Esprit

European Strategic Programme
for Research and Development in
Information Technology

The Project Synopses

Information Processing Systems

Part I: ESPRIT I Projects

Volume 3 of a series of 8

September 1989

Directorate General XIII
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Commission of the European Communities

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Information Processing Systems

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XIII/321/89

LEGEND

COMMUNITY MEMBER STATES

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NL	The Netherlands
P	Portugal
UK	United Kingdom

ROLES

M	Main Contractor
C	Coordinator
P	Partner
S	Sub-Contractor
A	Associate Contractor

INDEX BY PROJECT NUMBER

INDEX BY ACRONYM

Projects without acronym can be found in the main index

INFORMATION PROCESSING SYSTEMS

Part I

INTRODUCTION

This directory contains information on 94 projects supported both within the Software Technology and Advanced Information Processing areas of the first phase of the ESPRIT programme. The entry against each provides a summary of its objectives together with information on the progress made and results obtained. Further information can be obtained from the person indicated on the project sheet.

Software Technology

From its outset in 1984, the objective of this part of the ESPRIT programme has been to encourage the development of a scientific basis for software engineering from which a range of industrial practices can be designed and implemented.

The approach has been primarily one of viewing the software development process in the wider context of complex system development. This has ensured that the collaborative, precompetitive research and development actions of the ESPRIT programme have addressed the real problems faced by today's software industry in Europe, particularly the production of high quality software products and improving the productivity of the software development process.

To achieve these dual goals, the Software Technology programme has concentrated on four key subareas:

(i) Theories, Methods and Tools

The definition and development of rigorous design methods and the development of the appropriate support tools. The work covers formal methods (formal in the mathematical sense) and informal techniques, and the appropriate use of knowledge engineering techniques.

(ii) Management and Industrial Aspects

The development of techniques for project management and production management. The complexity of many software development projects is such that they require the coordination of large development teams, the production and revision of large amounts of documentation and code, the use of distributed computing facilities, etc. Appropriate techniques are therefore needed for resource management, documentation control, configuration management and version control.

(iii) Common Environment

Clearly, the information which is generated during each phase of the development process needs to be stored in a relevant form, not only for easy access by the design team and the project managers, but also for the appropriate relationships to be maintained between the various design descriptions produced as the design proceeds. To provide the mechanism for this "object management", a common utility is necessary which provides the relational database mechanism and the relevant common interfaces for design tools, project management tools, user access, etc. This common environment provides the framework within which many of the results of the Software Technology programme can be integrated to form industrial systems. Within the subarea the first generation environment, based on the entity relationship model, has already produced common interface definitions which have entered the international standardisation process, and industrial systems are available. Next generation systems, eg incorporating knowledge engineering techniques, are under development.

(iv) Evaluation and Demonstration

Proper evaluation of the environment, methods and tools within industrial contexts is crucial for the industrial take-up of results of the programme. Therefore, a number of projects have been launched to provide cost-benefit data on the use of these systems in industry.

Advanced Information Processing

The objective of this part of the ESPRIT programme has been to develop the necessary technologies for the implementation of the next generation of computing systems, by supporting three main lines of action:

- the development and application of knowledge engineering techniques;

- the development of new computer architectures for symbolic and numeric processing, and fault-tolerant systems;

- the development of advanced system interfaces for effective communication between computing systems, the computer and its environment, and the computer and the user.

Priority has been given to consolidating and accelerating the industrialisation of the results emerging from the projects. Results have been achieved particularly in the knowledge engineering and computer architecture projects, where a firm base is being built for the future enhancement and exploitation of these technologies and techniques by European industry.

The Advanced Information Processing programme has concentrated on three key sub-areas:

(i) Knowledge Engineering

The development and application of knowledge-based systems. The approach adopted has been to:

- develop the methods and techniques for knowledge acquisition and knowledge representation;
- develop application-independent knowledge-based system shells, supporting languages and user interfaces;
- develop domain-specific systems;
- evaluate knowledge-based systems in the industrial environment.

(ii) New Computer Architectures

The development of high-performance computers capable of processing symbolic and numerical information, concentrating on highly parallel architecture machines.

Such computers will provide the computing capacity needed as the results of knowledge engineering work and advanced man-machine interfaces become embedded in a wide range of applications, eg CAD and office systems.

(iii) Advanced Systems Interfaces

The work has concentrated primarily on image processing, natural language understanding and speech processing, and is complemented by studies of multi-sensor operation.

ESPRIT II

Part II of this document gives similar information for the projects launched under the second phase of the ESPRIT programme.

PROJECT SYNOPSES

ADVANCED ALGORITHMS AND ARCHITECTURES FOR SPEECH AND IMAGE PROCESSING (SIP)

PROJECT NUMBER: 26

Objectives/Programme of Work

The objective is to develop the algorithmic and architectural techniques required for recognising and understanding spoken and visual signals, and to demonstrate these techniques by means of suitable applications.

The work has been planned in three parallel areas: speech analysis, image analysis and pattern recognition and understanding.

With respect to speech, the initial application target is to extend as far as possible current state-of-the-art techniques for speech recognition. The resulting system will be tested using a vocabulary of the order of 1,000 words with constrained syntax and using continuous speech.

For image processing, the project is attempting to go beyond treating the image merely as sampled data. Applications involved in medical imagery and industrial inspections will be used to test the tools and to study architectural and implementation issues. At the higher level of processing, close commonality can be expected between techniques for speech and image processing. Subsequent work will study architectures suitable for the higher levels, which can interface with the lower level systems.

Progress and Results

Progress on speech processing is along two complementary lines: a statistical approach and a knowledge-based approach. Preliminary results have been obtained from the statistical approach, based on a first implementation, using very large lexicons. For the knowledge-based approach, a methodology for representation of the lexical and acoustical knowledge has been chosen and development tools are under development. In addition, the architecture of the acoustical front-end is being realized and the first digital signal processing boards are being tested. The lexical access and the verification based on a Hidden Markov Model have been demonstrated on a VAX machine to a set of short sentences uttered by a single speaker in a noisy environment. Methods to incorporate syntactic and semantic information are being studied to achieve understanding of uttered sentences. A small question-answering system running on a Symbolics machine has been demonstrated. The system starts from the word lattice produced by the speech system, builds a representation of the query-using syntax and semantics, and finally answers the query.

A coordinated set of algorithms and architectures for image recognition and understanding has been developed and demonstrated. Layer approaches based on Single Instruction Multiple Data (SIMD) and Multiple Instruction Multiple Data (MIMD) machine are being realised for image feature extraction. An hetereogeneous approach has been taken linking together a SIMD GAPP array for the low level processing and an MIMD transputer-based machine or an array processor for the medium level processing. The interfaces and the I/O of the data are being developed and optimized. Estimates of performance have been derived from a set of algorithms running on the different parts of the architecture. This will be improved by setting up real benchmarks. Specific work has been done to provide a coordinated set of algorithmic tools for digital angiography applications.

Implementation aspects of the physical architecture for high-level processing based on transputers fully interconnected through a switching network have been analysed in detail; a switching element for non-local communication has been designed outside the project and the first building-block comprising two processing elements and a hardware emulation of the interconnection network is now available.

PIPES, the first prototype realisation of a Prolog transputer-based machine where the transputers are fully interconnected using a packet-switched network, has been demonstrated. It will be implemented on the high-level architecture for speech and image understanding and applied to real-time tasks.

Exploitation/Time Horizon for Industrial Application

SIP has been the source of applications in sound, vision and robotics through the development of a coordinated set of algorithms and architectures for image recognition and understanding. It provides the foundation for applications in medicine, in industry and in other domains. Project results also support the development of intelligent workstations to support both graphic processing and image processing.

The successful combination of statistical techniques and knowledge-based techniques for speech recognition will result in a major breakthrough in the field. The complete real-time stand-alone system displaying spoken Italian which is now under development will be adapted for French and German.

Contact Point

Mr. G. Perucca
CSELT
Via G. Reiss Romoli 274
I-10148 TORINO

Tel: +39-11-2169311
Tlx: 220539
Fax: +39-11-2169520

Participants	Country	Role
CSELT	*I*	*M*
AEG Telefunken	*D*	*P*
University of Strasbourg	*F*	*P*
University of Turin	*I*	*P*
Thomson-CSF	*F*	*P*
Polytechnic of Turin	*I*	*P*
HITEC	*GR*	*P*

Start Date	Duration	Resources
01-SEP-83	*60 months*	*142 PY*

A BASIS FOR A PORTABLE COMMON TOOL ENVIRONMENT (PCTE)

PROJECT NUMBER: 32

Objectives/Programme of Work

The objectives of the project were to define the necessary interface specifications and to implement the basic utilities and working prototypes of a portable common tool environment (PCTE) to support tool development. The tool and user interface specifications were to be maintained as public domain documents to ensure common tool portability.

Progress and Results

The kernel which constitutes the environment was evaluated by developing a Configuration Management System (CMS), a Knowledge-Based Programmer's Assistant (KBPA), and other tools.

Specifications of the tool and user interfaces were made and are available in the public domain, under the control of the independent PCTE Interfaces Management Board (PIMB). Both Ada and "C" specifications are also available.

Various prototypes of the PCTE functionalities have been demonstrated. Commercial implementations are already available on the market (Emeraude on Bull SPS7 and Sun 3). An Ada version of the PCTE OMS and tool interfaces is available in order to ensure that the PCTE can provide the basis for an efficient Ada Project Support Environment.

Exploitation/Time Horizon for Industrial Application

PCTE provides a European standard for support environment interfaces enabling the growth of a software tools market and the efficient, coherent development of large systems across multi-company development teams. Links are presently being established with various European national programmes and European development agencies, and industry prospects appear good for achieving a high level of coordination.

PCTE is used in national programmes and EUREKA projects, and is forming the basis for international efforts to build standard programmer environments.

The PCTE Interfaces Management Board (PIMB) is controlling the interfaces and will be in charge of their evolution. Particular attention is given to standardisation through the activities of ECMA Technical Committee 33. Many tool designers and

developers have adopted these interfaces in Europe and the Ada version will have a considerable impact in the US.

Contact Point

Mr. R. Minot
Direction Recherche et
Technologie
BULL S.A.
Route de Versailles, 68 *Tel: +33-1-39025000*
F-78430 LOUVECIENNES *Tlx: 697030*

Participants	Country	Role
Bull S.A.	*F*	*M*
GEC Research Laboratories	*UK*	*P*
Nixdorf Computer AG	*D*	*P*
Olivetti	*I*	*P*
Siemens AG	*D*	*P*
ICL	*UK*	*P*

Start Date	Duration	Resources
01-OCT-83	*54 months*	*113 PY*

EXPERT SYSTEM BUILDER (ESB)

PROJECT NUMBER: 96

Objectives/Programme of Work

The project investigated the extent to which the production of expert systems could be industrialised. It created an Expert System Builder (ESB) for the use of personnel not experienced in artificial intelligence to develop and test expert systems. Trial applications were made. The result compares with the most advanced products in the world.

Progress and Results

The following components of the ESB system were realised:

- the object-oriented system (FLAME)
- the inference engine (called the Basic Expert System Builder or BESB)
- the knowledge representation formalism (CONCEPT)
- the model system
- the Man-Machine Interface system (MMI).

Three simple expert systems for the diagnosis of electronic equipment and one for the diagnosis of a process control system were developed by the partners to provide practical feedback.

The full system is now completed and a commercial product is available with special conditions for CEC-supported projects.

Exploitation/Time Horizon for Industrial Application

A preliminary version of the ESB has been used by third parties since early 1988.

Soeren T. Lyngsoe has announced the commercial release of TOR (based on BESB) and ODIN (based on an early version of the ESB) for the automatic creation of the domain and product layers for power plant applications.

Plessey has started porting and developing industrially the latest version of the ESB. Internal exploitation is planned for the whole or part (MMI) of the system.

Tecsiel has announced porting to various machines and the commercialisation of the system.

Syseca plans to exploit the system internally (especially the MMI system).

ESB will be used extensively in the study of multimedia MMI for expert systems in a real-time environment in ESPRIT II Project 2397, PROMISE.

Contact Point

Mr J. Gray
PLESSEY RESEARCH Ltd
Grange Road, Christchurch
UK-Dorset BH23 4JE

Tel: 202-486344
Tlx: 418417
Fax: 202-486344 ext 2221

Participants	Country	Role
PLESSEY RESEARCH Ltd	*UK*	*M*
CSELT Spa	*I*	*P*
SOEREN T. LYNGSOE A/S	*DK*	*P*
CIMSA SINTRA	*F*	*P*
TECSIEL	*I*	*P*

Start Date	Duration	Resources
01-JUL-83	*63 months*	*130 PY*

A LOGIC-ORIENTED APPROACH TO KNOWLEDGE AND DATA BASES SUPPORTING NATURAL USER INTERACTION (LOKI)

PROJECT NUMBER: 107

Objectives/Programme of Work

LOKI aims to provide the technology for the development of knowledge representation, knowledge use and knowledge consultation systems, and other aids to the development of knowledge and database systems. User-friendly graphics and natural language are to be combined in a single interface.

LOKI applies logic programming in a number of novel ways to systems software and to knowledge-based applications. The systems software work is based on a new Prolog, and special tools allow access to databases at source level by a variety of Prolog-type languages. These tools will form the implementation language for a high-level knowledge representation formalism. A conceptual modelling language (CML) will be developed for general real-world application, based on frames definable within predicate calculus. Two application domains are considered: project management and aircraft design.

Progress and Results

The following results have been achieved in three different fields:

1. Knowledge Representation: development of three formalisms, LOLA and CML to support natural language interfaces and STRUDEL to support a CAD system for aircraft design.

2. Knowledge Use: development of a parser-generator pair (LOQUI) for English and German to support access to databases in natural language, and of a constraint propagator mechanism used for the aircraft design application (ADROIT). The natural language interface is loosely coupled with graphics interface facilities.

3. Knowledge Consultation: development of tools to support inspection of knowledge structures suitable for the project management application and to support explanation facilities in ADROIT.

A first prototype of the aircraft design system, restricted to wing design, is already complete.

Exploitation/Time Horizon for Industrial Application

The partners are already lining up concrete prospects for the exploitation of the work done. BIM-Prolog is already on the market and benefiting from the comprehensive testing afforded by the project. LOQUI will lend itself as an immediate enhancement of the SCS project management materials, and independent developments are already in train within Scicon International Ltd. The constraint propagation tools being developed for aircraft design are being evaluated for use in other contexts.

Contact Point

Mr. M. Vandenbossche-Marquette
Belgian Institute of Management
Kwikstraat 4 *Tel: 2 -7595925*
B - 3078 Everberg *Tlx: 63518*

Participants	Country	Role
BIM	*B*	*M*
Fraunhofer Institut IAO	*D*	*S*
SD-Scicon	*UK*	*P*
University of Crete	*GR*	*P*
SCS	*D*	*P*
INCA	*D*	*S*
University of Stuttgart	*D*	*P*

Start Date	Duration	Resources
01-AUG-83	*62 months*	*68 PY*

KNOWLEDGE INTEGRATION AND MANAGEMENT SYSTEMS

PROJECT NUMBER: 112

Objectives/Programme of Work

The project was designed to investigate key areas of information such as knowledge representation, inferencing techniques and human computer interfaces. Emphasis was given to a language for knowledge representation and management based on LISP and PROLOG; an expert system suited to assist sales engineers in designing computer configurations; and to an expert system serving office personnel to perform complex office procedures (eg resource planning). These complementary tasks focused on the development of hardware and software components to manage the problems resulting from the size and complexity of large knowledge bases, and the associated reasoning mechanisms.

Progress and Results

The wide potential applications were underpinned by an engineering approach where existing tools like OMEGA were studied to investigate the fundamental structure. A development system for the combination of knowledge sources and for communities of cooperating knowledge bases was implemented. The development of a manipulation system for large knowledge bases was planned. The project was terminated on 1.4.86. The contractors agreed that the project could not succeed within the terms defined. They had, however, been successful in integrating the AMORD, CSSA and OMEGA representations, and introducing time dependencies. The reviewers were impressed by the work done.

Exploitation/Time Horizon for Industrial Application

A book relating the progress of the project is being produced. The OMEGA/AMORD/CSSA time reasoner work will be exploited by partners in other development efforts such as message-passing architectures and logical programming environments.

Contact Point

Mr. K. Wimmer
SIEMENS A.G.
Dept. ZTI INF 22
Postfach 830955
Otto-Hahn-Ring, 6
D - 8000 MUENCHEN 83

Tel: 49-89-63644639
Tlx: 521090

Participants	Country	Role
Siemens	*D*	*M*
CII-HB	*F*	*P*
Lab. de Marcoussis, CGE	*F*	*P*

Start Date	Duration	Resources
01-OCT-83	*30 months*	*50 PY*

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

PROJECT NUMBER: 125

Objectives/Programme of Work

The objective is to develop a personal software development workstation for incremental graphical specification and stepwise formal implementation of nonsequential systems by mixing informal diagrams with formal textual information.

The methodological framework is characterized by an integration of formal and informal techniques in the development process:

- Structured analysis diagrams and entity relationship diagrams are used for requirement analysis.

- An extension of the "initial semantics" approach to algebraic specification and high-level Petri-nets is used in a well-engineered merge for specification of large distributed systems. Rapid prototyping is provided by the analysis of abstract implementations.

- Modula and Ada-like languages are considered for the programming activity.

Progress and Results

Semi-formal transformations of system descriptions at different levels are supported by validation and documentation activities. A set of tools supporting the GRASPIN methodology is designed on top of PCTE common tools, which makes a significant use of graphics and of concepts such as focussing techniques, multiple windowing concepts, and simultaneous handling of different contexts.

GRASPIN has produced and demonstrated an integrated tool set which supports all aspects of software system development: requirements analysis, formal specification, incremental program development, design validation, documentation, etc.

The final architecture of the system has been defined. Facilities include support for structured analysis techniques and for the SEGRAS specification language. The workstation provides both language-dependent and independent tools. Among the former are the tools for validation and verification (analyzer, simulator, testbench) as well as the tools providing the user interface. The latter (language-independent tools) include plain and structure editors, a parser and unparser, and an abstract machine. This abstract machine includes the language definition

system and the manipulator which interfaces with the database management system.

The enhancement of the prototype, which runs on a number of systems, has given each partner the opportunity to exploit it as required, and exploitation plans are being prepared by all partners.

Exploitation/Time Horizon for Industrial Application

GRASPIN provides a powerful contribution to computer-aided software engineering. It is being marketed by Epsilon and by Tecsiel, and by Olivetti by whom it has been demonstrated to European universities under the academic support programme for UNIX.

Contact Point

Mr. W.D. Itzfeldt
Dept FB11
GMD - GES. F. MATHEMATIK
& DATENVER.
Postfach 1240
D - 5205 St Augustin 1

Tel: +49.2241.142440
Tlx: 889469
Fax: +49.2241.142889

Participants	Country	Role
GMD - GES. F. Mathematik & Datenver	*D*	*M*
Siemens	*D*	*P*
Olivetti	*I*	*P*
Tecsiel	*I*	*P*

Start Date	Duration	Resources
01-SEP-83	*60 months*	*141 PY*

TIME DEPENDENCY AND SYSTEM MODELLING IN KBS DESIGN FOR INDUSTRIAL PROCESS APPLICATIONS

PROJECT NUMBER: 256

Objectives/Programme of Work

The project addressed some of the research topics connected with the design of KBSs that have to interact closely with complex processes (eg industrial diagnosis, plant monitoring, process control, etc.). It thus developed the capability of dealing with a type of reasoning where time dependency is crucial, and where there is a specific need for representing and using qualitative models of physical systems.

A detailed study at the level of system design assessed the state of the art and defined effective architectures for distributed KBSs.

Progress and Results

The project has produced a literature survey of three topics, namely time-dependent reasoning, qualitative modelling, and distributed expert systems. It has produced a detailed example of the application of three different approaches to modelling the behaviour of physical systems in a qualitative way, and a functional study of two approaches to distribution in expert systems. Finally, an initial specification of a toolkit for the development of KBSs for process monitoring was produced.

Exploitation/Time Horizon for Industrial Application

One participating organisation is using the experience gained in qualitative modelling in the project it is working on. The three deliverable mentioned above are publicly available. Project 820 is implementing and validating through demonstrators the toolkit initially specified in this project.

Contact Point

Dr. Ing. Alberto Stefanini
CISE
Dept. Systems and Software Design
P.O. Box 12081 *Tel: 39-2-2167 2482*
I - 20134 MILANO *Tlx: 311643*

Participants	**Country**	**Role**
CISE	*I*	*M*
FRAMENTEC	*F*	*P*

Start Date	**Duration**	**Resources**
19-DEC-84	*12 months*	*4 PY*

SOFTWARE DEVELOPMENT USING CONCURRENTLY EXECUTABLE MODULES (PEACOCK)

PROJECT NUMBER: 266

Objectives/Programme of Work

The objective of the project was the design and implementation of a unified family of languages covering the whole software lifecycle. All languages were to use the concept of Concurrently Executable Modules (CEM), and have a common signature (abstract syntax).

Progress and Results

The project, which ended in March 1988, achieved the following results:

- completion of the development of a unified set of design and implementation languages covering the whole of the design process (the Pi language)
- the specification of a single model of system structure, defined in a language reference manual
- the construction of a model of system development based on the model of system structure, and a primer giving guidelines for its use.

Exploitation/Time Horizon for Industrial Application

Plessey will be using the method in its RACE ARISE project and in product development. The concepts and methods are being used at Dortmund University in other projects. The use of the Pi language concepts is envisaged, though no support tools were developed by Peacock, in view of its basic research nature.

Contact Point

Mr. B. Sowerbutts
Dept.of Software Technology
PLESSEY ELECTRONIC SYSTEMS
Roke Manor *Tel: +44-794-515222*
UK - ROMSEY, HANTS SO5 OZN *Tlx: 47311*

Participants	Country	Role
Plessey Electronic Systems	*UK*	*M*
University of Dortmund	*D*	*P*
Eurosoft Systems S.A.	*F*	*P*
University of Karlsruhe	*D*	*P*
Hatfield Polytechnic	*UK*	*P*

Start Date	Duration	Resources
01-JAN-85	*51 months*	*36 PY*

AUTOMATED SUPPORT FOR SOFTWARE ENGINEERING TECHNOLOGY (ASSET)

PROJECT NUMBER: 267

Objectives/Programme of Work

The objective of this feasibility study was to demonstrate the technical feasibility of a proposal to develop advanced interactive graphics support for a range of methods covering each phase of the software lifecycle. The aim was to take the existing EPOS toolset out of its original framework and port it into a new generation of technology.

Progress and Results

The final report of this study is complete. It shows that the EPOS system could be a valuable basis for developing advanced interactive graphics support.

Contact Point

Mr.J.E.Sawbridge
Dept.:Software Technology Steering Group
PLESSEY COMPANY
Trafalgar Road Beeston
UK - Nottingham NG9 1LA

Tel: +44-602-254831 ext. 4590
Tlx: 37201
Fax: 602-259610

Participants	Country	Role
PLESSEY	*UK*	*M*
GPP	*D*	*P*

Start Date	Duration	Resources
01-OCT-84	*9 months*	*2.5 PY*

INTELLIGENT HELP FOR INFORMATION SYSTEMS USERS (EUROHELP)

PROJECT NUMBER: 280

Objectives/Programme of Work

The project aims to find ways of helping enquirers learn how to make optimal use of the functions of information systems. The findings will be implemented operationally in the form of a prototype HELP system to provide guidelines, instructions and explanations in response to user requests for information systems facilities. Intelligent computer-based assistance will be provided from the terminal while the system is in use, with the advice tailored to individual needs from knowledge of the use each has made. Among the trial implementations will be a help system for UNIX-Mail and for a planning system.

Progress and Results

A prototype system to provide guidance in the form of both instruction and help to users of UNIX-Mail has been demonstrated. The results of experimental sessions have been recorded and analysed.

Several demonstrations have been made of modules of a prototype Intelligent Help System Shell. Specifically:

- the construction of the passive help component is well advanced
- the active instructional component (courseware) is undergoing further development
- the application modelling formalism is at the implementation stage.

Exploitation/Time Horizon for Industrial Application

The Intelligent Help System Shell will be implemented and ported to a target environment. Demonstrations and the next review are planned for August 1989.

CRI and ICL have internal exploitation plans aimed at the reuse of the components of EUROHELP in product lines.

The university partners will be incorporating the results in research projects and using them in teaching.

Contact Point

Sten Hansen
CRI A/S
Vesterbrogade *Tel: 1-131166*
DK - 1620 Copenhagen V *Tlx: 16066*

Participants	**Country**	**Role**
CRI A/S	*DK*	*M*
Courseware Europe	*NL*	*P*
ICL	*UK*	*P*
University of Leeds	*UK*	*S*
University of Amsterdam	*NL*	*S*

Start Date	**Duration**	**Resources**
01-OCT-84	*60 months*	*115 PY*

SOFTWARE PRODUCTION AND MAINTENANCE MANAGEMENT SUPPORT (SPMMS)

PROJECT NUMBER: 282

Objectives/Programme of Work

The project aims to design and implement a system supporting all management activities in the software lifecycle.

The SPMMS system should be capable of monitoring the distributed engineering environment to determine the status of the development process. One of the most important requirements of the system is adaptability to different management methods.

The project plans to reach this objective by building a basic generic SPMMS kernel which is easily customisable, possibly using a rule-based approach.

Progress and Results

Progress so far consists of:

- specification of the SPMMS system
- first prototype of the semantic data model
- complete architectural design.

Progress is being made on mapping simplified breakdowns of work onto the semantic data model. A subset of an organisation structure has been successfully mapped and demonstrated. Ongoing work is aimed at further validation of the semantic data model and implementation of further applications aimed at proving the sufficiency of the model.

The SPMMS project has produced a prototype for the development of an information system to support management activities in the software product lifecycle, constructed in CRL (Carnegie Representation Language). Implementation of the easily customisable prototype in a PCTE environment is in progress. This includes a semantic data model for software development projects in order to provide a conceptual schema of the project process.

Progress is being made in implementing and demonstrating functionalities in a PCTE environment.

Exploitation/Time Horizon for Industrial Application

The project continues to contribute to the common data schema and the vocabulary used by several ESPRIT management tools projects.

The project is expected to contribute to the PCTE by providing management tools operating on a data schema in a distributed PCTE system.

Exploitation plans are in preparation.

Contact Point

Mr. P. Barrière
GSI-TECSI
6 Cours Michelet
F - 92064 Paris la Défense Cedex 52

Tel: 33-1-4778-1530
Tlx: 616897
Fax: 33-1-47745218

Participants	**Country**	**Role**
GSI-TECSI	*F*	*M*
CAP SESA Innovation	*F*	*P*
SEMA METRA	*F*	*P*
Data Management SpA	*I*	*P*
Sofemasa Sistemas	*E*	*P*

Start Date	**Duration**	**Resources**
01-OCT-84	*54 months*	*101 PY*

FORMALISMS, METHODS AND TOOLS (FOR-ME-TOO)

PROJECT NUMBER: 283

Objectives/Programme of Work

The goal of the project was to define, implement and experiment with a technology for the systematic development, verification and validation of software systems, based on the principle of reusability of software components. The software development process, when conceived as a process with special attention given to the reuse of pre-fabricated components and to the structuring of the system to be developed into usable components as building blocks, is characterised as a combination of "top down" and "bottom up" approaches.

Reusability of descriptions and analysis of the sequential aspects of software systems was based on a specification language defined by using some of the primitives of ASL (a kernel specification language with "loose" semantics).

Reusability of descriptions and analysis of the concurrent aspects of software systems is based on various classes of Petri-nets, from condition-event nets to high-level and stochastic nets.

An environment of support tools was to assist the developer in following a discipline for stepwise derivation and development of software components, for retrieval of components and for composition of software components.

Progress and Results

Work was undertaken in the following areas:

- Study of the LPG (Langage de Programmation Générique) specification and programming language.
- Taxonomy of reusable components and requirements for a library of reusable components.
- Investigation of Petri-nets and algebraic techniques.

Exploitation/Time Horizon for Industrial Application

Through an extensive use of case studies, the For-Me-Too project should improve the general understanding of components reusability within a project development. From an industrial point of view, these large-scale and real-life experiments will permit a broad technology transfer.

Contact Point

Mr. H. Brix
Corporate Technology Div. ZTI SOF 1
SIEMENS AG
Otto Hahn Ring 6
D - 8000 MUENCHEN

Tel: +49-89-63644627
Tlx: 521090
Fax: +49-89-63651

Participants	**Country**	**Role**
Siemens AG	*D*	*M*
SYSECA LOGICIEL	*F*	*P*
CSELT SpA	*I*	*P*

Start Date	**Duration**	**Resources**
01-FEB-85	*55 months*	*110 PY*

RELIABILITY AND QUALITY OF EUROPEAN SOFTWARE (REQUEST)

PROJECT NUMBER: 300

Objectives/Programme of Work

The objectives are to provide improved and validated techniques for measuring and modelling software quality and reliability, supported by the appropriate prototype tools. The metrics and models are to span as much of the life cycle as possible, and to provide information for project management decision-making and control. Particular targets are to develop:

- a Constructive Quality Model (COQUAMO) to predict quality characteristics throughout the software development process
- metrics and models for reliability prediction
- a database for software quality and reliability for validating models and metrics
- prototype tools to enable ready use to be made of quality and reliability metrics and models.

Progress and Results

Quality models and tools for prediction, control and assessment, together with the associated support tools for data collection and analysis, have been developed. The development of successive prototypes of Quality Management System (QMS) provides a frame for COQUAMO and its surrounding tools. The realisations of prototypes of COQUAMO that this allows constitute important and novel outputs.

Work on modelling the reliability of single systems has concentrated on two aspects:

- the integration of testing activities and reliability modeling in order to improve the control of testing activities
- provision of a suitable human-machine interface; a prototype has been demonstrated.

Contributions to the theory of modelling the reliability of fault-tolerant systems have been made in two areas. Firstly, in the quantification of dependency in models which predict the reliability of systems with multiple versions of software. Secondly, in comparing the cost-effectiveness of testing and fault-tolerance in achieving required reliability levels.

Software project data have been collected as part of the process of metric and model validation, and a database has been established. Related actions include:

- the development of pre-standard software metrics definitions, with respect to reliability, quality, complexity, performance and cost, in the several phases of the product lifecycle
- the development of a first version of an entity-relationship data model for quality and reliability modellers
- the provision of guidelines to other ESPRIT quality-related projects for the support of data collection and analysis activities.

The data model has been implemented within a data library which holds results from projects throughout Europe.

Exploitation/Time Horizon for Industrial Application

An exchange of all tools related to data collection has been agreed between the Alvey Software Data Library and the REQUEST consortium. Further agreements are under negotiation with other enterprises. The availability of a public database dealing with software quality and reliability is of particular interest for organisations new to those fields.

REQUEST definitions for software metrics standards are used in other ESPRIT projects. The large number of countries represented in the project should facilitate the emergence of European standards for metrics.

The REQUEST quality results are being used by ICL to define the requirements of a software quality environment for the ESA. Industrial trials to test the usability of the quality tools are to begin in 1988/9. Prototypes evolved from the reliability models are currently under trial. A product will be available to industry at the end of the project.

Contact Point

Mr. G. H. Browton
STC Technology Ltd
Copthall House
Nelson Place
Newcastle-under-Lyme
UK - ST5 1EZ

Tel: 44-782-662212 ext. 213
Fax: 44-782-636602
Tlx: 51 36404

Participants	Country	Role
STC Technology Ltd	*UK*	*M*
Elektronik Centralen	*DK*	*P*
Thomson CSF	*F*	*P*
Esa Control	*I*	*P*
Gesellschaft fur Reaktorsicherheit	*D*	*P*
CISI/II	*F*	*P*
UK Atomic Energy Authority	*UK*	*P*

Start Date	Duration	Resources
01-JUL-85	*60 months*	*70 PY*

INVESTIGATION OF PERFORMANCE ACHIEVABLE WITH HIGHLY CONCURRENT INTERPRETATIONS OF FUNCTIONAL PROGRAMS

PROJECT NUMBER: 302

Objectives/Programme of Work

The project investigated the functional programming approach for achieving an efficient exploitation of highly concurrent hardware architectures. This involved measurement of the complexity and parallelism of functional programs written in the FP, Lisp and Me-Too languages. The project aimed at:

- a tool for translating Lispkit and Me-Too to FP
- tools to provide a static measure of complexity and potential for parallelism of FP programs
- an emulator for the parallel execution of functional programs.

Progress and Results

The main success of the project has been in the static analysis of concurrency. A theory of complexity and parallelism for functional programs was developed based on the previous work of the partners. This was supported by development of a complexity and parallelism analysis tool (CAT).

This analysis was based on the FP language and included the use of abstract types in the language.

Work on the parallel interpretation facility based on DACTYL was less successful. The output from this task is a study of machine architectures suitable for functional programs.

Exploitation/Time Horizon for Industrial Application

The CAT tool is an early version of a new generation of programming tools for concurrent systems. The parallel architectures now becoming generally available require the development of such programming tools and methods to support applications programming.

Contact Point

Mr R.P. Oakden
Software Engineering Technology Centre
ICL
Westfields, West Avenue
UK-Kidsgrove, Stoke-on-Trent ST7 1TL

Tel: +44-782-29681 ext 3366
Fax: +44-7816-76527
Tlx: 22971

Participants	Country	Role
ICL	*UK*	*M*
University of Sterling	*UK*	*P*
Cap Sogeti Innovation SpA	*F*	*P*
INRIA/IRISA	*F*	*P*

Start Date	Duration	Resources
01-JAN-84	*42 months*	*20 PY*

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

PROJECT NUMBER: 304

Objectives/Programme of Work

This pilot project investigated the types of tools and design techniques necessary for the analysis, design, implementation and testing of knowledge-based systems. The purpose was to specify the techniques which will aid in the building of expert systems. In particular, valuable work was done in analysing the process of knowledge acquisition.

Progress and Results

The knowledge elicitation system KADS, demonstrated at the end of 1984, is the most relevant result of this project. The project was terminated because the initial participants to this pilot project did not manage to find in due time the additional industrial participation indicated by them and required by the Commission.

Exploitation/Time Horizon for Industrial Application

The project terminated in February 1985.

The findings of the project were used for the proposal of Project number 1098 (KADS).

Contact Point

Mr. S. Hayward
STC
Technology Division
Six Hills House
London Road
STEVENAGE *Tel: 44-438-726161*
UK - HERTS SG1 1YB *Tlx: 266991*

Participants	**Country**	**Role**
STC	*UK*	*M*
SCS	*D*	*P*
University of Amsterdam	*NL*	*P*
KBSC/Polytechnic of the South Bank	*UK*	*P*

Start Date	**Duration**	**Resources**
01-SEP-83	*18 months*	*30 PY*

ADVANCED DATA AND KNOWLEDGE MANAGEMENT SYSTEMS (ADKMS)

PROJECT NUMBER: 311

Objectives/Programme of Work

The objective of ADKMS is to develop a knowledge-based system with an inferential capability for the intelligent and efficient management of large databases, suitable for both naive and domain-expert users. Access to the system is provided by a Natural Language (NL) interface.

The task for Phase 1 was to develop the NL handlers, and to integrate a relational database management system with a knowledge-based system.

The tasks for Phase 2 are the improvement, integration and evaluation of the Phase 1 results in an industrial application domain.

Progress and Results

The major results of Phase 1 are:

- The design of a functional layered architecture for an ADKMS.
- Running prototypes of natural language interfaces for German and Italian from Nixdorf and Olivetti.
- A running prototype of BACK, a "hybrid" knowledge representation and inferencing system (KRS), by the Technical University of Berlin, and a partial reimplementation from Nixdorf.
- A mapping of the KRS to the database in a transparent fashion, through a Prolog/SQL interface.
- A prototype of a database extension module, and its coupling to a RDBMS.
- Evaluation of the system in field and laboratory trials.

Phase II started with:

- The evaluation of the whole project and the definition of requirements according to a real application proposed by Datamont.
- the specification of a common semantic representation for Italian and German.
- a new version of BACK-System, including a new query language to fulfill industrial demands and interfacing DDB4.

- the porting of the extended database query language onto Nixdorf Targon 35.

The NL handlers, the BACK knowledge representation system and the extended RDBMS are state of the art.

Exploitation/Time Horizon for Industrial Application

The industrial prototypes provide a foundation for intelligent database management systems with greater functionality and non-restricted natural language handlers, allowing sophisticated AI applications to very large data and knowledge bases. These systems should combine the advantages of expert systems and database management systems.

Contact Point

Mr. Samuel
Dept Entwicklung
Nixdorf Computer AG
Pontanusstr. 55
D - 4790 Paderborn

Tel: 05251/146603
Fax: O5251/302105
Tlx: 936753

Participants	Country	Role
Nixdorf Computer AG	*D*	*M*
Bull S.A.	*F*	*P*
Technical University of Berlin	*D*	*P*
University of Turin	*I*	*P*
University of Bologna	*I*	*P*
Hochschule Hildesheim	*D*	*P*
Olivetti	*I*	*P*
Datamont	*I*	*P*

Start Date	Duration	Resources
01-DEC-84	*71 months*	*124 PY*

RIGOROUS APPROACH TO INDUSTRIAL SOFTWARE ENGINEERING (RAISE)

PROJECT NUMBER: 315

Objectives/Programme of Work

The project aims to create a formally based software development method together with a comprehensive support environment. RAISE is an enhancement of the VDM method, maintaining intrinsic properties of this such as model-based specification techniques and the "Invent and Verify" development strategy.

The development process, described by "project graphs", will be mathematically modelled. This will be done in terms of logical systems (institutions eg equational logic, temporal logic), their transformations, system descriptions in various logical systems, and transformations of descriptions. Operational models of the project graphs will be related to the activities of project managers, software engineers, programmers and project librarians.

A wide-spectrum language supporting specification design will be defined. Extensions of the model-based VDM method, particularly for the specification of concurrent systems, will be considered, together with property-based methods and other model-based methods.

Tools supporting the RAISE methodology will be built (first in prototype form, then in production quality form), several industrial applications will be undertaken, and training and educational material will be produced.

Progress and Results

The RAISE project has produced the following results:

- A specification language. This is a wide-spectrum language suitable for expressive high-level abstract specifications as well as low-level detailed designs. The specification language offers facilities for specifying sequential and parallel systems and for structuring specifications, and it supports applicative and imperative styles combined with axiomatic, implicit or explicit specification techniques. The specification language is equipped with a formal semantics enabling proofs of and reasoning about properties of specifications.

- A development method. This is based on the notion of stepwise refinement in which software development proceeds in a number of increasingly concrete steps. The method is rigorous in the sense that it supports a completely formal development - one in which each step in a development is proven correct with respect to the former step - but it does not insist on formality. One can choose the level of formality appropriate to each particular development.

- A set of tools supporting method and language. The heart of the tools is a library for storing specifications and developments. Version control and configuration management is integrated with the library, as well as browsing tools for navigating and querying.

  Other tools are language and method specific: a type-checking syntax-directed editor for the specification language and a pretty-printing tool for it; translators from the specification language to various programming languages; and cross-referencing tools and proof tools. The proof tools include a proof obligation generator, a simplifier to automatically discharge proof obligations, and a proof editor to assist in dealing with those left.

  Many tools are generated by the Cornell Synthesizer Generator (a tool that generates structure editors from attribute grammars). This in itself ensures a uniform interface of the tools, but careful planning of available functionality and on-line help has created an integrated set of tools. The tools run on UNIX workstations using the X Window system.

- Technology transfer material. Includes courses and seminars on all aspects of RAISE, with a target audience spanning high-level managers to development and maintenance engineers, and ranging from 1-2 hour overview seminars, to educational courses of a few days, to one week in-depth training courses.

Exploitation/Time Horizon for Industrial Application

The tool-set is being used by ICL and Asea Brown Boveri.

The emphasis of the entire RAISE product is on industrial usability. This is ensured by undertaking, as a part of the project, realistic trials in industrial environments of the resulting product. The RAISE product will enhance the possibility of large-scale use of VDM-based methods in industrial applications.

The technology transfer process will be equally supported by the provision of educational material.

Contact Point

Mr P. Haff
CRI AS
Vesterbrogade 1A, 4SAL
DK - 1620 Copenhagen

Tel: +45.1 91 26 22
Tlx: 37805
Fax: +45.1 323847

Participants	Country	Role
CRI	*DK*	*M*
STC Technology Ltd	*UK*	*P*
ICL	*UK*	*P*
Brown Boveri A/S	*DK*	*P*

Start Date	Duration	Resources
01-JAN-85	*60 months*	*115 PY*

AN ARCHITECTURE FOR INTERACTIVE PROBLEM SOLVING BY COOPERATING DATA AND KNOWLEDGE BASES (ESTEAM)

PROJECT NUMBER: 316

Objectives/Programme of Work

The objective is the design and implementation of an expert system architecture for advice-giving systems.

The function of the automatic adviser is to assist an enquirer with a problem. The problem may be ill-defined, and the number of potential solutions may be large. In this situation, the adviser helps the enquirer to provide a statement of his goals and a description of his problem sufficient for the generation by machine of trial solutions for his consideration.

Progress and Results

The architecture has been divided into two complementary strands.

One is the AGES architecture, dealing with concepts and tools for designing and implementing architectures for heterogeneous distributed advice-giving systems. This architecture has been ported from its development environment (TI Explorer) to a SUN/UNIX environment.

The other deals with methods and tools to model knowledge in advice-giving expert systems. These "cooperative agents", which each take control in turn, are a dialogue manager, a problem solver, a cooperative answering agent and a database agent (to ORACLE).

The main computational problem tackled by combined cooperative action of the agents has been to manage those complexities of advice-giving that require the integration of knowledge and data from a variety of sources. This has been solved by controlling the cooperative functioning of several sources of knowledge, using different representational schemes interpreted by different inference engines. Each knowledge source is considered to be an independent agent, only communicating with other such agents via messages encoding queries and answers.

In addition to architectural issues, the dialogue system has been provided with the capability for modelling lines of thought of the user, as perceived through the person-machine interaction.

A simplified financial investment adviser has been constructed to provide a limited example suitable for an application study. Knowledge acquisition has been

completed, and the capability of pairs of actors to cooperate has been tested by processing problems on this domain.

Exploitation/Time Horizon for Industrial Application

The major contribution of this project will be the provision of a prototype architecture for heterogeneous distributed advice-giving systems.

Contact Point

Mr. T. Grossi
CAP SOGETI Innovation
Chemin du Vieux Chêne
F - 36240 MEYLAN

Tel: 33 76 90 80 40
Tlx: 980514

Participants	Country	Role
CAP Sogeti Innovation	*F*	*M*
CSELT	*I*	*P*
CERT	*F*	*P*
Philips Research Labs.	*B*	*P*

Start Date	Duration	Resources
01-JAN-85	*60 months*	*109 PY*

GENERATION OF INTERACTIVE PROGRAMMING ENVIRONMENTS (GIPE)

PROJECT NUMBER: 348

Objectives/Programme of Work

The main objective of the project is to investigate the possibilities of automatically generating interactive programming environments from language specifications.

Such an interactive environment will be generated from a complete syntactic and semantic characterization of the language to be used.

Such syntactical and semantical characterization will be formally expressed in a Language Definition Formalism (LDF): an inference rule-based approach and an algebraic approach are considered as the starting point for the design of the LDF.

A prototype system will be designed and implemented, consisting basically of an LDF compiler, a file system and a user interface.

Progress and Results

Significant progress has been achieved by the GIPE project in several areas. One is the definition of TYPOL, a language for specifying static constraints declaratively; the formalism is compiled into Prolog for execution.

Another important set of results concerns the work performed about obtaining a method of enhancing first-order algebraic data type specifications to support concrete syntax descriptions, using a sub-typing mechanism. Central to the future system to be built is the definition of the Virtual Tree Processor (VTP), which has been specified and implemented.

The integration phase is now in progress and a first version of the GIPE (Centaur) system presenting major improvements with regard to the MENTOR system (developed at INRIA) has been demonstrated to more than 50 research organisations. One direction of work is now the improvement of the man-machine interface. Portability of those developments is assured by a software development environment common to all partners, connecting UNIX, LE-Lisp, C-Prolog, the VTP, and a virtual window manager. A port onto PCTE is envisaged.

Exploitation/Time Horizon for Industrial Application

The first version of CENTAUR has been distributed to academic and research laboratories, and already 14 systems have been installed.

This research-oriented project will result in a prototype system which should be easily transformed into an industrial project, very much in the line of the Mentor system. The results should advance the understanding and implementation of semantic descriptions. The industrial applicability will also be demonstrated through well-targeted experiments. It is also intended to use some of GIPE's results in the definition of a software factory (EUREKA Project ESF).

Contact Point

Miss J. Sidi
Basic Software & Advanced Technology
SEMA METRA
16-18 Rue Barbes *Tel: 33-1-46571300*
F - 92126 MONTROUGE *Tlx: 200601*

Participants	**Country**	**Role**
Sema Metra	*F*	*M*
BSO	*NL*	*P*
CWI Amsterdam	*NL*	*P*
INRIA	*F*	*P*

Start Date	**Duration**	**Resources**
01-NOV-84	*60 months*	*42 PY*

KNOWLEDGE REPRESENTATION AND INFERENCE TECHNIQUES IN INDUSTRIAL CONTROL (KRITIC)

PROJECT NUMBER: 387

Objectives/Programme of Work

The objective is to construct a set of tools for the development of expert systems for process control.

The tool set is to be tested and demonstrated by designing and implementing two expert systems. The systems will assist maintenance, fault diagnosis, optimisation of data flows and control in an industrial process-control environment. The major attributes of this class of expert systems are:

- a high level of organisational complexity
- time-dependent reasoning
- a large number of inputs and outputs
- learning/adaptation.

Progress and Results

A consolidated set of basic tools for the development of expert systems in complex industrial process-control environments is complete. The tools include: a knowledge representation language, AVALON; a rule-based expert system shell, MIKIC (which originated from an academic development); two graphical description languages, G-MOD and V-GRAPH; a blackboard system BBF; a planning system incorporating dependency-directed backtracking, CELL-PLAN; and a high-level environment for explicitly specifying the control flow, CELL-TISSUE. The tools have benefited from use in building the demonstrators. For example, the use of MIKIC in the two demonstrator applications resulted in two sets of extensions, which were then merged into a "Common MIKIC".

The research results from the project have been well integrated in tools, and validated by the demonstrators. For example, the work on truth maintenance systems (TMS) resulted in a novel use of the TMS to limit search in the rule base that, in turn, resulted in a combined MIKIC/TMS tool used in one of the demonstrators.

Two demonstrators, the first for the control and diagnosis of advanced telecommunications switching systems, the second for the control of power distribution networks, have been completed and are available to the partners for experimental purposes.

Exploitation/Time Horizon for Industrial Application

The tools are being used by the partners in other projects. To facilitate their use by other organisations engaged in ESPRIT projects, they are being packaged, documented, and ported to SUN.

Contact Point

Mr Thies Wittig
KRUPP ATLAS ELECTRONIK GmbH
Sebaldsbruecker Heerstrasse 235 *Tel:421-4572465*
Postfach 44 85 45 *Tlx:2457460*
D-2800 BREMEN 44 -FRG *Fax: 421-4572900*

Participants	Country	Role
British Telecommunications plc	*UK*	*M*
FRAMENTEC	*F*	*P*
Queen Mary College	*UK*	*P*
Krupp Atlas Electronik GmbH	*D*	*P*

Start Date	Duration	Resources
01-JAN-85	*48 months*	*32.5 PY*

PROGRAM DEVELOPMENT BY SPECIFICATION AND TRANSFORMATION (PROSPECTRA)

PROJECT NUMBER: 390

Objectives/Programme of Work

The objective of this project is to develop a strict methodology for program development by applying successive transformations to an initial requirement specification down to the final implementation. This will allow the user to prove that the implementation meets the specification, and that the program is correct. A wide-spectrum language ranging from formal specifications to Ada programs will be defined, with its semantics covering concurrency aspects. The use of Ada and Anna as a basis will ensure a high portability of the methodology. In order to support it, a collection of tools will be developed.

At each level of the methodology (from requirement specification to implementation) tools will be generated according to a uniform paradigm; this includes a syntax-directed editor, a transformation and control language, a method bank (where rules and heuristics are stored) a library manager (where objects like developments and versions can be stored), and a verifier.

PROSPECTRA is closely associated with PROSPECTRA DEMO, Project 835.

Progress and Results

PROSPECTRA is showing significant progress in a number of areas:

- at the methodology level, where the abstraction and development mechanisms are now better understood

- at the transformation level, where considerable experience has been gained by developing the OPTRAN System (a generator for batch-made transformers on attributed trees).

The semantics of PAnndA-s (Prospectra Ada/Anna), which is based on a two-valued logic, have also been stabilised, and scenarios were designed to investigate the applicability of the PROSPECTRA methodology to practical systems.

PROSPECTRA and PROSPECTRA DEMO (Project 835) have produced a design support system which guides the user through a series of successive refinements by a set of rules which ensure correctness is preserved as the design proceeds.

In addition to this general core, some work has also been carried out on verification techniques, one outcome being the so-called CEC (Conditional

Equational Completion) System, originally based on Knuth-Bendix completion techniques.

Experiments are currently being carried out to check whether the PROSPECTRA basic system architecture could be based on the Cornell Synthesizer Generator, ensuring a high degree of homogeneity among the various tools being developed. Both the method bank and the library manager are based on PCTE, which is considered to be the ultimate basis for the PROSPECTRA system.

Exploitation/Time Horizon for Industrial Application

It is expected that the PROSPECTRA project will make significant advances in the field of the transformational approach (most of the partners formerly contributed to the CIP Project, which was a leader in that direction) and bring it close to industrial exploitation. In that sense, a demonstrator project is coupled with PROSPECTRA, and very tight links have been established between academic and industrial partners.

Contact Point

Prof. Dr. B. Krieg-Brueckner
Dept: FB 3 Mathematik-Informatik
University of Bremen
Postfach 330330
D - 2800 BREMEN 33

Tel: 49-421-2182676 or 2182488
Fax: 49-421-320149
Tlx: 245811

Participants	Country	Role
University of Bremen	*D*	*M*
University of Dortmund	*D*	*P*
Syseca Logiciel	*F*	*P*
University of Passau	*D*	*P*
University of Strathclyde	*UK*	*P*
University of Saarland	*D*	*P*
CRI	*DK*	*P*
ALCATEL-SESA	*E*	*P*

Start Date	Duration	Resources
01-MAR-85	*60 months*	*85 PY*

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

PROJECT NUMBER: 393

Objectives/Programme of Work

The project focuses on a trilingual system (English, French and German), investigating the use of both natural language (typed text) and graphics to build and query a knowledge base. The analysis of texts is based on recent results in theoretical linguistics (discourse representation theory and functional grammars). To support dialogue, the system selects appropriate presentation of output, text or graphics, and identifies relevant information for output. The system interface features an interplay of graphics and natural language.

Progress and Results

The project has produced results in specifying and implementing grammatical theories and parsers for the different languages: Unification Categorical Grammar (UCG) for English and French, and Lexical Functional Grammar (LFG) for German. All the parsers for text and dialogue deliver a common semantic representation based on Discourse Representation Structures (DRS). Inverse parsing in UCG is used for generation of English and French.

The dialogue manager has been implemented and is used to co-ordinate graphical and textual human computer interaction, including features such as anaphora (pointing).

Exploitation/Time Horizon for Industrial Application

A prototype and demonstrator of advanced linguistic and AI techniques is being built so as to show the relevance of the research to existing business practice. As it stands, the project is working towards a system for computer-aided decision-making in the field of logistics.

Contact Point

Mr. M.Brilman
Division Informatique
LABORATOIRES DE MARCOUSSIS
Compagnie Générale d'Electricité *Tel: 33-1-644491000*
Route de Nozay *Fax: 33-1-644490694*
F - 91460 MARCOUSSIS *Tlx: 692415 F*

Participants	Country	Role
CGE-LDM	*F*	*M*
Bull S.A	*F*	*P*
Triumph Adler AG	*D*	*P*
Fraunhofer Instit. IAO	*D*	*P*
University of Edinburgh	*UK*	*P*
University of Stuttgart	*D*	*P*
University of Clermont-Ferrand	*F*	*P*

Start Date	Duration	Resources
01-JAN-85	*60 months*	*90 PY*

APPLICATION SOFTWARE PROTOTYPE IMPLEMENTATION SYSTEM (ASPIS)

PROJECT NUMBER: 401

Objectives/Programme of Work

The object of this project is to construct tools, called "Assistants", to support the partial automation of the first phases of the life-cycle, by the exploitation of state-of-the-art techniques in the fields of specification languages and artificial intelligence.

The main problems to be tackled are:

- capturing the domain knowledge to be used by the Assistants
- choosing an appropriate representation formalism for coding knowledge
- defining the basic architecture of Assistants
- defining an appropriate language for interaction between Assistants and users.

The final objective of the project is the creation of a set of advanced methods and tools which will permit a flexible approach to applications software production based on an interactive style, including:

- rapid prototyping by interpretation of the components specifications
- reusability of components through knowledge-based Assistants.

Progress and Results

A prototype system to assist in the analysis and design stages has been developed and demonstrated by building a computer-aided software engineering environment. The system is based on a knowledge representation formalism called KRS (Knowledge Representation System) developed inside the project, mainly by Olivetti.

A study of reusability techniques has been made. These techniques have become the basis for the definition of the reuse Assistant. A version of a rapid prototyping facility is included in the analysis Assistant. Its refinement and its strong integration with the analysis Assistant are in progress.

The reuse Assistant can be applied to the analysis and to the design phases. Interfaces have been built to the Analysis Assistant and to the Design Assistant.

All the demonstrations have been successfully applied in the field of security control systems, the chosen application domain.

Exploitation/Time Horizon for Industrial Application

A product is in the course of definition by Tecsiel.

The implementation of prototype Assistants for the early phases of the software life cycle and their application in an industrial domain will reduce the misinterpretation of the user requirements by the design team, which is a major source of errors in software development process.

Contact Point

Mr. P. Puncello
TECSIEL SpA
via S. Maria, 19
I - 56100 Pisa

Tel: 39-50-50 25 02
Fax: 39-50-50 25 02

Participants	Country	Role
Tecsiel SpA	*I*	*M*
Marconi Software System	*UK*	*P*
CAP Sogeti Innovation SpA	*F*	*P*
Ing. C. Olivetti & Co, SpA	*I*	*P*

Start Date	Duration	Resources
01-MAR-85	*48 months*	*80 PY*

SOFTWARE ENVIRONMENT FOR THE DESIGN OF OPEN DISTRIBUTED SYSTEMS (SEDOS)

PROJECT NUMBER: 410

Objectives/Programme of Work

The objective of the project was the definition of formal description techniques and support tools for the development and implementation of OSI protocols and services and, more generally, of open distributed systems.

Two formal languages have been defined: ESTELLE (based on a state-machine model), and LOTOS, which combines the algebraic specification language ACT-ONE and the CCS calculus.

Progress and Results

The end results are:

- Prototypes of syntax-directed editors, compilers, simulators, debugging tools, and verification (proof) tools for both ESTELLE and LOTOS.
- Formal descriptions of a large number of OSI protocols and services.
- Ongoing work in ISO on standardisation of the FDT (Formal Description Techniques) has resulted in both languages attaining draft international standard. This has resulted in an international standard in 1988.
- New theories for verification of protocol specifications.

A follow-up project (1265) will develop an ESTELLE workstation, and will use some real life projects in an industrial environment to demonstrate the benefit of the SEDOS approach towards protocol development.

Exploitation/Time Horizon for Industrial Application

There is a strong commitment to exploit the results of the LOTOS part of the project. Through the contribution of this project, formalisation of the development of protocols and communication software is becoming one of the most important approaches for industry to develop the increasingly complex distributed systems of tomorrow.

Contact Point

Mr. M. Diaz
Software and Communication Team
LAAS/CNRS
7 av. du Colonel Roche *Tel: +33.61252147*
F - 3111077 TOULOUSE *Tlx: 520930*

Participants	Country	Role
CNRS/LAAS	*F*	*M*
Bull	*F*	*P*
STC Technology	*UK*	*P*
University of Twente	*NL*	*P*
Agence de l'Information	*F*	*P*

Start Date	Duration	Resources
01-NOV-84	*36 months*	*83 PY*

PARALLEL ARCHITECTURES AND LANGUAGES FOR AIP: A VLSI-DIRECTED APPROACH (PALAVDA)

PROJECT NUMBER: 415

Objectives/Programme of Work

PALAVDA was launched to study the performance of the different approaches to symbolic processing on parallel architecture computers as a step towards establishing a European standard for a generic architecture for logic, functional and object-orientated language. The project aims to investigate the different non von-Neuman architectures and implement some of them. The prime objective is to reduce the execution times required by AI applications by a substantial factor. Concurrency will be achieved through a large number of identical processing elements implemented in VLSI. Ideally, a concurrent machine should support all three programming styles (object-oriented, functional and logic), which will allow the full exploitation of concurrency, but the principles upon which such a machine could be based are not yet fully understood. All three styles will be explored through studies of machines which support each programming style separately, and through common working groups which will explore several areas of general relevance.

The project is divided into a series of subprojects. In subproject A, the relation between an object-oriented style with active and passive objects and a highly parallel architecture has been investigated and developed. The parallel architecture will typically contain up to 1024 Processor/Communication Modules (PCMs). Three applications (a natural language translator, a knowledge-based system and a multi-level VLSI simulator) will be implemented on the machine.

In subproject B, the relation between a functional style and a highly paralleled architecture is investigated. Here the approach is how a paralleled reduction machine can be supported by up to 10 000 PCMs.

In subproject C, the relation between a logic programming style and a highly parallel architecture is studied. The approach here is how a parallel inference machine can be supported by PCMs.

The relation between a mixed logic and functional style and a highly parallel architecture is studied in subproject D. Here, the algorithmic parts of an application will be handled within the functional part, while the nondeterministic (inferential) parts are treated within the logical subset of the language. This improves the efficiency. Of course, an important point here is the relation between the semantics of functional and logic styles. The question here is again how this style can be supported by PCMs.

In subproject E, the relation between functional programming and data-flow is investigated. The approach is how the data-flow machine could be structured from about 100 PCMs and supported by a high-level application language.

Finally, subproject F addresses the three main styles of new generation programming: functional programming, parallel programming and logic programming. The long-range objective is to arrive at a VLSI implementation of a highly parallel inference machine. On the way to that objective the connection method will be used.

All subprojects are based on messages passed between identical units (PCMs), consisting of communication hardware, processing hardware and local memory. In addition to the subprojects, an application study group will be formed to select applications with which the various styles may be evaluated and their suitability for various fields of application established.

Progress and Results

The design of the architecture for parallel object-oriented systems has been completed and a first version of the compiler POOL-2 (Parallel Object Oriented Language) is available and in use. In the project it is being used to estimate performance aspects of the system. A first prototype of DOOM (Distributed Object Oriented Machine) with 25 nodes has been demonstrated. A 100-node machine is being built.

SILKE (Simple Logic Specification) is being used to compare POOL-T with other solutions, and determine how to exploit parallelism at the application level. Execution model and hardware design for logic programme execution are in progress. The integration of functional and logic programming has been successfully demonstrated. The language FP2 (Functional Parallel Programming) has been designed, and an FP2 compiler is running on SUN and being used by some partners (for example by AEG for SILKE specifications). Implemented theorem provers are being actively used to debug various designs (SETHEO and PARTHEO). A parallel database machine, DDC, has been developed on a test-bed machine. A basic data-flow architecture, SDFM, together with its programming language, has also been developed, and a four processor system has been demonstrated. The system is being evaluated for relational database applications.

Exploitation/Time Horizon for Industrial Application

The result of this project will provide specifications of computer architectures on a chip (processor, communication, memory) and highly parallel computer architectures by 1989. This project has the potential to provide a European standard for a generic architecture for a logic, functional and object-oriented language.

Licence agreements have been offered to a number of research institutes for the POOL 2 compiler.

Contact Point

Dr. E. Odijk
Nederlandse Philips Bedrijven BV
Natuurkunding Lab.
Building WB 3
P.O. Box 80.000
NL - 56000 Eindhoven

Tel: +31.40.742644
Fax: +31.40.743783
Tlx: 35000

Participants	Country	Role
NED - Philips Bedrijven B.V.	*NL*	*M*
AEG Telefunken	*D*	*P*
Bull S.A.	*F*	*P*
CSELT	*I*	*P*
CWI	*NL*	*P*
GEC	*UK*	*P*
University of Munich	*D*	*P*
LIFIA	*F*	*P*
Nixdorf	*D*	*P*
Philips	*NL*	*P*
Stollman & Co	*D*	*P*
University of Berlin	*D*	*P*
ESIEE	*F*	*P*

Start Date	Duration	Resources
01-NOV-84	*60 months*	*277 PY*

IMAGE AND MOVEMENT UNDERSTANDING (IMU)

PROJECT NUMBER: 419

Objectives/Programme of Work

The research is directed to understanding the computational bases of vision and movement, with particular reference to scene understanding and cursive script understanding. In scene understanding (based on stereo pairs or multiple views of pictorial images as input to the system) the project is focussed on the interface between the early stages of computation, which provide a rich but ambiguous description in terms of low-level features, and the knowledge-based processing which generates descriptions of the 3-D organisation of the visual world compatible with the properties of the physical world. Cognitive modeling techniques based on a functional description of objects and perceptual rules will be studied. The ultimate goal is to merge the data-driven and the knowledge-driven recognition approaches.

With regard to cursive script, basic knowledge still needs to be acquired about the mapping from linguistic material to hand trajectories; the goal of the project is to understand the writing process more than recognize it. Techniques to code cursive script signals into symbolic descriptions will be studied.

Progress and Results

After 42 months of work, the following results have been obtained:

- Development of basic libraries of computational modules that perform early processing of image data (including the integration of stereo and motion algorithms to obtain depth information) and cursive script data (cursive script is the topic of attention of the project as regards movement).

- Development of a portable interactive software environment called VIS. This makes it possible to generate and interrogate multiple regional representations of images or image sequences (iconic representations, regional representations, contour representations). It has been implemented on PC-AT, Transputer network, 68020, VAX, etc.

- Development of cognitive-driven modules that interface with low-level representations of images:

  (a) using basic perceptual rules for dealing with occlusions of surfaces in low level representations;

  (b) using semantic representations of objects for interpreting perceptual representations and describing scenes.

- Development of the firmware necessary for the real-time acquisition of sequences of stereo pairs of images on the VDS Eidobrain workstation and the porting of VIS on the Eidobrain.

Exploitation/Time Horizon for Industrial Application

The results of the project will serve the R&D community, both academic and industrial, as conceptual/computational support when developing specific applications of image or movement analysis. Moreover the VIS system, incorporating well-engineered implementations of advanced algorithms, can be the basis for a marketable product.

Contact Point

Prof. Pietro Morasso
University of Genoa
Dip. di Informatica,
Sistemistica e Telematica
Via All'Opera Pia 11A *Tel: 39 10 303651*
I-16145 GENOA *Tlx: 271114*

Participants	**Country**	**Role**
University of Genoa	*I*	*M*
CAPTEC	*IRL*	*P*
Trinity College Dublin	*IRL*	*P*
University of Nijmegen	*NL*	*P*
Video Display System SRL	*I*	*P*

Start Date	**Duration**	**Resources**
01-JAN-85	*60 months*	*33 PY*

AN INTEGRATED FORMAL APPROACH TO INDUSTRIAL SOFTWARE DEVELOPMENT (METEOR)

PROJECT NUMBER: 432

Objectives/Programme of Work

The objective of this project is to develop an integrated formal approach to industrial software development, particularly for the telecommunications industry. The development process will be studied and modeled by individualising building components for analysing existing methods and by developing new methods of software development.

A language for requirement engineering will be defined with a semantics covering temporal aspects. Algebraic methods will be adopted for specifying passive and active objects (process algebras and the algebraic specification language, ASL). Denotational models of concurrent systems will provide a basis for defining a calculus in which various properties of such systems can be proved.

In particular, the project aims at integrating the object-based language paradigm, the algebraic approach to software specification, the relational approach and the so-called formal heuristics.

The impact on management and metrics of the application of formal methods in software development will be considered. Industrial take-up, especially in the area of constructing real-time distributed systems, is provided for by the planned construction of prototype environments.

Progress and Results

After a pilot phase devoted mainly to an extensive survey of existing methods, METEOR has made advances in several fields. Industrial achievements include the development of a requirement engineering methodology based on an extension of the entity-relationship model ERAE, and the definition of a powerful formal design language, COLD. Both these tools are currently under field test in real-life software product development. In addition, the relational algebra, ALGRES, has been extended, and the RAP rapid prototyping system has been created.

Progress has also been made in the formal specification of concurrency in ACP (Algebra of Communicating Process), an extension of Hoare's and Milner's work.

A software engineering toolbase has been developed through the establishment of a generic environment. This facilitates the work of the project teams and provides a setting for the investigation of the various formalisms.

The different facets of this project, which addresses most of the fields in software technology, were presented in a three-day workshop. This supported the processes of technology integration and transfer.

A telecommunication transfer node has been taken as a case study to prove the feasability of the transitions from the ERAE requirement to the RAP prototytpe implementation, through the intermediate SFP stage of the specification.

Exploitation/Time Horizon for Industrial Application

Some preliminary results have already been applied by one of the partners for a customer. Prototypes and the requirement engineering methodology, ERAE, and the design language, COLD, are both currently in field test in real-life production developments.

In the universities, the RAP rapid prototyping system is taught at the University of Passau, and the PLUSS algebraic specification language developed by University d'Orsay is being used by LRI and CGE. The various formalisms, each addressing a different segment of the software development activity, are being investigated in the IDEAS environment.

Contact Point

Dr. P. Wodon
Philips Research Laboratory
PHILIPS N.V. & MBLE ASSOCIATED S.A.
Av. Van Becelare 2, Bte 8 *Tel: 32-2-6734190*
B - 1170 BRUXELLES *Tlx: 61511*

Participants	**Country**	**Role**
Philips N.V. & MBLE Associated	*B*	*M*
Laboratoires de Marcoussis	*F*	*P*
ATT & Philips Telecomm Bedr	*B*	*P*
CWI Cen. v. Wiskunde & Informatica	*NL*	*P*
Realace	*IRL*	*P*
Tech. Int. Software Telemetica	*I*	*P*
University of Passau	*D*	*P*
Philips Gloeilampen	*NL*	*P*
University of Paris South/LRI	*F*	*P*

Start Date	**Duration**	**Resources**
01-OCT-84	*60 months*	*108 PY*

MESSAGE-PASSING ARCHITECTURES AND DESCRIPTION SYSTEMS (MADS)

PROJECT NUMBER: 440

Objectives/Programme of Work

The project will build three levels of tools for the development of expert systems:

- message-passing languages
- description languages for knowledge representation
- reasoning and strategy programming.

The project will develop techniques for implementing message-passing languages that will exploit new highly parallel architectures. The techniques will cover issues of run-time support like allocation, migration, garbage-collection and persistency of actors. A description system will be developed to support the basic mechanisms of knowledge representation: conceptual hierarchies, inheritance, and attributions. To perform reasoning on the description system, rather than providing a fixed strategy, primitives and constructs will be developed that will allow the programming of deductive strategies tailored to specific applications. Strategy execution will be performed concurrently by a large number of actors each exploring a small portion of the knowledge-base.

At the end of the project there will be a solid implementation of message passing; techniques for exploiting specialised concurrent hardware to implement actors efficiently; a package of knowledge representation primitives; and a description system and related interaction tools, with applications ranging across the KBS and MMI spheres.

Progress and Results

Prototypes of message-passing architectures and two description systems, OMEGA and KRS, that will exploit highly parallel machines, have been developed:

- OMEGA is a description-oriented knowledge representation which allows reasoning and includes a viewpoints mechanism. Graphical tools provide an efficient environment to support the knowledge engineering activity.

- KRS is a concept system which allows reasoning and includes inheritance mechanisms and a consistency maintenance system. A graphical user interface is under development. Parallelism in knowledge representation is currently under study.

The use of LISP in parallel processing and appropriate knowledge representation is being investigated.

Exploitation/Time Horizon for Industrial Application

The prototypes that have been implemented constitute the first steps to a future industrialisation. Both OMEGA and KRS are being used in pilot applications outside the project.

Contact Point

Mr Giuseppe Attardi
DEPHI SpA
Via della Vetraia 11
I-55049 VIAREGGIO

Tel: 584-395161
Tlx: 623558

Participants	Country	Role
DELPHI SpA	*I*	*M*
Free University of Brussels	*B*	*P*
CGE/LdM	*F*	*P*

Start Date	Duration	Resources
01-NOV-84	*60 months*	*63 PY*

AN ADVANCED SUPPORT ENVIRONMENT FOR METHOD-DRIVEN DEVELOPMENT AND EVOLUTION OF PACKAGED SOFTWARE (TOOL-USE)

PROJECT NUMBER: 510

Objectives/Programme of Work

This project will develop techniques for the formal definition of methods used in the development of software. The project focuses on one main idea, namely that the building of a support environment should be parameterised by methods expressed in a development language. It will seek to achieve understanding and formal modelling of:

- the software construction process
- the application domains
- the target systems.

It will continue with the definition, implementation and evolution of a prototype environment for software development based on formally defined methods

Progress and Results

The methods used in the development of software are currently being explored and formalised. Starting from the requirements defined in an early stage of the project, the DEVA development language has been specified and documented.

A first version of DEVA is available in prototype form for internal project applications, and tools to facilitate its use have been demonstrated. However, the specification of DEVA is not frozen and it will be modified as and when the results of the intensive experimentation that will ensue throughout the project life warrant it.

The support tools for the prototype of a parameterised environment have already been defined. The specification of a requirement requisition tool and method advisors is in progress.

Exploitation/Time Horizon for Industrial Application

The production of environments in an almost automatic way, parameterised by the methodology used, will provide the evolutionary path from the current generation of PCTE (Portable Common Tool Environment) environments to the next.

This ensures the compatibility of European industrial investment in software development facilities and will be extremely useful for setting up case studies on the use of the development language for office systems and computer-integrated manufacturing.

However, a long period of refinement is anticipated before concepts developed inside this project are ready for commercial exploitation. In the meantime, the project experience is creating a pool of R&D knowhow among the partners' staff.

Contact Point

Mr. M. Heitz
CISI Ingénierie
2, rue Jules Védrines
Z.I. de Montaudran
F - 31400 TOULOUSE

Tel: 3 61-20 43 24
Fax: 3 61-34 95 82
Tlx: 06252

Participants	**Country**	**Role**
CISI Ingénierie	*F*	*M*
Catholic University of Louvain	*B*	*P*
GMD-GES FMathematik & Datenver	*D*	*P*
Generics (Software) Ltd.	*IRL*	*P*
Centre d'Etude et des Recherches de Toulouse	*F*	*P*
I. I. Biomatik GmbH	*D*	*S*
University of Dublin	*IRL*	*S*
University of Ulster	*UK*	*S*

Start Date	**Duration**	**Resources**
01-OCT-84	*60 months*	*101 PY*

COMMUNICATION FAILURE IN DIALOGUE: TECHNIQUES FOR DETECTION AND REPAIR (CFID)

PROJECT NUMBER: 527

Objectives/Programme of Work

The aim of this project is the development of a robust and portable natural-language interface to a relational database system.

The initial stages of the project involve the study of human dialogues in a simulated database-query environment, including recovery from various types of communication failure. From an analysis of these dialogues a formal model of the dialogue process will be developed. The formal model will serve as a basis for a computer implementation of an English and Italian natural-language front-end to a student record database. An important element of the implementation will be the use of non-verbal systems (e.g. graphics, pointing, icons) in roles analogous to the non-verbal components of human dialogues. The robust dialogue component of the project has potential applications outside the database domain. Elements of it can be used in the development of a front-end expert systems, or for information retrieval in an office environment.

Progress and Results

A review of the various approaches to human-computer dialogue has been completed; particular care has been taken to exploit possibilities of multidisciplinary cooperation. A system for the classification of dialogue has been developed, and tools defined, some of which have been implemented. A series of experiments have been carried out to evaluate the proposed approach. The development of a hardware and software configuration for the collection of dialogue data is complete. The general dialogue model has been specified and a prototype has been demonstrated. An interface metaphor has been designed and implemented.

Exploitation/Time Horizon for Industrial Application

The construction of a formal model of dialogue and communication breakdown has potential applications to more user-friendly natural language interfaces for systems of various kinds. The integration of non-verbal information, such as gestures, in this model, could form the basis of very intelligent interfaces, although this is a longer-term prospect. In view of the burden of translation from natural language in the extensive and increasing use of relational databases, ensuing products are likely to have a substantial industrial impact.

Contact Point

Dr. R. Reilly
Educational Research Centre
St Patrick's College
Drumcondra
IRL - DUBLIN 9
Tel: 1 - 373789

Participants	Country	Role
Educational Research Centre	*IRL*	*M*
Linguistic Institute of Ireland	*IRL*	*P*
Memory Computer plc	*IRL*	*P*
University of Leeds	*UK*	*P*
University of Pisa	*I*	*P*
Alcatel-Sel	*D*	*P*

Start Date	Duration	Resources
01-FEB-85	*50 months*	*30 PY*

ADVANCED KNOWLEDGE BASE MANAGEMENT SYSTEM (EPSILON)

PROJECT NUMBER: 530

Objectives/Programme of Work

The objective of this project is to build an environment for the development and use of knowledge-based management systems (KBMS). The system is based on standard technologies: relational databases and Prolog. It is to be portable and extensible, and will be available on a wide range of minicomputers and workstations.

Three technical goals have been set for these objectives to be achieved:

- integration of Logic Programming and Data Base technologies
- linguistics extensions and analysis and verification tools
- a user interface for non-expert users.

Progress and Results

The project has made progress in the following four areas:

- The prototypical integration of the general system.
- The development of a kernel inference engine that allows the construction of different inference machines by specifying the control structure.
- The graphical user interface, using window techniques.
- Connection of distributed data and knowledge bases through local area networks.

The project has developed the notion of theories and the object-oriented concept of links between theories. Techniques that allow a combination of rules and relational algebraic expressions have been established.

A prototype system has been developed to assess company credit-worthiness in accordance with the financial and credit policies of the Italian government. A further system (the Loan Expert) assists bankers in their assessment of customer loan applications.

Exploitation/Time Horizon for Industrial Application

A prototype workstation has been produced which allows the use of UNIX-based Prolog and a commercially available relational database in one system.

A second prototype connects the DBMS workstations to form an integrated KBMS.

The work on theories could prove to be a very flexible and powerful approach to the development of knowledge-based systems, especially in a Prolog environment.

Contact Point

Dr. M.Modesti
R & D Laboratories
SYSTEMS & MANAGEMENT SPA
Vicolo S. Pierino 4 *Tel: 50-598084*
I - 56100 PISA *Tlx: 224064*

Participants	Country	Role
S & M	*I*	*P*
Bense KG	*D*	*P*
Criss	*F*	*P*
University of Pisa	*I*	*P*
University C. Bernard, Lyon	*F*	*S*
University of Dortmund	*D*	*P*

Start Date	Duration	Resources
01-NOV-84	*60 months*	*73 PY*

REAL-TIME GENERATION AND DISPLAY OF THE 2.5-D SKETCH FOR MOVING SCENES (GENEDIS)

PROJECT NUMBER: 532

Objectives/Programme of Work

The project will develop and implement a demonstrator prototype of an imaging system which is capable of producing a form of 2.5-D sketch directly. This sketch, in which image intensity will be related to range, will be in one-to-one pixel correspondence with an illumination intensity representation generated simultaneously. Statistical operations performed on successive range estimates should permit a marked improvement over the single measure resolution.

Progress and Results

At the conclusion of the project conception phase, it was decided that the system should be composed of four parts:

- two cameras arranged to deliver two images of the same scene.
- two feature extractors for extraction of relevant features in both images (an edge-based stereopsis approach based on the Moravec operator was chosen).
- one correlator, based on dynamic programming, which detects the corresponding features in both images and computes the range of the imaged point in the viewfield from their disparity.
- one interpolator, which interpolates range from the ranges delivered by the correlator, allowing determination of the range of all the points in the viewfield.

As the result of the first phase of the project, a successful demonstration of the integrated system (except the interpolator) was presented. Already the three main components, the aligned twin cameras, the real-time edge extractors, and the pipeline real-time correlator are attractive features that might be reused in a variety of systems for pattern recognition purposes.

A breakthrough in the speed of measurement of scene depth matches the pace of interpretation to changes in the scene from stereo images. Real-time applications, such as the identification of grasp points for robots, have become possible.

Exploitation/Time Horizon for Industrial Application

A prototype of a low-priced system to deliver range images for industrial scenes is under development. The expected performances are 2 mm error at 1 metre for a 512 x 512 pixels image for a system working at video rate and 1.3 mm of lateral resolution. At the moment, no similar low-priced system exists on the market. Further developments to upgrade the system for image processing will be necessary prior to industrialisation.

Contact Point

Dr. R.J. Fryer
University of Strathclyde
Dept. Computer Science
26 Richmond Street
UK-GLASGOW G1 1XH

Tel: +44-41-5524400 ext. 3387
Tlx: 77472
Fax: +44-41-5520775

Participants	Country	Role
University of Strathclyde	*UK*	*M*
Barr & Stroud Ltd	*UK*	*P*
Zeltron	*I*	*P*
Olivetti	*I*	*P*

Start Date	Duration	Resources
01-FEB-85	*36 months*	*28 PY*

KNOWLEDGE-BASED ASSISTANT FOR ELECTROMYOGRAPHY (EMG)

PROJECT NUMBER: 599

Objectives/Programme of Work

The aim of the project is to develop a knowledge-based assistant to support physicians in all stages of an electromyographical (EMG) examination of patients with neurological diseases.

The objective is to produce a system which is sufficiently robust to withstand clinical trials in a clinical neurophysical laboratory. Particular attention will be given to obtaining user involvement in the definition of requirements and in system acceptance testing, and to bringing medical knowledge-based systems to a fully functional state.

Progress and Results

The prototype EMG expert system constructed in Phase I both supports the diagnostician in the analysis of EMG signals, and advises on the test procedures to be performed. It includes a report generator, and contains a database of case studies. It incorporates a causal-probabilistic network model to allow a unified approach to planning, diagnosis, explanation and reporting.

Phase II has seen a substantial improvement in real-time performance and the development of the following major features:

- robust inference systems
- new ways of handling uncertainty by probabilistic methods
- methodologies of general applicability in knowledge representation, blackboard architecture, and user-interface specification.

Exploitation/Time Horizon for Industrial Application

The integrated EMG knowledge-based assistant, due for completion by January 1989, will broaden the scope of the use of electrophysiological techniques.

Contact Point

Mr J. Vahlstrup
Computer Resources International
Vesterbrogade 1A
DK - 1620 COPENHAGEN V

Tel: 45 1-32.11.66
Tlx: 16066
Fax: 45 1-13.92.15

Participants	Country	Role
CRI A/S	*DK*	*M*
LOGICA UK Ltd	*UK*	*P*
Nordjydsk Udviklings Center	*DK*	*P*
National Hospital for Nervous Diseases	*UK*	*P*
Judex Datasystemer Aps	*DK*	*P*

Start Date	Duration	Resources
01-DEC-84	*50 months*	*45 PY*

A PROJECT INTEGRATED MANAGEMENT SYSTEM (PIMS)

PROJECT NUMBER: 814 (1223)

Objectives/Programme of Work

The project aims at developing an integrated project management support system to be used as a consultant or as training system. The prototype management consultant and management instructor will be evaluated through field trials.

This project is associated with Project 938 (1223).

Progress and Results

A theoretical approach has developed the concept of a story-board as a suitable vehicle for representing the general activity of project management. The representation of project management knowledge in a more formal way is currently under investigation.

Important insights have been gained from a series of structured interview sessions with individual project managers from the three industrial partners of the consortium.

A tools survey has identified and appraised many commercial packages aimed at project management.

The first complete prototype (PIMS*1) was successfully demonstrated in February 1988. This prototype emphasises a truly integrated toolset covering all phases and tasks of project management. Currently, the system is being made more intelligent and customizable, and the functionalities of the individual tools are being extended.

Exploitation/Time Horizon for Industrial Application

The results are being used by CAP-Sogetti and PACTEL, and industrialisation and marketing are scheduled for 1989.

There has also been an exchange of results with the Integrated Product Management Workbench (Project 938) and a transfer to the EUREKA ESF.

This project will have immediate impact on project management in the software industry when the resulting prototype is industrialised and marketed (scheduled for 1989). The potential for exploitation appears very promising once this system has been integrated within a software factory in the 1990s.

Contact Point

Mr. J. Paris
CAP SOGETI INNOVATION
Centre de Recherche de Grenoble
Chemin du Vieux Chêne *Tel: 33-76-908040*
F - 38240 MEYLAN *Tlx: 980514*

Participants	**Country**	**Role**
Cap Sogeti Innovation	*F*	*M*
Pactel	*UK*	*P*
Turing Institute	*UK*	*P*
BSO	*NL*	*P*

Start Date	**Duration**	**Resources**
01-Dec-85	*42 months*	*52 PY*

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

PROJECT NUMBER: 818 (1226)

Objectives/Programme of Work

The objectives of the project are to formulate, develop and demonstrate an open system, fault-tolerant, distributed computer connection architecture, conforming to the OSI model. The architecture will be capable of being configured to support a range of performances and dependabilities and to manage distributed processing. It will also offer transparent fault-tolerant and network management to the user. These features, plus the ability to connect heterogeneous computer systems into one architecture, will be directly applicable to the computer integrated manufacturing and office systems areas. Emphasis will be placed particularly on new communication techniques (optical and electrical) and concepts. Finally, a key feature of the project will be a series of progressive demonstration prototypes, which will form the basis for rapid commercial exploitation of the results.

Progress and Results

The initial phase concentrated on the three main topics needed to build an open dependable distributed system:

- Specification and implementation of a multicast communication system on a LAN. A prototype of the MCS has been demonstrated.

- Specification of a high-performance and cost-effective "network station" to support the DELTA-4 system architecture. Specifications have been produced and two demonstrators have been developed (RT Unix and RSR (Remote Service Request) prototypes).

- Delta-4 network management to guide the overall work on dependability. A first level of specification has been achieved.

These developments are continued in the main phase where they will be augmented by work on:

- The design and development of an application support environment, to give distributed computer systems protection against local station failures via replication of tasks over the network.

- The validation of protocols through the use of the ESTELLE formal description technique (see work carried out in ESPRIT projects SEDOS, number 410, and SEDOS DEMO, number 1265).

- The study of pilot sites, to be used in a possible next phase.

Results from these areas will provide the project with:

- a network which supports advanced protocols
- a node architecture
- the global framework to integrate dependability into a distributed system.

Exploitation/Time Horizon for Industrial Application

The interconnection equipment for heterogeneous systems to be delivered by this project is particularly relevant for distributed application in computer-integrated manufacturing and office systems.

Product marketing is planned by Bull, and Ferranti is marketing a UNIX-based real-time system derived from work on this project.

Contact Point

Mr. P. Martin
BULL S.A.
Direction Technique
R. de Provence 1-208 *Tel: 33-76098055*
F-38342 ECHIROLLES CEDEX *Tlx: 980648*

Participants	Country	Role
BULL S.A.	*F*	*M*
IEI-CNR	*I*	*P*
Ferranti-Electronics	*UK*	*P*
GMD	*D*	*P*
LAAS	*F*	*P*
INESC	*P*	*P*
MARI	*UK*	*P*
JEUMONT-SCHNEIDER	*F*	*P*
LGI	*F*	*P*
Telettra	*I*	*P*
University of Bologna	*I*	*P*

Start Date	Duration	Resources
01-MAR-86	*36 months*	*90 PY*

DESIGN AND EXPERIMENTATION OF A KBS DEVELOPMENT TOOL KIT FOR REAL-TIME PROCESS CONTROL APPLICATIONS (QUIC)

PROJECT NUMBER: 820 (1220)

Objectives/Programme of Work

The objective of the project is to design, implement and validate a toolkit for building KBS (Knowledge-Based System) applications in the area of process control/supervision. The toolkit comprises a general system architecture, a set of special-purpose building modules, a set of support tools for the construction, and testing of the knowledge base, aids to construction of interfaces to traditional software packages and sensors, and a KBS analysis and design methodology.

Progress and Results

The kernel toolkit and the representation languages to be used have been specified. The toolkit will contain a facility for qualitative simulation, a rule-based component based on fuzzy logic, a production rule system, and a very-high-level procedural language in the form of event graphs. Implementation of a first version of the tools has been completed. A user manual has been delivered.

The tools have been validated in the following three demonstrator applications:

- for the control of a thermal power plant, by Ansaldo and CISE
- for supporting operators in the control of the altitude of a geostationary telecommunications satellite, by Aerospatiale and Framentec
- for the control of a cement manufacturing plant, by Smidth, CAP Sogeti Innovation and Heriot-Watt University.

From the experience gained with these validations, a redesign of the toolkit has been proposed and is now being implemented.

Exploitation/Time Horizon for Industrial Application

The project is viewed as a way of developing and reviewing a technology, in terms of both methodology and tools. A continuous interaction with similar projects in progress at the participating institutions is occurring.

Two of the demonstrator projects have already spun off exploitation projects by the partners concerned.

The toolkit provides a set of KBS tools for automating such tasks as monitoring, fault diagnosis, feedback control, simulation and training. It will be ready in March 1990 for use in the commercial development of process control applications and will be incorporated in commercially available expert system shells.

Contact Point

Alberto Stefanini
CISE
Systems & Software Design Dept.
P.O. Box 12081 *Tel : 2-2167.2482*
I-20134 MILANO *Tlx: 311643 CISE I*

Participants	Country	Role
CISE	*I*	*M*
Ansaldo Impianti	*I*	*P*
Aerospatiale	*F*	*P*
FRAMENTEC	*F*	*P*
CAP Sogeti Innovation	*F*	*P*
Nea-Lindberg A/S	*DK*	*P*
Heriot-Watt University	*UK*	*P*

Start Date	Duration	Resources
01-MAR-86	*48 months*	*59 PY*

DEMONSTRATION OF PROSPECTRA METHODOLOGY AND SYSTEM (PROSPECTRA DEMO)

PROJECT NUMBER: 835 (1227)

Objectives/Programme of Work

PROSPECTRA (Project 390) will provide a rigorous methodology for developing correct software based on transformations, together with a comprehensive support system. Both the method and the tools represent a significant departure from current practice in the industry.

PROSPECTRA DEMO aims to show the feasibility of applying this methodology and its support tools to real-life industrial projects, as well as providing feedback to PROSPECTRA itself.

Formally, this project is associated with Projects 1265, 1271 and 1227.

Progress and Results

Technology transfer actions by means of courses taught by some academic members of the PROSPECTRA project have been undertaken. It is intended to increase this transfer by having some members participating directly in PROSPECTRA itself.

Preliminary experiments have been conducted on specifying some examples with PAnndA-S, with data being collected about the way the PROSPECTRA methodology is understood by its users.

With PROSPECTRA, PROSPECTRA DEMO has produced a design support system which guides the user through a series of successive refinements by a set of rules which ensure correctness is preserved as the design proceeds.

Exploitation/Time Horizon for Industrial Application

The partners aim to gradually introduce this new technology into their industrial practices and to test its effectiveness and efficiency by applications to large problems.

Contact Point

Mr A. Perez Riesco
Alcatel Standard Electrica SA
Ramirez de Prado, 5
E - 28045 MADRID

Tel: 34-1-4673000
Tlx: 27707
Fax: 34-1-2286122

Participants	Country	Role
Alcatel Standard Electrica SA	*E*	*M*
Syseca	*F*	*P*

Start Date	Duration	Resources
01-JAN-86	*36 months*	*19 PY*

GRAPHICS AND KNOWLEDGE-BASED DIALOGUE FOR DYNAMIC SYSTEMS (GRADIENT)

PROJECT NUMBER: 857

Objectives/Programme of Work

The objectives of the GRADIENT project are to investigate the use of knowledge-based systems to support the operator of industrial supervision and control systems, and to enable the operator to conduct an intelligent dialogue with the process, supported by graphical expert systems.

These objectives will be achieved by building a set of cooperating expert systems which support a dynamic dialogue. This complex of systems is designed to provide the system operator with intelligent support during fault investigation, emergency containment and system modification, as well as during normal operation. The GRADIENT system is intended to be introduced as additional support to be used in parallel with existing supervision and control systems, with a potential of replacing the conventional systems in the future.

A further aim of the project is to assemble KBS demonstrators for use in "hard-tech" industrial environments and to identify appropriate metrication aspects and methods.

Progress and Results

The final GRADIENT system will be implemented as a number of independent modules cooperating in predefined roles. A number of these modules have been implemented and demonstrated. In particular, the Quick Response Expert System responsible for fast reaction to system faults (October 87), the Response Evaluation System which monitors the operator actions and relates them to procedural plans (October 88), and the Dialogue System which channels communications between the operator and the system (October 88), have been demonstrated in the context of one demonstrator. In addition, the first version of the Intelligent Graphics Editor was demonstrated (June 88); this is an off-line tool for the design of graphics displays.

In parallel, a collection of decision support systems for materials and treatment selection in the field of corrosion have been demonstrated in October 88; studies on metrication aspects are now under way with those systems.

Exploitation/Time Horizon for Industrial Application

The decision support systems in the field of corrosion, together with the metrication study of expert systems, is expected to have a major impact on

industrial applications. Methodologies and tools for the construction of operator interfaces of large industrial systems will be available by October 1990. These will be supported by demonstrators in two key industrial application areas for control room systems, namely power plants and communication networks.

Contact Point

Mr. E. Hollnagel
CRI A/S
Bregnerodvej 144
DK - 3460 Birkerod
Tel: 2-822500

Participants	Country	Role
CRI A/S	*DK*	*M*
University of Kassel	*D*	*P*
University of Strathclyde	*UK*	*P*
University of Leuven	*B*	*P*
ASEA - Brown Boveri	*D*	*P*

Start Date	Duration	Resources
01-OCT-85	*60 months*	*100 PY*

NON-MONOTONIC REASONING TECHNIQUES FOR INDUSTRIAL PLANNING APPLICATIONS (MUMP)

PROJECT NUMBER: 865 (1220)

Objectives/Programme of Work

The aim of the project is to produce a prototype of a flexible tool package for knowledge-based planning systems incorporating specified planning techniques. These techniques are to be refined by developing demonstration systems in design and manufacturing applications. It is planned that the tool package should be interfaced to engineering tools, such as packages for CAD solid modelling, technical databases, and numerical calculation.

Progress and Results

A definition document providing guidelines based on the requirements in the intended application fields has been produced. The preliminary design for the planning system can be described as follows. The goals to be pursued by the planning system and their interaction must be extracted from CAD and other data. Each goal generates a process plan corresponding to a form feature of the piece to be machined. Inconsistency among the plans will be resolved by a constraint propagation mechanism.

The Multi-Method Production Planner (MUMP) embodying a simple representation language, has been expressed in a large Prolog program, and draft documentation has been completed. A preliminary toolkit organisation, centered around MUMP, has been designed and partially implemented. A prototypical frame and rule interpreters have been implemented and tried on simple problems.

MUMP has been demonstrated through an application to the machining of mechanical parts, where it interfaces a CAD system. In the course of this trial, a knowledge engineering approach was used to identify the attributes of form features and to analyse the task of a human process planner.

Exploitation/Time Horizon for Industrial Application

The prospects for the exploitation of the planning shell planned for completion by May 1990 are good.

The AI group of Aeritalia has taken over internal customisation following a successful trial based on the machining of aircraft parts.

Other partners have plans for the use of the shell in the course of consultancy projects, in air traffic control, and in extensions to CAD systems.

Contact Point

Mr. N. Iudica
BATTELLE INSTITUT
Technology Management Dept.
Am Romerhof 35 *Tel: 697-9082275*
D-6000 Frankfurt am Main *Tlx: 04 11966*

Participants	Country	Role
Battelle	*D*	*M*
Aeritalia	*I*	*P*
ELSAG S.p.A.	*I*	*P*
ITALCAD	*I*	*P*

Start Date	Duration	Resources
01-MAY-86	*48 months*	*19 PY*

INTEGRATED OPTIC TECHNOLOGIES FOR REAL-TIME WIDEBAND OPTICAL SIGNAL PROCESSING (COUSTO)

PROJECT NUMBER: 866

Objectives/Programme of Work

The objective is to develop an integrated acousto-optical device including processing in the 0.1-1 GHz range. It will include various optical elements as well as the radiation source and suitable detectors for a one-dimensional signal. Applications for such a device range from super-fast LAN connections to 1-D correlation in radar processing systems (for dynamic clutter rejection). The device is to be rugged and compact.

Progress and Results

The key to acousto-optics is the interaction between sound and light in a crystal (the Bragg cell). The interaction modifies not only the amplitude, frequency and phase of the light beam but also its direction. In this way, the information carried by both the sound and light is processed and revealed.

By the use of integrated optics, the information brought by the device under development measures the degree of similarity between an input signal and a reference signal through computing their correlation. The Bragg cell used in the integrated device is a surface acoustic wave (SAW) cell.

Various alternatives for the different components were studied and compared with respect to the required performances:

- The lithium niobate ($LiNbO_3$) substrate on which the waveguides are fabricated were found to be the best option for the acousto-optic interaction zone. The most significant alternative material, silicon, has been put aside because of its poor acoustic properties in spite of the possibility of integrating the optical detectors directly on the silicon substrate. The protonic exchange technique has been selected to build the waveguides on the Y-cut of $LiNbO_3$. The two signals, received and reference, are launched in opposite directions, and their correlation, taking place in the interaction zone, results in the deviation of the incoming laser-produced light.

- The Nb_2O_5 Fresnel option has been selected to build the collimating lens (between the laser source and the acousto-optic interaction region) and the detector lenses (between the acousto-optic interaction region and the detector).

A successful demonstration of the first prototype of an integrated device, working at a central frequency of 0.3 - 0.4 GHz, was given at the end of the first phase of the project. Optimisation and miniaturisation of the device has started.

Exploitation/Time Horizon for Industrial Application

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

The project provides a real opportunity for the development of a complete and economic real-time optical signal processing system using advanced analogue techniques. By February 1990, a first prototype of a space integrating correlator will have been built. Envisaged applications in this new field range from multiport switching to wideband signal detection.

Contact Point

Mr. M. Varasi
SELENIA SpA
Via Tiburtina, Km 12.4
I-ROMA 0013

Tel: 6-43602448
Fax: 6-4123436
Tlx: 613690

Participants	Country	Role
SELENIA SpA	*I*	*M*
GEC	*UK*	*P*
University College London	*UK*	*P*

Start Date	Duration	Resources
01-FEB-86	*48 months*	*22 PY*

ADAPTING REAL-TIME STRATEGIES FOR IMAGE PROCESSING: A CASE FOR SATELLITE DATA (ARTS-IP)

PROJECT NUMBER: 867

Objectives/Programme of Work

This focusing project consisted of a definition phase for the development of new architectures for processing satellite Synthetic Aperture Radar (SAR) images.

Progress and Results

An implementation workplan was prepared, covering aspects of real-time signal processing both on-board and on-ground, image interpretation through expert systems, and the related hardware and software.

The design of end-to-end remote sensing systems for crop monitoring and maritime surveillance was formulated in conceptual terms. This work included an initial feasibility study, with Landsat SAR images taken from different orbits. A comparative review of several texture analysis algorithms was carried out.

Exploitation/Time Horizon for Industrial Application

The feasibility study revealed the European interest in this technical domain. Advances are foreseen in the signal processing area through the study of new algorithms for the production of custom high-speed integrated circuits, and the application of knowledge-based techniques for automated image interpretation.

However, the definition phase has also shown that many basic technological problems remain to be solved, and that the project goals need reformulating vis-à-vis the objectives of ESPRIT.

Contact Point

Mr. F. Marcoz
SELENIA SPA
Via Tiburtina KM 12,400
I - ROMA 00131

Tel: 6-43602130
Tlx: 613690

Participants	Country	Role
Selenia Spa	*I*	*M*
Dornier System Gmbh	*D*	*P*
Ecole Sup. Ing. Electronic	*F*	*P*
Hunting Tech. Services	*UK*	*P*
GEC	*UK*	*P*
Polytechnic of Central London	*UK*	*P*
Polytechnic of Milan	*I*	*P*
Thomson-CSF (LER)	*F*	*P*

Start Date	Duration	Resources
01-FEB-86	*9 months*	*12 PY*

INTEGRATED ENVIRONMENT FOR RELIABLE SYSTEMS (CONCORDIA)

PROJECT NUMBER: 874

Objectives/Programme of Work

This project aims at providing an environment which integrates a set of hardware and software mechanisms and components to facilitate the construction and support the operation of reliable distributed application systems based on local area networks.

The intended architecture will provide a programming model which integrates the communication needs of distributed software with the various mechanisms required for fault tolerance.

The model will allow the construction of fault-tolerant systems based on the concept of active stand-by, with software redundancy supported by hardware redundancy in the network.

Progress and Results

The project ended on 30 November 1986, having completed a system architecture specification and a demonstration task specification.

The environment provides a computational model in which objects communicate by means of remote operations calls. Objects are replicated at different nodes of the system for reasons of back-up in the event of a node failure.

Checkpointing is invoked automatically during the remote operations calls, thus ensuring that a back-up object will start executing from a known state in the event of a failure.

Exploitation/Time Horizon for Industrial Application

The results of the project, mentioned above, are being used in ESPRIT Project 818.

Contact Point

Mr. N. Ghani
Mari Advanced Microelectronics
22 Jesmond Road *Tel: 632-817861*
UK - Newcastle-upon-Tyne,NE2 4QP *Tlx: 537038*

Participants	Country	Role
Mari Advanced Micro.	*UK*	*M*
Jeumont Schneider	*F*	*P*
University of Bologna	*I*	*P*
Telettra	*I*	*P*

Start Date	Duration	Resources
01-DEC-85	*12 months*	*7 PY*

FORMAL DESCRIPTION OF ARBITRARY SYSTEMS BY MEANS OF FUNCTIONAL LANGUAGES (FORFUN)

PROJECT NUMBER: 881

Objectives/Programme of Work

The project aims to develop a prototype of a general purpose system description environment based on so-called "system semantics".

System semantics is an extension of the denotational semantics of programming languages in the sense that it is applicable to arbitrary systems: various properties of a system are described by corresponding meaning functions.

A prototype general purpose system description environment based on functional languages and extended with primitives of system semantics will be developed.

Another goal of the project is the design of a prototype system description language for two specific areas: analog electronic circuits and digital systems (including VLSI).

Progress and Results

The feasibility of the approach has been demonstrated through case studies using the system description language to describe digital and analog electronic circuits.

A general language for system semantics (GLASS) has been defined and a support environment specified.

Implementation of the environment is under way through the construction of a coherent set of program generators to support Miranda, Pascal and C.

Plans for future work include the implementation of a macro-expander, the definition of more advanced, semantic functions for digital and analog systems, and the elaboration of examples of increasing complexity.

Exploitation/Time Horizon for Industrial Application

The partners held a seminar to explain the project results to VLSI designers in industry and thus to support their eventual exploitation.

An academic partner is applying the results in analog circuit design in other projects.

An industrial partner has started the informal transfer of technology to IMEC, the Belgian Inter-university Micro-Electronics Centre.

Contact Point

Prof. Dr. R. T. Boute
Dept. Informatics
Catholic University of Nijmegen
Toernooiveld
NL - 6525 ED NIJMEGEN

Tel: 31-80-558833
Fax: 31-80-553450
Tlx: 48228 NL

Participants	Country	Role
Catholic University of Nijmegen	*NL*	*M*
Sagantec	*NL*	*P*
University of Delft	*NL*	*P*
Alcatel Bell	*B*	*P*

Start Date	Duration	Resources
01-MAY-86	*48 months*	*19 PY*

DEVELOPMENT OF AN EFFICIENT FUNCTIONAL PROGRAMMING SYSTEM FOR THE SUPPORT OF PROTOTYPING

PROJECT NUMBER: 891

Objectives/Programme of Work

The objective of this project is to develop a functional programming system for the efficient support of prototyping.

Investigation and definition of capabilities and uses of a functional programming system will be examined in the following areas:

- rapid prototyping
- efficient code generation for functional programs to be processed on conventional sequential hardware
- large programmes, binding and modularity being the main issues
- persistent object management for long-term storage.

A prototype system will be developed to demonstrate the approach.

Progress and Results

The study of a hospital dispensary has been completed as a model application and the development of a functional programming environment with persistent storage is in progress.

From the results obtained, the programming environment is being further developed by ICL.

Exploitation/Time Horizon for Industrial Application

The steps preceding industrial application are:

- development of functional programming for large projects
- development of a functional programming system as a prototyping environment, with application areas such as industrial process and data base design.

Contact Point

Mr. R.P. Oakden
STC (ICL)
Westfields, West Avenue,
Kidsgrove
GB - STOKE-ON-TRENT

Tel: 44-782-29681
Tlx: 22971
Fax: 44-7816-76527

Participants	Country	Role
STC (ICL)	*UK*	*M*
Technical University of Twente	*NL*	*P*
University of St. Andrews	*UK*	*P*
Non-Standard Logics	*F*	*P*

Start Date	Duration	Resources
01-DEC-86	*36 months*	*24 PY*

ADVANCED INTERACTIVE DEVELOPMENT OF DATA-INTENSIVE APPLICATIONS (DAIDA)

PROJECT NUMBER: 892

Objectives/Programme of Work

The DAIDA project aims at the definition and prototype implementation of languages, methods, software tools, and environments to support the interactive development and maintenance of data-intensive information systems. Particular emphasis is placed on integrating all stages of the information systems development life-cycle with each other and with system maintenance. To achieve this goal, a knowledge-based management system (KBMS) perspective is taken as a basis for going beyond expert systems for software development. The evolving results of analysis, design and implementation will each be treated as co-operating knowledge bases, rather than being under the control of existing external expert systems.

The overall aim of the project is to contribute to the definition and implementation of tools for the production of quality software products for data-intensive applications. Behind the chosen approach is the conviction that the problem of software engineering is not solvable, in general, using current technology, and that the introduction of knowledge-based environments for all stages of the software life-cycle is needed.

Progress and Results

Work is in progress in three areas:

- For modeling and requirements specification, a System Modeling Language (SML) and a design support environment will be developed. These include a SADT-like interface and PROLOG-based prototyping, and theorem-proving tools for validation and verification.

- For logical system design, the TAXIS language is being redesigned as a pure design language (TDL) with predictive specifications for transactions; the TDL environment will include editors, viewing and prototyping.

- For database structure and transaction design and implementation, an environment for the database programming language DBPL will be built. This will include syntax-oriented components as well as database and transaction design tools.

Each level will be equipped with knowledge-based mapping assistants that support the realisation of requirements set by the level above. A global knowledge-base manager observes the development process and records

information about the use of the development environments; this information subsequently facilitates efficient and consistent maintenance of the multi-layered system representation.

The basis of SML as well as of the global KBMS is the Conceptual Modeling Language (CML). The hardware/software environment is based on advanced workstations (Sun-3 and Micro Vax), making intensive use of BIM-PROLOG.

After a preparatory phase, work progressed in parallel in a number of key project areas, including:

- language design (SML, TDL)
- functional analysis of the knowledge-based tools (mapping assistants, global KBMS)
- design of the DAIDA development support environments (prototyping, user interface questions, architectural integration of tools).

The main achievements of the first two years of the project can be summarised as follows:

- The extensions from CML to a Systems Modeling Language have been established and the implementation has begun.
- A first TDL design has been completed. It largely satisfies the diverse requirements of compatibility with SML (designing from functional specifications in the context of a world model); with DBPL (designing for modular relationally oriented database programming); and with Prolog (design into full functional prototypes).
- Preliminary prototypes of the mappings between the three layers mentioned above were demonstrated in May 1988.
- The principles, methods, tools etc behind the prototyping activity (in Prolog) were also demonstrated in May 1988.

Progress towards formulating concepts for a uniform design of the SML, TDL, and DBPL environments has been substantial, and initial experiments with the existing components to be included have been completed.

The preparation of a DAIDA programmers' manual is in progress and is due for completion by 1989.

Exploitation/Time Horizon for Industrial Application

The impact of using the techniques developed in this project could be to increase the productivity and quality of the software products of the European IT industry.

The reaction to the DAIDA programmers' manual will provide first evidence of DAIDA's commercial viability. However, this complex set of concepts will require many refinements (mainly syntactical) before being ready for commercial exploitation.

Contact Point

Mr. R. Venken
BIM S.A.
Kwikstraat, 4
B - 3078 EVERBERG

Tel: 32-2-759 59 25
Fax: 32-2-759 47 95
Tlx: 63518

Participants	Country	Role
BIM S.A.	*B*	*M*
GFI	*F*	*P*
University of Frankfurt	*D*	*P*
Cretan Computer Institute	*GR*	*P*
SCS Technische Automation und Systeme GmbH	*D*	*P*
BP-ITRU	*UK*	*S*
University of Passau	*D*	*S*

Start Date	Duration	Resources
01-MAR-86	*48 months*	*46 PY*

EXTERNAL INTERFACE FOR PROCESSING 3-D HOLOGRAPHIC AND X-RAY IMAGES FOR ANALYSIS AND CONTROL (PHOX)

PROJECT NUMBER: 898

Objectives/Programme of Work

The aim of the project was the development of an external interface system for linking physically generated 3-D images to inspection and analysis procedures. While this had to be a general and flexible system, it was demonstrated through the application of holographic interferograms and X-ray radiographs to real-time testing and inspection and to 3-D measurement. For this task, optical and electronic methods had to be combined in order to extract the relevant information from multiple 3-D images. A further aim of the project was the automation of the holographic interferometry and the X-ray radioscopy for online testing in the manufacturing process.

Progress and Results

The challenge of the project was to combine two non-destructive testing methods. This was done by first detecting deformations of the surface of materials by a holographic method. The deformations were then interpreted in terms of stress and compression on the material, using finite element methods. The stress and compression were then further explained by the use of X-ray image processing to give information regarding the interior of the materials.

Various techniques for quantitative holographic interferometry were investigated, and the phase-stepping method and a method based on the Fourier transform, invented within the project, were selected. Holographic processing combined with finite element analysis had already been successfully demonstrated. X-ray radiography interface requirements (mainly concerned with filtering noisy signals) were identified. The quality of the images was found to depend on the X-ray source, on the geometrical structure of the inspection system, and on the detector and image processing system. Consequently, controlling hardware and software were developed to automatically optimise these conditions for performing the testing. A manipulator and its control were produced and a source control (microfocus X-ray control) developed. Low-level image-processing techniques were adapted for use with both X-ray images and interferograms. A common set of objects (honeycomb structures) were selected to test the methods developed for holographic interferometry and X-ray radioscopy, both individually and in combination.

Exploitation/Time Horizon for Industrial Application

The project advanced the technologies for designing and testing engineering structures, which is a priority for the achieving improved product quality. The creation of a prototype combining optical and electronics technologies successfully demonstrated the feasibility of a low-cost system for online testing for surface defects.

Knowhow on non-destructive testing methods acquired through work in holographic interferometry is to be marketed by one of the partners.

Contact Point

Dr. Ing. Werner Jüptner
BIAS GmbH
Optoelectronics
Ermlandstrasse 59 *Tel: 49 421 606063*
D-2820 BREMEN 1 *Tlx: 17 421 21 45*

Participants	Country	Role
BIAS GmbH	*D*	*M*
GEC	*UK*	*P*
IRAM	*F*	*P*
University of Dortmund	*D*	*P*
SCANRAY	*DK*	*P*

Start Date	Duration	Resources
01-MAR-86	*24 months*	*14 PY*

A RULE-BASED APPROACH TO INFORMATION SYSTEMS DEVELOPMENT (RUBRIC)

PROJECT NUMBER: 928

Objectives/Programme of Work

The objective is to develop a system for creating information systems for business applications which match the requirements of users more accurately than is presently possible.

Individual end-user requirements are to be collected using a rule-based approach. This data will then be integrated into a single model and used to generate the applications software.

A prototype system will be developed consisting of:

- a rule-based fact-gathering and presentation system with different views for presentation and with validation tools
- a unified rule base (URB) to store, aggregate and validate individual requirements;
- an application generating system to realise applications from rule-based descriptions in the URB, either by transformation or by interpretation of the rules.

Progress and Results

The conceptual design of the URB and the fact-gathering and presentation system are under development. As far as the conceptual design of the URB is concerned, research on the ability to use rules to describe the business and its activities is complete.

A stable set of concepts for representing user knowledge was presented in June 1988. This set integrates three paradigms: entity-relationship, object-oriented, and rule-based. Work concerning the logical formalisation of the semantics of these concepts is in progress.

An object-oriented extension to Prolog developed, within the project by the UMIST team, was successfully demonstrated in June 1988.

Work is currently being done on the MMI tools to support the final RUBRIC system and on the implementation of the RUBRIC support tools.

Exploitation/Time Horizon for Industrial Application

The project seeks to establish and to validate the principles for the use of AI technology in the development of business applications software.

AI technology will not only bring a reduction of costs to business software development but will also permit applications of increased scope and complexity to be tackled.

The Irish Electricity Supply Board is, with the support of the other partners, providing the trial site for both concept development and tool implementation. This application of the RUBRIC system to a real-life situation provides important feed-back for its future commercialisation.

Contact Point

Mr.F.Van Assche
JAMES MARTIN ASSOCIATES
Genevestraat 10 Bte 4
B - 1140 Brussel
Tel: +32-2-241.88.00/2
Tlx: 20899

Participants	Country	Role
James Martin Associates	*B*	*M*
University of Manchester	*UK*	*P*
BIM S.A.	*B*	*P*
Micro Focus Ltd	*UK*	*P*
IESB	*IRL*	*P*

Start Date	Duration	Resources
01-FEB-86	*45 months*	*26 PY*

DEBUGGING AND SPECIFICATION OF ADA REAL-TIME EMBEDDED SYSTEMS (DESCARTES)

PROJECT NUMBER: 937

Objectives/Programme of Work

The project intends to assist developers of real-time embedded systems in Ada by investigating formal methods and by designing software and hardware tools.

Formal semantics and proof systems for real-time languages, with emphasis on composability, will be investigated. A specification language including real-time constraints and correctness-preserving transformations will be designed.

Traceability of transformation decisions in the context of real-time constraints and analysis tools will be developed.

Progress and Results

Work is in progress on the formalization of the semantics of an extension of Statelan with temporal logic, and on checking the consistency of combined specifications. Two directions have been taken, concentrating on the incorporation of Me-Too in the Statemate system and on the methodology of refinement. Work has been started on the translation of Me-Too and Statelan specifications in Ada, and a system for tracing and analysing execution histories of Ada programs without disturbing the target machine has been specified, with these tools implemented and demonstrated.

Exploitation/Time Horizon for Industrial Application

An Ada debugger system has been developed by ES Dassault, a partner in the aerospace industry, for testing real-time Ada systems through internal use. An immediate impact on the quality and reliability of real-time embedded systems implemented in Ada is expected.

Contact Point

Mr. O. Maurel/C.Bonnet
GSI - TECSI
6 Cours Michelet
F - 92064 Paris La Défense *Tel: +33 1 47 78 87 00*
Cedex 52 *Tlx: 616897*

Participants	**Country**	**Role**
GSI-TECSI	*F*	*M*
Foxboro Nederland N.V.	*NL*	*P*
ES Dassault	*F*	*P*
Systeam KG	*D*	*P*
Technical University of Eindhoven	*NL*	*P*
University of Stirling	*UK*	*P*

Start Date	**Duration**	**Resources**
01-MAR-86	*36 months*	*48 PY*

INTEGRATED MANAGEMENT PROCESS WORKBENCH (IMPW)

PROJECT NUMBER: 938 (1223)

Objectives/Programme of Work

The objective is the implementation of a prototype workbench with particular emphasis on planning, project control and decision support. The tools rely heavily on a common knowledge base. The system is intended to be UNIX V and PCTE portable.

This project is associated with Project 814 within Project 1223.

Progress and Results

Current emphasis is on the design of the workbench software, and the design and implementation of a comprehensive set of use functions, covering all automatable project management actions.

Other important results are:

- the development of an object-oriented development method
- the design of a standard manager workbench interface
- the preparation of a user requirements specification for estimation purposes
- the specification and design of the risk analysis tool
- the development of a first version of an estimation tool.

Following the survey of cost modelling theories and practices, a generic cost estimation tool has been developed that can be customised for all existing models and combinations thereof.

Exploitation/Time Horizon for Industrial Application

The prototype system will be demonstrated and used in industrial trials. An evaluation of the effectiveness of the system will be based on the results obtained.

Industrialisation of the prototype will have immediate impact on software development project management.

Contact Point

Mr D. Creasy
INTERNATIONAL COMPUTERS Ltd.
Westfields, West Avenue,Kidsgrove *Tel: +44-782-29681*
UK-ST7 1TL Stoke-on-Trent *Tlx: 22971*

Participants	**Country**	**Role**
International Computers Ltd	*UK*	*M*
CETE Mediterranée	*F*	*P*
Verilog	*F*	*P*
NIHE	*IRL*	*P*
Imperial College	*UK*	*P*

Start Date	**Duration**	**Resources**
01-FEB-86	*36 months*	*35 PY*

DEPTH AND MOTION ANALYSIS (DMA)

PROJECT NUMBER: 940

Objectives/Programme of Work

The objective is to develop a vision system integrating passive information from stereo and optical flow (motion) for industrial robotics and passible navigation, with hardware realization of real-time vision modules. The system will be integrated in two demonstrators:

- A mobile vehicle to be able to move in different environments, avoiding obstacles and making visual maps of the scene.

- A manipulating arm for industrial robots for object manipulation and inspections, and for tool assembly.

The project has been organised into different tasks covering passive stereo vision, the computation of optical flow, integration of stereo and flow, the computation and representation of 3-D shapes and motion, and hardware implementation demonstrators for a mobile vehicle and for a manipulating arm.

Progress and Results

All partners have concentrated on the study and subsequent harmonization, or standardization, of software (eg the "C" language for low-level processing, and LISP for high level processing) and hardware tools (eg tape formats, performance study of TV cameras, and interfaces).

Three strongly interrelated lines of research have been followed: a study of algorithms for (passive) stereo and motion analysis, a hardware feasibility study, and a specificaton of the demonstrators (mobile vehicle and robot manipulator).

Research on stereo algorithms resulted in two approaches (matching either image regions or image edges) which were implemented using a set of three cameras. Research in motion analysis has concentrated on the recovery of 3-D structure from already available feature correspondence in temporal image sequences, rather than from optical flow. Basic methodologies for reconstruction from 3-D stereovision and from 2-D flow-field have been established.

DMA has provided systems that recognize objects well enough for a robotic inspection to be made both from mobile and stationary platforms and for their positions to be estimated with sufficient accuracy for them to be grasped by a robot hand.

Exploitation/Time Horizon for Industrial Application

Vision systems resulting from work in this project are being developed by ELSAG, MATRA and ITMI for robotic inspection and robotic handling. Demonstrators for both the mobile vehicle and the manipulating arm are planned by the end of the project (1991). These will provide advanced solutions for most applications of factory development, testing and integration of different algorithms for stereovision, motion analysis and 3-D object reconstruction. This will make an essential contribution to basic research in scene understanding.

The achievement of the project objectives will represent substantial progress in image understanding and offer considerable technological improvements for factory automation.

Contact Point

Mr. G. Musso
ELETTRONICA SAN GIORGIO SpA
Via Puccini 2 *Tel: 10-60011*
I-16154 GENOVA *Tlx: 270660*

Participants	Country	Role
ELSAG SpA	*I*	*M*
GEC	*UK*	*P*
MATRA E.P.T.	*F*	*P*
INRIA	*F*	*P*
ITMI	*F*	*P*
Noesis	*F*	*P*
University of Cambridge	*UK*	*P*
University of Genoa	*I*	*P*
Lifia	*F*	*P*

Start Date	Duration	Resources
01-JUN-85	*60 months*	*112 PY*

PCTE-ADDED COMMON TOOLS (PACT)

PROJECT NUMBER: 951

Objectives/Programme of Work

The objective is the development and documentation of a toolset for PCTE (Project 32). This implementation of a layer of functionalities above PCTE basic mechanisms will provide the tool developer with a higher level interface to PCTE. The project will be conducted in close collaboration with the PCTE project.

The prototype version will include:

- tools for data definition and data query
- tools for environment administration
- document preparation tools
- communication facilities (user-user and gateways)
- support for C, Pascal, Lisp and Prolog
- configuration management tools.

Progress and Results

The initial toolset is now available on top of PCTE. It consists mainly of the following tools which have been adapted or ported: shell; basic object management system tools; data definition language interpreter; general text editor; Pascal and C compiler, linker and debugger; general text formatter; system administration tools; and basic archiving and back-up tools.

More basic work on the design and development of tools supporting advanced features is underway, especially in the following critical areas:

- Object Management System: design of advanced data definition, query and manipulation tools.

- Dialogue management: definition of a model and an accompanying formalism to describe the interactions between any tool and a user.

- Common services: construction of a functional level offering well-defined language interfaces exploitable by tools. This will form the basic layer for the integration of future tools.

Exploitation/Time Horizon for Industrial Application

PACT has a range of tools running on Bull and Sun computers and a PACT toolset contributes to the EUREKA EAST development of PACT-based products.

The partners plan to provide a complete general purpose environment to industry in 1989. This environment will support tools developed by other projects and widen the use and acceptance of PCTE.

Contact Point

R. Minot
BULL S.A.
68 Route de Versailles *Tel: +33-1-39025000*
F - 78430 LOUVECIENNES *Tlx: 22971*

Participants	Country	Role
BULL S.A.	*F*	*M*
GEC Software Ltd	*UK*	*P*
ICL	*UK*	*P*
Olivetti	*I*	*P*
Syseca Logiciel	*F*	*P*
System & Management SpA	*I*	*P*
Eurosoft Systems S.A.	*F*	*P*

Start Date	Duration	Resources
01-FEB-86	*36 months*	*144 PY*

PARALLEL ASSOCIATIVE DEVELOPMENT MACHINE AS A VEHICLE FOR ARTIFICIAL INTELLIGENCE (PADMAVATI)

PROJECT NUMBER: 967

Objectives/Programme of Work

The objective of PADMAVATI is to develop a high-performance computer system suitable for real-time speech and image understanding, and for other time-critical applications.

The machine architecture will be based on an array of computational transputer nodes, each containing a high-performance multiprocessor and memory and communication interfaces. The memory architecture to be developed will be based on hashed DRAM and associative memories. The programming environment will be standard Prolog and LISP with extensions to support parallel execution. The complete machine will be tested by implementing experimental, computationally-intensive tasks from the fields of parallel expert systems, speech, and image understanding. Signal processor interfaces will be developed by the use of bit-serial parallel array machines.

Progress and Results

The first building block of the architecture is available and ready for replication: it consists of a board of two nodes and hardware emulating the switching elements.

The software orientation consists of a Prolog and a LISP annotated by the user when parallelism is required, the implementation being done through OCCAM.

The performance of the system for a restricted number of processors has been evaluated and a set of distributed algorithms for speed processing written in Lisp is now ready to be tested on a small network of Lisp machines.

PIPES, the first prototype realisation of a Prolog transputer-based machine where the transputers are fully interconnected using a packet-switched network, is targeted for real-time applications in speech and vision understanding in SIP, Project 26.

Exploitation/Time Horizon for Industrial Application

Efficient real-time sub-systems will be available by 1990 and tested on three different applications: speech and image understanding and a parallel expert system for the use of mathematical libraries.

The viability of associative devices in an efficient implementation of concurrent LISP and sequential and parallel Prolog will be demonstrated.

Contact Point

Mr Laurent Mistral
CIMSA SINTRA
Parc d'Activitiés KLEBER
160 Boulevard de Valmy — *Tel: 33-1-47 60 30 30*
F - 92704 Colombes — *Tlx: 204780*

Participants	Country	Role
CIMSA SINTRA	*F*	*M*
FIRST	*D*	*P*
GEC	*UK*	*P*
Non-Standard Logics	*F*	*P*
Thomson CSF	*F*	*P*

Start Date	Duration	Resources
01-MAR-86	*58 months*	*55 PY*

ADVANCED LOGICAL PROGRAMMING ENVIRONMENTS (ALPES)

PROJECT NUMBER: 973

Objectives/Programme of Work

The project aims at an analysis and definition of a complete programming environment, based on logic programming. It will analyse program synthesis from first-order logic specifications, theorem proving and meta-reasoning, distributed logic programming, and abstract data type specifications.

The application of these results to classical environment tools, such as debuggers, browsers, editors and interfaces with graphic systems, to the specific needs of logic programming, will be developed in parallel.

Finally these results will be integrated in programming environment modules.

Progress and Results

A common Prolog Kernel (C-Prolog) was adopted and a workshop held on its implementation. The specification of the Kernel, together with the prototyping and integration work, has been completed, and task covering both theoretical and implementation aspects of the following areas are in progress:

- Prolog and graphic systems
- editors
- program synthesis
- program analysis
- non-classical logics

A demonstration of prototypes for each of the 12 working tasks of the project was followed by combined demonstrations of the components of an advanced logic programming environment.

An integration strategy and an architecture for the global system have been developed and an integration technical board established.

Exploitation/Time Horizon for Industrial Application

The provision of a common Prolog Kernel for the constitution of a logic programming environment constitutes an important step towards a European standard on logic programming.

Work on the exploitation of the results will follow the availability of the integrated prototype.

Enidata intends to exploit the ALPES results, with the ultimate goal of developing a rapid prototyping environment for applications manipulating large quantities of data and knowledge. Internal experimentation with the ALPES environment is planned.

Bull will use the ALPES knowhow to enhance the robustness and portability of its SP-Prolog product.

CRIL has an industrialisation study for the ALPES environment under way in preparation for early commercial exploitation. Applications in progress include:

- the development of SPIRAL, an expert system shell, under a contract from CEA, the French nuclear energy authority
- Prolog-based applications for customers
- an in-house use of the ALPES environment.

TUM will exploit the results of ALPES within such R&D actions as:

- the construction of an MMI for an assembly design expert system
- the construction of an ES for dealing with contractual matters.

Contact Point

Mr. Jean Hentinger
CRIL
Centre d'Affaires Colombia
146, Bd. de Valmy
F - 92700

Tel: 33 1.47 76 34 37
Fax: 33.1.47 78 45 46
Tlx: 614359

Participants	Country	Role
CRIL	*F*	*M*
Bull	*F*	*P*
Enidata	*I*	*P*
CNRS-LRI	*F*	*P*
TUM	*D*	*P*
New University of Lisbon	*P*	*P*

Start Date	Duration	Resources
01-JUN-86	*48 months*	*89 PY*

A KNOWLEDGE-BASED ENVIRONMENT FOR SOFTWARE SYSTEM CONFIGURATION REUSING COMPONENTS (KNOSOS)

PROJECT NUMBER: 974 (1221)

Objectives/Programme of Work

The objective of this project is to develop an environment supporting a method for components reuse during software configuration.

The user requirements for such an environment will be captured through studies conducted by industries familiar with large applications development. A KNOSOS prototype will be constructed by integration and adaptation of a relational DBMS, a knowledge representation and manipulation tool, a software configurer, an automated configuration management system, and a common user interface with graphics capabilities. This prototype will be evaluated through field trials.

KNOSOS is embedded in composite project 1221 (consisting of 974 and 1094).

Progress and Results

The user requirements for the global system and an implementation of an interface between the LISP language and a relational DBMS have been presented.

These tools constitute the basic building blocks of the KNOSOS system and contain different facilities for knowledge representation. Case studies have been developed and the different building blocks tested separately.

A first version of the total KNOSOS prototype was successfuly demonstrated. Work is currently in progress on what concerns its final implementation.

The exploitation of the results, mainly to space applications, has been planned by the industrial partners.

Impact/Time Horizon for Industrial Application

The results of this project, which will be a general model of software components and a method to reuse them and configure large software systems, are to be available to facilitate the implementation of large industrial applications. The reason for this is that a considerable part of the cost of software development today is due to unintentional redevelopment or necessitated by modifications due to a change in the requirements, or to errors. This cost can be significantly reduced once reusable processes and associated tools become available.

Contact Point

Mr. R Valent
Engineering System International
20, Rue Saarinen, Silic 270
F - 94578 RUNGIS Cedex

Tel: 33-1-46 87 25 72
Fax: 33-1-46 87 72 02
Tlx: 200283

Participants	**Country**	**Role**
ESI	*F*	*M*
CNET	*F*	*P*
Dornier System GmbH	*D*	*P*
Matra	*F*	*P*
CIT-Alcatel	*F*	*P*
Yard Software Systems	*UK*	*S*

Start Date	**Duration**	**Resources**
01-JUN-86	*40 months*	*29.5 PY*

NEXT-GENERATION DATABASE MANAGEMENT SYSTEM (MUST)

PROJECT NUMBER: 1005

Objectives/Programme of Work

The objective of MUST was to establish the basis for the development of a new generation of database management systems (DBMS) with the following features:

- Treatment of new data types (documents, images, sounds, time).
- Use of inference techniques to ensure data integrity, to deduce new data from recorded data, and to help the user to set up his queries.
- Compatibility with existing DBMS through use of the actual interface SQL.

Progress and Results

During the first months of the project, a market survey identified the user requirements and the manufacturer perspectives for the next generation of DBMS.

The concept of a resource dictionary was derived from work on new data types (time, graphics, etc.) and on the refinement of a data dictionary.

Experience of deductive components was gained by treating this topic separately from the rest of the work.

A prototype of a natural language menu interface and a tentative mock-up of a graphical interface were demonstrated in the final review.

Exploitation/Time Horizon for Industrial Application

The impact of MUST on the compatibility of existing DBMS, and on the treatment of new data types and the inclusion of a deductive component, will be exploited by the main contractor.

Contact Point

Mr. J.C. Badault
SYSECA LOGICIEL
315, Bureaux de la Colline
F - 92213 ST. CLOUD CEDEX
Tel: 33-1-49 602 70 47
Tlx: 260045

Participants	Country	Role
Syseca Logiciel	*F*	*M*
University of Kaiserslautern	*D*	*P*
ABSY NV	*B*	*P*

Start Date	Duration	Resources
01-JUN-86	*21 months*	*12 PY*

INTEGRATION OF ARTIFICIAL INTELLIGENCE, VOCAL I/O AND NATURAL LANGUAGE DIALOGUE: APPLICATION TO DIRECTORY SERVICES (PALABRE)

PROJECT NUMBER: 1015 (1226)

Objectives/Programme of Work

The PALABRE project aims at defining and realising an acquisition and interrogation system for a large and evolving knowledge base. Information, interrogation and updating are performed using natural language. The input-outputs are either textual or vocal (speech understanding and synthesis). Common tools and methods will be developed independently so that several languages (French, English, Italian) can be used. Requests will be converted with the help of inference rules and will be sent to an intelligent retrieval process based on semantic knowledge representation. LISP and PROLOG on a LISP machine will be used. The feasibility of such a system will be demonstrated through a phone directory "Yellow Pages" prototype application, in Italian, English and French.

Progress and Results

The first year was devoted to the design of the system. Different parts of the system were identified and their interfaces defined. The general architecture is based on a blackboard approach to combine several sources of knowledge. Two different approaches are proposed to parse a query inputted by the user: a deterministic parser for written input, and an augmented transition network parser for spoken input. These two approaches are likely to be combined. The knowledge is represented using KL-ONE. The deduction module allowing the interpretation of a user query by the knowledge-base and the answer generation module have been investigated.

Exploitation/Time Horizon for Industrial Applications

The first prototype will be a major breakthrough in the domain of the information systems. This multilingual user-friendly system, combining the most advanced techniques of speech processing, natural language processing, and knowledge engineering, will open the way to the next generation of information systems.

Contact Point

Mr. H. Noyer
SESA
RENNES ATALANTE
3 rue du Clos Courtel
BP 1897
F - 35018 RENNES

Tel: 33-99635050
Fax: 730095

Participants	Country	Role
SESA	*F*	*M*
CNET	*F*	*P*
SARIN	*I*	*P*
British Telecom plc	*UK*	*P*
ERLI	*F*	*P*
CRNS-LIMSI	*F*	*P*
Polytechnic of Turin	*I*	*P*

Start Date	Duration	Resources
01-MAR-86	*48 months*	*120 PY*

FORMAL METHODS FOR ASYNCHRONOUS SYSTEM TECHNOLOGY (FORMAST)

PROJECT NUMBER: 1033

Objectives/Programme of Work

The project aims to provide a formal framework and a suitable toolset for the development of asynchronous embedded micro and distributed systems.

The toolset includes presentation language and tools such as a design database, formal design provers based on theorem proving techniques, designer's assistants, and simulators. The toolset will be linked to an asynchronous system development environment, which is currently being implemented, and will also be compatible with PCTE.

Progress and Results

Progress has been made in developing a compositional method for asynchronous system design. Work has been advancing in proof methods and in defining a case study, based on an aerospace system.

The specification method has been defined and the case study and theorem-proving activity have made progress.

Exploitation/Time Horizon for Industrial Application

The project will facilitate collaboration between universities in the UK and Germany to harness expertise on asynchronous systems and formal methods and to advance these developments into an industrial context in the two countries. The project will be targetted towards producing early results, which could lead to early exploitation as well as longer term industrial benefits.

Contact Point

Mr. M. A. Wright
Advanced Systems Architectures
Johnson House
73 -79 Park Street
Camberley
GB - SURREY GU15 3PE

Tel: +44-276-682756
Tlx: 932905
Fax: +44-276-684245

Participants	Country	Role
Advanced Systems Architectures	*UK*	*M*
Imperial College, London	*UK*	*P*
University of Kaiserlautern	*D*	*P*
Erno Raumfahrttechnik GmbH	*D*	*P*

Start Date	Duration	Resources
01-MAY-86	*24 months*	*14 PY*

2D COHERENT OPTICAL DYNAMIC PROCESSOR (COOP)

PROJECT NUMBER: 1035

Objectives/Programme of Work

The objective is to develop and implement an optical processor for pattern recognition based on the most recent technological developments. The feasibility of parallel optical signal processing will be demonstrated by using a spatial light modulator (electrically and/or optically), a solid state laser, and non-linear components based on the Four Wave Mixing (FWM) process, allowing real-time modification of the correlation function or alternatively matched filters. By improving the spatial light modulator a corresponding improvement in processor performance is expected, which will lead ultimately to a resolution of 1200 x 1200 pixels in parallel at a standard TV frame rate.

The system will be demonstrated and evaluated on a robotic application.

Progress and Results

Excellent results on both materials and components have been obtained. High resolution spatial light modulators, optically or electrically addressed (based on thin film transistor technology) and working at video rate have been produced and successfully demonstrated with a 300 x 300 spatial resolution. For performing correlation two techniques were pursued: a static one using holographic match filters, and a dynamic one using the FWM technique. The latter has been abandoned because it could not support the video rate.

For the robotic application, to enable one object among others to be recognized quickly and independently of its orientation and position, two approaches have been followed.

The first, needing a sophisticated correlation analysis, is to synthesise a reference image called a Synthetic Discriminant Function (SDM) by the computation of a special kind of linear combination of related reference images. Then an SDF-matched filter or an SDF transparency is produced to be used, respectively, by the static or dynamic processor.

The second approach is the production of a holographic multichannel filter that can be used to correlate in parallel a test image with various reference images, recording, for example, various objects of a training set seen from different orientations. This method does not need sophisticated correlations analysis as all the values of the cross correlations may be used to recognise the test object. It is now being implemented in the integrated prototype working in an industrial environment to recognise cutting tools: object recognition and determination of

the orientation at +/- 5^{o} and of the displacement at +/- 0.5 mm are expected to be performed in 0.5 s.

On the materials side, the technique of growing BSO crystals (up to 40 mm diameter) has improved and good photorefractive performances have been obtained.

More exploratory studies are also being carried out within the project in order to develop the next generation of SLMs able to work at very high speed (in the range of kHz full image frequencies).

Exploitation/Time Horizon for Industrial Application

By June 1989 an early prototype of an optical processor able to perform up to 400 x 400 pixels image correlation at video rate will have been demonstrated in an industrial environment. Optical processing, by its very nature, allows real-time and wide-band applications. In the future, it could become an alternative to the digital technologies.

This project provides marketing a opportunity for a European supplier of BSO crystals, which at the moment are mainly obtained from Japan.

Contact Point

Mr. J.M. Brodin
THOMSON CSF
Dept. AVG
31 rue Camille Desmoulin
F - 92132 ISSY-LES-MOULINEAUX
Tel: 33-1-45 54 92 40
Tlx: 204780 F

Participants	**Country**	**Role**
Thomson CSF/AVS	*F*	*M*
GEC Hirst Laboratories	*UK*	*P*
ULB	*B*	*P*
Thomson CSF/LCR	*F*	*P*
Krupp	*D*	*P*

Start Date	**Duration**	**Resources**
01-MAR-86	*39 months*	*29 PY*

A GENERAL ENVIRONMENT FOR FORMAL SYSTEMS DEVELOPMENT (GENESIS)

PROJECT NUMBER: 1041 (1222)

Objectives/Programme of Work

The project aims to create a meta-system generating syntax-directed editing, transformation and proof tools from descriptions of the syntax and semantics of the formalisms used in software development. Metalanguages for the description of context conditions, transformation rules, proof rules and tactics will be defined.

This project is associated with Project 1158 within Project 1222.

Progress and Results

GENESIS is an ambitious project on which significant progress has been made, in particular concerning the design and implementation of the projection language KENSHO and the structure displayer's command language. Further work has been done on understanding the relations among the semantics framework for the metalanguage, the abstract definition of computation rules for a subset, ideas for implementing these in Prolog, and some relatively concrete example theories for manipulating syntax and inference rules. The semantic framework is based on ideas from classical first-order logic, which fits well with the use of Prolog for prototype implementation. As a test, the specifications of VDM and Z (by means of GENESIS) have been carried out, and several kinds of proof in different logical systems (eg Goldblatt's imperative program logic and modal logic) can now be processed and supported by the actual prototype. A convincing demonstration of a proof-editor prototype was presented, and recommended for future academic distribution. Work is now continuing on testing the usability of GENESIS through the VDM specification environment, defining and implementing more specialised logic machines for comparison.

Exploitation/Time Horizon for Industrial Application

GENESIS will make it possible to generate tools for a wide range of methodologies based on different notations and logics from descriptions of the syntax and semantics of the notations used. In the long term, the development of GENESIS will lead to an order-of-magnitude reduction in the cost of providing support tools for formal methods.

A polished version of the prototype, suitable for academic use, has been released.

Contact Point

Mr. W.Harwood
IMPERIAL SOFTWARE TECHNOLOGY LTD
60 Albert Court
Prince Consort Road
UK-LONDON W7 2BH
Tel: 44-1-5818155 or 223-316155
Tlx: 928476

Participants	Country	Role
Imperial Software Technology	*UK*	*M*
Philips	*NL*	*P*
Imperial College, London	*UK*	*P*

Start Date	Duration	Resources
01-FEB-86	*60 months*	*54.5 PY*

INTEGRATION OF SYMBOLIC AND NUMERIC LEARNING TECHNIQUES (INSTIL)

PROJECT NUMBER: 1063

Objectives/Programme of Work

The objective is to improve knowledge acquisition for knowledge-based systems by the application of machine learning techniques. The method of knowledge acquisition to be developed is the generation of a knowledge-base from an analysis of examples of sets of field data by the formulation of rules in the application domain.

The project will identify the best features from different approaches to knowledge acquisition, in order to improve the quality of rules extracted from "noisy" data. Use will be made of existing software: MAIN, which is based on Michalski's INDUCE and AQ11, a symbolic learner; AGAPE and AGAPE-C, which use theorem-proving techniques and taxonomies of descriptors of example sets; and NEDDIE, which is an extended version of Quinlan's ID3, which uses numerical manipulation to constrain its search space.

Progress and Results

An example application was demonstrated to show integrated learning of rules using symbolic and numerical methods.

Improved versions have been produced of the programs previously developed separately by project team members at their locations, and ported to the chosen development environment. Prototypes integrating MAIN, NEDDIE and AGAPE were completed and distributed to the partners for experimentation. The most promising prototype uses MAGGY (augmented AGAPE) to generalize cluster descriptions obtained by NEDDIE. This prototype forms the basis of the INSTIL system, which is now being finalized and documented. An object-oriented representation language, the generalization-oriented language (GOL) has been implemented and documented. It is used to represent background knowledge, examples, and the rules synthesized by INSTIL. The integrated learning system is being strengthened by studies on dealing with noise in knowledge acquisition.

The INSTIL system has been tested on several large-scale applications in various domains including agriculture (diagnosis of disease in crops), image understanding (object recognition), mosquito recognition, medical diagnosis, air traffic control and fault recognition in turbine generators.

Exploitation/Time Horizon for Industrial Application

It is expected that the lessons learned will be incorporated in tool environments for expert system construction in the form of an automatic rule refinement and acquisition module. The final prototype of this module and a complete user manual is now available.

Cognitech intends to enhance the set of expert systems under development for diagnosing disease in 30 different crops by the addition of an automatic rule-refinement and acquisition module. Cognitech also intends to incorporate a similar rule-learning module in their integrated laboratory for teaching AI.

GEC-RL intends to link a rule-learning element from INSTIL to a tool environment for expert system construction with which they are involved.

Test sites of an industrial, commercial, or medical nature are being sought for the INSTIL system. GEC and the University of Paris are using INSTIL in traffic control, case law deduction, and the identification of address locations on parcels.

Results from INSTIL will be incorporated into ESPRIT II Project 2154.

Contact Point

Mr. E.A. Pacello
GEC Research Labs.
Software Research Division
West Hanningfield Road
UK - Great Baddow, Chelmsford CM2 8HN
Tel: 44-245-73331 ext. 3241
Tlx: 995016

Participants	Country	Role
GEC Research Labs.	*UK*	*M*
Cognitech	*F*	*P*
University of Paris Sud	*F*	*P*

Start Date	Duration	Resources
01-OCT-85	*36 months*	*13 PY*

DEVELOPMENT AND INTEGRATION OF ACCURATE OPERATIONS IN NUMERICAL DATA PROCESSING (DIAMOND)

PROJECT NUMBER: 1072

Objectives/Programme of Work

The objective of this project is to develop methods and tools for accurate floating point arithmetic on computers, based on a mathematical theory of computer arithmetic in which all operations are defined by so-called semimorphisms. Such a systematic theory of computer arithmetic aims at performing the basic arithmetic operations to maximum accuracy and providing sufficient control over the rounding process so as to ensure reliable error bounds. This project will pursue several different approaches: embedding of convenient arithmetic notations into ADA and Pascal; AI techniques for formula transformation and symbolic manipulation; and construction of a methodological framework and a knowledge-base for numerical programming.

Progress and Results

- Packages for general scientific computation have been implemented into Pascal SC (Scientific Pascal) and Ada. They accurately state the intervals (due to truncation and rounding) in which their results lie. They include real and complex arithmetic, operations on scalars, vectors, matrices and linear equations, and the computation of eigenvalues and the roots of polynomials.

- The application of the prototypes to some critical examples has demonstrated the greater accuracy and reliability of the new operators in comparison to classical arithmetic operators.

- DIAMOND has been presented at eleven international conferences. Workshops have been held to tell potential users about DIAMOND tools.

- A facility to allow problems to be stated by the use of symbolic notation has been specified and is being implemented. This will simplify system use and give faster execution of operations.

- A Pascal SC-Ada translator has been completed for use in the translation of the Pascal-SC modules, and has been used to create some Ada packages with market potential. Their release through the NAG library is planned for 1989.

- A submission of a joint American-European proposal to standardise Ada has been made.

Exploitation/Time Horizon for Industrial Application

The improved accuracy, reliability and efficiency that the use of the project's packages brings to numerical programming is a field of interest for many scientific and industrial domains. Consequently, the market possibilities of the DIAMOND results are being studied, in particular, through a French initiative on numerical quality.

Tools are released through the numerical algorithms library for which the first edition of the catalogue has been published. The exploitation of Diamond tools and the standardisation of floating-point arithmetic is to be expected in ESPRIT II through the participation of the partners in Supernode II, Genesis and other projects.

Tools, documents and demonstrations are available on request to Diamond partners.

Contact Point

Dr. A. Zoellner
SIEMENS AG
K SP APS 23
Otto Hahn Ring 6
D - 8000 MUNCHEN 83

Tel: 49-89-63 64 01 82
Fax: 49-89-63 64 16 88
Tlx: 5210960

Participants	**Country**	**Role**
Siemens AG	*D*	*M*
Numerical Algorithms Group Ltd	*UK*	*P*
University of Karlsruhe	*D*	*P*
CWI - Centrum voor Wiskunde & Informatica	*NL*	*P*
University of Bath	*UK*	*P*

Start Date	**Duration**	**Resources**
01-JAN-86	*40 months*	*41 PY*

SHIPBOARD INSTALLATION OF KNOWLEDGE-BASED SYSTEMS (KBS-SHIP)

PROJECT NUMBER: 1074 (1226)

Objectives/Programme of Work

The objective of KBS-SHIP is to develop design concepts for the implementation of advanced IT systems in ships.

It aims to provide the stimulus for engaging the support of the marine industry for the introduction of KBSs expected by the early 1990s.

It also aims to assist bridge and engine-room officers in duties ranging from voyage planning to alarm handling. It will do this by providing:

- a framework for the integration of information in ships
- a decision-support system for the efficient operation of a complex ship by a small crew.

The viability of the concepts will be ensured by building a prototype KBS-SHIP system incorporating a limited number of expert systems.

Progress and Results

In the first project definition phase, the onboard information flow was described and a limited bench model of an expert subsystem - the Expert Voyage Pilot (EVP) - was built.

In the second phase, the status of the work which has been structured round four themes, is as follows:

- The development of the EVP in regard both to voyage planning and to route planning. An Atlantic crossing scenario is under preparation, and a change from Prolog to LISP for later inclusion in the THOR shell of STL (a product resulting from Project 96) is in progress.
- The development of a comprehensive design specification for the KBS-SHIP architecture; specification prototyping will be finished in October 1988.
- The delineation of the scope of the final KBS-SHIP system in terms of the number and scope of individual subsystems - the maintenance expert system has been defined as a causal model and includes the checking and monitoring of sensors. Cost functions have been introduced for optimisation calculations, and numerical algorithms have been combined with rules.

- The preparation of requirement specifications and outline design specifications for a number of expert systems within the KBS-SHIP for use in later work.

Exploitation/Time Horizon for Industrial Application

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

The study of the development of an acceptance procedure for expert systems onboard ship being made by Lloyd's Register is one of the several ways in which the project is encouraging the acceptance of AI technology by the European marine industry. The project is also expected to influence international standards for local area networks onboard ship as well as the design of maritime surveillance and control equipment.

The results of KBS-SHIP are incorporated into ESPRIT II Project 2163.

Contact Point

Mr. E. Kasper
Danish Maritime Institute
Hjortekaersvej, 99
DK - 2800 LYNGBY

Tel: 45-2-879325
Tlx: 37223

Participants	Country	Role
Danish Maritime Institute	*DK*	*M*
Soeren T.Lyngsoe A/S	*DK*	*P*
Krupp-Atlas Elektronik GMBH	*D*	*P*
Lloyd's Register	*UK*	*P*
The East Asiatic Co. A/S	*DK*	*P*
Technical University of Athens	*GR*	*P*

Start Date	Duration	Resources
01-MAR-86	*33 months*	*14 PY*

DEVELOPMENT AND APPLICATION OF LOW-COST, HIGH-PERFORMANCE, MULTIPROCESSOR MACHINE (SUPERNODE)

PROJECT NUMBER: 1085

Objectives/Programme of Work

The objective was to develop a high-performance, multiprocessor, prototype computer with a flexible architecture, suitable for a wide range of scientific and engineering problems.

Progress and Results

- Hardware

The basic component (the T800 version of the transputer with a floating-point multiplier facility) and the Supernode computer developed in the project are representative of the present state of the art. A 1000-transputer machine was implemented as an array of supernodes. The machine architecture is expandable, and the interconnection of nodes is reconfigurable, as are the transputers at the node level. A high-speed input/output interface (100M bits/sec) was developed for real-time vision applications. Further multi-node machines are currently under test prior to delivery.

- Base level software

The basis for software development is OCCAM and the INMOS transputer development system. The software development host is either MSDOS or UNIX using the Transputer Development System with extensions. The target code is downloaded to Supernode over a transputer communications connection.

- User software

Important applications in signal processing and logic simulation benefiting directly from the parallel processing environment have been successfully developed. Other studies have been made of the user software environments in the following areas: image processing, scientific applications, CAD, ray tracing, CAM, and in the provision of a numerical algorithms library.

Exploitation/Time Horizon for Industrial Application

The T800 transputer is a significant industrial result from INMOS and is now manufactured for industrial use. Five hundred designs worldwide are based on the T800 and its spin-offs. Single and multiple node Supernode-based machines are being marketed.

Among the applications and products that have resulted from the work packages of this project are the following: the LUCKY-LOG logic simulator in the CAD for VLSI area, now presented as an add-on card for PCs; several image-processing applications; digital signal processing applications; applications of image generation by the ray-tracing method; multi-transputer architecture studies in CAM; the provision of diagnostics and debuggers; and Occam and Fortran libraries.

The Supernode computer has been further developed to the product level by Telmat and Thorn-EMI. A new subsidiary of Thorn-EMI, PARSYS, has been set up to handle the product. Manufacturing of components is shared between the companies to encourage economies of scale.

The project has attracted wide interest in the architectures community, particularly through several international presentations.

Contact Point

Mr J.G. Harp
Signal Processing Group
Royal Signals and Radar Est
St. Andrew Road
UK-Malvern WR14 3PS
Tel: 44 684 892733 ext 2824

Participants	Country	Role
RSRE	*UK*	*M*
APTOR	*F*	*P*
INMOS	*UK*	*P*
Telmat SA	*UK*	*P*
Thorn-EMI Research Labs.	*UK*	*P*
University of Southampton	*UK*	*P*
University of Grenoble	*F*	*P*

Start Date	Duration	Resources
01-DEC-85	*36 months*	*100 PY*

SUPPORT SYSTEM FOR PRAGMATIC REUSE OF SOFTWARE CONCEPTS (PRACTITIONER)

PROJECT NUMBER: 1094 (1221)

Objectives/Programme of Work

The objective is to develop methods for the pragmatic reuse of software concepts at the design stage. The task is to identify, isolate, document, store and retrieve program concepts, ie design ideas, schema for software subsystems and components.

The potential of a linguistic approach as a basis for analysing existing programs will be investigated. A prototype system supporting these methods will be evaluated by performing extensive experiments.

This project is associated with Projects 974 and 1221.

Progress and Results

A metamodel for the reuse scenario has been agreed by all the partners. A questionnaire for collection, storage and retrieval of program concepts has been developed and is considered to have proved its utility. Work is continuing on a linguistic approach to classification and retrieval, and tool construction has begun.

Exploitation/Time Horizon for Industrial Application

The approach adopted will result in the development of a support environment which will be immediately exploitable by the consortium. One partner will use the results to support existing large libraries of software while other partners will apply the results to future developments.

Contact Point

Dr. Jan Witt
PCS - Periphere Computer Systems GmbH
BST - Basic Software Technology
Pfaelzer-Wald Strasse, 36 *Tel: 49-89-68 00 42 72*
D - 8000 MUNICH 90 *Tlx: 523271*

Participants	**Country**	**Role**
PCS	*D*	*M*
Asea Brown Boveri (ABB)	*D*	*P*
Computer Resources International	*DK*	*P*
Brunel University	*UK*	*P*

Start Date	**Duration**	**Resources**
01-DEC-86	*60 months*	*53 PY*

A METHODOLOGY FOR THE DEVELOPMENT OF KNOWLEDGE-BASED SYSTEMS (KADS)

PROJECT NUMBER: 1098

Objectives/Programme of Work

The objective is to assist the transfer of knowledge-based systems (KBS) technology into use, by providing methodological guidance for the development process. It is believed that KBS development can be treated as a particular case of software engineering and that the same requirements must be placed on the development of KBS as on other types of software. In short, KBS must be produced to specification and to acceptable standards by a controllable process.

Progress and Results

Work is progressing according to schedule. The conceptual modeling methodology and tools have been applied in eleven projects with well-documented success in at least one revenue-earning study for a commercial client in the UK.

Theoretical work on the production of design specifications from conceptual models has already generated a useful classification of existing design tools. Several tools were demonstrated in March 1987. A detailed lifecycle model of the analysis phase has been produced and used as an interpretative schema to extract guidelines for future developers of KBS.

The KADS (Knowledge Acquisition and Design Support) methodology is currently supported by a suite of tools, including:

- a hypertext editor for protocol analysis
- a domain concept editor
- an interpretation model librarian
- a cognitive model editor.

Each tool has been implemented using a configuration of Prolog and the object-oriented graphical language, PCE. Final integration and implementation of the toolkit, probably in a PCTE-based environment, will be completed by September 1990.

Exploitation/Time Horizon for Industrial Application

PCE, developed at the University of Amsterdam, is to be marketed in Europe and America through non-exclusive licensing agreements.

Contact Point

Mr. L. Hailes
STL
London Road
UK - Harlow CM17 9NA

Participants	Country	Role
STC	*UK*	*M*
CAP-SESA	*F*	*P*
SD-Scicon	*UK*	*P*
SCS	*D*	*P*
University of Amsterdam	*NL*	*P*
Touche Ross Management Consultants	*UK*	*P*

Start Date	Duration	Resources
01-SEP-85	*60 months*	*83 PY*

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

PROJECT NUMBER: 1106

Objectives/Programme of Work

The objective is to design and implement a new Prolog, Prolog III. The new language will integrate reasoning mechanisms and numeric processes and be based on the efficient integration of constraint resolution. It will include the possibility of adding inequalities and arbitrary propositional well-formed formulae as constraints.

The project will demonstrate the usefulness of Prolog III for the construction of knowledge-based systems in technical areas, in particular in the diagnosis of faults in car injection systems. It will show the deduction of knowledge from an analysis of functional and structural designs.

Progress and Results

On the language side, the following results have been obtained :

- Design, implementation and testing of a new algorithm to verify the degree of satisfaction of arbitrary well-formed formulae in propositional logic. This algorithm exhibits satisfactory performance in a class of practical cases.

- Choice of a sufficiently general subset of arithmetic operators to be allowed in the inequalities appearing as constraints in Prolog III clauses. This subset was chosen in a way that the solution of sets of such inequalities would be computationally efficient.

- Design, implementation, and test of algorithms to solve inequalities.

- The first implementation of PROLOG III has been revised and debugged. New optimized simplification algorithms and floating point arithmetic have been implemented.

On the application side, the following preliminary results have been achieved:

- Construction of a simple expert system using an expert system shell developed by one of the partners before the start of the project.

- Study of the strategies for diagnosis and repair used by human specialists and their classification of knowledge.

- Specification and full implementation of a pilot expert system.

- Specification and implementation of a comprehensive expert system demonstrator (PROMOTEX II) which models components, entirely based on PROLOG III has been achieved and demonstrated. Characteristic curves of some component parts of the automobile have been studied and modeled in PROLOG III.

Exploitation/Time Horizon for Industrial Application

Some tools for the development of expert systems have been developed by the partners, although final tools using the new language Prolog III are not expected to be completed until the first half of 1989.

The language Prolog III is scheduled to be completed by the end of the project, after the expert system is integrated, tested, and optimized. It is expected that the knowledge-based system itself will be displayed in the field. Besides its use in the development of the application expert system, it can be expected to have an impact on the industrial partners, both as a learning experience, and as an organised record of possibly unstructured information. The achievement of a working relationship between the inventor of Prolog, Professor A. Colmerauer, and two large industrial companies, Daimler Benz and R. Bosch, is in itself significant.

Moreover, constraint logic programming is a very promising approach in many industrial application domains (model based reasoning, planning, and control).

Contact Point

Prof. Alain Colmerauer
Prolog IA
70 route Léon Lachamp
Case 919
F-13288 Marseille Cedex 09

Tel: 91 269092
Tlx: 402094

Participants	Country	Role
Prolog IA	*F*	*M*
GIA	*F*	*P*
GIT	*D*	*P*
Robert Bosch	*D*	*P*
Daimler Benz	*D*	*P*

Start Date	Duration	Resources
01-JAN-86	*50 months*	*47 PY*

KNOWLEDGE-BASED USER-FRIENDLY SYSTEM FOR THE UTILISATION OF INFORMATION BASES (KIWI)

PROJECT NUMBER: 1117 (1218)

Objectives/Programme of Work

The objective of this project is to develop a knowledge-based user-friendly system for managing access to external information bases. Four aspects will be emphasised:

- a knowledge representation formalism, through the development and use of the OOPS language, based on an object-orientated approach
- an Advanced Database Environment (ADE), based on the combination of logic programming and databases
- the integration of the knowledge representation formalism and ADE within a single concept
- an intelligent interface between the end-user and the system, based on graphics.

This project was originated by another ESPRIT project (number 641) which was a feasibility study of such a system and whose results constituted the starting point.

Progress and Results

The definition of the OOPS language, and its prototype implementation together with specification of the architecture of the global system, are available.

The architecture of the ADE layer has also been established, and theoretical work on the concept of the bottom-up execution of Prolog programs was performed.

Demonstrations have been given of the User Interface (UI), the Knowledge Handler (KH) and the Advanced Database Environment (ADE), which are the three main KIWI modules, and of the full KIWI system. A tight integration between the UI and KH was achieved and shown to be possible between KH and ADE.

A final prototype including all the modules of the KIWI system (loosely integrated in what concerns KH and ADE) was sucessfuly demonstrated during the final review.

Exploitation/Time Horizon for Industrial Application

The combination of the deductive powers of logic programming with the data management capabilities of large relational databases will result in powerful computing environments, which will dominate computing in the 1990s.

KIWI will contribute substantially to meeting the key requirements for establishing such environments. It will do this especially in the areas of knowledge representation formalisms, recursive queries handling, and the execution of Prolog programs.

The results of KIWI will be the basis for the ESPRIT II project KIWIS (number 2424).

Contact Point

Mr. Domenico Sacca
CRAI
Research Division
Contrado S. Stefano
I - 87030 RENDE

Tel: 39-984-83 32 85
Fax: 39 984 44 60 44
Tlx: 80 00 85

Participants	Country	Role
CRAI	*I*	*M*
DDC	*DK*	*P*
Enidata	*I*	*P*
Philips	*NL*	*P*
University of Antwerp	*B*	*P*
La Sapienza University of Rome	*I*	*P*
INRIA	*F*	*S*

Start Date	Duration	Resources
01-FEB-86	*36 months*	*36 PY*

ADVANCED MODEL FOR INTEGRATION OF DB AND KB MANAGEMENT SYSTEMS (ISIDE)

PROJECT NUMBER: 1133 (1218)

Objectives/Programme of Work

The objective is to develop an advanced model for integration of data- and knowledge-based (DB and KB) management systems.

The ISIDE team intends to work on three main tasks:

- the specification of a knowledge representation formalism
- the specification of a logical inference formalism
- the definition of the architecture of an efficient storage and access layer using specialized VLSI hardware (Database machine).

Progress and Results

From practical observations of the ARS/AGUSTA Helicopter Maintenance Training System (ITS) and CRIL's Software Engineering Documentation System (CACAO), ISIDE reached the realistic conclusion that no single universal paradigm would resolve the DB programming problems. Instead, both a rule-based approach (RDL1) and an object-oriented approach (ODL1/LDR2), with capabilities to switch from one to the other, were advocated.

Both approaches have been intensively experimented upon, and prototype support systems were demonstrated in April 1988. The more mature, RDL1, already has a computational model (Predicate Transition Networks). An object server (GEODE) with sufficient flexibility to interface with rule-based, object-oriented and SQL languages has been built.

On the architecture side, a consolidated draft has been proposed, emphasising future needs for large-capacity core memories, to allow all the information needed during a transaction to be stored in the main memory. MALG, a theoretical algebraic machine, has been built over GEODE.

Following performance evaluation studies for these systems, demonstrations have been given of ITS with RDL1, Performance Evaluation, GEODE, and ITS alone.

Exploitation/Time Horizon for Industrial Application

Some partners envisage developing a knowledge-based training product within the next two years, based on the RDL1 formalism.

Contact Point

Mr. M. Darchen
SAGEM
1, rue Louis Meunier
Parc de la Defense — *Tel: 33-1-42912154*
F-92002 NANTERRE Cedex — *Tlx: 614520*

Participants	Country	Role
SAGEM	*F*	*M*
Agusta SpA	*I*	*P*
Ars SpA	*I*	*P*
CRIL	*F*	*P*
INRIA	*F*	*P*
Simulog	*F*	*P*

Start Date	Duration	Resources
01-MAY-86	*36 months*	*42 PY*

ADVANCED TECHNIQUES INTEGRATION INTO EFFICIENT SCIENTIFIC APPLICATION SOFTWARE (ATES)

PROJECT NUMBER: 1158 (1222)

Objectives/Programme of Work

This project aims to integrate advanced techniques into an integrated software development environment within the area of scientific application programming, with particular emphasis on efficiency.

A programming language (ATES), integrating three advanced techniques, will be developed, incorporating:

- abstraction of data types and operators
- relational database programming for scientific data
- formal specification and proof, defined by taking into account the specificity of scientific programming.

An efficient software development environment will include a proof subsystem allowing the user to validate an algorithm with respect to some specification, or to get error information if the algorithm is invalid. The adequacy of the whole system will be evaluated by developing application libraries.

This project is associated with Project 1041 within Project 1222.

Progress and Results

- A specification of ATES has been made based on the 4x programming system. It consists of an algorithmic programming language derived from Fortran, some program manipulation tools, and an execution environment. The code generation capabilities of the system have been improved and enhanced.
- The overview of program proof systems has been completed.
- The specification of the proof system has been progressed. A specification language has been designed, allowing the semantics of the user's operators, including selectors and iterators, to be defined. The method uses models like VDM and the pre- and post-conditions of the operators. The conditions are expressed in the VDM models and use predicates of the first-order logic. Axiom chapters give properties of the models. A proof language allows a description to be given of how one type implements another type giving a so-called "abstract function". Loop invariants can be also given to the system. Generation of verification conditions has been defined using Hoare's logic and the semantics

of the programming language. The architecture of the whole system has also been designed.

- A test application to the resolution of thermodynamic equations using the finite element method has been demonstrated. The test is the first of several specifically designed to provide user feedback on the ATES environment.

Exploitation/Time Horizon for Industrial Application

As they will have an industrial system available at the end of the project, it is expected that the delivered system will reach a pre-industrial state, with enough demonstrative value to act as an advanced reference for scientific software and CAD software designers.

Contact Point

Mr. J.P. La Hargue
CISI Ingenierie
26, rue Saarinen
F - 94528 RUNGID Cedex

Tel: +33.1.46 87 32 23
Fax: +33 1 45 60 57 63
Tlx: 260 482

Participants	**Country**	**Role**
CISI/II	*F*	*M*
Technische Hogeschule Twente	*NL*	*P*
University of Liège	*B*	*P*
University of Paris VII	*F*	*P*
Philips	*NL*	*P*
CEA	*F*	*P*

Start Date	**Duration**	**Resources**
01-JAN-86	*48 months*	*45 PY*

A MULTI-METHOD APPROACH FOR DEVELOPING UNIVERSAL SPECIFICATIONS (AMADEUS)

PROJECT NUMBER: 1252 (1229)

Objectives/Programme of Work

The objective was to define a unified conceptual model semantically rich enough to describe specifications derived from any of the leading development methods. This would provide a basis for the integration of the wide range of existing and well-understood tools and techniques currently used. This project aimed to provide for the harmonisation of system development environments by introducing an approach which permitted the use of multiple methods, but with a common and unified system specification as the outcome of its use. This was intended to be achieved by the availability of a unified representation scheme which could be accessed through appropriate interfaces, by tools and techniques relating to a method.

This project is associated with Projects 1262, 1277, 1282 and 1283 within Project 1229.

Progress and Results

The project team surveyed a number of different software development method comparison studies and classified the development methods, mapping the model of development against the approach used. Methods include SSADM, SADT, JSD and NIAM.

A range of application and support system types such as office communications systems, control systems and robotic systems were examined to identify the real-world objects dealt with.

These objects were grouped under headings such as objects manipulated, relationships, and activities.

A model was developed on the basis of the analyses performed. Whilst the model had some value in judging the completeness of the methods, much of the semantic information was lost in the transformation.

Exploitation/Time Horizon for Industrial Application

Reviewers recommended publication of the "Analysis of Methods" document. The results of the feasibility study were not sufficiently convincing to continue the work.

Contact Point

R. Scholten
Interprogram BV
Wildenborch, 3
NL - 1112 XB DIEMEN
Tel: 31-20-996121

Participants	Country	Role
Interprogram B.V.	*NL*	*M*
UMIST	*UK*	*P*
BIM S.A.	*B*	*P*
Telefonica - CTNE	*E*	*P*
Hitec Ltd.	*GR*	*P*

Start Date	Duration	Resources
01-APR-86	*12 months*	*48 PY*

DYNAMIC SOFTWARE MIGRATION BETWEEN COOPERATING ENVIRONMENTS (CHAMELEON)

PROJECT NUMBER: 1256 (1228)

Objectives/Programme of Work

The objective of the project is to build a dynamic software migration system. The purpose of this system is to enable the migration and execution of active objects throughout a heterogeneous computer network. The elements of the system are an abstract common machine, an abstract common machine environment and the network.

This project is associated with Project 1261, HTDS.

Progress and Results

The starting point for this project was the AMBER machine, an intermediate machine model. The abstract machine is a model which reflects target machine and programming language concepts to support the portability of programs. Two intermediate machine models, IACM and HARP, were proposed and examined by the partners. HARP is a general purpose machine model and makes no assumptions about the supported languages; IACM is more closely modeled on the AMBER machine. These designs differ in the ease with which they could support the languages "C" and SCHEME. Models of both abstract machines have been developed within the project.

Demonstrations of software migration in a homogeneous environment using abstractions of two intermediate machine models were given during the year.

Exploitation/Time Horizon for Industrial Application

The productivity gains will allow users to undertake important projects which would be prohibitively time consuming with existing technology. For example, a software porting task which nowadays could take several months, could conceivably be accomplished in, at most, one morning. Therefore, this project is expected to greatly improve productivity and to drastically reduce the cost of moving software. The concepts being developed could also be exploited in networks where programs could be moved around the network and activated at remote nodes.

Contact Point

Mr. G. Attardi
Delphi SpA
Via della Vetraia,11
I - 55049 VIAREGGIO

Participants	Country	Role
Delphi SpA	*I*	*M*
Non Standard Logics	*F*	*P*
Harlequin Ltd.	*UK*	*P*

Start Date	Duration	Resources
01-SEP-86	*42 months*	*36 PY*

SOFTWARE QUALITY AND RELIABILITY METRICS FOR SELECTED DOMAINS: SAFETY MANAGEMENT AND CLERICAL SYSTEMS (MUSE)

PROJECT NUMBER: 1257

Objectives/Programme of Work

The objective of this project is to produce demonstrable quality and reliability metrics focused on three specific application domains: safety, management and clerical systems. These metrics will be applied on real software development projects to provide experimental trials data and user reactions for their analysis and evaluation. The research staff will include specialists from the fields of software engineering, artificial intelligence, human factors and statistics. In addition, external fields such as construction, engineering and manufacturing will be surveyed to see if they have quality and reliability paradigms which can be of relevance to software.

In addition to researching and testing both domain-specific metrics and generic metrics for the selected areas, the project will seek to establish a basis for new generation metrics using AI methods.

Progress and Results

Following a comparative survey in USA and Europe, the quality and reliability metrics and factors for use in the project were selected.

Demonstrations have been made of:

- SAM, an Expert System for measuring and assessing the quality of safety critical systems
- SMACK, the use of quality tools integrated within a smalltalk environment
- ATHENA, tools for complexity measurements and maintenance assistance.

Exploitation/Time Horizon for Industrial Application

Software quality and reliability metrics in the field of safety, management and clerical systems are of immediate interest for the European IT industry.

Contact Point

Dr. J.R.Hemsley
Brameur Ltd
237 High Street
Aldershot
UK - Hants

Tel: +44.252-313437
Tlx: 858893

Participants	Country	Role
BRAMEUR	*UK*	*M*
CRIL	*F*	*P*
RWTUEV	*D*	*P*
EBO	*GR*	*P*

Start Date	Duration	Resources
01-JAN-87	*42 months*	*33 PY*

TESTING AND CONSEQUENT RELIABILITY ESTIMATION FOR REAL-TIME EMBEDDED SOFTWARE (TRUST)

PROJECT NUMBER: 1258

Objectives/Programme of Work

The objective of the project is to assess the impact of the major current design methods on the testability and reliability of software. The aim is to generate software which is not only testable but, by virtue of its intrinsic structure, more reliable.

The approach includes investigating development method characteristics and measuring progress through the use of tools especially developed within TRUST.

Progress and Results

Results to date are as follows:

- A survey of languages (high and low level) usable for real-time embedded systems has been completed. This survey includes the identification of the characteristic features of these languages, varying between generations and levels, which impact on the ability to adequately test real-time embedded systems. These characteristics include hardware and I/O support, concurrent task support, and exception handling.

- Analysis of source host/target communication has been completed. This has also identified the key features such as speed and capacity, that are affected by the host/target communication mechanisms.

- Surveys of software test usage and testing tools have been completed.

- Statistics and metrics for software reliability and scope have been identified, and a first analysis tool has been written for several assembler languages.

- An interactive mutation tool, SMUT, has been developed.

The following tools and prototypes have been developed for use in monitoring and analysing real-time systems embedded in target computers:

- ComBox: a communication box which facilitates communication between software systems embedded in a target computer and a host computer.

- Statistical Profiler: a set of modules to be incorporated into an existing testbed to provide statistical reports from statistics accumulated over many analysis runs.

- CS-Testbed and IL-Testbed: two prototypes of efficient source code instrumentors.

Exploitation/Time Horizon for Industrial Application

The results of the project will help to assess the real-time and host/target aspects of software products during the test and development phases. This will provide data for management control. The prototype tools developed provide a basis for commercial products.

Contact Point

Dr. M.H.Hennell
Statistics and Computational
Mathematics Dept.
University of Liverpool
Victoria Building
UK - Liverpool L69 3BX

Participants	**Country**	**Role**
University of Liverpool	*UK*	*M*
Liverpool Data Research Assoc.	*UK*	*P*
Software Engineering Services	*D*	*P*
The City University	*UK*	*P*
John Bell Systems	*UK*	*P*

Start Date	**Duration**	**Resources**
01-NOV-86	*36 months*	*24 PY*

HOST-TARGET DEVELOPMENT SYSTEM (HTDS)

PROJECT NUMBER: 1261 (1228)

Objectives/Programme of Work

The objective of the HTDS project is to develop a prototype integrated tool system based on a PCTE environment to support automatic testing, high-level debugging and remote maintenance.

The project aims to establish a framework for the test and debug process between the the compiler output and executable target code.

The host-target development area will be examined with a view to specifying a development system. Naked microprocessors, industry standard boards and industry standard computers will be considered as targets. The advantages of distributing the tools between the host and target systems will be considered.

Prototype systems will be realised with tools in the areas of automatic testing, high-level debugging and remote maintenance.

Standard solutions to the communications problems of developing host target systems, will be sought. It is anticipated that results from the Chameleon project (number 1256) will be of help in this task.

Progress and Results

A preliminary test and debug specification has been written. This specification includes a full list and description of commands necessary to test and debug executable code in the proposed environments.

Two levels of interface are being defined in the process between the compiler output and the execution mapping. The upper level lends itself to the human interface and the lower level to the machine.

Exploitation/Time Horizon for Industrial Application

This project will engender a common approach to the test and debug phase of system development with the associated standardisation benefits.

Contact Point

Mr. N'guyen Thuy
SFGL
30, Quai du Dion Bouton
F - 92806 PUTEAUX Cedex
Tel: +33 1 45 60 41 37
Tlx: 206252

Participants	**Country**	**Role**
SFGL	*F*	*M*
Softlab GmbH	*D*	*P*
Marconi Systems Ltd	*UK*	*P*
Logica Ltd	*UK*	*P*

Start Date	**Duration**	**Resources**
01-DEC-86	*46 months*	*40 PY*

SOFTWARE FACTORY INTEGRATION AND EXPERIMENTATION (SFINX)

PROJECT NUMBER: 1262 (1229)

Objectives/Programme of Work

This project has a dual purpose:

- To combine the results from a number of ESPRIT Software Technology (ST) projects into a preprototype of what can be described as a software factory or an integrated software engineering environment.

- To use the software factory as a vehicle for evaluating some of the tools and methods developed within the ESPRIT ST programme and therefore as a focal point for demonstrating to a wider forum the results obtained within the ST programme.

A number of specific objectives may be derived from the overall objective:

- A comparison with similar efforts by evaluating features of the work of other organisations in the same software factory field, namely ISF of Alvey, EAST and ESF of EUREKA, the STARS program of the US DoD, and the SIGMA program of Japan.

- The demonstration of prototypes in a common environment, which will take place after the following preparatory actions have been completed:

    - assistance in the exchange of information between the teams developing prototypes

    - the preparation and distribution of descriptions and definitions of the software factory concepts and the necessary underlying concepts, such as PCTE

    - training personnel working in the ST programme in the software factory concepts.

The project is associated with Project numbers 1252, 1277, 1282, and 1283 within 1229.

Progress and Results

The first year of the project, in 1986/7, was a definition phase.

A number of problems (quality, integration, documentation, training, etc.) have been investigated with a selected set of existing ESPRIT projects (eg Projects 410,

315, 125 and 282). The more specific approach to the software factory concept that emerged forms the basis of the workplan for the main phase of the project.

The development of techniques and tools for the acceptance and integration of PCTE-based ESPRIT-developed tools is in progress.

Exploitation/Time Horizon for Industrial Application

This project will be an enforcement of the PCTE and PCTE compatible tools, in the sense that it aims to:

- Enforce the PCTE concept as a possible European standard for tool development.
- Evaluate and test PCTE as the backbone of, and of PCTE compatible tools as components of, a software factory.
- Disseminate knowledge of ST tools and methods, in general, and of PCTE-based tools and methods, in particular.

Contact Point

Mr. P. Picard
Société Française de Génie Logiciel
98, rue du Chateaux
F - 92100 Boulogne *Tel: +33.1.48 25 09 09*
F - 94518 RUNGIS Cedex *Fax: +33 1 46 04 86 01*

Participants	Country	Role
SFGL	*F*	*M*
CRI A/S	*DK*	*P*
CSATA	*I*	*P*
ERIA Research & Dev.	*E*	*P*
SEMA CAP	*UK*	*P*

Start Date	Duration	Resources
01-SEPT-86	*60 months*	*88 PY*

SEDOS ESTELLE DEMONSTRATOR (SEDOS DEMO)

PROJECT NUMBER: 1265 (1227)

Objectives/Programme of Work

The objectives are:

- the demonstration of the maturity (applicability, efficiency, etc.) of the SEDOS technology (ESPRIT Project 410) for the design of open distributed systems by the development of an industrial prototype, the so-called "ESTELLE Work Station" (being an integrated toolset for the use of the ESTELLE formal description technique, editor, translator, code generator, simulator motor and implementation motor).

- the demonstration of the applicability of the ESTELLE language for the formal description and development of protocols for the interconnection of systems. This will be done by means of application-oriented evaluation, industrial networks, telecommunications, and space.

The project will provide a precompetitive demonstration (i.e. applicability, efficiency, etc.) of the SEDOS technology in different relevant fields.

This project is associated with Project 835 and with 1271 within 1227.

Progress and Results

The ESTELLE work station is running on SUN and APPOLLO, and is to be implemented on other systems.

The ESTELLE FDT has been standardised by ISO in IS 9074. The ESTELLE language has been developed to describe the services and protocols of the layers of Open System Interconnection (OSI) architecture. ESTELLE's potential application area is wider than OSI protocol specifications. It has been demonstrated that ESTELLE is a powerful tool for the description of distributed systems in many other important fields, such as telecommunications, computer-integrated manufacturing (CIM) and office automation.

The SEDOS ESTELLE demonstrator is available today, providing:

- a basic set of prototype tools (EWS) including a syntax-oriented editor, a translator, a C code generator, a debugging-oriented simulator, and an implementation kernel

- the first results of the project evaluation task, conducted on 10 selected examples of industrial applications.

(7)

Exploitation/Time Horizon for Industrial Application

Distribution of the environment to European universities is planned for 1989 as part of the process of standardising the Estelle language.

A product is being built which the partners will market.

A first release of the EWS prototype is now available via Verilog for universities and non-profit research centres for evaluation.

Contact Point

J. Dufau
VERILOG SA
150 rue Vauquelin
F - 31081 TOULOUSE CEDEX

Tel: +31.61.403888
Fax: +31.61.408452
Tlx: 531639

Participants	Country	Role
VERILOG	*F*	*M*
Expert Software Systems NV	*B*	*P*
MARBEN	*F*	*P*
Bull	*F*	*S*
CNET	*F*	*S*
CNRS/LAAS	*F*	*S*
ENTEL	*E*	*S*
ETSIT	*E*	*S*

Start Date	Duration	Resources
01-JUL-86	*43 months*	*44 PY*

SETL EXPERIMENTATION AND DEMONSTRATOR (SED)

PROJECT NUMBER: 1271

Objectives/Programme of Work

This project is a design method demonstrator. It is intended to provide an early feedback on the viability of using PCTE-OMS to support the kind of prototyping and design techniques which have been successfully used to develop a full Ada translator within 16 person years. The main vehicle for these prototyping and design techniques is the SETL language.

This project is associated with Projects 835 and 1265 within 1227.

Progress and Results

A prototype environment for SETL (Set Theoretical Language) has been implemented under MENTOR (an environment generator for programming languages developed at INRIA).

Some important results are:

- The definition of a flexible grammar for the full first-order logic extended with abstraction terms.
- Definition of a MENTOR environment for low-level rewrite rules, using this new grammar, and based on RAPTS.
- The translation of SETL into Ada.
- Requirements for developments in cartography; this particular domain demonstrated the shortcomings of SETL when handling complex data structures and modularity.

Work was performed on the automatic translation into Ada.

Exploitation/Time Horizon for Industrial Application

The project assessed the adequacy of SETL as a specification and implementation language for industrial use.

Contact Point

Mr. J. P. Keller
Thomson CSF/DCI
DSE
1,rue des Mathurins *Tel: 33-14-6571365 ext. 3404*
F - 92222 BAGNEUX *Fax: 33-14-7357791*

Participants	**Country**	**Role**
Thomson CSF/DCI	*F*	*M*
Enidata SpA	*I*	*P*
CNAM	*F*	*P*
Hildesheim Hochschule	*D*	*P*
University of Patras	*GR*	*P*

Start Date	**Duration**	**Resources**
01-JUL-86	*24 months*	*23 PY*

PCTE PORTABILITY (SAPPHIRE)

PROJECT NUMBER: 1277 (1229)

Objectives/Programme of Work

The main objective of the project is to evaluate the adequacy, completeness, performance and portability of the PCTE.

Other objectives are:

- To link the Alvey Fortune and Eclipse projects with the ESPRIT PCTE initiative by porting them on top of the PCTE interface.
- To support the PCTE interface on a number of common machines.
- To port an Ada compiler to PCTE.

Progress and Results

EMERAUDE has been ported to the SUN. A first version of a SUN-based PCTE was shown at the Stockholm Ada conference in May 1987. The SUN PCTE, with the Eclipse IPSE and a tool to generate Ada code from MASCOT 3 diagrams, was demonstrated at the ESPRIT Conference (October 1987). ECLIPSE, the Alvey-developed integrated project support environment (IPSE), has been integrated on the SUN PCTE implementation, and was demonstrated at the ESPRIT 1987 Workshop.

A demonstration of the OMS on the IBM PC/AT was given at the June 1988 review. This reflected some of the problems, due mainly to incompatibility in word sizes, that occur in porting the PCTE to PC/AT.

The port to VAX STATION ULTRIX-based machines is nearing completion.

Exploitation/Time Horizon for Industrial Application

PCTE implementations on the various hardware architectures will maximize the industrial application of PCTE and will provide a de facto standard PCTE for European software development projects.

The SUN version, available since December 1987, has been distributed and is in use on several sites. The HP9000 port was demonstrated recently.

Contact Point

P. Czerniewski
CAP Industry Ltd.
147-149 Farringdon Road
UK - London ECIR 3AD

Tel: +44-1-8406144
Tlx: 265128
Fax: +44-1-8371956

Participants	Country	Role
CAP Industry Ltd	*UK*	*M*
GIE Emeraude	*F*	*P*
Software Sciences Ltd	*UK*	*P*

Start Date	Duration	Resources
01-OCT-86	*36 months*	*62 PY*

PCTE AND VMS ENVIRONMENT (PAVE)

PROJECT NUMBER: 1282 (1229)

Objectives/Programme of Work

The aim of the project is to encourage existing VAX/VMS users to use the PCTE, thereby increasing the acceptance of the PCTE as a standard in Europe.

The main objective is to develop a number of software components, each completing a usable system, with the following functions:

- to give access to a PCTE workstation from industry-standard DEC-compatible terminals
- to allow remote usage of VAX/VMS disk storage by a PCTE workstation
- to give efficient access to PCTE OMS objects stored on VAX/VMS-disks
- to provide direct access to PCTE tools for users of VAX/VMS-based systems
- to port the PCTE/PACT tools into a VAX/VMS environment

This project is associated with Projects 1252, 1262 and 1283 (1229).

Progress and Results

This small project team studied how the VAX storage could be used in the PCTE environment and chose to do this by dedicating a VAX virtual volume to a non-VAX PCTE workstation. They have implemented access to this virtual volume and so have achieved the second of the objectives.

An implementation of PCTE on a VAX station has been made.

Exploitation/Time Horizon for Industrial Application

This project will pave the way to the PCTE for VAX/VMS users and allow PCTE workstations to interwork with a VAX/VMS environment. This will enlarge the domain of application of PCTE in the information technology community.

Contact Point

J. Nissen
GEC Software Ltd.
132-135 Long Acre
UK - LONDON WC2E 9AH

Tel: 44-1-407171
Tlx: 21403
Fax: 44-1-24093229

Participants	**Country**	**Role**
GEC Software Ltd.	*UK*	*M*
Syseca Logiciel	*F*	*P*

Start Date	**Duration**	**Resources**
01-NOV-86	*36 months*	*13 PY*

VDM INTERFACES FOR PCTE (VIP)

PROJECT NUMBER: 1283 (1229)

Objectives/Programme of Work

The objective of the project was to produce a formal specification giving a precise semantic description of the interfaces to the Kernel of the PCTE.

This project is associated with Projects 1252, 1262, 1277, 1282 and 1229.

Progress and Results

The PCTE specifications were produced using an extended version of VDM (VVSL-VIP VDM specification language).

Both tool and user interfaces were specified using the same style of language and partially verified and validated.

The project also demonstrated the feasibility of using formal methods to specify systems of this type. The publication of the formal specifications in book form is planned for early 1989.

Exploitation/Time Horizon for Industrial Application

The availability of a precise and correct interface specification supports the reduction in the costs of evolutionary development. Tool writers now have access to the precise specification needed to derive a PCTE environment and to support tools emerging from other ESPRIT projects. Implementations can be compared against the formal specification by rapid prototyping using a precise specification. The formal specification can be used to derive an improved natural language specification.

Contact Point

M.I. Jackson
Praxis Systems plc
20 Manvers Str
UK - Bath BAI IPK
Tel: +44-225-335855

Participants	**Country**	**Role**
Praxis Systems plc	*UK*	*M*
Dr. Neher Laboratories	*NL*	*P*
St. Mathematisch Centrum	*NL*	*P*
OCE	*NL*	*P*

Start Date	**Duration**	**Resources**
01-NOV-86	*24 months*	*12 PY*

ADVANCED SOFTWARE ENGINEERING ENVIRONMENT LOGISTICS FRAMEWORK/ACCUEIL DE LOGICIEL FUTUR (ALF)

PROJECT NUMBER: 1520

Objectives/Programme of Work

The objective of ALF is to create an operating framework for third generation, integrated project support environments by developing the required software infrastructure.

ALF can be seen as a continuation of the PCTE and PACT projects. It is based on the PCTE-defined operating system for software engineering environments.

The project will integrate knowledge-based systems and information system techniques into software engineering environments. Thus it will provide the basis for a rationalised approach to building initiative-taking, project-support environments.

The provision of an initiative engine by the incorporation of rule-based mechanisms into the underlying framework of the common integrated environments demonstrates a novel approach to software engineering.

Progress and Results

The requirements of the ALF system has been specified and existing tools for use in building the system and for integration in the final environment have been identified.

A practical policy for defining enhancements to PCTE to meet the requirements of the next generation of development environments has been formulated.

The Model for Assisted Software Processes (MASP) has been formalised and a specification language is being built. Work is currently being performed in a knowledge-based system for piloting the use of the development environment. Special care is being given to the user interface.

Exploitation/Time Horizon for Industrial Application

The production of software systems will be facilitated by the adoption of the disciplined software and systems engineering approach of which ALF is part. It is expected that it will constitute the progression from the PCTE to the next generation of software engineering environments.

Contact Point

Mr. Amaury Legait
GIE Emeraude-Bull-58F25
38 Bd. Henri Sellier
F - 92154 Suresnes Cedex

Tel: 33-1-39 02 50 00
Tlx: 697030
Fax: 33 1-39 02 49 77

Participants	**Country**	**Role**
GIE Emeraude	*F*	*M*
ICL	*UK*	*P*
CIG Intersys	*B*	*P*
Computer Technologies Co.	*GR*	*P*
University of Nancy - CRIN	*F*	*P*
University of Dortmund	*D*	*P*
Grupo de Mecanica del Vuelo	*E*	*P*
Catholic University of Louvain	*B*	*S*
University of Bourgogne	*F*	*S*
CERILOR	*F*	*S*

Start Date	**Duration**	**Resources**
01-OCT-87	*48 months*	*120 PY*

SOFTWARE PRODUCTIVITY EVALUATION MODEL (SPEM)

PROJECT NUMBER: 1527

Objectives/Programme of Work

The main objective of the SPEM project is to build a constructive model for evaluation of software productivity, usable in an industrial context and for real-world software projects.

The goals of the SPEM project can be summarized as follows:

- To contribute to the measurement, comparison and improvement of software development productivity in an industrial context.
- To better formalise the choice and the measurement techniques of significant estimation models.
- To develop, use and validate a prototype of a new model of productivity.
- To standardise data-collection procedures usable for software productivity measurement.

This model will be an input for the SPMMS environment (Project 282).

Informal agreements of data exchange with MERMAID (Project 2046) have already been signed.

Progress and Results

Development resource cost models have been reviewed and classified, and a list of variables (eg complexity) sufficient for the productivity model has been made.

A trial set of relationships between quality and cost has been defined and an estimate prepared of the influence on cost of quality attribute characteristics, eg product complexity and project duration. Data from 15 projects have been collected and of these 10 have been analysed. Preliminary work on comparisons of the SPEM model with Cocomo and SPQR have been made. Further data collection and validation of the model are planned.

Exploitation/Time Horizon for Industrial Application

This model should allow:

- the measurement of software development productivity on various types of project

- a comparison of software productivity, to allow more accurate planning
- the identification of the factors which affect software development productivity, so that remedial action can be taken.

Contact Point

Roberto Ciampoli
FUIGI ITALIANA SrL
Via Benedetto Croce 19
I - 00142 ROME
Tel: +39-2-6070941
Tlx: 314108

Participants	Country	Role
Fuigi Italiana SRL	*I*	*M*
SEMA-METRA	*F*	*P*
Odati Espagnola S.L.	*E*	*P*
SOFEMASA	*E*	*P*
UKAEA	*UK*	*P*
VERILOG	*F*	*P*

Start Date	Duration	Resources
01-MAY-87	*36 months*	*22 PY*

A PRELIMINARY STUDY OF A VECTOR PROCESSING-ORIENTED PARALLEL ARCHITECTURE

PROJECT NUMBER: 1532

Objectives/Programme of Work

This project was a preliminary study of a vector oriented-processing parallel architecture for a supercomputer. It combined a user and a technological approach. Its two objectives were:

- To define, with the help of some qualified users, the architectural concepts for a high performance scientific and numeric supercomputer working in the 10-30 GFLOPS range. Compatibility with existing programmes and applications was a major criterion.

- To evaluate the defined architecture by simulations at the hardware and software levels. The different technologies available to develop this type of machine were analysed (eg circuits, memories, interconnections, packaging, cooling), with reliability and maintainability two of the main criteria for selection.

Progress and Results

- A study of the needs of 25 users for applications software, basic software and hardware was made and the product choice criteria examined.

- An evaluation was carried out of the application of different types of architecture to several fields.

- The existing technologies - integrated processors and memory chips - were studied and trends extracted.

- Pre-studies of a MOS chip for 15 ns, 64-bit processors and a 60 Mips scalar processor were made.

- A study of a very high-speed ring system was performed.

- Different FORTRAN programming methods usable in parallel processing tasks were studied.

The final report failed to draw any conclusions on the type of systems that Europe should support. Equally, there was no decision on the buy or make options for most of the components studied in the project.

Exploitation/Time Horizon for Industrial Application

This pre-study allowed the partners to identify the need to develop high-performance computers, an area where Europe is very weak. However, the report failed to reach a conclusion about the type of systems the partners should develop.

Contact Point

Mr. H. Felix
BULL S.A.
121 av. de Malakoff
F - 75016 Paris

Participants	**Country**	**Role**
Bull	*F*	*M*
Siemens	*D*	*P*

Start Date	**Duration**	**Resources**
01-JUN-87	*12 months*	*14 PY*

A PCTE HOST-TARGET DISTRIBUTED TESTING ENVIRONMENT (APHRODITE)

PROJECT NUMBER: 1535

Objectives/Programme of Work

The objective is to provide an initial basis for a PCTE host-target distributed testing environment.

The project will result in:

- A set of recommendations for programming and interfacing target systems, and for allowing their testing in a distributed host-target environment.
- A prototype of this PCTE host-target distributed testing environment, implemented on a network of PC/AT hosts and including one or more target systems.
- A preliminary evaluation of the prototype to assess the viability of the system as a production system.

Progress and Results

Based on the results of the first review, a study of the adaptations necessary to port Emeraude/PCTE to Chorus has been made. A model of the overall architecture has been defined but is not yet complete. Details of the actual actor model to be used are being discussed.

Exploitation/Time Horizon for Industrial Application

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

Contact Point

Ian Campbell
BULL S.A.
68, Route de Versailles
F - 78430 LOUVECIENNES

Tel: 33-1-3902500
Tlx: 697030
Fax: 33-1-39024977

Participants	Country	Role
Bull	*F*	*M*
Chorus Systèmes	*F*	*P*
Delphi SpA	*I*	*P*
Ferranti Computer Systems	*UK*	*P*
University of Liège	*B*	*P*
Philips/TRT	*F*	*P*

Start Date	Duration	Resources
01-JAN-87	*24 months*	*20 PY*

INTELLIGENT DOCUMENTS PRODUCTION DEMONSTRATOR (INDOC)

PROJECT NUMBER: 1542

Object/Programme of Work

The objectives of INDOC are twofold:

- to validate an approach incorporating the use of AI techniques in Advanced Information Systems for the production of complex documents; and

- to define the requirements of a user tool-set for document development and maintenance.

The production of complex documents such as a contract, a licence, an insurance policy, etc., requires the merging of operational information (data and images), handled by traditional tools, with advanced text processing.

This project investigates A.I. techniques that can be contribute to this process by developing and maintaining large sets of conceptual descriptions of documents and organizational procedures.

The feasibility of the approach will be tested on a narrow, but real-life application domain for which a demonstrator will be built. An evaluation of the results will assess the portability of the approach to a large application.

Progress and Results

A methodology for knowledge acquisition and analysis which provides a reference pattern for questioning experts and classifying the knowledge acquired has been agreed.

The application domain selected for the demonstrator is the creation of legal deeds and contracts. Two different cases have been analysed: the production of deeds of gift and sale by a lawyer's office, and the production of deeds for a loan receipt by a bank.

A formalised behavioural model has been defined, and the requirements for a formal language for conceptual modeling have been stated. A language for the definition of presentation schema has been specified. A prototype of the inference machine is being implemented in Prolog.

Exploitation/Time Horizon for Industrial Application

The INDOC project will constitute a strong contribution to the fundamental harmonization of AI techniques, by proving and verifying their effectiveness in a real-life application. The demonstrator produced by INDOC, can be exploited by European Industry to evaluate the use of AI and KB techniques, within real-life Information Systems.

Contact Point

Mr. S. Copelli
Applied Research Group
Via Fratelli Bronzetti
I-20129 MILANO

Tel: +39-2-7380451
Tlx: 321311
Fax: +39-2-738 0455

Participants	**Country**	**Role**
Applied Research Group	*I*	*M*
INESC	*P*	*P*
Mnemonica	*GR*	*P*

Start Date	**Duration**	**Resources**
01-JAN-87	*18 months*	*12 PY*

DISTRIBUTION AND REUSABILITY OF ADA REAL-TIME APPLICATIONS THROUGH GRACEFUL AND ON-LINE OPERATIONS (DRAGON)

PROJECT NUMBER: 1550 (1651)

Objectives/Programme of Work

The objective is the development of methods and the provision of tools for designing reusable software for distributed real-time applications of a long-lived nature (such as flexible manufacturing systems and space application systems).

Criteria for structuring systems in terms of reusable, target-independent Ada components will be investigated in two directions: formal specifications of module interfaces and operations, and support for distribution and target computer and plant configuration management.

In fact, changes in target architecture and plant dimension and parameters are a major cause of unanticipated software changes, making software hard to reuse: the issue is addressed in the project by structuring the program as distributable units which are completely insensitive to target characteristics.

Provisions for reconfiguration, task migration and modification in non-stop mode require careful analysis of the Ada tasking system: the intended approach is to start from existing formalisations of Ada semantics and then extend them. Reusability will be obtained by assembling components and tailoring highly generic ones. A database library of existing components will be designed.

Progress and Results

Problems of distribution and real-time performance have been resolved, and a library and classification scheme is under development. The industrial enhancement of a maritime surveillance system has been selected for trial use of the methods and tools developed in DRAGON. An object-oriented approach is being followed.

Exploitation/Time Horizon for Industrial Application

The project will contribute to the industrial use of Ada and will advance industrial understanding of the problems and opportunities of software re-use.

Contact Point

Mr. A. Dapra
TXT-Technint Software e Telematica
Software and Architecture Division
Via Guastalla 2
I - 20122 Milano

Tel: +39-2-5456761
Tlx: +326826
Fax: +39-2-5456600

Participants	Country	Role
TXT-Technint Software e Telematica	*I*	*M*
Dornier System GmbH	*D*	*P*
Tecsi Software	*F*	*P*
University of Wales Aberstwyth	*UK*	*P*
University of Lancaster	*UKP*	

Start Date	Duration	Resources
01-APR-87	*36 months*	*55 PY*

EFFICIENT QUALITATIVE AND QUANTITATIVE USE OF KNOWLEDGE-BASED SYSTEMS IN FINANCIAL MANAGEMENT (EQUUS)

PROJECT NUMBER: 1558

Objectives/Programme of Work

The area of application of the planned knowledge-based systems is financial portfolio management. This is not a new area for knowledge-based computing: it was identified early in the USA as a profitable area for expert system development. However, until now, success has been limited. Clients' needs have not been correctly appreciated and there have been shortcomings in the standard rule-based model for knowledge representation when applied to financial problems.

The project aims to remedy this situation. Its objectives are:

- to develop an expert system for portfolio management
- to provide the tools for acquiring knowledge and applying knowledge in the same area.

In consequence, a major direction of the project is to supplement standard tools and methodologies with facilities for mixed quantitative and qualitative reasoning and to organise the collected knowledge accordingly.

Progress and Results

The functional requirements for system development have been stated. Financial knowledge has been successfully acquired and represented in the rule base. Two developed expert systems - a portfolio designer and a portfolio manager - have been demonstrated.

A survey of the French, American and British tools and applications has been released. The Italian QSL expert system shell has been chosen for use by the partners in the construction of the expert system for portfolio management, and tools are actually ported on it.

The requirement to reason qualitatively from time-dependent quantitative data has been approached through a study of the fundamental issues involved in applying fuzzy logic. This work is sufficiently advanced for incorporation of the results in the demonstrator.

A generalised methodology for knowledge acquisition in the financial domain is in preparation.

The project has produced documents on expert systems, evaluation and metrication. These are relevant to other evaluation projects (numbers 857, 1257, 1570 and 2148).

Expoitation/Time Horizon for Industrial Applications

An expert system for portfolio management is expected to be available by September 1989.

At the same time, a user handbook of procedures for the production of such systems should also be published. This will include measures of performance and cost estimates for the introduction of expert systems.

Contact Point

Dr. J.G. Davies/A.A. Abu El-Ata
Citymax Integrated Info. Systems Ltd
Research and Development — *Tel: 44.1.929 5605/3340034*
6, Laurence Pountney Hill — *Fax: 44 1 621 1531*
UK-London EC4R 0BL — *Tlx: 914682*

Participants	**Country**	**Role**
Citymax Int. Inf. Systems	*UK*	*M*
University College London	*UK*	*P*
Riada & Co.	*IRL*	*P*
Dataid	*F*	*P*

Start Date	**Duration**	**Resources**
01-MAR-87	*30 months*	*14 PY*

SIGNAL AND KNOWLEDGE INTEGRATION WITH DECISIONAL CONTROL FOR MULTI-SENSORY SYSTEMS (SKIDS)

PROJECT NUMBER: 1560

Objectives/Programme of Work

The purpose of the project is to provide a basic, generic approach, for both software and hardware, in the area of integration of sensory information and knowledge. "Sensory information" is understood as information coming from an outside, physical, real world; "knowledge" corresponds to high-level symbolic representations and models of the external world and of the system's features and abilities. Such models are dynamically updated and partially acquired through learning.

The ultimate goal of the research programme is a perception machine represented by the SKIDS demonstrator prototype and realising:

- a unified perception of the observed world
- real-time reasoning, planning and adaptation of the whole software and hardware configuration to the actual observations strategy.

Progress and Results

The demonstration environment where the prototype perception machine will run has been specified, in particular the sensor configuration. The functional architecture has been defined; it consists of four parts:

- the MMI
- the sensory chain
- the interpretative chain
- the control and decisional chain.

The last two parts are essential: the interpretation process, which is data-driven (continuous surveillance task) or goal-driven (object recognition upon request) is segmented into elementary tasks which are driven by the Knowledge-Based Control System (KBCS). The KBCS selects the optimal interpretative path and manages the global resources allocation. The basic perception tasks that have been identified fall into five categories:

- detection
- characterisation

- localisation
- tracking
- identification.

The sensors consist of fixed and pan and tilt cameras, microphones, optical barriers, and a laser range finder, an ultrasonic belt, and an odometer, all mounted on a mobile platform. The hardware has already been specified and consists of a set of nodes (VME clusters) linked via a Capitan ring bus. Basic tools for the software architecture have already been identified: they include inference engines and a rule compiler (KJEOPS) for achieving real-time performance of the perception system. The objective is to achieve response time of a few seconds for indoors scene surveillance.

The fusion of information from multiple cameras has been demonstrated successfully for single event tracking. Various tasks of detection, localisation and recognition demonstrated the soundness of the vision node architecture, which consists of a Datacube system connected to a transputer array and hosted in a SUN 3.

Exploitation/Time Horizon for Industrial Application

The approach is basically a generic one, but is driven by two classes of application:

- mobile robots for public safety applications in nuclear plants, etc.
- surveillance systems for offshore oil fields, nuclear plants, airports, etc.

Contact Point

Mr. A. Ayoun
MATRA S.A.
Space, Products & Technology
3, Avenue du Centre
F - 78182 St-Quentin-en-Yvelines
Cedex
Tel: 33.1.30 64 42 42
Fax: 33.1.30 44 00 31
Tlx: 696 943

Participants	Country	Role
MATRA	*F*	*M*
British Aerospace	*UK*	*P*
University of Oxford	*UK*	*P*
LAAS	*F*	*P*
MAPS Informatica Industrial	*E*	*P*
U.Catalunya	*E*	*P*
Mediprint	*D*	*P*
Krupp Atlas Electric	*D*	*P*

Start Date	Duration	Resources
01-JUN-87	*48 months*	*109 PY*

APPLICATION OF EXPERT SYSTEMS TO INDUSTRIAL CHEMICAL ANALYSIS (ESCA)

PROJECT NUMBER: 1570

Objectives/Programme of Work

The project will replicate a specific area of chromatography and chemistry knowledge by artificial intelligence systems. There are two main areas of research. One is the formalization of the knowledge base in this area, and the other is the selection of the most suitable expert system shells and tools to represent this type of knowledge base.

The first workpackage is to select a suitable specific area of chromatography application to pharmaceutical analysis, where the knowledge is sufficient to provide a valid test of an artificial intelligence system.

The second workpackage is to formalize the knowledge of this specific area by a set of logical rules and facts suitable for expression as an expert system.

It is planned to select about eight candidate shells and tool sets and to evaluate their suitability for representing this type of knowledge. The next step is to evaluate these candidates, in order to make a final selection of three for the implementation task.

The application of AI to chemometrics, ie the use of mathematical techniques for setting-up experiments and for analysing the results, is to be examined.

The final product will be a comparison of the performance of these three expert systems (using different characteristics, but with identical knowledge) for real chemical analyses.

Progress and Results

High Performance Liquid Chromatography (HPLC) has been chosen as the area of application. Three expert system development tools have been selected from the eight evaluated. The acquisition of knowledge from each of the application domains which together cover the entire area of method development in HPLC has been completed. Its representation in the form of several expert systems is in progress, and their integration into one system is being studied from the chemist's point of view.

The presentation of the results at international symposia has increased awareness of the field and heightened debate about the issues involved.

Exploitation/Time Horizon for Industrial Application

Chromatography is a major analytical tool in pharmaceutical research. However, its use requires the selection of a suitable chromatographic method and the optimisation of parameters for each analysis. At present these actions are dependent on the skills of an expert chromatographer.

The project aims to alleviate this situation by developing the application of expert systems to a real-life analytical problem: method development for the analysis of novel compounds in the pharmaceutical industry.

The results of the comparison study are expected to accelerate the introduction of expert systems in real-life industrial applications.

Contact Point

D.P. Goulder
Philips Scientific Ltd.
York Street
UK - Cambridge CBI 2PX

Tel: +44-223-358866 ext. 518
Tlx: 817331
Fax: +44-223-312764

Participants	Country	Role
Philips Scientific Ltd	*UK*	*M*
University of Nijmegen	*NL*	*P*
Free University of Brussels	*B*	*P*
Organon International BV	*NL*	*P*

Start Date	Duration	Resources
01-MAR-87	*38 months*	*27 PY*

PARALLEL COMPUTER SYSTEMS FOR INTEGRATED NUMERIC AND SYMBOLIC PROCESSING (SPAN)

PROJECT NUMBER: 1588

Objectives/Programme of Work

The objective is to investigate programming languages and parallel architectures for the integration of symbolic and numeric processing, and to develop a common virtual machine. The project is organised in distinct layers: application software packages; high level languages and tools; the "virtual machine" kernel system; and parallel architectures.

The kernel system comprises an intermediate representation, currently implemented by a target machine language (TML) and its associated virtual machine code (VMC), through which all high-level languages will be compiled onto a range of architectures for execution. It forms a focal point of the project. Two high-level language compilers will be produced, together with an object-oriented framework for language integration. Three types of parallel architecture will be evaluated, and an investigation will be conducted into novel VLSI architectures for efficient execution of the VMC. To demonstrate the utility of these techniques, a range of applications software will be developed.

Progress and Results

Work is continuing in parallel language definition and architectures, and in the four application areas: image interpretation, real-time expert systems, partial differential equation solvers, and parallel relational DBMS. Evaluation of the applications on Supernode and other architectures is in progress.

Exploitation/Time Horizon for Industrial Applications

The project will terminate in early 1990 with signifiant results in the area of virtual machine definition, compilers for parallel systems, object-oriented frame-works and investigations into several architectures.

Contact Point

Dr. David Watson
Thorn EMI Central Research Labs.
Information Processing Department
Dawley Road
Hayes
UK - MIDDX UB3 1HH

Tel: +44-1-8486522
Fax: +44-1-8486565
Tlx: 934135

Participants	Country	Role
Thorn EMI	*UK*	*M*
CIMSA SINTRA	*F*	*P*
PCS	*D*	*P*
University College London	*UK*	*P*
INESC	*P*	*P*
CTI	*GR*	*P*

Start Date	Duration	Resources
01-JAN-87	*36 months*	*95 PY*

THERAPY ADVISER FOR ONCOLOGY (TAO)

PROJECT NUMBER: 1592

Objectives/Programme of Work

The project aims to evaluate the effects consequent on the introduction of a knowledge-based system to advise on the chemotherapy of lung cancer. A therapy adviser for oncology, TAO, is to be developed, to provide chemotherapy, patient and other information in response to interactive queries by doctors.

The early phase of the project is concerned with the refinement of knowledge bases now in development, the construction of the patient-specific database and the design of the man-machine interface.

The second phase of the project consists mainly of the implementation of the knowledge and inference architecture, using a skeletal system already developed by one of the partners.

The final phase focuses on the evaluation of the system in the context of its use in a domain where heavy reliance is already placed on data analysis techniques. This will take into account the attitude of staff and patients and the impact of the tool on work practices, against measures of efficiency, safety, and costs. The description of the evaluation scheme is an early deliverable.

Progress and Results

The clinical database has been selected and the elicitation and structuring of medical knowledge is in progress. The system building tools developed in Project 387 (KRITIC) are being ported by Framentec to the project for the implementation of TAO on the MIKIC system. Two preliminary implementations of modules of the knowledge-based system using different tools have been demonstrated. HCI and graphic interfaces are partly specified and implemented.

Three hospitals have been chosen for the validation of the system, located in England, France and Spain, and a statement of the evaluation criteria and an analysis of the operational environment are under development.

Scientific links have been established with the ONCOCIN project at Stanford University.

Exploitation/Time Horizon for Industrial Application

By its provision of evaluation methodologies and by reporting experience of their use, the project will enlarge our knowledge of the design and introduction of successful techno-medical knowledge-based systems. Such an evaluation both of

expert systems in themselves and of their performance in an operational environment is a prerequisite to their use in industry.

Being involved in the project, Metasa (an industrial subcontractor) is improving the clinical database provided for hospital use.

The project is providing a demanding testbed for the system building tools from KRITIC (Project 387).

Contact Point

Mr M Wilkinson
MEDIMATICA
15, Irvine Street
UK-London WC2H 7AU
Tel: 44-1-794-0500

Participants	Country	Role
University of Leeds	*UK*	*M*
Medimatica	*UK*	*P*
CITSA	*E*	*P*
Framentec	*F*	*P*

Start Date	Duration	Resources
01-JAN-87	*39 months*	*24 PY*

REPLY AND EVALUATION OF SOFTWARE DEVELOPMENT PLANS USING HIGHER-ORDER META SYSTEMS (REPLAY)

PROJECT NUMBER: 1598

Objectives/Programme of Work

The objective of REPLAY is to provide evidence of the feasibility of reusing development plans and their component modules within the process of creating industrial software. It is an experimental research project, aiming at advancing the rather poorly understood domain of reusability.

Besides building on progressive generalisation of case studies, REPLAY is exploring both top-down replay of developments and bottom-up assembly of components. The possibilities of continually controling these development plans is investigated by means of abstract interpretation and modeling of operational properties.

This project will make extensive use of the DEVA language defined in the TOOL-USE project (number 510).

Progress and Results

Current domains under analysis are replays of:

- proofs
- transformation sequences
- development (process or programs)
- configuration.

The examples used for observation and experimentation are derived from the compiler generation world (MIRA and ABSYNT tools), VDM and theorem proving (ABRIAL's B system/ML/LCF), configuration expert systems (Adèle/Pélagie) and specification (LPG/F1). The operational properties are being explored through building a prototype medical expert system for HLA typing.

The latter phase of technical integration will allow experimental validation, together with the development of some support tools, such as an expert system for the description and generation of assembly plans.

Exploitation/Time Horizon for Industrial Application

Although no immediate industrial exploitation is to be expected, the knowledge gained should be valuable in achieving reusability in the longer-term and brings nearer the dramatic improvements of productivity and quality that could follow.

Contact Point

Mr. D. Marchat
CISI/II
2 rue Jules Vedrines
ZI de Montaudron — *Tel: +33 61 20 43 24*
F-31400 TOULOUSE — *Tlx: 206252*

Participants	Country	Role
CISI/II	*F*	*M*
ALPHA SAI	*GR*	*P*
CERT	*F*	*P*
CRI	*DK*	*P*
E2S	*B*	*P*
Catholic University of Louvain	*B*	*S*

Start Date	Duration	Resources
01-FEB-87	*36 months*	*37 PY*

SYSTEM MEASUREMENT AND ARCHITECTURES TECHNIQUES (SMART)

PROJECT NUMBER: 1609

Objectives/Programme of Work

The aim of this project is to support the efficient production of cost-effective fault-tolerant information systems to stated design specifications. Its object is to define techniques and to provide tools to support the design and development of such systems throughout their life-cycle. This involves:

- identifying the parameters to be measured and processed
- formalizing and modelling performance within the reference systems for single components and for structured fault-tolerant systems
- validating the models on existing projects.

Progress and Results

Task 1: A survey of three metrics reference systems concerning product, project and process, has been achieved. The Tools Directory, the Metrics Directory and the Data Directory for the support of the design and development of fault-tolerant systems are finished. The Tools Directory describes currently available reliability and cost estimation tools. The Metrics Directory lists metrics of fault-tolerant architectures with their definitions. The Data Directory defines the entities and relationships which constitute the data model.

Task 2: The characterisation of fault-tolerant architectures (eg in regard to hardware dependability, software design, hardware/software physical description etc) has been made, based on studies of existing information systems for a space shuttle, a nuclear power-plant and an airbus.

Task 3: Performance modeling and quantification is in progress.

Task 4: A first release of the SMART tool requirement specification has been made.

Three tools have been identified as essential for the design and evaluation of RT-FT systems:

- dependability evaluation tool (Met Fac +)
- Petri-Net simulators of real time system functionalities
- fault-tree analysis.

Exploitation/Time Horizon for Industrial Application

The validation of the proposed approach will promote architecture techniques and associated performance recommendations for the next generation of fault-tolerant systems.

The application of the models and tools that the project will provide should lead to increased efficiency in the European fault-tolerant data-processing industry by strengthening project monitoring processes. Improvements in other industries using fault-tolerant software will follow.

Several partners intend to make internal use of the SMART environment after the end of the project.

Contact Point

Mr. J.M. Tortoza
CCS/SCYT
Orense 34-10 A Planta
Edificio Iberia Mart
E - 28020 MADRID

Tel: 34-1-597 23 23
Fax: 34/1 597 2343
Tlx: 44590

Participants	Country	Role
CCS/SCYT	*E*	*M*
CRI	*UK*	*P*
CEA-DEIN/SIR	*F*	*P*
MATRA	*F*	*P*
Paisley College of Technology	*UK*	*P*
Technical University of Catalunya	*E*	*P*

Start Date	Duration	Resources
01-MAY-87	*30 months*	*31 PY*

EVALUATION OF AN INTELLIGENT TUTORING SYSTEM SHELL FOR INDUSTRIAL AND OFFICE TRAINING (ITS)

PROJECT NUMBER: 1613

Objectives/Programme of Work

The project will evaluate an ITS (Intelligent Tutoring System) shell on the basis of data gathered from commercial, scholastic and industrial field trials. The field trials will be on office automation procedures, on scholastic skills and on maintenance procedures. This project will identify how to use intelligent tutoring systems to cut training costs and increase training effectiveness. A new prototype (DOMINIE) will be designed and implemented.

Progress and Results

The system shell and the trainer interface were respecified from an analysis of the results of the first field trials. Design modifications were made with regard to the teacher's help in choosing tutorial material and in refining the tutorial control loop and tutorial strategies. Simple applications demonstrations have been given of their implementation.

A second field trials phase has evaluated the implementation of the enhanced prototype. The final building loop iteration, covering field trials, redesign and implementation, has been completed.

An enhanced prototype version of the trainer interface has been sucessfully demonstrated.

Exploitation/Time Horizon for Industrial Application

This project has a strong commercial potential: the rapidly growing shortage of advanced tools to provide training in new disciplines is well known.

The use of DOMINIE within other divisions of Alcatel is planned, thereby providing continuing feedback to the consortium. DATAMAT has planned to add to any package software application they will provide in the future a tutorial package based on DOMINIE. The Open University will develop a spreadsheet tutorial based on DOMINIE for its students and will carry on cognitive research in this area. The results of the project will also be taken as valuable input into two DELTA projects in which partners are involved.

Contact Point

Dr.P.Byerley
ALCATEL SEL
Dept. ZT PI FZT
Ostend Strasse
D - 7530 PFORZHEIM

Tel: 49-7231-71041
Fax: 49-7231-71045
Tlx: 783-565

Participants	Country	Role
SEL/Alcatel	*D*	*M*
IET	*UK*	*P*
Datamat	*I*	*P*

Start Date	Duration	Resources
01-MAR-87	*24 months*	*8 PY*

MORE INFORMATION?

If you require more information, please contact:

COMMISSION OF THE EUROPEAN COMMUNITIES

DGXIII/A2

Telecommunications, Information Industries and Innovation
ESPRIT INFORMATION
200 Rue de la Loi
B-1049 Brussels

Tel: +32 2 235 16 03
Fax: +32 2 235 38 21
Tlx: 21877 COMEU B

or

COMMISSION OF THE EUROPEAN COMMUNITIES

DG XIII/E5

Telecommunications, Information Industries and Innovation
Ref: ESPRIT
200 Rue de la Loi
B-1049 Brussels

Tel: +32 2 235 09 90
Fax: +32 2 236 27 23
Tlx: 21877 COMEU B