Esprit

European Strategic Programme
for Research and Development in
Information Technology

The Project Synopses

Computer Integrated Manufacturing

Volume 6 of a series of 8

September 1989

Directorate General XIII
Telecommunications, Information Industries and Innovation
Commission of the European Communities

The Project Synopses

Computer Integrated Manufacturing

Volume 6 of a series of 8

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XIII/321/89

LEGEND

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INDEX BY PROJECT NUMBER

INDEX BY ACRONYM

Projects without acronym can be found in the main index

COMPUTER INTEGRATED MANUFACTURING (CIM)

INTRODUCTION

The Computer Integrated Manufacturing (CIM) area relates to the total range of computer integrated manufacturing activities including computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM), flexible machining and assembly systems, robotics, testing, and quality control. The area has been selected for its potential impact on the methods and economies of production, which are strongly geared to success specifically for the IT industries, and for manufacturing industry in general. The world market for CIM products was established as 37 BECU in 1987 and is expected to rise to 64 BECU in 1993.

The main objective of the CIM subprogramme of ESPRIT is to expand the Community share of the market for Computer Integrated Manufacturing to a dominant level in the European market and to achieve a significant penetration of non-EC markets. In addition it is expected that the CIM programme will help to accelerate the modernisation process in a wide range of industries, from discrete parts production to continuous processes, thus improving the competitiveness of the European manufacturing industry.

To work towards this objective, 39 projects have been launched under ESPRIT II to consolidate and extend the advances made by the 32 ongoing and completed CIM projects in ESPRIT I.

The synopses of ESPRIT CIM projects provide a brief description of the objectives, the technical content and the updated state of progress of each project. A list of partner names and a technical contact address, as well as the starting date and the duration, are also given. This volume provides an index of the synopses of projects (including those already terminated) listed in increasing project number order. A cross-reference list of projects identifiable by acronym is also provided.

Overview of the CIM Programme

The ESPRIT strategy is based on three concurrent and interrelated lines of attack. These are:

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

The joint involvement of both vendors and leading-edge users is fundamental to the success of the programme.

The work is divided into the following R&D topics:

1. CIM Architecture and Communications

The ESPRIT strategy is to pursue an approach to integration based on the concept of open systems interconnection (OSI), ie non-proprietary architectures based on the principle that components must be able to interconnect and interwork within a coherent, comprehensive and complete framework which is itself capable of supporting systems evolution. The resultant architectures and protocols, developed, validated and refined in ESPRIT, will be made progressively available to Community manufacturers and systems builders.

2. Manufacturing Systems Design and Implementation

There is a need for methods and tools which reduce the present high costs and long lead times for the design, implementation and optimisation of systems and subsystems, including batch and continuous process plants, factory layouts and shop floor control systems. The methods and tools to be developed should exploit recent advances in AI techniques which provide support to the system designer and increase the number of automatic design procedures available to him or her. The developments should also take into account the necessary verification steps for the design phases.

3. Product Design and Analysis Systems

The product design process is changing rapidly under the influence of IT and there is potential for adopting a new integrated approach to design in order to replace today's fragmented methods. The product model should be the nucleus of future design and analysis systems, and the model should be closely integrated with the main pre-production planning activities, thus eliminating redundancies between the design and production processes.

4. Management and Control of Manufacturing Processes

A unified approach to the control of production would bring considerable advantages to the flexibility and economics of manufacturing. Present systems do not achieve the required degree of integration, although significant advances have been made in ESPRIT, where work on cell and shop floor level control is already underway. Current work on an open system architecture will also support the development of unified systems.

5. Robotics and Shop Floor Systems

The integration of robots and handling systems for materials, parts and tools is currently one of the major problems faced by both vendors and users and it lies on the critical path to achieving fully automated systems in most manufacturing domains. To realise fully the potential of robotic and other shop floor systems, further work towards integrated systems using developments within the overall architectural framework for CIM is required on the IT-based components of these systems. The restructuring of control algorithms and their implementation in specialised hardware is fundamental to success in this area.

ESPRIT I PROJECTS

EXPLOITATION OF REAL-TIME IMAGING FOR ARC WELDING

PROJECT NUMBER: 9

The objectives of this project were to develop image analysis systems for single and multi-pass arc-welding operations, together with sensor and control system interfaces, to achieve the real-time adaptive control of automated welding processes in industrial environments. The programme was as follows:

- initial demonstration of laboratory prototype image analysis equipment (achieved March 1986)
- initial demonstration of pre-production prototype automated welding equipment (September 1987)
- industrial evaluation of pre-production prototype automated equipment (May 1988)
- definition of hardware and software specifications for production equipment (August 1988).

Image analysis systems based on the use of structured and incident light sensors have been tested under simulated production conditions for single pass welding. A robot welding system, equipped with structured light vision sensors for automatic seam tracking, has been developed.

An arc-welding system for multi-pass welding has been developed. It consists of a 5-axis robot interfaced to a grey-scale image processing system. Vision guided multi-pass welding methods are being studied.

Although specialist sensors are currently available, they are limited in application range. The impact of this project will be to increase the range of industrial tasks which can be automated, bringing consequent improvements in the quality and economics of arc-welding operations.

Single pass sensor developments have already been incorporated in industrially evaluated products. Multi-pass sensor applications have been developed and successfully evaluated.

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Start Date	Duration
01-SEP-83	*60 months*

DESIGN RULES FOR COMPUTER INTEGRATED MANUFACTURING SYSTEMS

PROJECT NUMBER: 34

The objective of the project was to produce a comprehensive report detailing recommendations for a proposed set of European design rules for computer integrated manufacturing (CIM) systems. One type of rule relates to the function and design of particular subsystems. A second type of rule relates to the nature, scope and form of the data constituting the interfaces between subsystems. The programme was divided into four parts:

- processing strategy
- communications study/strategy
- integration of processing and communications
- general management.

Five CIM subsystems (CAPE, CAD, CAPP, CAST and CAM) were analysed and flowcharts prepared. These detailed in chronological sequence the activities and procedures required to take a product from initial design to final manufacture.

The end results have been widely used by the developers of systems, whether manually operated or computer based, to define clearly the boundaries within which subsystems operate, and to identify interfacing requirements. The work has made a significant contribution to many other ESPRIT projects.

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Start Date	Duration
01-SEP-83	*12 months*

DESIGN RULES FOR THE INTEGRATION OF INDUSTRIAL ROBOTS INTO CIM SYSTEMS

PROJECT NUMBER: 75

The project had two aims, to develop draft design rules for the integration of robots into Computer Integrated Manufacturing systems and to identify suitable development paths for the design of robot subsystems for CIM. The programme was as follows:

- analysis of applications of industrial robots in current CIM systems
- analysis of user requirements for the integration of robots into CIM systems
- development of alternative structures for the integration of robots to perform basic tasks
- definition of draft design rules for the integration of robots.

Robot application areas were identified and requirement specifications identified trends for future developments. Design rules were formulated for a planning system, for product design of robot-oriented manufacture and technology, and for CAD/robot integration.

Further investigations have been undertaken in ESPRIT Project 623. The design rules information is of value to manufacturing industry, and has already proved useful to other ESPRIT CIM projects.

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Start Date	Duration
20-JULY-83	*12 months*

A COMPUTER INTEGRATED PRODUCTION INSULA: DESIGN RULES AND STANDARDS

PROJECT NUMBER: 92

The objective of the project was to define a Computer Integrated Production Insula environment (CIPI) and the requirements for data and dataflow. It also aimed to define the data interfaces and to investigate the relevance of appropriate standards institutions. The programme was as follows:

- define CIPI environment
- review standards
- analyse database structures
- identify de facto standards
- investigate data interfaces and dataflow
- prepare recommendations for design rules.

The work has been commercially applied by Logica.

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Start Date	Duration
01-SEP-83	*12 months*

GENERAL PURPOSE SENSORY-CONTROLLED SYSTEMS FOR PARTS PRODUCTION

PROJECT NUMBER: 118

The objective of this project was to develop a general purpose integrated sensor-controlled system for parts production, enabling:

- flexible positioning and orientation of parts using 3-D object recognition
- flexible adaptive assembly using multi-dimensional force/torque sensing.

The project included the development of a grey-scale sensor, a modular force-torque sensor system, an ultrasonic range finding system, a direct 3-D sensor and a stereoscopic 3-D sensor. The integration of these sensors in robot-based assembly of car wheels and electromechanical switches has been demonstrated.

The assessment of the demonstration systems in two different industrial environments has given valuable insights into needs and requirements for multi-sensor systems, and hence will directly influence product development.

The displacement-independent force/torque sensor with a wire-reduced transmission system has become a commercial product. The grey scale sensor system has been applied industrially in depalletising applications and in an automotive factory for classifying car wheels emerging from the foundry.

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Start Date	Duration
01-OCT-83	*48 months*

INTEGRATED SENSOR-BASED ROBOT SYSTEM

PROJECT NUMBER 131

The project planned to develop a sensor-based system prototype (vision and tactile) for real-time application in parts handling and/or assembly. The programme was as follows:

- definition of system specifications
- development of a grey-scale vision system for workpiece recognition
- development of continuous path adaptive algorithms for integrated vision and tactile sensors
- development of a test installation for the bin-pitching of unoriented workpieces.

The withdrawal of PCS due to company reorganisation seriously weakened the consortium, causing its eventual dissolution. The same objectives with an amended consortium, a new project definition and recast time horizons were undertaken by project 278.

The sensor integration developed by the project for the handling of parts in an unstructured environment should lead to the development of exploitable products with wide industrial application.

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Start Date	Duration
01-OCT-83	*12 months*

INTEGRATED ELECTRONIC SUBSYSTEMS FOR PLANT AUTOMATION

PROJECT NUMBER: 179

The objectives of this project were to design LSI/VLSI subsystems for the control of machine tools, mechanical manipulators, robots and assembly systems, and to develop a general methodology for control system VLSI design.

The programme was as follows :

Year 1: Detailed study of control systems and circuits. Specification of large scale and very large scale integrated (LSI/VLSI) circuits. Selection of IC technology. Specification of functional circuits to be integrated.

Year 2: Design of LSI/VLSI circuits. Specification and initial development of design methodology.

Year 3: Design of a DC servo interface chip (current controller). Development of design methodology.

Year 4: Test of a DC servo interface chip. Design of an AC servo interface chip. Design of matrix co-processor chip.

Year 5: Pilot application of chips. Verification and testing of the design methodology.

A current controller for DC drives, an AC servo interface chip, and a matrix co-processor, have been selected for design in VLSI.

The current controller chip has been completed. Circuit design of the AC servo interface and the matrix co-processor have been completed.

The availability of these LSI/VLSI subsystems will permit the development of cheaper controllers with enhanced performance.

The LSI/VLSI designs will be available for third parties. The design methodology will be made generally available and will be supported by manuals, seminars, etc.

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Start Date	**Duration**
01-AUG-83	*60 months*

COMPUTER-AIDED THERMAL IMAGE TECHNIQUE FOR REAL TIME INSPECTION OF COMPOSITE MATERIAL

PROJECT NUMBER: 197

The objective of this project was to develop a real-time thermal image processing system for the identification of flaws in fibre reinforced composite materials. The technique involves the application of a short thermal radiation pulse which, as it diffuses through the target, appears as a time varying surface temperature change, to be monitored by a high resolution thermal scanner. The programme was as follows:

- Development of low noise thermal scanner, yielding multiple 2-D views with high resolution.
- Development of image restoration and reconstruction algorithms yielding 3-D structure from 2-D sequences.
- Development of software to recognise flaws from image processed views.
- Integration of hardware and software components into a prototype real-time thermal image processing system, operating in an industrial environment.

A complete solution has been developed for solving the inverse problem of identifying interior flaws from surface thermograms. 3-D simulation models for thermal propagation have been developed which have been used to collate a Database of thermal response parameters for composite materials. Numerous image processing techniques, including mathematical morphology, have been employed to size and characterize flaws.

A real-time prototype system has been developed and its preference assessed both on synthetic samples, and on numerous practical composite parts, in industrial (manufacturing) environments (at Westland Helicopters).

The project was completed in June 1988, and a final report has been submitted.

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Start Date

01-OCT-83

Duration

60 months

INTEGRATED SENSOR-BASED ROBOT SYSTEM

PROJECT NUMBER: 278

The objective of this project was to develop advanced tactile and vision sensor systems, a sensorised gripper system and a sensor integrating robot controller, and to integrate these into a flexible workpiece handling system capable of dealing with randomly-oriented parts in an unstructured environment. The integration of such a system with CAD will also be investigated.

A number of parallel subsystem developments provided prototype hardware and software subsystems (tactile sensors, gripper, vision system, and robot controller). These were then incorporated into a main test bed configuration. The vision system provided initial guidance to locate touching and non-touching parts. The tactile system incorporated into the gripper provided correction data. Orientation of the workpiece was facilitated by a rotation capability built into the gripper fingers. Integration was achieved between all the major subsystems enabling the successful demonstration of a sensor based robot workpiece handling system.

The sensor integration developed by the project for the handling of parts in an unstructured environment should lead to the development of exploitable products with wide industrial application.

Work on vision and on the controller has already led to successful commercial exploitation by Joyce Loebl (Vickers) and Bosch. A dedicated manufacturing facility established by MARI for a product range based on the tactile sensor development is in commercial production. IPA has exploited the results through seminars for leading industrial companies and contracts for material flow planning.

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Start Date	Duration
01-JAN-85	*36 months*

KNOWLEDGE & DECISION SUPPORT FOR MATERIAL HANDLING SYSTEMS

PROJECT NUMBER: 293

The objective of this project was to investigate the applicability of knowledge based techniques for modelling material handling systems to improve the efficiency of the design process and to optimise performance and cost. The programme was as follows:

- specify design of cost modelling functions and cost database
- define information and modelling structures for decision support within material handling systems
- implement modelling functions into decision support within the material handling system and generate a cost database for a special material handling application
- verify prototype for cost modelling in material handling application
- specify modelling knowledge base and develop a prototype implementation using suitable artificial intelligence tools
- integrate prototype and decision support system in one tool.

A prototype cost modeller has been completed. Categories of cost data and of cost calculation algorithms have been finalised. By using the Manufacturing Description Method (MDM), a layout oriented representation has been generated from a functionally oriented representation. Material handling system design knowledge has been classified as a major step towards the envisaged expert system.

The project was terminated prematurely after one year of work.

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Start Date	Duration
01-SEP-85	*36 months*

DATA TRANSFER BETWEEN CIM SYSTEMS & MANAGEMENT INFORMATION SYSTEMS

PROJECT NUMBER: 319

The purpose of this project was to substantially improve the integration of CIM with management information products and systems for small and medium-sized enterprises (SMEs). The principal goal of the project was to develop design rules to assist the task of interfacing data between factory-level CIM and management-level business systems in these types of enterprises.

The manufacturing process (factory-level CIM) was defined for the purposes of this project as product design, production process, product distribution, manufacturing plant, equipment, workforce, and the actual transaction level of the accounting process. The management process was defined as the reporting, analysis, and control elements used by management to co-ordinate the manufacturing process to ensure achievement of company objectives.

The programme was as follows:

- to specify the most significant data interfaces between factory-level and management-level processes for SMEs
- to study appropriate data transfer methods for the interfaces at various stages of CIM development
- to establish Design Rules for the specification of these commonly used interfaces
- to develop prototype subsystems for data transfer using the Design Rules
- to evaluate the benefits of the application of these Design Rules in a variety of industrial situations
- by widespread dissemination of project results, to improve the common approach whereby factory level CIM and business system markets are separately addressed by products and systems.

A study of progress and implementation of CIM subsystems in companies in the UK and Ireland was carried out by making case studies and by reference to published survey results. This study led to the identification of industries which were likely to benefit from CIM, and to the priority interchange points selected for the development of experimental prototypes providing these linkages.

The design rules developed by the project and validated by the prototype tests, have been submitted to the Task Force for final approval before publication. When published (by Springer Verlag) it will provide guidance to SMEs for the introduction of computer integration to factory and management levels. There are

two main target audiences for these design rules: designers and integrators offering Information Technology systems to the market, and system users wishing to enhance the application of existing systems or seeking guidance on systems to ensure future integration compatability.

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Start Date	Duration
01-JAN-85	*36 months*

CAD INTERFACES (CAD*I)

PROJECT NUMBER: 322

The objective of this project is to develop a family of consistent, compatible standardised interfaces for CAD, allowing:

- representation of 2-D and 3-D geometrical models of CAD design objects
- archiving and retrieval of these models by various CAD/CAM systems
- exchange of such models over networks
- storage of parametrised part libraries in databases connected to networks
- access to such libraries from various CAD/CAM systems
- use of advanced modelling techniques for model generation
- standardised application of different finite element model analysis programs
- comparison of experimental and analytical dynamic analysis results
- dynamic model optimisation resulting from experimental and analytical analysis.

The availability of a standard interface will facilitate the free flow of geometrical design data between different CAD systems without expensive conversion and data restructuring. It will also permit CAD systems to be interfaced with Computer Aided Engineering systems, such as those used for the static and dynamic analysis of structures.

The project has produced the main portions of the projected international STEP standard, adopted as draft proposal by ISO TC184 SC4 in December 1988. CAD*I contributions include the neutral file for CAD geometry (covering solids, wireframes and free form surfaces), a high level data specification language (HDSL), and an interface to finite element analysis systems. Many partners have incorporated the interface into commercial products, eg Leuven Measurement and Systems (CADA LINK, CADA TEST and CADA MODAL), which has implemented the interface in a product for the experimental testing of dynamic behaviour in the development of eg. machine tools, cars and aircraft. BMW has implemented the standard interface internally.

A wide range of CAD interface pre- and post-processors and dynamic analysis systems developed within the project are available. KfK is providing CAD geometry interface software to a German CAD vendor for incorporation in marketable products.

Programs to perform syntactical and semantic checks (SYNTAX) and statistical analyses (STATISTIC) of IGES files have been licensed by BMW.

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Start Date	Duration
01-NOV-84	*60 months*

PRODUCT DESIGN FOR AUTOMATED MANUFACTURE & ASSEMBLY

PROJECT NUMBER: 338

The objectives of the project were to:

- provide the designer with information which would enable him to design products which are compatible with automated manufacturing and assembly systems

- investigate the alternative methods of making this information most readily available to the designer.

A set of design rules has been generated as the result of a detailed analysis of the constraints imposed by different automated and robotic assembly techniques. These have been validated in the light of applications experience available from the industrial partners in the consortium. The design rules have been categorised under the headings: Part Reduction, Part Quality, Part Production, Part Geometry and Shape, and Part Handling.

A set of design rules has also been developed to assist in the design of components intended for manufacture in a flexible machining cell. These have been categorised under the headings: Standardisation, Tooling Related, Handling Shape, Dimensions, Tolerances, and Surface Finish.

A structured framework has been developed within which process capability data can be stored. The designer is given access to the data through a menu driven computer program, leading him to the appropriate data under the headings: Linear Dimensions, Surface Finish, Geometric Shapes and Relationships.

Initial work has been carried out to investigate the possibility of deriving some elements of product design information directly from the CAD system. This has been shown to be possible, for example in obtaining information on component symmetry which is important in assessing the difficulty of handling and orientating parts during assembly operations.

Consideration has been given to the use of an expert systems approach to the presentation of design rules to the designer. Six modules of design advice are available in an expert systems shell covering product design for: transportation, orientation, handling, insertion, structure and parts reduction.

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Start Date	**Duration**
01-FEB-85	*60 months*

INTEGRATED INFORMATION PROCESSING FOR DESIGN, PLANNING AND CONTROL OF ASSEMBLY

PROJECT NUMBER: 384

The objective of this project is to demonstrate the principle of an integrated information processing system covering the design, planning, scheduling and control phases of small batch assembly in the mechanical and electromechanical industries. The main advances are in the level of integration, in the system's ability to make a high level description of the assembly process and in the demonstration of decision support tools used to achieve this end. Control and monitoring of an assembly cell has also been demonstrated.

The programme is as follows:

Initial Phase: Study existing assembly related systems and establish artificial intelligence implementation methodologies for automated assembly.

Development Phase: Develop the system specification, gather assembly expertise and define data structures required. Develop the proposed system as two integrated subsystems: product development (CAD, product structure, connection selection, assembly planning) and production subsystem (assembly scheduling, cell scheduling, assembly cell control). Develop a testbed system to demonstrate results.

Studies of assembly systems and AI implementation methodologies have been completed. A target system has been defined which will allow a highly integrated approach based on emerging AI techniques. The validity of the system has been tested by constructing a functional prototype that contains the functions, modules and models indicated by the target system, which even if embryonic in form are fully integrated. Prototype software modules are being developed based on an enhanced internal architecture and with attention being given to the requirements of potential end users.

Flexible Automated Assembly Systems (FAAS) are potentially a key market area for IT vendors. The availability of comprehensive integrated information processing systems with good decision support tools could lead to high revenues annually.

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Start Date	**Duration**
01-APR-85	*60 months*

DEVELOPMENT OF AN INTEGRATED PROCESS AND OPERATIONS PLANNING SYSTEM WITH THE USE OF INTERACTIVE 3-D MODELLING TECHNIQUES

PROJECT NUMBER: 409

The objective of the project is to develop an interactive, graphically manipulated process and operations planning system to close the gap between CAD-model data, factory administrative data and the manufacturing facilities. A particular emphasis is the fast and economical interactive preparation of detailed process plans and NC programs using CAD data. The programme is as follows:

- initial design of the system using detailed studies of existing systems as a basis

- sequential development of programming systems for three-dimensional milled parts, turned parts and multi-axis milled parts

- assess the integration of the programming of measuring machines.

In parallel with the above, CAD systems will be developed to provide all data necessary for planning the production of parts which may be described in two and three dimensions.

An extended prototype of the EUCLID-EXAPT integration has been prepared which is operational at a work station. The extensions which have been developed within the framework of the project have been integrated into the EUCLID and EXAPT systems established on the market.

The availability of this system will considerably reduce the time between the design of mechanical parts and their manufacture. Early spin-offs are planned. EXAPT expects to market the extensions of its software together with the EXAPT system.

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Start Date	**Duration**
01-DEC-85	*60 months*

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

PROJECT NUMBER: 418

The objective of this project was to develop methods and tools for the design of open, highly integrated production management systems for the purpose of supporting improvement of existing systems as well as the design of new ones.

The target domain is small batch, flexible, discrete manufacturing.

The project has provided the following results:

- User manual, including an application of the GIM Method, an integrated method for the analysis and design of manufacturing systems.

  Computer tools relevant for the support of this method are evaluated and specifications are provided for improvements and integration of tools.

- The MMCS Architecture, an open, integrated architecture with multi-level planning and scheduling, providing predictive and dynamic production management and control.

  Implementation models consistent with the ISO-OSI model and relevant international standards are provided for the shop and cell manager and the principles for the communication and control of work stations are specified in detail.

- A shop scheduler prototype has been developed, pioneering knowledge-based facilities for schedule evaluation, improvement and repair.

- A cell scheduler prototype has been developed, featuring dynamic, finite capacity planning and scheduling using a hierarchical procedural network for the stepwise refined schedule.

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Start Date	Duration
01-APR-85	*60 months*

CONTROL SYSTEMS FOR INTEGRATED MANUFACTURING (COSIMA)

PROJECT NUMBER: 477

The objective of this project is to design, develop and test the software modules required for Production Activity Control (PAC), of small batch manufacturing. The aim is to close the loop between production planning and execution, reducing human intervention and reaction time as much as possible, and relying on data automatically captured from the shop floor. The programme is as follows:

Year 1: Definition of user requirements; production control architecture definition.

Year 2: Functional specification for production control; definition of algorithmic building blocks.

Year 3: Delivery of simulation capabilities; design of application generator; release of application network.

Year 4: Delivery of building blocks; delivery of application generator.

Year 5: PAC application generated from PAC application generator; global evaluation.

User requirements have been identified and analysed. A global architecture for Production Activity Control has been defined, as well as a simulation environment. A novel method of modelling flow through production systems, based on Petri nets, has been developed. The original top down approach has been modified and a bottom-up approach has been followed to better understand manufacturing and to develop the software prototype.

The project's results will fill a gap in the range of CIM applications in small batch manufacturing. The ability to configure a Production Activity Control system to the requirements of a specific manufacturing environment will facilitate reductions in unit costs and improve flexibility of response to market requirements.

The first live production application of the technology was put in place in a PCB manufacturing plant, Digital Clonmel, early in 1989, and performance is currently being evaluated. Two further application pilots are being commissioned in the Renault automobile engine plant at Cleon, and at the COMAU Grugliasco plant for machine tool manufacture. These pilots will be operational in October 1989.

Production and commercial exploitation of the integrated PAC system will commence in early 1990.

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Start Date	Duration
01-JAN-85	*60 months*

DESIGN AND SPECIFICATION OF CONFIGURABLE GRAPHICS SUBSYSTEMS FOR CIM (PAPILLON)

PROJECT NUMBER: 496

The objective of the project was to develop a software environment to enable the configuration of graphics software to fulfil the varying application dependent requirements of CIM graphics subsystems. The programme of work consisted of:

- identification and classification of the differing requirements for graphics in the various areas of CIM
- overall design and specification
- design, specification and implementation of kernel software modules
- design, specification and implementation of utility functions, man-machine interface and CIM application
- assembly and testing of a prototype graphics system satisfying the requirements of a CIM applications area.

An object-oriented approach to the design was adopted to ensure configurability. An Ada implementation of GKS was developed with a skeleton device driver to increase subsystem portability.

The ability to configure graphics hardware and software modules to specific requirements within CIM should provide the basis for a range of products with wide application. A software tool enabling software engineers to build Ada applications by coupling object-oriented design with sophisticated graphical interfacing techniques was announced by Generics Software in January 1988.

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Start Date	Duration
01-DEC-84	*36 months*

PLANT AVAILABILITY AND QUALITY OPTIMISATION (PAQO)

PROJECT NUMBER: 504

The objective of this project has been to develop technology for efficient integration of process and machine monitoring and diagnostics with the control of discrete parts manufacturing plants at the machine and cell level. It aims at providing the plant with a degree of fault tolerance through improved control during abnormal or fault conditions thus maximising plant availability, product quality and operational safety.

An early demonstration of methodology was made during 1986 using a stand-alone milling machine. This machine was fitted with various sensors including a unique "tactile" machine spindle which was designed and built by the consortium. Real-time model based diagnostics of the cutting process as well as the machine drives was demonstrated together with a net-based software tool permitting the application of expert knowledge to machine surveillance and action planning.

A full scale demonstration of an integrated fault tolerant control system operating with a flexible machining cell based in Spain was achieved to conclude the project in December 1988. This included the use of a prototype modular data acquisition and analysis computer which was designed and built by the consortium and which has now been commercially exploited at other sites. The system operated through a local area network developed by the Spanish partners and cell control was coordinated by an "Expert" cell controller operating on a PC.

Automated monitoring and diagnostics which is integrated with machine or cell control offers financial benefits arising from reduction in waste and machine damage and increased productivity through higher machine availability and efficient rescheduling to avoid problem areas.

Commercial exploitation of the computer hardware and software in the area of real-time process surveillance and diagnostics as well as the system integration tools is well advanced.

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Start Date	Duration
01-JAN-85	*48 months*

DEVELOPMENT OF A FLEXIBLE AUTOMATED ASSEMBLY CELL AND ASSOCIATED HUMAN FACTORS STUDY

PROJECT NUMBER: 534

The objective of this project was to design and develop a prototype automated flexible assembly cell for the manufacture of mechanical assemblies of up to 0.5 cubic metre size and 30 kg weight, in low batch quantities, ideally as low as one. The project aimed to combine vision, manipulation and non-contact inspection technologies into an integrated system.

The project was terminated early, due to the withdrawal of the prime contractor. However, the following was achieved:

- a design for a highly flexible assembly system
- an extremely versatile parts transfer system
- an innovative robot vision system demonstration using optical image processing technology
- a modular gantry type assembly robot
- a highly versatile robot gripper design
- a concept for non-contact gauging during the robotic assembly process
- a set of criteria for the inclusion of human factors in the design of CIM systems and methods of enhancing their usability.

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Start Date	Duration
01-JAN-85	*60 months*

THE APPLICATION OF CIM TO WELDED FABRICATION

PROJECT NUMBER: 595

The objective of this project is to apply CIM concepts to the heavy welded-fabrication industry, replacing the traditional "islands of automation" approach with an integrated approach which can be developed and exploited economically. The programme was as follows:

- Analysis of heavy fabrication manufacturing systems using Data and Functions Networking (DAFNE) methodology.

- Design of a generalised CIM framework using DAFNE.

- Development of selected production subsystems within the CIM framework, eg automated welding cells with CAD-simulation cell-instrumentation quality control linkages. Study of Computer Aided Production Management.

Arc welding cells have been developed, and the links to the necessary subsystems: quality inspection, instrumentation, databases, CAD, simulation and off-line programming are defined and demonstrated. The organisational and production models of heavy fabrication have been studied with the use of appropriate methodology tools (DAFNE) and a General Reference Model for the industry type has been produced.

Successful implementation of a CIM architectural model, adapted to welding in heavy industry (eg shipbuilding), has demonstrated the opportunities for considerable improvements in productivity and product quality and help to make the industry more responsive to market needs.

The two project demonstration cells make use of simulation and off-line programming through the application of modular and structured techniques for generating welding torch trajectories.

Weld cell performance is also monitored via a specially constructed data gathering and file system which will have the potential for real time intervention including adaptive control of the weld production activities.

The industrial partners in the project have adopted the results and developed them for their own industrial exploitation.

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Start Date	Duration
01-AUG-84	*60 months*

OPERATIONAL CONTROL FOR ROBOT SYSTEM INTEGRATION INTO CIM

PROJECT NUMBER: 623

The objective of this project is to specify and build prototype systems to demonstrate the integration of robots into CIM systems. The critical path of this integration concerns the operational level of CIM systems and includes two closely interrelated fields of research: the design of a computer-aided layout planning system and the design of an off-line programming system for robots integrated into CIM systems.

The project has three strands of work:

- development of an explicit programming system for robot control which is integrated with work-cell architecture
- development of a knowledge-based implicit programming system
- development of a planning system for robotised cells.

Work in the three areas will proceed simultaneously. In all cases, definition and specification of software modules will be followed by their development, application and demonstration in real or simulated industrial environments.

Design rules for the integration of robots into CIM have been defined and published. In April 1988 the following project groups for realising demonstrator systems have been installed to integrate realised components and subsystems developed in the area of Systems Planning, Explicit and Implicit programming:

- integrated planning and Explicit Off-Line Programming System (demonstrated in October 1988).
- task Level Programming System (demonstrated in April 1989)
- high Level Interpreter (demonstrated in April 1989)
- planning and Interactive Programming System (to be demonstrated in October 1989).

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Start Date	Duration
01-FEB-85	*60 months*

A EUROPEAN COMPUTER INTEGRATED MANUFACTURING ARCHITECTURE (AMICE)

PROJECT NUMBER: 688

The objective of this project was to design an open systems architecture for CIM and to define a set of concepts and rules to facilitate the building of future CIM systems.

CIM-OSA is composed of a consistent set of complementary reference models capable of modelling the enterprise requirements, in terms of functions, information, resources and organisation, and modelling the implemented CIM systems derived from the requirements model. A key part of the implementation model is the Integrating Infrastructure, dealing with the definition of the integrating services like communications, information, machine and human front-ends, and the business process.

The Integrating Infrastucture builds on and uses the upper layers of the ISO Open Systems Interconnection model concentrating on layer 6 (presentation) and layer 7 (applications). The work is complementary to the Manufacturing Automation Protocols (MAP) initiative and to CNMA (ESPRIT project 955).

A public document defining the CIM-OSA reference architecture specifications has been published.

The project is expected to have a major impact on international standardisation in CIM. A standards proposal on the CIM-OSA modelling framework has been submitted to ISO TC 184 and another one on the Integrating Infrastructure Framework is currently being prepared. It is the intention to base future specific standards proposals on these frameworks.

The architecture will be employed by both users and vendors in the consortium in evaluation and planning their future developments. Promotion of CIM-OSA includes presentations and demonstrations at international events, publication in international journals and the use of modern media education.

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Start Date	Duration
01-OCT-84	*52 months*

ADVANCED CONTROL REAL-TIME CIM SYSTEMS AND CONCEPTS FOR FLEXIBLE AUTOMATION

PROJECT NUMBER: 809

The objective of this project was to develop, implement and integrate advanced control system techniques to improve the control of manufacturing systems for small-batch production machined parts at the machine and cell level. The system developed will be modular, to allow progressive implementation, and will be demonstrated in real production environments. Work on the project includes:

- integrating advanced information processing techniques into machine control systems
- developing data capture and analysis techniques to treat system perturbations in real-time
- adopting and implementing standard interfaces between the system and CAD, CAM, CAE and CAP systems.

The integration of the system is reaching completion with successful demonstration of the initial linking of the information with the scheduling and monitoring systems. The expert system shell has been completed. The results of the research are being implemented at the demonstration site at Morskate BV in the Netherlands.

The major impact will be to decrease the lead time for the manufacture of small batches of machined parts and to increase system availability. An important feature of the modules being developed will be that they can be retrofitted to existing production systems, allowing progressive advances in the level of automation.

The system, including DNC and machine monitoring, has been installed. Exploitation of control, data capture and analysis, and decision support systems will follow.

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Start Date	Duration
01-MAR-86	*48 months*

EXPERIMENTAL CENTRE FOR SYSTEM INTEGRATION IN CIM

PROJECT NUMBER: 812

The objective of this project is to provide a centre where tools, subsystems and prototypes developed in ESPRIT CIM projects can be integrated, tested and refined in a near production environment. The centre, providing the necessary basic hardware, software and manufacturing equipment, will be developed from an existing test facility. European standardisation efforts will be supported by implementing emerging communications and system architectures standards. The programme was defined as follows:

- definition of the functionality and mode of operation of the centre
- definition of specifications for the communications systems, data structures, hardware subsystems and manufacturing characteristics
- design and installation of software and hardware systems and manufacturing equipment for the Centre
- development of integration modules and an appropriate user interface.

All essential elements of the programme have been achieved and the Centre, comprising manufacturing hardware and integrated CAD, CAM and CAP modules, has been installed. The Centre architecture is convergent with that defined in EP 688, CIM-OSA, and the backbone communications network is capable of migration to specifications outlined with the projects 955 and 2617, CNMA.

The availability of the Centre will accelerate the exploitation potential of CIM modules developed by teams using the Centre and generally facilitate CIM system integration. The increased exploitation potential arising from the impact of the Centre will be available to project teams beginning in late 1989.

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Start Date	Duration
01-APR-86	*36 months*

PREDESIGN OF FMS FOR SMALL BATCH PRODUCTION OF ELECTRONIC CARDS

PROJECT NUMBER: 850

The objective of the project was to produce a provisional specification for an Application and Development Centre.

The programme was as follows:

- study of demand and production of PCBs by SMEs in Europe
- study of assembly methods and return on investment versus volume and variety
- analysis of present and future assembly machines, soldering technologies, inspection, automated materials handling and warehousing
- specification of centre facilities including integration with CAD/CAE, manufacturing, planning and control and transport and storage.

The study was intended to be preparatory to the establishment of an ESPRIT Application and Development Centre.

The study results are being used directly by the three partners and are available to other SMEs involved in PCB production for the selection of manufacturing hardware and the configuration of manufacturing systems.

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Start Date	Duration
01-APR-86	*12 months*

DEVELOPMENT OF TOOLS FOR ECONOMIC EVALUATION OF CIM IN SMALLER MANUFACTURING COMPANIES

PROJECT NUMBER: 909

The objective of this project was to develop strategies and methods for the economic evaluation of CIM systems, supported by a set of tools (known as C-BAT). The tools have been tailored to the needs of small manufacturing enterprises and are portable to a range of widely available personal computers (IBM AT compatibles using MS-DOS). The tools are able to accommodate the effects of different national investment programmes, different timescales for implementation, and varying levels of industrial sophistication. The programme was as follows:

- gather data and prepare C-BAT provisional specification
- analyse requirements and complete C-BAT specification
- develop and verify methods and toolkits
- implement C-BAT at demonstrator site and at industrial sites in the partners' member states.

The partners evaluated requirements by meeting over 50 CIM users and potential users in their member states. A survey of existing methods of CIM investment evaluation was completed before a provisional specification was generated. The specification included a suitable methodology, supported by a set of tools. The tools were designed, programmed and developed at the partners' sites.

C-BAT provides a powerful tool for SMEs wishing to introduce CIM concepts. By facilitating the analysis of alternative approaches, taking into account both direct and indirect effects, better investment decisions will be reached and risks will be reduced.

AMTRI and BIBA are using the tools for commercial training and consultancy.

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Start Date	Duration
01-JAN-86	*36 months*

KNOWLEDGE-BASED REAL-TIME SUPERVISION IN CIM

PROJECT NUMBER: 932

This project has the following objectives :

- To develop a dynamic scheduling system for the factory based on Knowledge-Based System (KBS) techniques. The system will bridge the time gap between the large planning horizons of logistic systems, eg COPICS/MRP II, and the real-time conditions on the shop floor (microplanning).

- To develop generic shells for: knowledge acquisition modules both for factory analysis and factory operation; user interface modules for different kinds of operators, including management in the factory using KBS techniques and multi-windowing; expert systems for production planning, preventative maintenance and quality control.

- To build these modules, implement them in two very different plants (electronic appliances and tyre manufacturing), and test the applicability of one generic shell to such different applications.

The programme includes the development of:

- Software modules for plant data acquisition, real-time plant data updating, interpretation KBS, plant simulation.

- KBS for maintenance, quality, and process planning.

- Knowledge acquisition modules for GRAI and SADT analysis methodologies.

The decision network acquisition tool (DNAT) has been programmed and the decision network analysis of the factories finished. The workcell controller for SMD (surface mounted devices) workcell has been designed at Philips. The general system design has been finished for the dynamic planning task at Pirelli and BICC. The diagnosis KBS has been programmed for Pirelli. Demonstrations are available for:

- workcell controller at PFH

- AI simulation of FMS at PFH

- diagnosis KBS at ARS

- planning KBS at BICC

- commonality analysis of electronic products at PZI

- planning KBS at AEG

(3)

- DNAT tool at Graphael/SGN

- knowledge acquisition tool at Politecnico di Milano.

The use of KBS for dynamic scheduling will enable a rapid response to changes in requirements and in machine and material availability. The first KBS was introduced into the Pirelli factory during 1987. Piloting of workcell controllers in Philips CIM production line took place in late 1988 for short term production planning. It will be followed by quality and maintenance controllers in late 1989. Final result of the project will be the description of the various KBSs developed by each partner following the project's CIM-AI Implementation Guide.

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Start Date	**Duration**
01-JAN-86	*48 months*

COMMUNICATION NETWORK FOR MANUFACTURING APPLICATIONS (CNMA)

PROJECT NUMBER: 955

The objective of the CNMA project was to select, implement and demonstrate profiles of existing and emerging communications standards in real production environments, thus extending MAP developments. Widespread acceptance of the communications methodology was encouraged by providing implementation guides and common testing procedures. The project addressed all layers of the ISO/OSI model, but particularly layers 6 and 7.

The development and compilation of the implementation guide and conformance testing tools proceeded concurrently.

A Phase I Implementation Guide was published in October 1986 and was widely circulated. The Phase 2 Implementation Guide was published at the beginning of 1988.

The achievements of the first phase of the project were demonstrated at the Hanover Fair in April 1987. A typical manufacturing cell was controlled by computing hardware from five vendors, interworking by using CNMA communications software. The success of this demonstration drew attention to the feasibility of multi-vendor systems and affected the development of the relevant international standards.

The CNMA Phase 2 software was demonstrated by participation in the Enterprise Networking Event '88 International in Baltimore in June 1988. This underlined the compatibility of the CNMA and MAP profiles of communications standards, and provided an opportunity for Europe to influence the development of MAP standards. Siemens demonstrated a MAP 3.0/SINEC gateway at the 1989 Hanover Fair. A product release based on this device is planned for the third quarter of 1989. The CNMA profiles are used in real production applications by BMW, British Aerospace and Aeritalia. Parallel to the specification and development of communications software, conformance testing tools were released to testing institutes.

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BULL MTS	*F*	*P*
BMW-BAYERISCHE MOTORENWERKE AG	*D*	*P*

Start Date	Duration
01-JAN-86	*36 months*

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

PROJECT NUMBER: 975

The objective of this project is to develop a transponder system for the identification of parts and assemblies flowing through automated assembly plants. The transponder must fulfil the following requirements:

- the ability to survive reliably all manufacturing processes involving vibration, dust, oil, acid, paint and heat
- no requirements for special positioning of transponders or interrogators
- no faults in allocation even in high-density stocking
- programmability.

The results will be applied to the computer integrated manufacture of automobiles, where up to now no information carrier is available which can be used throughout the total manufacturing process.

They are furthermore targeted for application in material flow management systems, which are essential in CIM environments.

The hardware and software requirements have been defined. Transponders with 2K byte storage have been developed and tested. The data transfer rates have been speeded up by a factor of 5 to 10. Software for connecting read/write stations to automobile manufacturing workstations has been developed. A first test has shown encouraging results. In the near future interfacing to another automotive plant will be started.

The intelligent transponder system will enable the reliable and efficient tracking of parts through the factory as well as outside the factory. The provision of local storage will considerably reduce the load and the dependency on the central CIM database and on the related communication channels.

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Start Date	**Duration**
01-APR-86	*36 months*

COMPUTER-AIDED ENGINEERING SOFTWARE FOR ADVANCED WORKSTATIONS IN THE CIM ENVIRONMENT (ACCORD)

PROJECT NUMBER: 1062

The objective of this project is to develop an enhanced CAD environment (ACCORD) for performing design analyses for CIM in the electronics industry.

The work is concentrating on the development of:

- APPEAL (ACCORD Parallel Processing Engineering Analysis Library), a software package which will bring improvements in the computational speeds of numerical procedures commonly used in design analysis tools.

- ASSET (ACCORD Suite of Software Engineering Tools), a software package which will provide a unique integrated environment for performing thermal, reliability and cost analyses to evaluate ranges of design options to improve functionality and reduce costs.

The basic structure of APPEAL has been specified and will comprise two levels:

- Level 1 routines, containing basic building blocks that address maximum commonality areas in engineering computational methods such as matrix, vector and scalar operations, linear operations, eigenvalue solvers, quadrature calculations, finite element basic functions, naive matrix assembly, coordinate geometry, special and utility functions. The first level of APPEAL will be founded on existing low-level libraries such as BLAS (Basic Linear Algebra System).

- Level 2, containing example programs that are constructed from a combination of calls to level 1 routines (for example solving a nonlinear set of equations).

APPEAL will initially be implemented for FPS, IBM 3090, CRAY XMP/48 and the TRANSPUNTERS. Specifications for the structure of ASSET have also been completed. A common database, managed by a relational system, INGRES, will allow convenient exchange of design information across the three analysis domains that are initially considered in ACCORD (viz: thermal, reliability, cost analyses). Relevant analysis tools, such as resistive network modelling, reliability prediction, fluid-flow modelling and availability prediction will be integrated in the suite with a common user interface. A novel software suite devoted to life-cycle costing of systems (LCC) will be developed and integrated with ACCORD later in the project. ASSET will initially be implemented on VAX under VMS.

Demonstration prototypes for both APPEAL and ASSET are running. Some improvements have been decided and an integrated ASSET/APPEAL demonstration is planned.

This project will strongly promote the use of advanced analysis tools and methods within the designer community.

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Start Date	Duration
01-JUL-86	*48 months*

DISTRIBUTED AUTOMATED SYSTEM FOR INSPECTION AND QUALITY CONTROL (DASIQ)

PROJECT NUMBER: 1136

The objective of the project was to design a new distributed system for inspection and quality control in flexible manufacturing systems (DASIQ). DASIQ will comprise three subsystems: inspection of surface finish, coarse dimensional control, and high precision inspection. The programme included:

- The design of the system architecture and the definition of distributed sub-systems and interfaces.
- The design of inspection sub-systems capable of interfacing with most types of existing sensors for data acquisition and information processing.
- The integration of already existing optical inspection techniques.
- DASIQ will provide diagnosis and alarms for the FMS management system. Special attention will be paid to the interfaces with CAD.

The design of the different inspection subsystems has been completed.

The automation of inspection and quality control in flexible manufacturing systems by the introduction of DASIQ will increase productivity and reduce costs.

The project had to be terminated after three years due to withdrawal of one of the partners.

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MICROTECNICA	*I*	*P*

Start Date	Duration
01-MAR-86	*48 months*

HUMAN-CENTRED CIM SYSTEM

PROJECT NUMBER: 1199

The objective of this project is to develop a prototype manufacturing system comprising integrable CAD, CAM and CAP packages in which the roles of human operators are optimised. The system will be implemented at user sites.

The flexibility and robustness of the human-centred approach will be proved by demonstrating machine/cell programming, planning and scheduling in a mixed human-oriented/conventional automation environment.

There will be three CAM demonstrations. One will be at the Rolls Royce Leavesden plant and will demonstrate a human-centred turning cell comprising turning centres, gantry work handlers and a cell controller. The second will be at the Selectro factory near Portsmouth and has been developed by BICC to demonstrate human-centred production principles within a small cell manufacturing electrical connectors. The third demonstration site will be at BITZ on the campus of the University of Bremen. Here CAP packages wil be demonstrated providing basic shop floor cell scheduling capabilities. A sketching module has been developed by the CAD group, which enables hand sketches to be drawn, discussed and finalised, and the data transmitted electronically to a CAD system. The sketching module will also be demonstrated at the BITZ demonstration site.

By employing a human-centred approach, as opposed to the 'total automation' approach, areas will be identified where the use and development of human skills within a CIM environment can be more effective than the conventional automation approach.

BICC, Krupp Atlas Elektronik, Rolls Royce, R D Projects, NEH Engineering and BIBA expect to market a range of products and services based on the work of this project during 1990.

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UNIVERSITAT BREMEN	*D*	*P*

Start Date	Duration
29-MAY-86	*36 months*

VISUALISATION STANDARD TOOLS IN MANUFACTURING INDUSTRY (VITAMIN)

PROJECT NUMBER: 1556

The main objective of this project was to develop tools, based on UNIX and X-Windows, to help the design and use of user interfaces and graphic subsystems on the shop floor in manufacturing industry. Two application areas were selected with corresponding graphics subsystems:

- the Active Management Dashboard (AMD) for production systems with a low level of automation
- the Active Control Dashboard (ACD) for the remote control and supervision of systems with a higher degree of automation, mainly in the mechanics industry.

For each area an industrial test bed was defined:

- for the AMD it was built around SYSECA's package ORDO for real-time production scheduling
- for the ACD it was built around MANNESMANN KIENZLE's package KIBIS for workshop planning and management.

The development was engaged in two parallel and complementary ways:

- short term approach based on toolkit design and use
- long term approach based on user interface management system (UIMS) design and use.

The toolkit approach led to redesigning ORDO and KIBIS. Functional analysis of manufacturing production management was performed and the AMD external specifications produced. This allowed the design of a toolkit - a library of user interface objects - and its use for implementing the AMD user interface. The resulting prototype was evaluated on a test bed in the Bull plant in Belfort (F). After architectural analysis the internal ACD specifications were produced whilst an X-Window system protocol was implemented. A business graphics library, GKS and window managers were then layered onto both MANNESMANN and BULL hardware.

The objective of the UIMS approach was to provide the man machine interface (MMI) engineer with tools that generate automatically the user interfaces code. It was based on the Seeheim model which divides a user interface into three logical components for: Presentation techniques (PT), Dialogue control (DC), and Application interface (AI). In a first step the MMI programmer specifies the Builder (UIMB) which generates the source code of the user interface (UI monitor), using

the so-called skeleton technique. Compilation of this code and linkage with the CIM application produces the run-time system. Two sets of tools were developed to implement the approach:

- the Logical Model Builder tools consisting of the graphical PT- DC and AI-editor
- the UIMB.

Presently integration is in progress and will be followed by a validation phase for which the benchmarks and scenarios were defined.

The final System Builder prototype will be demonstrated at the end of the project in October 1989. The results of the project will promote more efficient utilisation of manufacturing resources by the use of windowing and graphic display techniques.

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MANNESMANN KIENZLE	*D*	*P*

Start Date	Duration
01-JAN-87	*39 months*

A HIGH PERFORMANCE FLEXIBLE MANUFACTURING SYSTEM ROBOT WITH DYNAMIC COMPENSATION (SACODY)

PROJECT NUMBER: 1561

The objective of this project is to develop the necessary know-how to control a high performance robot for use in Flexible Automated Assembly System (FAAS) environments. The major design aims are to compensate for the reduced rigidity of the mechanical structure, while improving speed of operation and overall static and dynamic control. Solutions to the critical problems associated with active control of articulated non-rigid structures will be implemented within a comprehensive software package which, following the modelling of the structural dynamics, will permit computer-aided design of control rules. The programme is as follows:

- development of innovative sensors, aimed at improving the global positioning accuracy of FMS robots while ensuring tracking and vibration control
- development of software tools for test and identification, modelling and design of control laws for flexible poly-articulated mechanisms
- development of sensor systems adapted to the on-line control of robot vibrations and to the testing of robot performance
- demonstration of the improvement is performance obtained with the new control methods on an industrial robot.

Improved control and identification methodologies are available and have been demonstrated on laboratory prototypes. The modelling and simulation software is completed and commercialised. Some of the identification techniques developed have been integrated in commercial versions of Computer-Aided Testing (CAT) systems.

Development of identification control methods continues and development of sensor systems has been initiated.

At the end of 1989 the modelling and simulation software will be adapted to control design purposes and interfaced with a CAT system. By the end of 1990 a fully operational demonstrator with a new generation industrial robot controller is targeted.

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Start Date	**Duration**
01-JAN-87	*48 months*

BASIC TECHNOLOGIES FOR HIGH PERFORMANCE SOLID STATE IMAGE SENSORS

PROJECT NUMBER: 1572

The objective of this project was to conduct basic research in the field of high resolution optical sensors for CIM applications, eg robotics, pattern recognition and optical character recognition. The project provided fundamental technologies which will permit the development of the next generation of image sensors with more than 1 million pixels per chip. The following results have been obtained:

- Improvement of sensitivity: with the use of transparent conductive electrodes made out of Indium-Tin-Oxide layers instead of polycrystalline silicon electrodes, the loss in light sensitivity due to an area reduction of the pixels can be compensated completely. All processing steps have been worked out and the results of working devices show that the overall sensitivity can be increased by a factor of two or more for blue light by replacing three levels of polysilicon with two levels of Indium-Tin-Oxide.

- Automated functional test: a complete system for automatic functional testing of image sensors with respect to the most important operating parameters has been developed. It is suitable for laboratory applications and gets further improvement with an increased address space of the computer and larger capacity of the image processing system for use in a production environment.

- Reduction of amplifier noise: high resolution image sensors require high speed and low noise output amplifiers. By optimising the output stage on-chip as buried channel NMOS source, followed by two or three amplification stages for 1.5 micron NMOS technology, and using correlated double sampling of the CCD signal, an operation has been realised at 20 MHz driving frequency.

- Suppression of blooming: different structures for 1.5 micron NMOS technology have been analysed by computer simulation. Horizontal antiblooming structures with buried channel and with surface channel diode drains were realised with good spectral response in the whole visible area and near infrared spectrum.

- Study of image processing systems: an imaging architecture is proposed with a bus system where data addresses and control are freely communicated between the sensor, the buffer and the associated processors, realising the suite of specific functionalities.

The results of this project will be used in further high resolution sensor developments, with an industrial exploitation expected in the early 1990s.

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Start Date	**Duration**
01-DEC-86	*30 months*

INTELLIGENT PROCESS CONTROL BY MEANS OF EXPERT SYSTEMS (IPCES)

PROJECT NUMBER: 1653

Note: This project covers the first phase of IPCES. ESPRIT II project 2428 covers its continuation and completion. The following text relates to the whole project.

The objective of this project is to develop a set of modular building blocks, combining new and already available technologies, which can be tailored and assembled to perform a range of control system functions in small and medium sized manufacturing enterprises (SMEs). Typical application areas will be process control and on-line automatic vision systems for quality control in the textile, electronic, food, metal and automotive industries.

The principal tasks are:

- development of a fully automatic vision system for on-line product inspection, capable of performing ultra-high-speed hardware-based feature identification and contact-free measurement

- development of a process information system with feedback and visualisation capabilities, using colour graphics, process diagrams, product feature graphic enhancement and an information heirarchy in terms of urgency and importance

- development of self-learning, self-initiating expert systems working with real-time process and/or product data and with statistically-derived conclusions to provide suggestions for improved control, diagnoses of product defects and/or prognoses of future system behaviour, either on request or on their own initiative

- integration and validation of the prototype system in a real manufacturing industry environment.

The following commercial products are expected to be developed using the results of the project:

- a rapid, high resolution defect checker, capable of handling a wide image field, with possible applications in quality control of lacquering, textile printing, PCB checking, etc

- a contact-free, high-accuracy measuring system, generally applicable to a range of vision systems

- an expert-system-controlled process monitoring and supervisory system.

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Start Date	Duration
01-DEC-88	*12 months*

ESPRIT II PROJECTS

NEUTRAL PRODUCT DEFINITION DATABASE FOR LARGE MULTIFUNCTIONAL SYSTEMS (NEUTRABAS)

PROJECT NUMBER: 2010

The objective of this project is to develop standardised methods for the storage and exchange of data defining shipbuilding and ocean engineering products as representative examples of large multifunctional systems.

Building on the work of ESPRIT project 322 (CAD*I) and CAD interface formats such as STEP and PDES, the project will define the principles of application-oriented reference models relating to complex maritime products, which include many services and machinery systems within a constraining steelwork envelope.

A Neutral Product Definition Format will be defined to serve as an exchange and archiving medium for the complete standardised product definition model. In order to verify the validity of the basic principles which would be adopted in the preparation of the specification, the project will include the development of the part of the database concerned with the modelling of the steel structure, with tests simulating actual exploitation conditions.

The availability of a neutral product definition format will encourage the development of new applications and significantly assist cooperation between the large number of designers, manufacturers and subsystem vendors typically involved in marine engineering projects. A number of software products incorporating the product definition format are expected to be exploited as a result of the development.

It is also expected that the project will provide a valuable contribution to international standardisation in the area of product data exchange technologies and will serve as a test case for the viability of the ISO/STEP/CAD*I approach for complex multi-functional products.

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Start Date	Duration
01-APR-89	*36 months*

AUTOMATED PROCESS AND ASSEMBLY INSPECTION BY 3D VISION

PROJECT NUMBER: 2017

The objective of this project is to develop a high speed 3D inspection system for the electronics industry.

Severe inspection problems are generated by the combination of the increasing miniaturisation of electronic components and assemblies, the increasing speed of their production, and ever-increasing demands for high quality. The aim of this project is to provide a solution based on high-speed, high-resolution, 3D sensing and data processing.

In the first phase of the project basic investigations on 3D sensing, 3D data processing, and CAD/CAM support for inspection will be undertaken. These results will be used to specify and develop 3D sensor devices, data processing units, and CAD/CAM support software and interfaces.

The resulting hardware and software modules will be integrated and tested in two different applications:

- inspection of structured substrates (advanced printed circuit boards)
- precision, high-speed assembly of surface mounted devices.

If successful, the results of this project will be exploited by their implementation on project partners' own production lines and by the development of commercial products. This is a market currently dominated by US and Japanese vendors.

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Start Date	**Duration**
01-MAR-89	*48 months*

CIM IMPLEMENTATION ADDRESSING LEVELS OF INTEGRATION IN VARIOUS ENVIRONMENTS (CIM ALIVE)

PROJECT NUMBER: 2032

This project covers the Definition Phase of the CIM ALIVE Technology Integration Project.

The objective of CIM ALIVE will be to establish a common project CIM reference model identifying cost-effective reusable CIM concepts. The industrial environments to be addressed will be:

- component manufacture and assembly of electromechanical products
- chemicals production
- printed circuit board production.

During the Definition Phase approximately thirteen industrial environments will be surveyed. The current situation at each of the sites will first be established and their position relative to sites outside the project considered. The future requirements at each site will be detailed and used as an input to a common project CIM reference model, based on the work of ESPRIT project 688 (AMICE). Common requirements which will benefit from the adoption of relevant new technologies will be investigated..

A CIM ALIVE Technology Association Club will be set up to provide a focus for the information dissemination activities of the project, particularly for the benefit of SMEs.

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Start Date	Duration
01-FEB-89	*12 months*

MOBILE AUTONOMOUS ROBOT IN AN INDUSTRIAL ENVIRONMENT (MARIE)

PROJECT NUMBER: 2043

The objective of this project is to develop integrated hardware and software systems to give autonomy to robotic vehicles in a dynamically changing environment.

A key issue within the project will be the development and testing of an information framework: the Perception and Control Model. Based on this model, the decision system will use a combination of symbolic and numerical techniques, thus combining the strong points of both control engineering and artificial intelligence approaches. The combination of the two approaches will be demonstrated by developing two distinct testbeds. The first will emphasise the path finding and coarse manoeuvring capabilities of the robot vehicle, while the second will highlight the object recognition and flexible response capabilities required in a diagnostic data acquisition task.

The integration of symbolic and numerical models will enable these systems to meet the major requirements of the control system:

- understanding a complex environment
- manoeuvring in non-exceptional situations
- supervising the tasks, and decision making in unpredicted or degraded situations.

The techniques and products developed by the project are expected to have applications to mobile robots used within CIM installations or in underwater or hostile environments, eg the storage of nuclear waste products or other poisonous, inflammable or explosive materials, and the dismantling of old nuclear power plants. Automotive applications are also anticipated, for example in subsystems assisting the driver in dangerous situations or in taking over tedious driving tasks.

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Start Date	Duration
18-JAN-89	*48 months*

EARLY PROCESS DESIGN INTEGRATED WITH CONTROLS (EPIC)

PROJECT NUMBER: 2090

The objective of this project is to develop tools and techniques to support an integrated design framework for the process industries embracing:

- early process design and instrumentation with overall system performance objectives
- simple control schemes for multivariable processes
- hierarchical control and steady-state process optimisation of large-scale industrial processes.

The principal tasks will be:

- to specify and develop methods and tools for early process design, for both well- and ill-defined process models, to enable the formulation of the appropriate conceptual, qualitative and quantitative framework within which the designer may evaluate his early design options
- to specify methods and tools addressing the opimisation and regulation of complex industrial processes
- to specify and develop the required software infrastructure
- to evaluate the validity of the integrated framework and of the methods and tools and to demonstrate their usefulness compared with existing tools.

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Start Date	Duration
01-FEB-89	*36 months*

VISION BASED ON-LINE INSPECTION OF MANUFACTURED PARTS (VIMP)

PROJECT NUMBER: 2091

The aim of this project is to develop a vision-based on-line inspection system to detect faults in manufactured parts immediately after machining and assembly processes. Manual inspection methods are slow and can normally only be performed on a sampling basis. With automated production lines it is necessary to determine, at each step of the process, whether parts have been manufactured correctly. Automated inspection will increase production rates and lead to substantial savings in material and labour.

Classical inspection methods compare a reference part with the set of parts to be evaluated. The approach in this project will be to compare the image from an on-line vision system with an image derived from the data stored in the CAD system. To provide sufficient resolution it will be necessary to move the sensor to scan the full extent of large workpieces. The 3D data stored in the CAD system will be rasterised in a 2D projection corresponding to the angle of view of the sensor.

The system is expected to have considerable potential within an inspection systems market which is forecast to constitute some 10 to 15% of a five to ten billion ECU worldwide machine tool market. Applications are particularly expected in the automotive and aerospace industries, but there may also be applications in industries which do not currently use on-line inspection methods, eg the textile industry. Some of the system components, eg image processing and 2D and 3D pattern recognition software, are expected to be exploited as products in their own right.

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UNIVERSITAET KARLSRUHE	*D*	*P*
SPERONI SPA	*I*	*P*
FRAUNHOFER IITB	*D*	*P*

Start Date	**Duration**
20-JAN-89	*60 months*

HOLOGRAPHIC LABELLING TECHNIQUES FOR AUTOMATIC IDENTIFICATION IN CIM ENVIRONMENTS (HIDCIM)

PROJECT NUMBER: 2127

The objective of this project is to demonstrate the feasibility of holographic labelling techniques for automatic identification in a computerised industrial environment. A system based on holographic labels will have the following advantages:

- large data capacity
- immunity to electrical, mechanical and chemical interference
- simple, low cost read out
- wide range of reading distances
- simple, small, updatable, low cost labels.

The programme will include the following tasks:

- development of holographic storage techniques, providing redundancy and permitting movement of the image and reading at great distances
- assessment of a low-cost, erasable and reusable label material, suitable for large-scale production, easy to handle, and able to withstand an industrial environment
- development of a write station with the ability to generate holograms, and including a fast precision device for laser beam positioning and the necessary optics and man/machine interface
- development of a read station with the ability to recognise a label, reconstruct the stored holographic pattern and decode it into the original pattern
- simulation of the information path from pattern generation via holographic decoding, reconstruction, interpretation and recovering the original contents.

The applicability for CIM will be demonstrated in a laboratory environment for the following applications:

- computer integrated manufacture of mechanical parts as a tool identification system
- computer integrated manufacture of printed circuit boards as a parts identification system.

The project partners are well placed to exploit the results of the project. Following the internal application of the system in two of the partners own production facilities, the components of the system are expected to be exploited commercially within three years of the completion of the project.

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UNIVERSIDADE DO PORTO	*P*	*P*
MANDELLI SPA	*I*	*P*
STANDARD ELEKTRIK LORENZ AG	*D*	*S*

Start Date	Duration
15-MAR-89	*30 months*

INTEGRATED MODELLING OF PRODUCTS AND PROCESSES USING ADVANCED COMPUTER TECHNOLOGIES (IMPPACT)

PROJECT NUMBER: 2165

The objective of this project is to develop and demonstrate a new generation of integrated modelling systems for product design, process planning and the generation of machine control data.

The current limitations of CAD, CAE, CAP and CAM systems result from their application-dependent specific data representation. This makes integration very complex. The integrated system developed by this project will recognise that:

- during the manufacturing process, a workpiece appears in various intermediate stages, providing input data for the planning task of the next manufacturing step;

- the information system needs closed loops, which feed experience for planning and manufacturing back to the design process.

Reference models will be built based on requirements from design, planning and manufacturing. The reference model to be specified will serve as a general approach to deriving specific software development strategies, depending on the application areas.

This approach will allow companies to build up an integrated data processing environment which will lead to a better performance of the manufacturing processes and will support a stepwise realisation and implementation of integrated CAD-CAP-CAM systems. Knowledge-based technologies will be used for software development wherever practicable.

The capabilities of the system will be demonstrated by prototype software which will be installed on demonstrator sites.

The exploitable results of the project will include a generic model for standardised interfaces and data structures between different CAD/CAM components, and a range of improved algorithms relating to sheet metal parts, for:

- unfolding of surfaces in 3D models to produce flat surfaces

- recognition of form features

- part programming and nesting

- process planning and operations planning.

The industrial partners intend to exploit these results, in many cases by integrating them into existing modelling products.

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KRUPP FORSCHUNGSINSTITUT	*D*	*A*
UNIVERSITAET KARLSRUHE	*D*	*A*

Start Date	Duration
15-FEB-89	*36 months*

DISTRIBUTED INTELLIGENT ACTUATORS AND SENSORS (DIAS)

PROJECT NUMBER: 2172

The objective of this project is to:

- develop a range of prototype intelligent sensors and actuators
- work with related ESPRIT projects to define and promote the development of a suitable fieldbus for their connection
- define and promote the development of a process Control Maintenance and Management System, integrating the sensors, actuators and fieldbus with control and maintenance computers.

The sensors and actuators will address a range of functions, eg pressure, flow, temperature, and on-off valves, applicable to a broad range of industrial applications, ie power generation and distribution, chemical processes, the iron and steel industry, etc.

The work on a Control Maintenance and Management System will focus on the lowest level, in order to provide a consistent real-time database of the process instrumentation. Such a database will:

- improve the consistency of control reflex processing
- improve the consistency of control operator information
- enable the development of new maintenance and technical management functions, with the aim of reducing costs and increasing process plant availability
- facilitate the integration of future expert systems and increase their efficiency and relevance.

The specifications and implementations will be validated in three types of real process environment: thermal and nuclear power stations and a chemical plant.

The increasing emphasis within the power and chemical industries on reliability, safety, economy of operation, and protection of the environment is creating a large market for instrumentation and control systems of increasing sophistication, including the retrofitting of existing installations. The products arising from the industrialisation of the project results are expected to enjoy a widespread application.

It is expected that the project results will pave the way for an appropriate definition of new international standards of European origin in the field of intelligent actuators and sensors.

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SEMA-GROUP/BELGIUM	*B*	*P*
MONTEFIBRE SPA	*I*	*P*
MENTEC INTERNATIONAL LTD	*IRL*	*P*
ESA CONTROL SPA	*I*	*P*
ELECTRICIDADE DE PORTUGAL	*P*	*P*

Start Date	Duration
19-APR-89	*48 months*

REVISION ADVISOR - AN INTEGRATED QUALITY SUPPORT ENVIRONMENT (RA-IQSE)

PROJECT NUMBER: 2178

The objective of this project is to develop a system for the optimisation of the quality of products manufactured in highly automated production facilities. Through on-line guidance based on product quality observations and associated predictive knowledge, RA-IQSE will give corrective feedback to influence and optimise design and production planning.

The input to RA-IQSE will be, for example, on- and off-line quality feedback, production environment status, CAD data and CAPP data. The system will embody AI techniques as well as recent quality assurance developments in the US and Japan (eg the Taguchi approach). A methodology for quality integration will be developed, including:

- a generic method by which machined component quality data can be represented and captured
- a generic method by which manufacturing resources can be modelled and correlated with the component's quality goals
- the construction of predictive quality metrics for the design of machined components, based on these generic methods.

The approach to be adopted will be analogous to that used for software development in that an integrated project support environment (IPSE) will be provided which will enable the various manufacturing tools to be integrated and the 'islands of automation' effect minimised.

The principal components of the RA-IQSE will be an adaptation mechanism and a man-machine interface. The adaptation mechanism will apply and integrate advanced information processing and mathematical and statistical methodologies for evaluation of the acquired data and modelling and optimisation of design and production planning. The man-machine interface will provide a user-friendly dialogue, giving access to the results computed by the adaptation mechanism and providing guidance and support to the user.

Although initially focused on machined components, the project results are expected to have a wide application. The project partners intend to exploit the results generally in the aerospace and in the textile and carpet industries.

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HCS INDUSTRIAL AUTOMATION BV	*NL*	*P*
COMPUTER TECHNOLOGIES CO	*GR*	*P*

Start Date	Duration
24-JAN-89	*36 months*

BUILDING INDUSTRY PROJECT MANAGEMENT SYSTEM (BIPMS)

PROJECT NUMBER: 2189

The objective of this project is to develop a project management system for the building industry.

The facilities provided will include:

- coordination of the activities of a number of specialised partners cooperating on a building project
- expert system for the suggestion of preparatory and corrective actions
- simulation capabilities for evaluating the consequences of choices and decisions
- multiple access and outputs, including progress and modification reporting from portable terminals.

Various selections will be possible, eg according to: physical location, work team or a particular manager's responsibility, kind of resource, category of expense or receipt. This will enable the constitution of task groups with defined programmes and monitoring possibilities. Flexible enquiry facilities will be provided.

The system will be written in C under UNIX to ensure good portability.

The system will be tested on three real sites:

- a new building
- preventative maintenance of an existing building
- a joinery shop.

The project partners expect to find a market for the system not only in the building industry but also in the large number of small manufacturing shops, for which the problems are very similar.

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UTI-SERVICES	*F*	*P*

Start Date	Duration
01-MAR-89	*36 months*

ADVANCED INTELLIGENT MULTISENSOR SYSTEM FOR CONTROL OF BOILERS AND FURNACES (AIMBURN)

PROJECT NUMBER: 2192

The objective of this project is to develop, implement and test a general purpose intelligent multi-sensor system for large industrial process boilers and furnaces, such as those used in glass, cement and steel assemblies manufacture and power station plant. The system will be designed to:

- control and optimise operation
- provide fault diagnosis
- control and assist maintenance.

Two levels of control will be addressed:

- low level control, dealing with the acquisition, processing and integration of sensorial information as well as with local regulation loops
- intelligent level control which operates on a symbolic model of the whole system; qualitative knowledge about the relations between the subsystems will be used together with knowledge derived from advanced mathematical modelling of the flow and heat transfer characteristics inside the boiler or furnace.

The project will involve the development of:

- an advanced sensor system for the characterisation of burning conditions, comprising:
- a vision subsystem, to classify the flame (colour, homogeneity)
- other sensor subsystems, measuring pressure, temperature, gas composition, flow, level, etc
- an intelligent decision scheme, based on an expert system.

The results of the project will be directly exploited by project partners in the glass industry, in power generation and in boiler manufacture. IT vendor partners will exploit the results in terms of hardware and software products.

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ELECTRICIDADE DE PORTUGAL	*P*	*A*
INSTITUTO SUPERIOR TECNICO	*P*	*A*
IMPERIAL COLLEGE	*UK*	*A*

Start Date	Duration
21-JUN-89	*36 months*

CAD GEOMETRY DATA EXCHANGE (CADEX)

PROJECT NUMBER: 2195

The objective of this project is to support and further develop the ISO STEP standard for a neutral file format for CAD data exchange by:

- proving the practicality of the standard
- developing comprehensive implementations for CAD geometry exchange
- implementing state-of-the-art testing methodologies
- developing pre- and post-procesors to interface a range of CAD equipments and Finite Element Modelling (FEM) systems.

The project will continue the work of ESPRIT project 322 which directly led to the STEP standard.

A subset of STEP covering 3-dimensional design will be defined and tested by prototype processors covering surfaces, wireframes, boundary representations, compound solid geometry, compound boundary representations, properties and alphanumerical attributes.

Sites from the automotive industry will provide an ambitious target for the project and allow success to be measured and demonstrated in an area with high marketing potential. The participating software companies will be able to offer marketable products based on the processors developed in the project.

The experience gained in the project will be used to maintain and strengthen European influence in the relevant international standardisation bodies.

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PROCAD GMBH	*D*	*P*
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CAD CENTRE	*UK*	*P*

Start Date	Duration
20-FEB-89	*36 months*

FACTORY CUSTOMER PREMISES NETWORK (FCPN)

PROJECT NUMBER: 2198

The objective of this project is to develop a robust infrared factory communication system based on cordless mobile terminals and a microcellular addressing backbone. The system will provide flexible, secure, multiservice communications (data, voice and picture) suitable for SME factories and broad site plants. Interfaces will be provided with the services provided by MAP, TOP, ISDN and broadband ISDN.

The system will particularly address the need for mobility and for reliable communication in the presence of severe electromagnetic interference, as encountered in electrical generating plants and sub-stations.

The system will provide stand-alone communication subsystems and wireless communication inside limited size cells, together with a broadband backbone network linking the local subsystems. It will be possible to define low-cost limited-feature terminals as well as high-performance, multiservice mobile terminals.

Market opportunities are foreseen in industrial and office environments, in nuclear, fossil fuel and hydroelectric power plants, and in hospitals.

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UNIVERSIDAD POLITECNICA DE MADRID	*E*	*A*
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ENSEEIHT	*F*	*A*

Start Date	Duration
01-FEB-89	*38 months*

CIM SYSTEM PLANNING TOOLBOX (CIM-PLATO)

PROJECT NUMBER: 2202

The objective of this project is to develop a prototype toolbox consisting of computer-aided procedures and tools to design, plan and install FMS and FAS systems within CIM environments.

The toolbox will contain tools and components for:

- manufacturing system planning, including system configuration (component selection and layout planning) scheduling and verification

- manufacturing process planning, including the detailed execution of processes - technological process planning, event- and motion-oriented planning, application-oriented verification, simulation and test - and the conversion and transfer of application programs to the real manufacturing system

- integration of information flow between manufacturing system planning and excecution planning systems, including factory and subsystem information models, methods and tools for data and knowledge representation, and integration of knowledge bases and expert systems.

The toolbox is aimed at increasing the effectiveness of the planning process, resulting in the reduction of planning lead times and costs, and in the increase of the efficiency of manufacturing systems control. The project is intended to strengthen the competitiveness of European industry in international markets by enabling the speedy implementation of advanced manufacturing systems and by making the planning toolbox available in world markets.

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LADSEB-CNRP	*I*	*A*
POLITECNICO DI MILANO	*I*	*A*

Start Date	**Duration**
01-APR-89	*48 months*

CIM FOR MULTI-SUPPLIER OPERATIONS (CMSO)

PROJECT NUMBER: 2277

The objective of this project is to develop methods, tools, interfaces and architectures to facilitate the exchange of technical and commercial data between independent organisations working together in a manufacturing and/or distribution environment. The project will be focused on the requirements of the automotive industry.

The first step will be to identify the scope and content of the issues which must be addressed. This analysis will lead to the definition and construction of a laboratory model of a supplier/manufacturer/distributor supply chain which will be used to simulate information exchange and transfer in particular areas of investigation. The results of these activities will enable the preparation of a Requirements Specification for the necessary information system components for the integrated supply chain.

The project will also address the need for 'neutral' data to be exchanged in terms of both message format and message content.

The major benefits envisaged for the system are:

- control over total costs
- control over service levels
- smoother load on manufacturing
- lower stocks
- better planning. based on timely and synchronised information
- shorter, more reliable lead times
- availability of the right products at the right time
- increased customer satisfaction.

Initial simulations of the developments on the laboratory model will be followed by the implementation of pre-prototype demonstrator applications in several of the project partners' organisations. A number of software products are expected to result from the project. These will be exploited by the project partners - initially in the automotive industry but subsequently in other supply-based industries.

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CATIA SOFTWARE SERVICE GMBH	*D*	*S*

Start Date	Duration
15-DEC-88	*36 months*

LARGE MANIPULATORS FOR CIM (LAMA)

PROJECT NUMBER: 2280

The objective of this project is to develop a long-reach manipulator for high-load, high-speed, CIM applications. A reach of more than 20 m is planned which will permit new shop floor layouts and a CIM-oriented material flow and workpiece handling.

The principal tasks are:

- development of a new manipulator system
- introduction of fundamental improvements in the hydraulic drive system with various sensor feedback options to control high-inertia manipulator axes with high accuracy and precision
- development of new sensor systems to realise sensor-assisted control concepts for the manipulator and for collision avoidance
- development of a new generation of numerical robot controllers, incorporating:
- on-line trajectory planning and collision avoidance with optional links to off-line programming
- control concepts for flexible and redundant kinematics
- servo-level actions for improving accuracy and eliminating unwanted oscillations
- concepts and interfaces for CIM integration.

The validity of the developed concepts will be demonstrated by the realisation of a prototype. An operational system in a real shop floor environment is planned in 1993.

A range of hardware and software products are expected to be exploited by the project partners as a result of the development. Spin-offs are expected for application to more conventional robot systems and for non-CIM applications, eg giant cranes for ship loading and unloading.

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Start Date	Duration
01-APR-89	*48 months*

TESTING TECHNOLOGY FOR COMMUNICATION NETWORK FOR MANUFACTURING APPLICATIONS (TT-CNMA)

PROJECT NUMBER: 2292

This project continues the work on CNMA testing technologies started during phase 3 of ESPRIT Project 955 (Communication Network for Manufacturing Applications). Through that project European industry achieved a world lead in the provision of conformance testing technologies for CIM communication systems.

Specific objectives of this project are:

- Interoperability testing: to develop prototype tools which will enable practical interoperability testing for the Manufacturing Message Service (MMS) and Network Management (NM) protocols.

- Conformance testing: to extend conformance testing coverage into new areas where standards are now stabilising and to demonstrate that test facilities can be providied for these new areas; existing prototype conformance test tools will be further developed and demonstrated, resulting in tools for MAC Bridges, Routers, MMSI and embedded testing technology.

- Technology integration: to extend the integrated test tool environment developed during CNMA Phase 3 to ensure that all new test tool developments will be compatible with the same harmonised environment.

- CNMA support: to provide specific testing facilities in support of the CNMA project; to develop the required technology and to test and prove the facilities in the CNMA industrial pilots.

- Performance measurement: to conduct preliminary work on performance measurement with a view to establishing some user requirements and the principles of architecture and metrics definition.

The development of test tools is likely to impact European and worldwide standards where deficiencies or the need for increased clarification is identified.

Draft specifications resulting from the development of testing methodologies will form the basis of future developments, eg embedded testing, test tool integration, common technology and performance measurement. The prototype test tools will be available for further development and commercialisation as stand-alone products and as the basis of formally accredited testing facilities.

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TNC	*UK*	*P*
SWEDISH TELECOM	*S*	*P*
SIEMENS AG	*D*	*P*
FRAUNHOFER IITB	*D*	*P*
RTE GMBH	*D*	*S*
KMK KREUTZ & MAYR	*D*	*S*

Start Date	Duration
28-NOV-88	*42 months*

ADVANCED DISTRIBUTED ENVIRONMENT FOR PRODUCTION TECHNOLOGY (ADEPT)

PROJECT NUMBER: 2331

The objective of this project is to improve the development of distributed supervisory control systems by increasing system resilience and reducing development cost. This will be achieved by:

- establishing a model for the development of distributed supervisory control systems which addresses the problems of application fault tolerance, distributed control structure and reliability
- developing an associated methodology and development environment
- developing a simulator and reusable software components.

The model will emulate control at factory, department and cell levels. It will address the data flows between these levels with a particular emphasis on self-policing of the hardware and software components of the system to provide application tolerance. It will also address performance questions since many control systems are time-critical.

The set of integrated development tools will include a CASE tool for system design and an expert system for selecting the system components and identifying the areas where components are unavailable to match the proposed supervisory control system.

The simulator will investigate the implications of real implementations in a variety of manufacturing environments and will provide a means of testing design criteria throughout the implementation.

The model, the methodology and the tools will be verified by a pilot implementation on a manufacturing site. This will be followed by the introduction of a fully operational system.

The IT vendor partners plan to exploit the ADEPT architecture and methodology and the software products developed by the project. The pilot site will act as a reference for potential ADEPT customers.

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Start Date	Duration
01-MAR-89	*48 months*

INTEGRATED MANUFACTURING PLANNING AND CONTROL SYSTEM (IMPACS)

PROJECT NUMBER: 2338

The objective of this project is to develop and implement a generic dynamic integrated planning and control system for discrete parts manufacturing. The scope of the system will embrace the whole manufacturing enterprise from business planning to shop floor control and it will accommodate the strategic, tactical and operational planning and decision-making processes.

An IMPACS functional architecture will be developed, supported by an IT model and a set of software tools to assist dynamic group decision-making at all levels in discrete parts manufacturing planning and control. The architecture will be be based on CIM-OSA developed by ESPRIT project 688 (AMICE) and the PAC architecture developed by ESPRIT project 477 (COSIMA). The communications approach will be compatible with CNMA (ESPRIT project 955).

The system will enable dynamic responses to changes in demand, disturbances in material flow, fall-off in product quality and changes in the real-time availability of materials, machines and tools.

A rapid prototyping approach will be adopted, involving constant interaction with a number of industrial test sites which will act as pilot implementations.

The results of the project will be exploited by operational implementations at the project test sites, by extension to other sites of the same enterprises, by exploitation of the resulting software products, and by dissemination through design contracts, consultancy and seminars.

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Start Date	Duration
19-APR-89	*48 months*

FAULT TOLERANT CONTROL AND MANAGEMENT OF PRODUCTION SYSTEMS

PROJECT NUMBER: 2349

The objective of this project is to develop a system technology for the efficient integration of monitoring and diagnostics with the control of discrete parts manufacturing plant at the machine and cell level. This has the aim of providing the plant with a degree of fault tolerance through improved control during abnormal or fault conditions.

Taking as its example the European automotive industry, the project will extend the concepts and techniques already defined by ESPRIT project 504. The flexible machining cell test bed established by that project will be further developed as a research and educational tool, particularly for the industrial users and system vendors who will play a key role in the specification of generic requirements.

The principal tasks to be addressed are:

- Enabling Technologies:

  A toolkit of hardware and software modules will be developed which can be used alongside existing modules to provide the monitoring, diagnostic and action planning functions of a fault tolerant system.

- Application Tools and Methods:

  Support tools will be provided covering feasibility studies, investment justification, system installation, operation and enhancement, etc.

- Integration Methods:

  Integration methods will be defined which will be compatible with users' current and future manufacturing control systems.

- Industrial Application Demonstrators:

  It is planned to implement at least three demonstrator sites within plant operated by the industrial partners, incorporating the tools and methods appropriate to the demonstration of fault tolerant control concepts in each environment. It is hoped that at least one site will extend the system implementation to include end-of-line testing using the same generic hardware, software and reporting strategies as will be used for the production machinery.

Although the project is focused on metal working in the automotive industry, the tools and methods developed will be widely applicable to a range of processes in many other manufacturing industries.

The project partners intend to utilise the project results by commercially exploiting the resulting hardware and software products (as stand-alone products or embodied into their control system products), by internal application, or via planning and consultancy services.

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Start Date	Duration
20-JAN-89	*48 months*

DISTRIBUTED MANUFACTURING PLANNING AND CONTROL

PROJECT NUMBER: 2415

The objective of this project is to demonstrate that a higher level of efficiency and a greater level of job satisfaction can be achieved by maximising manufacturing planning and control decision-making to the lowest possible levels. Manufacturing efficiency will be increased and job skills and experience will be extended because:

- authority and responsibility will be delegated to the levels which have the relevant experience and the most immediate data necessary to make the best judgements;

- the volume of data passing through the system will be substantially reduced, resulting in reduced communications overhead, decrease in complexity and a more rapid response time.

The following systems will be developed:

- Operator Management System (OMS): there will be two versions - a stand-alone version running on PC type workstations and an on-machine version running on custom CNC hardware offering real-time monitoring of the machining process.

- Communications software and hardware will be implemented offering a configurable channel for information transfer into and out of the cell or functional layout environment.

- Production Management Support System (PMS): there will also be two versions - Standard PMS, supporting PMS software functions and linking to higher level MRP systems, and Multi-level PMS, also with links supporting communication with lower level management systems.

The project partners expect the project results to have a major impact throughout European manufacturing industry. It is planned to launch a series of products that can be used individually or as an integrated system to solve common problems in the control of small batch manufacture. Whilst the main focus will be on the very large metalworking industry it is expected that the system will also provide solutions to the problems of many other industries.

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Start Date	Duration
21-DEC-88	*36 months*

INTELLIGENT PROCESS CONTROL BY MEANS OF EXPERT SYSTEMS (IPCES)

PROJECT NUMBER: 2428

Note: The first phase of IPCES is covered by ESPRIT I project 1653. This project covers its continuation and completion. The following text relates to the whole project.

The objective of this project is to develop a set of modular building blocks, combining new and already available technologies, which can be tailored and assembled to perform a range of control system functions in small and medium sized manufacturing enterprises. Typical application areas will be process control and on-line automatic vision systems for quality control in the textile, electronic, food, metal and automotive industries.

The principal tasks are:

- development of a fully automatic vision system for on-line product inspection, capable of performing ultra-high-speed hardware-based feature identification and contact-free measurement

- development of a process information system with feedback and visualisation capabilities, using colour graphics, process diagrams, product feature graphic enhancement and an information hierarchy in terms of urgency and importance

- development of self-learning, self-initiating expert systems working with real-time process and/or product data and with statistically-derived conclusions to provide suggestions for improved control, diagnoses of product defects and/or prognoses of future system behaviour, either on request or on their own initiative

- integration and validation of the prototype system in a real manufacturing industry environment.

The following commercial products are expected to be developed using the results of the project:

- a rapid, high resolution defect checker, capable of handling a wide image field, with possible applications in quality control of lacquering, textile printing, PCB checking, etc

- a contact-free, high-accuracy measuring system, generally applicable to a range of vision systems

- an expert-system-controlled process monitoring and supervisory system.

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Start Date	**Duration**
01-MAY-89	*36 months*

KNOWLEDGE-BASED REAL-TIME CIM CONTROLLERS FOR DISTRIBUTED FACTORY SUPERVISION

PROJECT NUMBER: 2434

The objective of this project is to make modern production philosophies, such as OPT, JIT and LOP, available on the factory floor, by delivering decision support to each relevant function of the factory using knowledge-based software techniques.

A dynamic scheduling and planning system will be developed, bridging the time gap between high level planning systems, eg COPICS, and the real-time conditions on the factory floor. It will be based on the principle of the delegation of decision-making to the lowest possible level. The system will generate manufacturing schedules based on both higher and lower level constraints as these become apparent in real-time. Expert system and CIM modules will be tested at three large-scale manufacturing plants:

- car radio factory: small batch, large number, discrete production
- tyre manufacturing plant: large batch, mixed discrete production
- cable manufacturing plant: partly continuous, partly discrete production.

The results from these factory tests will be used to produce a generalised expert system development shell for the optimisation of internal production and the development of products for the IT market, such as software packages for dynamic scheduling, planning, diagnosis and maintenance, and microchips for distributed intelligent control.

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Start Date	Duration
01-JAN-89	*36 months*

REAL TIME MONITORING AND CONTROL OF CONSTRUCTION SITE MANUFACTURING (ROCOCO)

PROJECT NUMBER: 2439

The objective of this project is to improve productivity in the heavy engineering and construction site industries by the application of IT techniques to the monitoring and control of all aspects of the production process. The system to be developed will address the specific characteristics of the industry, ie 'one of a kind' construction, complexity, parallel design, procurement and construction, dependency on a large number of suppliers and subcontractors, and construction sites remote from pre-production assembly areas and workshops.

The programme comprises:

- generation of reference models for all aspects of the production processes which clearly define the principal data flows and decision-making processes

- identification of new techniques for the rapid feedback and processing of real-time data from the production process; advanced techniques for the capture, transfer analysis and visualisation of data will be evaluated in a number of pilot applications

- investigation of the application of IKBS techniques to dynamic resource scheduling; this will facilitate the introduction of just-in-time material and component flow

- implementation of the most promising techniques in a real-time manufacturing environment, selected to provide maximum scope in a specific production area

- implementation of a pilot demonstrator representing the needs of construction site industries.

The construction industry partners expect to apply the project results to their own construction activities. The IT vendor partners plan to exploit the results in the form of hardware and software products.

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Start Date	Duration
01-MAR-89	*36 months*

KNOWLEDGE-BASED PLANNING AND CONTROL IN MANUFACTURING ENVIRONMENTS (FLEXPLAN)

PROJECT NUMBER: 2457

The objective of this project is to develop knowledge-based tools for process planning (and replanning) and workshop control based on a non-linear directed graph process plan representation (Petri nets). The term non-linear denotes that the process plan comprises alternative and parallel sequences of manufacturing operations.

The system will enable the development of non-linear process plans out of a workpiece model and a workshop model. It will also enable reactive replanning to allow a sufficiently fast and flexible reaction to unexpected events in the workshop during execution of the plan.

The principal tasks are:

- development of a suitable non-linear representation (with alternatives and parallelisms) of process plans
- development of a knowledge based methods for the automatic generation of non-linear process plans
- development of workshop control algorithms and replanning strategies for the utilisation of non-linear process plans.

The development will be focused on small and medium batch production in the metalworking industry.

To ensure that the project results can be rapidly exploited, the general requirements of the market are being considered in the very early phases of the project and software engineering tools and programming languages are being used that will assure an easy portability to a wide range of hardware and software environments at users' sites.

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Start Date	Duration
01-MAR-89	*36 months*

PERCEPTION AND NAVIGATION SYSTEM FOR AUTONOMOUS MOBILE APPLICATIONS (PANORAMA)

PROJECT NUMBER: 2483

The objective of this project is to develop an advanced perception and navigation system for autonomous vehicles, enabling automatic path determination and continuous safe motion in partially structured and partially known environments. The project is mainly concerned with outdoor environments structured with paths or tracks (not necessarily well defined) and some natural or non-natural landmarks.

The specific objectives are:

- to develop a general purpose perception and navigation system (PNS) suitable for a large range of application domains
- to demonstrate capabilities of autonomous motion provided by the PNS within a mobile platform test-bench
- to build such a PNS prototype and to implement it on a vehicle working in a real application domain.

The main approaches will deal with:

- multisensor integration for optimal use of navigation/localisation sensor, 2D/3D vision sensors and proximity sensors
- knowledge-based coordination and planning of perception and navigation
- on board implementation of planning, reasoning and decision modules
- parallelism and modularity in system architecture allowing flexibility and extensibility.

The project partners are well placed to exploit the project results. Amongst the application areas foreseen for autonomous unmanned machines are:

- material transportation in building sites, forests, agriculture, open quarries, docks, warehouses
- special-purpose machines, such as harvesters, rock drilling machines, building machines, cleaning machines for large areas
- surveillance of outdoor sites
- hazardous environments, eg chemical and nuclear plants.

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Start Date	Duration
10-FEB-89	*60 months*

INTEGRATED CAE TECHNIQUES FOR DYNAMIC ANALYSIS OF STRUCTURES (ICTDAS)

PROJECT NUMBER: 2486

The objective of this project is to develop a technology platform for structural dynamic analysis that integrates fatigue analysis and acoustic radiation prediction with vibration analysis.

The prototype of the platform software will be targeted at engineering workstations, using advanced user interfaces and data management techniques, with interfaces to existing CAD and FEM systems and to experimental analysis programs for vibration analysis data. Other work areas will be aimed at:

- the extension of fatigue life estimation methods and integration with vibration analysis and test
- the extension of acoustic radiation prediction techniques and integration with vibration analysis and test
- the development of technical modelling techniques with respect to fatigue analysis and acoustic radiation prediction and the integration with geometric modelling
- the enhancement of vibration analysis techniques in view of specific requirements for fatigue analysis and acoustic radiation prediction.

The development will be validated in conjunction with major manufacturers in the automotive industry.

The methodology and tools to be developed will have important application in the automotive and aerospace industries and in the mechanical engineering industry in general. The following benefits are expected:

- superior products in terms of improved dynamic characteristics (reduced vibration and noise emission, improved fatigue life)
- shortened design cycles, since products with improved dynamic characteristics will require less prototype testing and trouble shooting in later phases of the design process
- higher degree of flexibility, as an improved understanding of the dynamics of the product will enable the prediction of the effects of design changes and the forecasting of the performance of variations of a new product (eg cars with different engines, gear transmisssions, etc).

The results of the development will be made available as commercial products by the IT project partners.

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Start Date	Duration
20-FEB-89	*48 months*

CIM SYSTEM WITH DISTRIBUTED DATABASE AND CONFIGURABLE MODULES (CIDAM)

PROJECT NUMBER: 2527

The objective of this project is to develop a range of IT tools to enable the bidirectional transfer of data between, and the functional integration of components of a CIM system, ie:

- product development
- product planning
- production control
- process coordination and management
- process monitoring and control
- regulation and control of plant and equipment
- process interface.

The tools will be applicable both to the discrete parts manufacturing and to the continuous and discontinuous process industries.

The following tools will be developed:

- Interface Management System (INMAS): this will link the CIM components together in a hardware-independent manner; a main component will be a bidirectional Data Exchange Mechanism, based on a LAN conforming to CNMA recommendations.
- Configuration System (COSY): this will allow the automatic, individual configuration of a CIM system to customer needs.
- Distributed Database: this will be based on a data dictionary and will allow the CIM applications to access the data held on physically separate and possibly homogenous or heterogenous systems.
- Man-Machine Interface: this will be based on ESPRIT research and will provide a common user interface across the range of systems operating at each level.

The tools will be based on UNIX, providing a high degree of hardware independence.

The project partners intend to utilise the results of the project by implementation in their own production facilities and by the development of software products for commercial exploitation.

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Start Date	Duration
01-MAR-89	*60 months*

DESIGN SUPPORT FOR DISTRIBUTED INDUSTRIAL CONTROL (DSDIC)

PROJECT NUMBER: 2588

The objective of this project is to develop an integrated set of design tools, linked by a central information base, to support all phases of the design of distributed control systems, including:

- tendering
- functional design
- rapid prototyping
- distribution design, to map the required functions on to a linked set of control units to meet the constraints of performance, cost, availability, operation under partial failure, etc
- hardware configuration
- software production by reuse of existing software components and code generation
- installation
- documentation.

This design support system aims to improve the quality of design by:

- forcing a structured approach to design
- encouraging the reuse of proven design
- carrying out automatically many of the routine configuration tasks which are liable to human error.

Linking the tools via a central knowledge base will greatly reduce the loss of information which otherwise occurs between the stages of a design and between similar designs. Artificial intelligence techniques will be used wherever appropriate to enable the system to adapt to: the rapidly evolving capability of a given range of control equipment; differences between equipments from different suppliers; different control applications.

Many of the project partners plan to use the support system for their own design activities and some of them intend to make the system available to control equipment customers who perform their own system design.

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Start Date	Duration
01-AUG-89	*60 months*

INTEGRATED PRODUCT DESIGN SYSTEM (IPDES)

PROJECT NUMBER: 2590

The objective of this project is to develop and validate a next generation CAD/CAM knowledge-based product modeller within an open architecture and open system communication protocols.

The project will focus on:

- the formalisation of design and production expertise into functional and technological part modellers
- the integration of the part modellers into a functional and technological product modeller, providing a unified approach to the design and production of a wide range of industrial products
- the use of AI techniques to utilise previous design experience and to generate process plans
- the provision to the user of an open architecture, enabling
- new modellers to be added or existing modellers to be interfaced
- new knowledge bases to be built or previous ones to be modified.

The project will be based on existing software resources (geometric modellers, inference engine, object data basec management system, computing algorithms, etc).

A fully integrated product modelling system will enable 'right first time' design, improve product quality, permit value analysis and cost monitoring at each design stage, and enable a rapid response to market needs in terms of reaction time and changing specifications.

The project partners intend to develop a commercial product based on the project results and to exploit this by internal application, by supporting their existing products and as a stand-alone product.

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Start Date	Duration
01-JUN-89	*48 months*

COMMUNICATIONS NETWORK FOR MANUFACTURING APPLICATIONS (CNMA)

PROJECT NUMBER: 2617

This project continues the work on CNMA, initiated under ESPRIT Project 955. Phases 1 to 3 of the project achieved the CNMA objectives of specifying, implementing, validating and promoting emerging communications standards, and placed its participants in an internationally competitive position.

This project covers the extension of the project into Phase 4 of the programme. During this phase MMS and FTAM industrial communications protocols will continue to be addressed, whilst the related standards stabilise, together with the associated application interfaces. Original work will be performed on an intelligent network management system. The project will also address: fieldbus, enhanced performance architectures, fibre optics and protocol gateways necessary to solve user migration problems.

These developments will be applied to two types of manufacturing environment. One experimental pilot free from the pressures of a manufacturing environment will be used for the first application of the communication developments. Further validation will then be achieved by the application of the communication software to real production environments.

The Phase 4 workplan includes:

- preparation of case studies of user communication strategies
- definition of CNMA Implementation Guide (revision 4.0)
- subsequent implementation by vendors on minicomputers and controllers
- verification of the profiles by the application of vendor hardware and software to experimental and real production environments
- promotion of experience gained within standards bodies
- provision of CNMA expertise through technical exchange and information dissemination.

By their participation in the project the partners will continue to ensure a high level of European expertise in this rapidly-evolving and vital area of CIM development. The CIM users are able to make informed choices on the evolution of their own internal communication systems whilst the IT vendors are able to ensure that international agreements on communications protocols are rapidly incorporated into commercial products.

As in the previous phases the project will continue to exert a strong European influence on the evolution of international standards for factory communications, particularly via national participation in ISO TC184.

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Start Date	Duration
01-DEC-88	*26 months*

METHODS FOR ADVANCED GROUP TECHNOLOGY INTEGRATED WITH CAD/CAM (MAGIC)

PROJECT NUMBER: 2623

The objective of this project is to develop a Computer Automated Group Technology (CAGT) system to facilitate the use of group technology methods and tools in small and medium sized factories by automating the methods and integrating the tools into CAD/CAM and CAPP systems.

The principal modules of the system will provide:

- automatic creation, during a design task on a CAD system, of computer internal representations of assemblies, subassemblies and parts, defining their geometrical, functional and production characteristics

- automatic retrieval, based on their functional or morphological characteristics, of existing similar designs of assemblies, subassemblies and parts, from a rough sketch on the CAD system, or a functional or production-oriented description of a new design

- automatic retrieval of appropriate operation sequences for manufacturing.

The automatic generation of the internal representation will avoid the time consuming and inconsistent coding of parts normally experienced with group technology systems.

The CAGT system will be interfaced to a range of CAD systems.

The project's industrial partners will make direct use of the system by applying to their own manufacturing operations. They expect to achieve more efficient design and process planning, an improved utilisation of their manufacturing equipment by standardising processes, and a reduction in inventories.

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MARES SA	*E*	*A*

Start Date	Duration
01-JUN-88	*36 months*

INTELLIGENT SYSTEM FOR AUTOMATIC PROCESSING OF DESIGN CODES OF PRACTICE (AUTOCODE)

PROJECT NUMBER: 2626

The objective of this project is to develop a computer system which will enable designs to be checked for conformity with design and test codes of practice. The system will accept data from four different sources:

- the results of a finite element modelling analysis, structured in the neutral file format defined by the CAD*I project (ESPRIT project 322)
- data introduced by the user, assisted by an expert system
- data from a knowledge base for each process or code of practice
- data from standard databases of industrial and scientific information (properties of materials, universal constants, industrial components, etc).

Specifications will be developed enabling further data, knowledge bases, standard databases and expert systems to be added to the system and programming and verification guides to be incorporated. A set of international design/test codes of practice will be incorporated into the system, covering a wide spectrum of applications, including construction, mechanical engineering, transportation, capital goods manufacturing (pressure vessels, heat exchangers, boilers, etc) and automotive manufacture.

The project partners plan to exploit commercial products developed from the results of the project to users of finite element modelling programs and design and test codes of practice.

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Start Date	Duration
26-APR-89	*48 months*

ADVANCED ROBOTICS MANIPULATION SYSTEM (ARMS)

PROJECT NUMBER: 2637

The objective of this project is to develop a robot manipulator system capable of performing a range of assembly tasks.

In the first phase, developments in electric drives, transmission and materials will be progressively introduced into existing manipulator designs. In parallel, new manipulator concepts will be developed.

A robot controller specifically adapted to assembly applications will be developed. This will have an off-line programmimg capability and will integrate inputs from a variety of sensors in an assembly environment. A three-level software structure will be adopted:

- robot level, corresponding to the basic functions required to control the robot (robot model, coordinate transformation, sensor processing)
- task level, eg trajectory following
- application level, allowing a description of an application as a sequence of level 2 tasks as a function of external (environment) or internal (robot state) events.

A simulation and off-line programmimg system will encompass advanced functions such as generation of task planning, collision avoidance and calibration tools.

The development will be targeted at applications in the automotive and domestic appliance industries:

- automotive subcomponent assembly (doors, dashboards, front ends)
- assembly of these components into vehicles
- washing machines, refrigerators, cookers.

The domestic product application will involve imprecise geometry, cooperation of multiple robots, and manipulation of pliable parts (electric cables, rubber hoses, etc).

The results of the project will be exploited within the project partners' own assembly operations and as commercial products by the IT vendor partners.

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TECNOMATIX EUROPE NV	*B*	*A*

Start Date	Duration
01-MAR-89	*36 months*

INTEGRATED INTELLIGENT PROCESS CONTROL AND INSPECTION IN ROBOT FINISHING (ICI)

PROJECT NUMBER: 2640

The objective of this project is to automate the polishing of castings or machined metal parts.

Quality requirements of many polishing processes are very strict, demanding a high degree of human skill and attention. The work is strenuous, noisy, dirty and uninteresting. Workers are exposed to hazardous environments and to machine vibration. Automating the process will provide lower production costs, higher productivity and consistent product quality.

The aim of the project is to develop a robot-based finishing system equipped with computer vision. The vision system will provide on-line inspection of the polishing operations and feed back instructions to the robot system to correct detected errors. Particular emphasis will be given to the design of a sensor head for image capture, the development of image analysis tools for powerful texture analysis and their implementation in dedicated hardware. The control system may need to include 'knowledge' based on human experience to address the uncertainties of varying metal properties, the variation with time of the sharpness of the polishing belt, and the ability of the robot system to follow the exact contour of the part or to exert accurately the force required.

A three-level design will be adopted:

- process level: path planning - addressing the presentation of the entire surface of the part to the polishing belt

- sequence level: planning a polishing sequence based on the part geometry and the inspection of the previous sequence

- tool level: modelling the status of the polishing belt and controlling the polishing parameters.

At sensor level the special problems of image capture and analysis will be addressed. A universal sense head for capturing 3D surfaces will be designed with automatically-controlled lighting so that surface texture and defects can be analysed.

The project will focus on the polishing of metal taps but potential applications of the techniques are foreseen to the polishing of propellers, turbine blades and precious stones, the deburring of plastic parts, and the finishing of shoes.

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UNIVERSITY OF NEWCASTLE	*UK*	*S*

Start Date	Duration
20-DEC-88	*36 months*

INTELLIGENT DRIVE FOR SHOP FLOOR SYSTEMS (IDRIS)

PROJECT NUMBER: 2656

The objective of this project is to enhance the capabilities, performance and cost-effectiveness of multi-axis machinery by the application of distributed systems techniques at the level of intelligent drives, motor systems and smart power conversion.

The provision of large amounts of processing power close to its application is becoming a possibility with the advances in VLSI (and specifically ASIC) components integrating both high processing and power control capabilities. The project intends to exploit this, together with advances in distributed computing architectures, in order to improve control, efficiency and flexibility of performance of multiple drive systems with particular reference to the requirements of highly coordinated applications such as multi-drive NC machines and robot manipulators.

Specific project objectives are:

- definition of a system architecture to support the flexible distribution of logical multi-axis functions
- development of reliable interactive simulation for electrically commutated drives
- development of prototype intelligent drives addressing the needs of electrically-commutated control
- specification and prototyping of focused tools using a European standard support environment, dedicated to the specialised needs of advanced distributed control systems
- definition and implementation of an applications demonstrator based on a multi-axis machine incorporating the prototypes developed by the project, to evaluate the modularity, autonomy and performance of the prototypes in a representative industrial application.

The project will result in the development of drives and control systems with higher precision than is currently available (0.1 micron), with simple start-up requirements, improved user-friendliness of status and error information and without detrimental influences such as harmonic pollution on the power supply line. This will be achieved by the use of completely digital systems with digital interfaces combined with progressive, innovative, distributed control algorithms. This will be coupled with the ability to replace drives and modules in service without worrying about the effects of motor parameter variations.

These characteristics are much in demand in the machine tool and robotics industries and a considerable market potential for the development is foreseen by the project partners.

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UNIVERSITY OF NEWCASTLE	*UK*	*P*

Start Date	Duration
16-JAN-89	*48 months*

ADVANCED ROBOTICS IN FLEXIBLE AUTOMATION: COMPONENTS, TOOLS AND STRATEGIES (ARTIFACTS)

PROJECT NUMBER: 2658

The objective of this project is to facilitate the design, integration and operation of flexible assembly and inspection cells using advanced sensor technologies by:

- the development of advanced multi-sensor capabilities closely integrated with easily programmable and adaptable automation components
- the provision of an advanced support environment, linked to CAD, to enable the off-line generation of programs and models for the various elements of a sensor-based workcell
- the definition of open architectural principles and guidelines for cell and control structures, and for sensor integration within those structures.

Prototype subsystems to be developed will include robot, cell and intracell communications controllers, and a range of sensor subsystems (2D modular vision with multiple sensor inputs, 2D and 3D grey scale vision, direct 3D, tactile imaging, and a sensor integration unit).

The support environment will provide:

- a set of tools to support the various programming and setting-up tasks to introduce a new product variant to the cell; these will include tools for programming sensor systems and generating models from CAD data where possible
- a common operating environment for the tools, providing unified access to and management of the associated data.

The system will be demonstrated and evaluated in an electronics assembly and inspection application involving both surface-mounted and through-mounted components.

The project results will be applied to the production environments of the major manufacturing partners and will be exploited as commercial products by the IT vendor partners. Whilst the initial application is expected to be in electronics assembly, subsequent application to other industries is anticipated.

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Start Date	Duration
15-FEB-89	*48 months*

KNOWLEDGE-BASED MULTI-SENSOR SYSTEMS IN CIM APPLICATIONS (KB-MUSICA)

PROJECT NUMBER: 2671

The objective of this project is to develop an integrated multi-sensor framework for process control and other industrial CIM applications, bringing together new generations of knowledge-based systems, control techniques and intelligent sensors.

The work programme will address a number of practical measurement and control problems covering a range of variables from the standard areas of pressure, flow, temperature and chemical measurement, to new systems coping, for example, with object recognition or tactile information.

The aim is to develop validated protoype systems for four industrial demonstrators, meeting technical requirements for new sensing systems, fault detection and diagnosis, using knowledge-based systems, multi-variable control and a standardised fieldbus system.

The following demonstrators will be established:

- chemical processing, with an emphasis on the improvement of safety, health and the environment, and on fault detection systems to prevent spurious plant shutdowns
- metal deburring, focused on minimising human intervention
- plastic processing, with an emphasis on lower operating cost
- glass manufacture, concentrating on energy savings and temperature control.

A considerable number of hardware and software products are expected to result from the project and plans for their exploitation are given a high priority by the project partners.

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Start Date	Duration
21-FEB-89	*48 months*

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