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The Project Synopses

Computer Integrated Manufacturing

Volume 6 of a series of 7

April 1988

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The Project Synopses

Computer Integrated Manufacturing

Volume 6 of a series of 7

April 1988

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LEGEND

Countries		Roles	
B	Belgium	M	Main Contractor
D	Federal Republic of Germany	P	Partner
DK	Denmark	S	Sub-contractor
E	Spain		
F	France		
GR	Greece		
I	Italy		
IRL	Ireland		
L	Luxembourg		
NL	The Netherlands		
P	Portugal		
UK	United Kingdom		

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INDEX BY ACRONYM

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COMPUTER INTEGRATED MANUFACTURING (CIM)

Introduction

This 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.

This is an area where the potential for significant advances through a unified approach are high, and it is therefore particularly suitable for effort on a Community scale.

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

EXPLOITATION OF REAL-TIME IMAGING FOR ARC WELDING

Project Number : 9

The objectives of this project are 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 is as follows:

- Initial demonstration of laboratory prototype image analysis equipment achieved March 1986.
- Initial demonstration of pre-production prototype automated welding equipment achieved 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 are expected in late 1988, after they have been successfully evaluated.

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Start Date: 01-SEP-83 *Duration: 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: 01-SEP-83 *Duration: 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 designs for 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: 20-JULY-83 *Duration: 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: 01-SEP-83 *Duration: 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 industrial application of the system for car wheel and electromechanical switch assembly is now in hand.

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

INTEGRATED ELECTRONIC SUBSYSTEMS FOR PLANT AUTOMATION

Project Number : 179

The objectives of this project are 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 is 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 after completion of the project in 1989. The design methodology will be made generally available and will be supported by manuals, seminars, etc.

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

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

Project Number : 197

The objective of this project is 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 is 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.

3-D simulation models for thermal propagation have been developed. Image processing techniques have been applied to thermal images. An algorithm has been proposed for achieving thermal tomography by solving the inverse propagation problem. A prototype system is being implemented, integrating thermal image acquisition and a real-time image processing system for the identification of flaws.

The successful application of thermal image processing techniques will enable the identification of flaws in composite materials which cannot be detected by other non-destructive testing techniques. Other industrial applications of thermal imaging are expected to be identified.

A prototype system for the identification of flaws in fibre reinforced composite material will be available by mid 1988

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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. MARI has established a dedicated manufacturing plant to exploit the tactile sensor systems.

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

KNOWLEDGE & DECISION SUPPORT FOR MATERIAL HANDLING SYSTEMS

Project Number : 293

The objective of this project is 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 is as follows:

- Specify design of cost modelling functions and cost data base.
- 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 data base for a special material handling application.
- Verify prototype for cost modelling in material handling application.
- Specify and implement modelling knowledge base into a prototype using a suitable artificial intelligence tool.
- 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 will provide a powerful tool to enable end users of material handling systems to tailor systems to their needs and to reduce risks in implementation.

An expert system for the design of material handling systems will be applied by CGP in 1988. Further applications are planned by the other project partners after the conclusion of the project.

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Start Date: 01-SEP-85 *Duration: 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 the product design, production process, product distribution, manufacturing plant, equipment, the 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 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. The Design Rules will be published early in 1988.

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Start Date: 01-JAN-85 *Duration: 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 data bases 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.

Different systems which will be interfaced have been installed, eg CAD systems, finite element processors, experimental systems, database management systems, network connections and other modules needed for product design and communication. The deficiencies of existing interfaces have been established by implementing and testing them with product data. A CAD system reference model has been defined. Version 3.2 of the specification of the neutral file for CAD geometry data exchange is available.

Skeleton pre-processors have been completed for the following CAD systems: PRONEN from ISIKON; EUCLID from Matra Datavision; Technovision from Norsk Data, BRAVO from Applicon, ICEM from Control Data and ROMULUS from Shape Data. Test files of solid models have been exchanged, in both directions, between EUCLID and BRAVO, and Technovision and PRONEN. Artificial intelligence methods applied to the design process have been analysed and a concept for an AI interface derived. CAD*I specifications concerning CAD geometry and product analysis data have been presented to ISO TC 184 SC4, and published in the ESPRIT Report series in 1986 and 1987.

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 CAD*I standard interface is a major contributor to the STEP standard, due to be finalised by ISO by the end of 1988. Industrial applications of pre- and post-processors are expected during 1989.

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

PRODUCT DESIGN FOR AUTOMATED MANUFACTURE & ASSEMBLY

Project Number : 338

The objective of the project is to develop methodologies and tools which will provide designers with the information and data necessary to ensure that product designs are compatible with automated manufacturing and assembly techniques. In particular, data enabling a rational choice of manufacturing tolerances compatible with automated assembly processes will be provided, together with data on the constraints imposed on design by particular flexible machining and flexible assembly systems. It is planned to incorporate the data in CAD systems or terminals linked to the design database, as appropriate to the application. The programme is as follows:

- Specification and validation of design rules for automated manufacture and assembly.
- Collection and collation of the full range of required manufacturing data.
- Construction of a database on a purpose-designed CAD workstation.

A set of design rules for automated and robotic assembly, and for automated manufacture, have been defined. Methods of presenting process capability data have been developed.

The use of these methodologies and tools will help to avoid costly and time-consuming product re-design to permit automated manufacture. The project will establish a set of design rules for incorporation into CAD workstations.

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Start Date: 01-FEB-85 *Duration: 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 will be 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 the information processing requirements to achieve this end. The description will enable the control of assembly cells.

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: computer-aided design and planning (using specialised data bases and feedback from simulation), and production subsystem (assembly task scheduling, control and error recovery). Develop a testbed system to demonstrate results. Demonstrations will be given throughout, at key stages of the development phase.

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. Prototype software modules are becoming available within the project. These will be further developed in the knowledge-based environment, studying their necessary interactions and integration with a computer-aided design system.

Flexible Automated Assembly Systems (FAAS) are, potentially, a key market area for IT vendors. The availability of comprehensive integrated information processing systems to facilitate FAAS could earn revenues of several million ECU annually. A series of system modules will be demonstrated at intervals between late 1987 and mid 1989. These include product, knowledge and production modelling functions, resource planning and assembly scheduling, assembly cell and station control modules. It is anticipated that these will be exploitable as spin-offs before the end of the project.

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Start Date: 01-APR-85 *Duration: 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.

The mode of system/user interaction has been specified. A prototype system is in the realisation phase. In the meantime, the EUCLID and EXAPT systems used in the project have been linked together and data exchange between the systems has been established. For frequently recurring planning and programming tasks in the pre-milling area, user elements have been created in the form of macros and user interfaces.

The availability of this system will considerably reduce the time between the design of mechanical parts and their manufacture. Early spin-offs are planned. Pilot applications are expected to commence in 1988.

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Start Date: 01-DEC-85 *Duration: 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 is to develop a CAM System with an open architecture which can integrate and monitor on-line batch production planning and control activities (eg shop floor control, handling, quality control) for the manufacture of mechanical products. A key consideration is establishing a workable balance between production cost and delivery time requirements. The potential benefits of the system will be demonstrated in a fully operational test bed.

The programme is as follows:

- Detailed analysis of existing manufacturing environments in terms of physical constraints, data and decision flows, and manufacturing process and strategies. This will support the design and verification of a basic system architecture.

- Development and integration of software and hardware subsystems in accordance with the system architecture and progressive implementation in a production environment.

A full set of methodologies and tools for manufacturing environment analysis, and reference models and a skeleton architecture of a manufacturing system, have been developed. These are based on a hierarchical decomposition of functions and the establishment of logical relationships and interdependencies among objectives, tasks and functions. For example, increased automation and the associated increase in flexibility causes an increase in planning complexity as the functions become more time critical.

The tools and methodologies developed by the project will be applicable to both machining and assembly environments, enabling improvements in flexibility and reductions in unit costs. The system will be implemented in a real production environment at FN during 1989. Additional development by software houses will be applied to produce exploitable software packages based on the common architecture from early 1988 onwards.

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Start Date: 01-APR-85 *Duration: 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:

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

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

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

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

Yr 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. A "breadboard" application generator has been demonstrated. Key building blocks have been designed, and prototypes are under development. A common data dictionary and glossary of terms has been provided for publication.

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.

In early to mid 1987 the following spin-offs will be exploitable by the partners: production scheduling modeller, production system modeller and materials warehouse modeller. Exploitation of the integrated system is targeted for 1989.

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

DESIGN AND SPECIFICATION OF CONFIGURABLE GRAPHICS SUBSYSTEM 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: 01-DEC-84 *Duration: 36 months*

PLANT AVAILABILITY AND QUALITY OPTIMISATION (PAQO)

Project Number : 504

The objective of this project is to improve the operational economics of automated discrete parts manufacturing by maximising plant availability and product quality within the constraints imposed by plant safety.

The strategy is based on developing a systematic approach to the whole question of plant monitoring so that with the integration of performance, diagnostic and quality monitoring within a closed loop operational control, degrees of fault tolerance can be introduced to the manufacturing processes with special emphasis on the lowest process levels.

The machine tool demonstrator based on a milling machine incorporating a "tactile" machine spindle was completed during 1986. This successfully demonstrated real-time diagnostic monitoring of the cutting process and the machine drives, as well as the in-process monitoring of surface finish. At the same time an independent demonstration was made of a model-based software tool designed to support fault interpretation from multiple inputs and expert knowledge.

A large-scale system demonstrator is being planned and will be operational during 1988. This will involve an advanced flexible machining cell based in Northern Spain and operated in conjunction with the Danobat Machine Tool Company. A new modular universal monitoring computer has been designed and built within the consortium which is capable of the demanding data acquisition, analysis and communications functions necessary for this cell to operate with fault tolerance capability.

This computer with associated real-time process surveillance, diagnostic and interpretation software is targeted for exploitation before the end of 1988.

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Start Date:	*01-JAN-85*	*Duration:*	*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 withdrawl of the prime contractor. However, the following was acheived:

- 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 gouging 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.

Plans are underway to utilise the parts transfer system within the Westland Group and there are possibilities of commercial exploitation by the conveyor supplier. A PC interface for optical fibres developed by the project is being marketed by VUB. The capability developed by Riso for the production of holographic optical elements will become increasingly important with the advent of minituarised and integrated optical systems and will certainly lead to commercial products.

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Start Date: 01-JAN-85 *Duration: 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 is 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 are being developed and the links to the necessary quality inspection, instrumentation and databases are defined. The organisational and production models of heavy fabrication are being studied with the use of the DAFNE methodology

Successful implementation of a CIM architectural model, adapted to the heavy welded-fabrication industry, (eg shipbuilding) will lead to considerable improvements in productivity and product quality and help to make the industry more responsive to market needs.

The use of simulation techniques and off-line programming in weld cells has commenced and will continue through 1988 and 1989. Weld cell performance will also be 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. Other opportunities for exploitation will follow during the DAFNE analysis/design cycle. The full industrial implementation of the system will commence in 1990.

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Start Date: 01-AUG-84	*Duration:*	*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. The following prototypes have been demonstrated:

- Knowledge based evaluation, simulation and optimisation tools for system planning of flexible robotised assembly cells.

- Interactive off-line programming and simulation system for robots realised and tested for different industrial applications.

- Automatic programming modules for action planning, error recovery and trajectory optimisation.

The provision of integrated planning systems will reduce the risks and planning time involved in integrating robots into CIM systems and the availability of off-line programming techniques will considerably reduce the downtime of robot systems.

Subsystems already developed are on industrial test for welding applications. Technology related to simulation and planning, developed in the project, is already being applied by the industrial partners. Other subsystems will be exploited as they become available.

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

A EUROPEAN COMPUTER INTEGRATED MANUFACTURING ARCHITECTURE (AMICE)

Project Number : 688

The objective of this project is 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, in terms of functions, information, control and resources. It can also implement CIM systems derived from the enterprise model. A key part of the implementation model is the Integrated Data Processing Architecture dealing with the integration of services like data communications, data storage, machine front-ends and related human interactions.

The architecture will address the upper layers of the ISO Open Systems Interconnection model concentrating on layer 6 (presentation) and layer 7 (applications). The work will be complementary to the Manufacturing Automation Protocols (MAP) initiative and to CNMA (ESPRIT project 955). The programme is as follows:

- Definition study (March 1985).
- CIM Open Systems Architecture (OSA) key concepts (February 1986).
- Complete and consistent architecture specification available (January 1987).
- CIM OSA version 0 available (July 1988).
- CIM OSA version 0.1 available (February 1989).

Key CIM Open Systems Architecture (OSA) concepts have been established. The first draft of the consistent architecture specification is available.

The project is expected to have a major impact on the formation of international standards in this area. In particular, the results are being used as inputs by European representatives to ISO TC 184.

The architecture will be employed by both users and vendors in the consortium when planning their next generation CIM systems.

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

ADVANCED CONTROL REAL TIME CIM SYSTEMS AND CONCEPTS FOR FLEXIBLE AUTOMATION

Project Number : 809

The objective of this project is 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 will include:

- 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 system design and implementation phase is in progress. The results of the research are being implemented at the demonstration site at Marskate 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.

It is intended to install the initial release of the system (including DNC and machine monitoring) into an industrial site by early 1988. The exploitation of control, data capture and analysis, and decision support systems will follow.

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Start Date: 01-MAR-86	*Duration:*	*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.

The preparatory study has been completed. The study of manufacturing characteristics and relevant processes of the centre has been prepared in order to provide a wide range of applicability. The configuration of the centre has been defined and it provides a system architecture suitably open to integration in a CIM multi-vendor environment in the area of flexible mechanical manufacturing.

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: 01-APR-86	*Duration:*	*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: 01-APR-86 *Duration: 12 months*

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

Project Number : 909

The objective of this project is to develop strategies and methods for the economic evaluation of CIM systems, supported by a set of tools (to be known as C-BAT). The tools will be tailored to the needs of small manufacturing enterprises and will be portable to a range of widely available personal computers (IBM AT Compatibles using MS-DOS). The tools will be able to accommodate the effects of different national investment programmes, different timescales for implementation, and varying levels of industrial sophistication. The programme is 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 have 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 complete specification has been prepared, including a suitable methodology which is supported by a set of tools. The tools are now being designed, programmed and developed at the partners' sites.

C-BAT will provide 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.

The methodology and software modules will be available for exploitation from late 1988.

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Start Date: 01-JAN-86 *Duration: 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, 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. A demonstration is 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.

- 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 is planned for late 1988. Other partners are exploiting the project results on a continuous basis.

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

COMMUNICATION NETWORK FOR MANUFACTURING APPLICATIONS (CNMA)

Project Number : 955

The objective of the CNMA project is to select, implement and demonstrate profiles of existing and emerging communications standards in real production environments, thus extending present MAP developments. Widespread acceptance of the communications methodology will be encouraged by providing implementation guides and common testing procedures. The project addresses 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 will proceed concurrently.

A Phase I Implementation Guide was published in October 1986 and has been widely circulated. The Phase 2 implementation Guide is due to be published at the beginning of 1988.

The achievements of the first phase of the project were demonstrated at the Hannover 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 impacted on the development of the relevant international standards.

It is intended to demonstrate the CNMA Phase 2 software by participation in the Enterprise Networking Event '88 International in Baltimore in June 1988. This underlines the compatibility of the CNMA and MAP profiles of communications standards, and provides an opportunity for Europe to influence the development of MAP standards. The CNMA profiles will be used in real production applications by BMW, British Aerospace and Aeritalia. Parallel to the specification and development of communications software, conformance testing tools are being established for release to testing institutes.

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Start Date: 01-JAN-86 *Duration: 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.

The hardware and software requirements have been defined. Transponders with storage of 128 bytes have been developed and tested and an industrialised prototype produced. A version with 1K byte storage has been tested at the VW test site. Higher storage versions are under development. These will require application-specific ICs which will also improve data transfer reliability and speed.

Work on temperature resistant transponders is complete. Two prototypes with widely different specifications have been developed. Software for connecting reader stations to automobile manufacturing workstations has been developed. A first test in the test field has shown encouraging results.

The intelligent transponder system will enable the reliable and efficient tracking of parts through the factory. The provision of local storage will considerably reduce the load and the dependency on the central CIM data base and on the related communication channels. The first application of the transponder system, implemented at Volkswagen, is planned for 1988.

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Start Date: 01-APR-86 *Duration: 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 of 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 found 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 non linear set of equations).

APPEAL will initially be implemented for FPS, IBM 3090, CRAY XMP/48 and the transputer. Specifications for the structure of ASSET have also been completed. A common database, managed by a relational system, INGRES, will allow convienient 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 will be available by mid 1988. The final demonstration will be an integrated ASSET/APPEAL demonstration.

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

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

DISTRIBUTED AUTOMATED SYSTEM FOR INSPECTION AND QUALITY CONTROL (DASIQ)

Project Number : 1136

The objective of the project is 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 possibility of the progressive implementation and further development of DASIQ by manufacturing industry, in a variety of FMS environments, will be demonstrated. The programme will include:

- 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 is complete.

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

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

HUMAN-CENTRED CIM SYSTEM

Project Number : 1199

The objective of this project is to develop a prototype manufacturing system comprising integrated 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 proven by demonstrating machine/cell programming, planning and scheduling in a mixed human-oriented/conventional automation environment. This will form the basis from which systems can be developed.

The CAM package will demonstrate the human-centred turning cell with lathes, robot and controller and subsequently demonstrate full operator control of the robot cell. The CAD package will demonstrate prototype CAD interface hardware and CAD database software. The CAP package will demonstrate a basic shop floor real-time monitoring and control workstation. An integrated CIM cell, incorporating CAM, CAP and CAD hardware and software, will be demonstrated. There will be demonstration sites at a BICC factory near Portsmouth, at BITZ on the campus of the University of Bremen and at the Rolls Royce plant at Leavesden, just outside London.

Definition studies are in progress in collaboration with complementary project 812.

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.

A comprehensive, highly interactive, machine control system will be exploitable by mid 1989. Exploitation of the CAM and CAD packages is targeted for 1990 and the integrated system, including CAP, for 1991.

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Start Date: 01-MAY-86 *Duration: 36 months*

VISUALISATION STANDARD TOOLS IN MANUFACTURING INDUSTRY (VITAMIN)

Project Number : 1556

The first objective of this project is to develop a toolkit of hardware and application independent software modules based on UNIX and X-Windows, to simplify the construction and use of graphic subsystems on the shop floor in manufacturing industry. Two application areas have been 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.

Each of these tools will be evaluated in industrial test bed sites. The use of target machines different from the development and integration hardware will demonstrate the hardware independency of the tools.

A second more ambitious objective of generating a system builder will be pursued in parallel. This approach is based upon the technology of the rapidly evolving UIMS (User Interface Management System). It will be built around presentation, dialogue control and application interface modules, and will draw upon the experience gained in the use of the initial toolkit.

A functional analysis of the tasks performed by the manager of a manufacturing production unit has been completed with the help of a computerised system. Work on the AMD is virtually complete. Analysis work has commenced in preparation for the specification of the system builder.

The industrial evaluation of the AMD will be performed at the end of 1987, and one year later (on another industrial site) the ACD will be evaluated. The results of this project will promote the more efficient utilisation of manufacturing resources, by the use of graphic display techniques.

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Start Date: 01-JAN-87 *Duration: 36 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.

- Design and construction of a generic assembly robot in order to validate the developed methodology, to integrate innovative technologies and to illustrate the applicability of these concepts for real FAAS applications.

- Installation of the equipped robot in an automated assembly cell, for testing and evaluation.

Analysis of current FMS/FAAS implementations and of the state of the art in the various disciplines have been completed. Development work on modelling software, on applicable control techniques and on identification methods is progressing.

The project will enhance the state of the art in CIM by improving accuracy, speed, repeatability and other performance characteristics of FMS robots in demanding environments. Improved control and identification methodologies will be available in 1989. A fully operational demonstrator with a new-generation numerical controller is targeted for exploitation by the end of 1990.

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

BASIC TECHNOLOGIES FOR HIGH PERFORMANCE SOLID STATE IMAGE SENSORS

Project Number : 1572

The objective of this project is 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 will provide the fundamental technology which will permit the development of the next generation of image sensors. These will have more than 1 million pixels per chip. The programme is as follows:

- Development of transparent electrodes
- Functional test of solid state image sensors
- Reduction of amplifier noise.
- Methods for anti-blooming and anti-smearing.

Suitable sputter deposition equipment for transparent electrodes, including monitoring systems for analysis of gas composition, has been selected, installed, and is operational. Theoretical calculations have shown that the light sensitivity of a frame transfer sensor can be increased by up to three times by replacing the three levels of poly silicon by two levels of indium-tin-oxide.

For functional testing, the first concept for the optomechanics has been realised, the software for controlling the optomechanics is installed and working, and the probecard for testing sensors on wafers is operational. The frame store concept is finalised and construction is under way.

Studies of ways of reducing amplifier noise and optimising speed have been completed and the influence of polarisation current and polarisation mode on noise spectrum has been investigated. These results have been used to determine the design of the test chip; masks have been manufactured and wafer processing is in progress.

For the suppression of blooming, a study has shown a horizontal AB structure with a buried channel to be compatible with the proposed s1.5 micron technology. Test chip design and mask set fabrication are complete. Wafer processing is proceeding.

The development of an image sensor with more than 1 million pixels/chip combined with high sensitivity and low noise will provide a high performance component for the development of high resolution solid state cameras for industrial applications.

A successful result to this research project could result in industrial exploitation in the early 1990s.

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Start Date: 01-DEC-86 *Duration: 24 months*

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