Heriot-Watt
Edinburgh

University of Hull
Hull

University of Jyvaskyla
Jyvaskyla

University of Keele
Keele

University of Kent
Canterbury

University of Kreta
Iraklion

University of Lancaster
Lancaster

University of Lappeenranta
Lappeenranta

University of Leeds
Leeds

University of Limerick
Limerick

University of Liverpool
Liverpool

University of London
London

University of London; Birkbeck College
London

University of London; Goldsmith's College
London

University of London; Queen Mary College
London

University of Lund
Lund

University of Manchester
Manchester

University of München
Garching-München

University of Newcastle
Newcastle upon Tyne

University of Nottingham
Nottingham

University of Oslo
Oslo

University of Oulu
Oulu

University of Oxford
Oxford

University of Patras
Patras

University of Reading
Reading

University of Sheffield
Sheffield

University of Southampton
Southampton

University of St Andrews
St Andrews

University of Stirling
Stirling

University of Stockholm
Stockholm

University of Strathclyde
Glasgow

University of Surrey
Guildford

University of Sussex
Brighton

University of the Aegean
Athinai

University of Thrace 'Demokritus'
Xanthi

University of Ulster
Coleraine

University of Uppsala
Uppsala

University of Wales
Cardiff

University of Warwick
Coventry

University of York
York

University of Zürich
Zürich

Vrije Universiteit Brussel
Brussel

Index

Project acronyms

All ESPRIT projects are listed on pages 97-123

*Page numbers in **bold** refer to captions or illustrations*

Project numbers

All ESPRIT projects are listed on pages 97-123

*Page numbers in **bold** refer to captions or illustrations*

Topics

*Page numbers in **bold** refer to captions or illustrations*

A

B

C

D

N

O

P

R

S

T

V

W

Credits

DG XIII rapporteurs
N. Richier
D. Broster — Microelectronics
D. Talbot — Information processing systems
R. Zobel — Advanced business and home systems — Peripherals
R. MacKay — Computer-integrated manufacturing
I. Hussla — Basic research
D. Thomas — Information exchange system
J-J. Manin — Bibliography
M. Vereczkei — Appendices

Assistant editors
B. Christie, Onstream Resources Ltd
R. Killick and I. Paterson, Fisher & Lorenz Ltd

Photographic editor
F. Remouchamps, Kéops Création SPRL

DG XIII-A would like to thank the following for providing photographs and for permission to reproduce copyright material. Whilst every effort has been made to acknowledge all copyright holders, we would like to apologize should any omissions have been made.

9 ASM-L; **11** CEC; **16** Siemens; **17** Philips; **18** Alcatel Mietec; **19** Siemens; **21** Siemens-Nixdorf; **23** Daimler-Benz; **25** ASM-L; **26** ASM-I; **28** Inmos; **29** DRA (Crown copyright); **30** Telmat; **31** Telmat; **32** Siemens; **36** Laborelec; **43** Philips Consumer Electronics; **44** Olivetti Systems & Networks/Acorn Computers; **45** Olivetti Systems & Networks; **46** Acorn Computers; **48** Press Association; **49** Brameur; **51** Association pour le développement de la domotique; **54** Kuka; **56** Kuka; **58** Heracles Milaky; **59** BMW; **60** Kuka; **63** Pirelli; **64** SAGEM; **65** Caption; **66** Krupp; **69** Universidad Autonoma de Barcelona; **70** AEA Technology; **72** Helmut Hund; **74** LIFIA; **75** Vrije Universiteit Brussel; **82** CEC; **85** CEC; **90** Daimler-Benz

European Communities — Commission

ESPRIT — Progress and results 1990/91

Luxembourg: Office for Official Publications of the European Communities

1991 — 153 pp., 42 ill. (col.) — 21.0 x 29.7 cm

ISBN 92-826-3132-X

Catalogue number: CD-NA-13583-EN-C

Venta y suscripciones • Salg og abonnement • Verkauf und Abonnement • Πωλήσεις και συνδρομές
Sales and subscriptions • Vente et abonnements • Vendita e abbonamenti
Verkoop en abonnementen • Venda e assinaturas

BELGIQUE / BELGIË

Moniteur belge / Belgisch Staatsblad
Rue de Louvain 42 / Leuvenseweg 42
1000 Bruxelles / 1000 Brussel
Tél. (02) 512 00 26
Fax 511 01 84
CCP / Postrekening 000-2005502-27

Autres distributeurs /
Overige verkooppunten

Librairie européenne/ Europese Boekhandel
Avenue Albert Jonnart 50 /
Albert Jonnartlaan 50
1200 Bruxelles / 1200 Brussel
Tél. (02) 734 02 81
Fax 735 08 60

Jean De Lannoy
Avenue du Roi 202 /Koningslaan 202
1060 Bruxelles / 1060 Brussel
Tél. (02) 538 51 69
Télex 63220 UNBOOK B
Fax (02) 538 08 41

CREDOC
Rue de la Montagne 34 / Bergstraat 34
Bte 11 / Bus 11
1000 Bruxelles / 1000 Brussel

DANMARK

J. H. Schultz Information A/S
EF-Publikationer
Ottiliavej 18
2500 Valby
Tlf. 36 44 22 66
Fax 36 44 01 41
Girokonto 6 00 08 86

BR DEUTSCHLAND

Bundesanzeiger Verlag
Breite Straße
Postfach 10 80 06
5000 Köln 1
Tel. (02 21) 20 29-0
Telex ANZEIGER BONN 8 882 595
Fax 20 29 278

GREECE

G.C. Eleftheroudakis SA
International Bookstore
Nikis Street 4
10563 Athens
Tel. (01) 322 63 23
Telex 219410 ELEF
Fax 323 98 21

ESPAÑA

Boletín Oficial del Estado
Trafalgar, 27
28010 Madrid
Tel. (91) 44 82 135

Mundi-Prensa Libros, S.A.
Castelló, 37
28001 Madrid
Tel. (91) 431 33 99 (Libros)
431 32 22 (Suscripciones)
435 36 37 (Dirección)
Télex 49370-MPLI-E
Fax (91) 575 39 98

Sucursal:

Librería Internacional AEDOS
Consejo de Ciento, 391
08009 Barcelona
Tel. (93) 301 86 15
Fax (93) 317 01 41

Llibreria de la Generalitat de Catalunya
Rambla dels Estudis, 118 (Palau Moja)
08002 Barcelona
Tel. (93) 302 68 35
302 64 62
Fax (93) 302 12 99

FRANCE

Journal officiel
Service des publications des Communautés européennes
26, rue Desaix
75727 Paris Cedex 15
Tél. (1) 40 58 75 00
Fax (1) 40 58 75 74

IRELAND

Government Publications Sales Office
Sun Alliance House
Molesworth Street
Dublin 2
Tel. (1) 71 03 09

or by post

Government Stationery Office
EEC Section
6th floor
Bishop Street
Dublin 8
Tel. (1) 78 16 66
Fax (1) 78 06 45

ITALIA

Licosa Spa
Via Benedetto Fortini, 120/10
Casella postale 552
50125 Firenze
Tel. (055) 64 54 15
Fax 64 12 57
Telex 570466 LICOSA I
CCP 343 509

Subagenti:

Libreria scientifica Lucio de Biasio - AEIOU
Via Meravigli, 16
20123 Milano
Tel. (02) 80 76 79

Herder Editrice e Libreria
Piazza Montecitorio, 117-120
00186 Roma
Tel. (06) 679 46 28/679 53 04

Libreria giuridica
Via XII Ottobre, 172/R
16121 Genova
Tel. (010) 59 56 93

GRAND-DUCHÉ DE LUXEMBOURG

Messageries Paul Kraus
11, rue Christophe Plantin
2339 Luxembourg
Tél. 499 88 88
Télex 2515
Fax 499 88 84 44
CCP 49242-63

NEDERLAND

SDU Overheidsinformatie
Externe Fondsen
Postbus 20014
2500 EA 's-Gravenhage
Tel. (070) 37 89 911
Fax (070) 34 75 778

PORTUGAL

Imprensa Nacional
Casa da Moeda, EP
Rua D. Francisco Manuel de Melo, 5
1092 Lisboa Codex
Tel. (01) 69 34 14

Distribuidora de Livros Bertrand, Ld.ª
Grupo Bertrand, SA
Rua das Terras dos Vales, 4-A
Apartado 37
2700 Amadora Codex
Tel. (01) 49 59 050
Telex 15798 BERDIS
Fax 49 60 255

UNITED KINGDOM

HMSO Books (PC 16)
HMSO Publications Centre
51 Nine Elms Lane
London SW8 5DR
Tel. (071) 873 2000
Fax GP3 873 8463
Telex 29 71 138

ÖSTERREICH

Manzsche Verlags- und Universitätsbuchhandlung
Kohlmarkt 16
1014 Wien
Tel. (0222) 531 61-0
Telex 11 25 00 BOX A
Fax (0222) 531 61-81

SUOMI

Akateeminen Kirjakauppa
Keskuskatu 1
PO Box 128
00101 Helsinki
Tel. (0) 121 41
Fax (0) 121 44 41

NORGE

Narvesen information center
Bertrand Narvesens vei 2
PO Box 6125 Etterstad
0602 Oslo 6
Tel. (2) 57 33 00
Telex 79668 NIC N
Fax (2) 68 19 01

SVERIGE

BTJ
Box 200
22100 Lund
Tel. (046) 18 00 00
Fax (046) 18 01 25

SCHWEIZ / SUISSE / SVIZZERA

OSEC
Stampfenbachstraße 85
6035 Zürich
Tel. (01) 365 54 49
Fax (01) 365 54 11

CESKOSLOVENSKO

NIS
Havelkova 22
13000 Praha 3
Tel. (02) 235 84 46
Fax 42-2-264775

MAGYARORSZÁG

Agroinform
Budapest I. Kir.
Attila út 93
1012 Budapest
Tel. (1) 56 82 11
Telex (22) 4717 AGINF H-61

POLAND

Business Foundation
ul. Krucza 38/42
00-512 Warszawa
Tel. (22) 21 99 93, 628-28-82
International Fax&Phone
(0-39) 12-00-77

YUGOSLAVIA

Privredni Vjesnik
Bulevar Lenjina 171/XIV
11070 Beograd
Tel. (11) 123 23 40

CYPRUS

Cyprus Chamber of Commerce and Industry
Chamber Building
38 Grivas Dhigenis Ave
3 Deligiorgis Street
PO Box 1455
Nicosia
Tel. (2) 449500/462312
Fax (2) 458630

TÜRKIYE

Pres Gazete Kitap Dergi Pazarlama Dağitim Ticaret ve sanayi AŞ
Narlibahçe Sokak N. 15
Istanbul-Cağaloğlu
Tel. (1) 520 92 96 - 528 55 66
Fax 520 64 57
Telex 23822 DSVO-TR

AUTRES PAYS
OTHER COUNTRIES
ANDERE LÄNDER

Office des publications officielles des Communautés européennes
2, rue Mercier
2985 Luxembourg
Tél. 49 92 81
Télex PUBOF LU 1324 b
Fax 48 65 73
CC bancaire BIL 8-109/6003/700

CANADA

Renouf Publishing Co. Ltd
Mail orders — Head Office:
1294 Algoma Road
Ottawa, Ontario K1B 3W8
Tel. (613) 741 43 33
Fax (613) 741 54 39
Telex 0534783

Ottawa Store:
61 Sparks Street
Tel. (613) 238 89 85

Toronto Store:
211 Yonge Street
Tel. (416) 363 31 71

UNITED STATES OF AMERICA

UNIPUB
4611-F Assembly Drive
Lanham, MD 20706-4391
Tel. Toll Free (800) 274 4888
Fax (301) 459 0056

AUSTRALIA

Hunter Publications
58A Gipps Street
Collingwood
Victoria 3066

JAPAN

Kinokuniya Company Ltd
17-7 Shinjuku 3-Chome
Shinjuku-ku
Tokyo 160-91
Tel. (03) 3439-0121

Journal Department
PO Box 55 Chitose
Tokyo 156
Tel. (03) 3439-0124

15

CD-NA-13583-EN-C

OFFICE FOR OFFICIAL PUBLICATIONS
OF THE EUROPEAN COMMUNITIES

L-2985 Luxembourg

ISBN 92-826-3132-X

9 789282 631324