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# The Alvey Programme



## Overview

The Alvey Programme was the dominating focus of Information Technology research in the period 1983 to 1988. Prior to the Alvey Programme, university, industrial and government research were primarily separate activities. The Science and Engineering Research Council's research grants were, on the whole, reactive in that proposals were sent in and SERC either accepted or rejected them. In the late 1970s, SERC had become more pro-active with the appearance of Specially Promoted Programmes such as the Distributed Computing Systems Programme that ran from 1977 to 1984. Here the emphasis was placed on a coordinated programme of research in an area which was regarded as particularly relevant.

The Alvey Programme made a major change to the way computing research was organised in the UK as a whole. For a variety of reasons, it was decided that there needed to be a more focused way of doing industrial and university research in this important area.

Some of the main points were:

- The area was pre-competitive advanced information technology research
- The focus was four areas that seemed particularly relevant at the time:
  - Software Engineering
  - Intelligent Knowledge Based Systems
  - Man Machine Interaction
  - Advanced Microelectronics (VLSI Design)
- Research was a collaboration between academia, government and industry
- Research was directed into important areas and coordinated
- Funding was substantial, £350M at 1982 prices

The involvement of Informatics Department in the Programme came about because of its role in coordinating the DCS Programme and later the Software Technology Initiative. Bob Hopgood, Rob Witty and David Duce were the three academic coordinators over the life of the DCS Programme. Rob Witty moved from DCS to fulfill a similar role with the Software Technology Initiative.

In both programmes, the importance of a standard infrastructure was emphasised. It allowed researchers to concentrate on research and fostered the interchange of results. The Atlas Computing Division had been heavily involved in the provision of that infrastructure and Informatics performed a similar role for the Alvey Programme.

Some of the ideas and directions that came about in the Alvey Programme borrowed from the work of an earlier SERC panel, the Roberts Panel. This was formed in October 1977 under the chairmanshhip of Derek Roberts of GEC and included Colin Haley of ICL, Iann Barron of Inmos (who had chaired the DCS Programme), and Philip Hughes of Logica, all of whom became members of the Alvey Committee. Bob Hopgood acted as secretary to the Roberts Panel. The panel recommended that silicon chip design, software technology, database utilization, man machine interaction, robotics and artificial intelligence were important areas that needed improvements in education and training as well as research. The recommendations were never implemented in full by SERC but it did lead to more directed research in SERC and paved the way for the Alvey Programme. New graduate-level courses in integrated circuit design, supported by RAL, were set up. The Software Technology Initiative was launched (it ran from 1981 to 1984). A Specially Promoted Programme in IKBS was under consideration when the Alvey Programme was

launched. The proposal was made to SERC in May 1982 and a Research Area Review Meeting (RARM) took place in September 1982 and the results of this meeting were a major input into the definition of the Alvey IKBS Programme.

A good source of information on the Alvey Programme is the book Alvey by Brian Oakley and Kenneth Owen (MIT Press).


1983 IT film on Alvey programme

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# The Alvey Programme



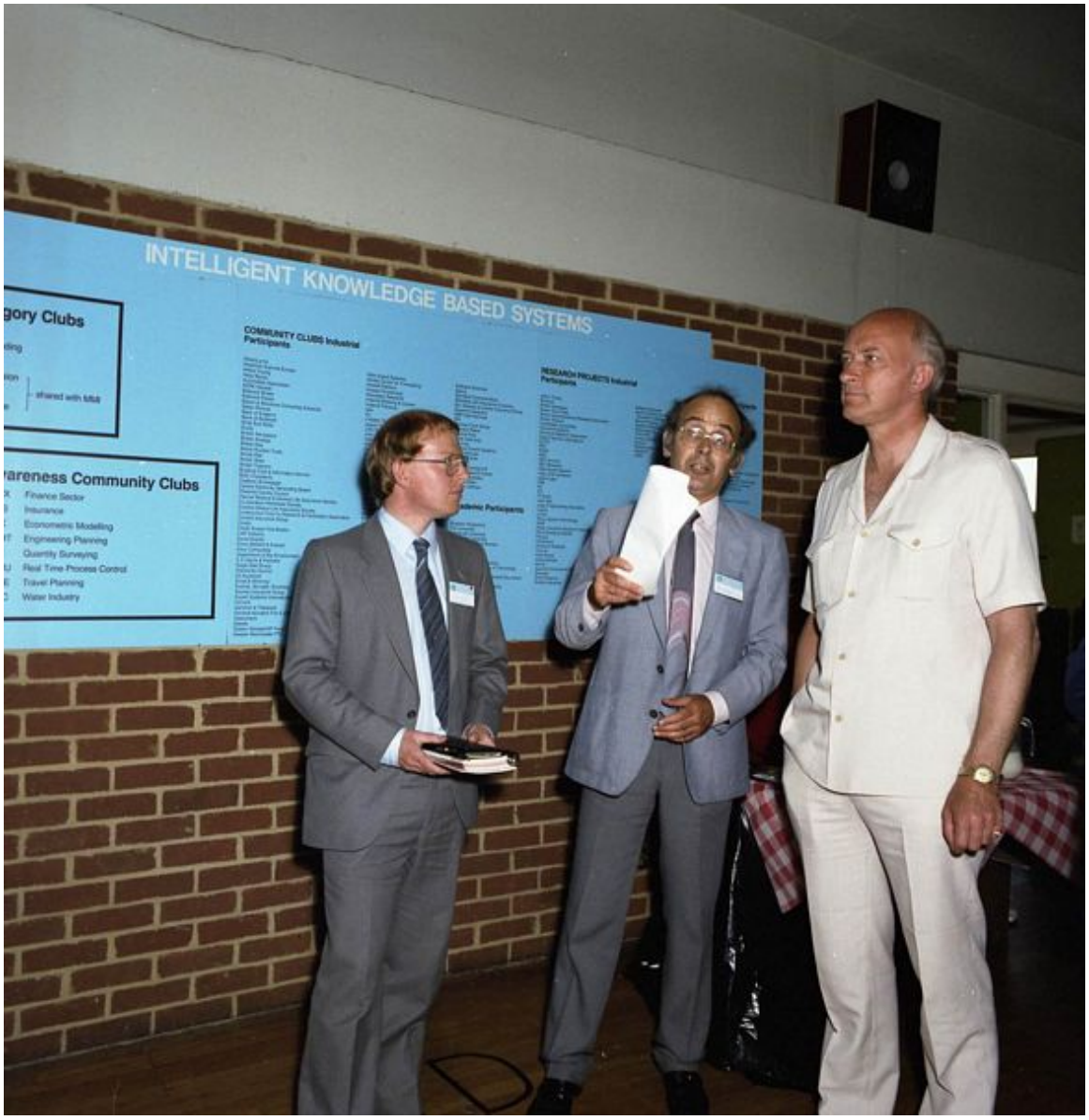
## Conferences

The first Alvey Conference was organised at Edinburgh in 1985. Geoffrey Pattie had by then succeeded Kenneth Baker as Minister for State and Industry. The second took place at Sussex University's Falmer campus in 1986. This was the time when a number of major changes took place in the Alvey Directorate:

- Rob Witty replaced David Talbot in Software Engineering
- David Shorter replaced David Thomas in IKBS
- Chris Barrow left MMI and his work was distributed between other Directors

**Alvey Conference, Sussex: Cliff Pavelin talks to Geoffrey Pattie, Rob Morland, Alvey VLSI Director looks on, July 1986**

**Large View**



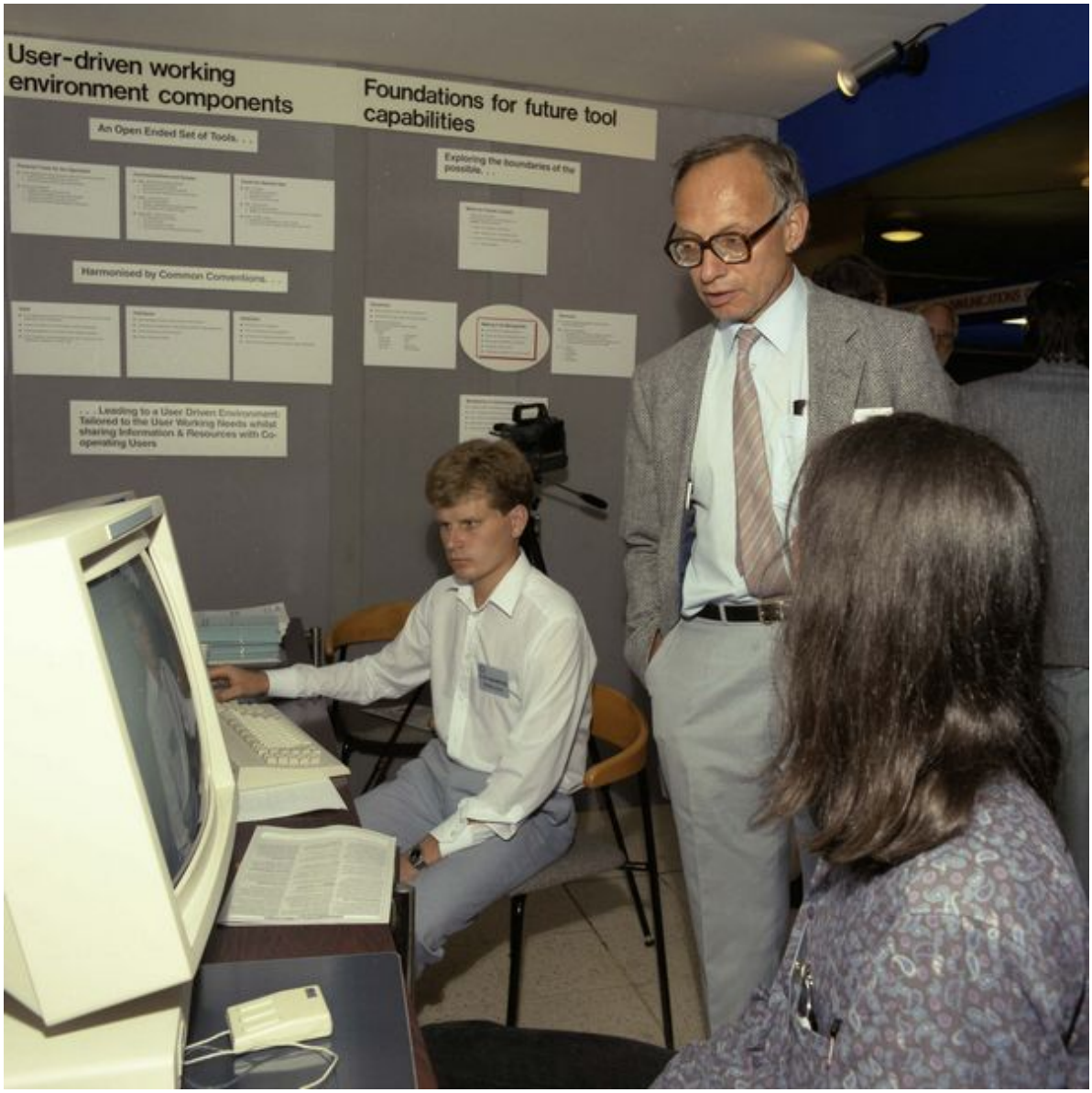

**Alvey Conference, Sussex: Left to Right: Tony Dignan (Ferranti), Mike Falla (Software Sciences), Hui Chiu and Mike Russell (RAL) who were part of the Software Engineering team run by David Talbot and Rob Witty. In the white suit behind is Geoffrey Pattie Minister for IT who took over from Ken Baker., July 1986**

**Large View**

The third Alvey Conference took place at UMIST in Manchester in 1987.


**Alvey Conference, Manchester: Informatics Graphical Tools Stand, July 1987**

**Large View**




**Alvey Conference, Manchester. Chris Crampton, Peter Kirstein, Crispin Goswell at the Informatics Stand, July 1987**

**Large View**

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# The Alvey Programme



## Alvey Directorate

Between April and September 1982, the Alvey Committee formulated the research programme that was submitted to Kenneth Baker on 3 September 1982. The Alvey Directorate was established by mid-1983.

The major events over that period were:

- the SERC original plan for an IKBS-led programme was changed to a broader-based programme based on four technologies with members of the Committee taking the lead in each:
  - VLSI: Derek Roberts
  - Software Engineering: Philip Hughes
  - IKBS: Charles Read
  - Man Machine Interaction (MMI): Colin Hayley
- The VLSI programme was a modification of the UK's input to ESPRIT
- The Software Engineering programme drew on the Software Technology Initiative and the ESPRIT software technology strategy
- The IKBS programme was significantly influenced by SERC's proposed SPP in IKBS
- The MMI programme was the one that was devised almost from scratch.
- The Alvey Report was published on 6 October 1982.
- Kenneth Baker presented it to industry at an IT82 event at the Barbican Centre in December
- Mrs Thatcher accepted the proposals on the 28 April 1983.
- Brian Oakley, who was at the time Secretary of SERC, became Director of the Alvey Programme in May 1983 with Laurence Clarke, GEC, as his deputy. Laurence had been Chairman of SRC's Information Engineering Committee.
- The Directors of the four programmes and the infrastructure were:
  - IKBS: David Thomas from SERC, previously Head of Technology at RAL supported by Bill Sharpe of Informatics
  - Software Engineering: David Talbot from ICL with Rob Witty from Informatics as his Deputy
  - VLSI: Bill Fawcett from RSRE
  - MMI: Chris Barrow from Plessey
  - Infrastructure: Derek Barber
- The Programme put together 210 projects lasting on average 3 years and involving 2500 people at its peak.

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# The Alvey Programme



## History

Some important events leading up to the Alvey Programme are listed.

**1973: Lighthill**
Sir James Lighthill's damning review of Artificial Intelligence led to a major cutback in AI research funding for the next 7 years

**1976 DCS**
Iann Barron appointed to lead SRC's Distributed Computing Systems Programme, SRC's first attempt to establish a coordinated programme of research in the Information Technology (IT) area.

**1977 Roberts Panel**
Special panel of SRC under the Chairmanship of Derek Roberts of GEC recommended a national programme of research and education/training in key areas of IT.

**1980 Kenneth Baker**
Presented a paper A National Strategy for Information Technology advocating a Minister for IT, joint research between academia, government and industry, better IT education.

**1981 Minister for IT**
Kenneth Baker appointed Minister for IT.

**1981 Project Universe**
Project Universe was the first large scale IT research project involving academia, industry and government

**1981 Software Technology Initiative**
SERC launch a Specially Promoted Programme (SPP) in Software Technology coordinated by Rob Witty of RAL.

**1981 Japanese Fifth Generation Project Announced**
Japan launches a major project in:

- Inference computer technologies for knowledge processing
- Computers for large-scale data bases and knowledge bases
- High performance workstations
- Distributed functional computer technologies
- Super-computers for scientific calculation

The aim was to an attempt to leapfrog existing computer expertise and create an entirely new computer technology.

**1982 Information Technology Year**
IT82 was a £4M national IT awareness campaign.

**1981/2 IKBS SPP Proposed**
Over the period 1981-82, the Artificial Intelligence community proposed a major advance in AI funding through an SPP in Intelligent Knowledge Based Systems (IKBS)

**1982 Cosener's House Meeting**
Workshop held by SERC at RAL's Cosener's House in January to define a UK response to the Japanese programme; UK academics were being solicited to join the Japanese research programme. Proposed IT87, a five-year programme starting in 1982, with thrusts in VLSI design/fabrication and IKBS.

**April 1982: Alvey Committee**
Kenneth Baker invited John Alvey, BT, to chair a study group to advise on the scope for a collaborative research project in Information Technology.

**September 1982**

IKBS Research Area Review Meeting outlines the IKBS Programme.


**Geoff Manning, Kenneth Baker and Brian Oakley (future Alvey Director) admiring the Atlas Computer Console, March 1982**

**Large View**

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## GEC Series 63

The Alvey programme believed strongly in having standard computer equipment where possible. Early on the decision was made by the software programmes that the operating system of choice was to be Unix. The IKBS programme needed a significant increase in computer hardware in university departments and the community was anxious to purchase Digital Equipment Corporation (DEC) VAX computers either directly from the company or from the UK company Systime that built VAX systems on top of processors purchased from DEC.

However, at the time of the procurement, GEC announced the Series 63 computer system which would be VAX compatible. The Alvey Directorate knew that the purchase of Series 63 computers would be a great boost to GEC and would help the UK's current balance of payments crisis. However, the IKBS community were not in favour of this and were unenthusiastic when GEC Series 63 computers were purchased.

**GEC 63/30 and MSc in VLSI Design PRIME**

**Large View**

Initially 10 GEC Series 63/30s and 5 Systime VAX 8750s were approved by the Software Engineering and IKBS Directorates. Software development on these machines was the subject of a Memorandum of Understanding between Alvey and GEC (MOU). The GECs were intended to provide a UNIX service, once the Operating System had been mounted, and the VAXes (running

BSD 4.2) were given to those sites whose function was to generate software, in order that they might have a reference machine, and also be able to import and export software. The sites were:

- Cambridge
- Department of Artificial Intelligence, Edinburgh *
- ERCC
- Essex
- Imperial **
- Oxford *
- RAL *
- Sussex *
- UMIST

Those marked with * had a VAX as well. Imperial, with active departments in both SE and IKBS, were assigned two GECs as well as a VAX. Subsequently, Newcastle was added to the set of sites as they had obtained a GEC Series 63 for another project. The machines were installed by early 1984.

The objective of the Infrastructure provision was to allow SE and IKBS researchers access to UNIX systems to run special software such as LISP, PROLOG, HOPE, ML. Berkeley 4.2 UNIX was the standard system used for research in these areas in the USA. Installing the VAX systems running BSD 4.2 Unix was quite easy as the operating system was well-known, and in consequence the VAX systems were heavily used early on. Each site had a Site Manager appointed to look after the machine and to contribute to the Programme in other ways. A group of 6 people under Eric Thomas supported the VAX and GEC systems from Informatics.

Early on, Informatics assisted GEC in providing UNIX on the Series 63, helping with the porting of utilities, providing accounting and distributing the software supplied by GEC to the sites. The work was covered by the MOU. Initially, GEC mounted System III UNIX but changed to System V by the autumn of 1984. The Infrastructure was managed centrally by Informatics initially, distributing software to sites and incorporating the extra software required. Support for the Series 63 computers was eventually moved to the Edinburgh Regional Computer Centre under contract.

The long-term role for the Series 63 systems turned into being fileservers for the SUN workstations.

The IBM Unix system called UTS was also mounted on the mainframe systems as part of the Infrastructure. This gave very encouraging results in running large programs on the system. PROLOG, FRANZLISP and ML/LCF were mounted. Cambridge University ran in a few minutes on the Atlas 10 proofs written in ML/LCF which would have taken all night on a VAX. The 4250 erosion printer was used extensively from UNIX utilities such as Ditroff and Pic to produce slides, technical reports and books. The combination of UNIX with the power and peripherals of an IBM mainframe service provided a facility unique in the UK at the time.

Over 50 Sun workstations were also purchased and distributed to University users.


**Informatics Machine Room, Systime 8750s in the foreground, 1986**

**Large View**

See also:

- 1984-85 Informatics Annual Report
- 1985 Annual Report

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# The Alvey Programme



## Infrastructure

Informatics provided support for the Alvey programme since its inception.

As the various Directors turned to Informatics for extra effort different functions emerged and evolved over the years in the areas of IKBS, SE and MMI. The scope of these activities eventually included:

- Programme Management and Support. This was direct in the case of Software Engineering, with Informatics staff occupying many of the posts in that area, and more indirect in IKBS where Informatics took on several specific functions. Some staff were seconded into the Directorate for more direct involvement in managing the IKBS programme.
- Co-ordination. This included organising workshops and conferences, providing administrative and secretarial support for Clubs (including Speech, Vision, Architectures, Knowledge Based Systems, Logic Programming and HI), SIGs (eg SIGAI) and Advisory Groups on IKBS and Formal Methods, and membership of committees and advisory bodies such as the ACARD working group on software.
- Awareness. This included running the SE, IKBS and MMI mailshots, setting up a Who's Who in MMI, a videotape library and an on-line version of the AI Tools Catalogue.
- Contracts. Numerous contracts were let and monitored for central purchasing and maintenance of SUNs, ICL Series 39, HLH Orions and Whitechapels; software development and support contracts (Prolog support, Prolog benchmarks, Poplog development and support, Lisp support and so on); and user support (eg GEC Series 63).
- Monitoring and Deliverables. Informatics was responsible for selecting and employing monitoring officers, for monitoring projects in many areas, and collecting and disseminating deliverables. In fact, the monitoring system was originally devised by Informatics staff.
- Technical Support for the Community
- Academic Computing Infrastructure. This was eventually based on four different Unix machines - SUN 2/3, GEC Series 63, Systime Vax 8750 and UTS on the IBM 3081 and Atlas 10 mainframes. Tasks included endeavouring to provide similar functions on four different versions of Unix and providing local and wide area communications. One of the main reasons for putting the GEC Series 63's into selected Universities was to speed-up provision of the software needed to make the machine a commercial success and a useful tool for the entire programme. The Vaxes were initially bought only for those sites with GEC's which were responsible for porting software from Berkeley Unix. Progress was disappointingly slow and eventually overtaken by the upsurge of workstations. The machines were, in fact, becoming a valuable resource by the end of the project - but too late. Alvey Mail eventually became part of this project and was the only part directly to benefit the industrial community; the programme's regulations meant that more direct support for industry could not be provided.
- Site Managers. Contracts were let to provide site managers at the sites with GEC Series 63 - Cambridge, ERCC, Edinburgh, Essex, Imperial College, Newcastle, Oxford, Sussex and UMIST. The site managers' jobs eventually grew to include support of all Alvey users at their site.
- Pump priming. Resources were made available to supply hardware and software for evaluation and exploration of ideas prior to projects being funded.
- Other tasks. The staff in post were a valuable resource which could be called on to carry out any tasks which arose suddenly and were needed urgently. For example, a survey was carried out of the equipment (hardware and software) being used on Alvey projects.

In many respects the achievements of this kind of work were invisible: meetings happen, minutes appear, invoices are paid, mailshots arrive, contracts run and so on. They only became visible when something failed. However, the development work undertaken by Informatics for delivery to the Alvey community did led to visible results; some of the highlights are given below.

a. ML/LCF Effort was made available to assist Edinburgh define a standard form of the functional language ML - this became Standard ML (SML). The ML/LCF package was converted into SML at RAL and made available to the Alvey community. The original implementation was on a Vax; it was subsequently ported to SUN, UTS and Pyramid. A code optimiser was then built which produced a tenfold increase in performance.
b. FORSITE Project The FORSITE project requested Informatics to build them a parser for the specification language Z, which generated SML output code. The staff to build this parser were seconded to PRG Oxford for this task. The result was initially used by FORSITE but was later more widely applicable.
c. The Alvey Prolog Benchmarks SIGAI believed that there was a need to improve upon the Portland State University Prolog benchmarks, which had been used to evaluate the performance of various Prologs . A contract was placed with Imperial Software Technology to produce the Alvey Prolog Benchmarks. Cambridge were asked to analyse both existing benchmarks and the new set, and the new set was run with various prologs on various machines. The software, the results and the Cambridge report were made available on request.
d. Concurrency Workbench Edinburgh's Laboratory for the Foundations of Computer Science built a set of tools written in SML - the Calculus of Communicating Systems _ but were aware that a proper user-interface was needed if the tools were to be used by non-expert users. A joint development project between the SE and HCI teams in Informatics was initiated which will result in a generalised user interface toolkit for SML.
e. Window Managers The Alvey directorate asked Informatics to organise a workshop on Window Management in the spring of 1985. The results were published as a book which was typeset at RAL. The book ended with a recommended work programme. Eventually it was agreed that an infrastructure project would be undertaken at RAL to define a low level interface between graphical applications and the window manager the Client Server Interface (CSI). Once defined it was implemented on a number of workstations, following discussions with manufacturers. A RAL-developed toolkit (WW) was built on top of it. The toolkit was used to build several portable demonstrators, including the editor SPY, and by the University of Kent for a collection of Unix utilities such as a file comparator and a directory/file browser. It was also used for a major demonstration at the UMIST Alvey exhibition.
f. ISO Communications GEC implemented low level ISO connectionless protocols (LLC1) for their Ethernet connection. ERCC received infrastructure funding to build the York version of JANET's Coloured Books code over ISO Transport Class 4. Informatics then ported this code onto a Vax (running Berkeley Unix 4.2) and UTS (Unix Version 7). GEC eventually agreed to provide the Arpanet protocol set (tcp/ip) on the Series 63. ERCC were then contracted to port SUN's Network File System over both ISO and Arpa protocols. Apart from the direct benefits to the infrastructure this gave ERCC, Informatics and the users an early awareness of the strengths and weakness of the OSI standards.

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# Informatics Annual Reports



## Informatics Annual Report 1984-85

## 1. INTRODUCTION

The Annual Report covers the year ending September 1985. As the Division was formed in July 1984, this first report covers the period from the formation of the Division until September 1985.

The aim is to produce a Report primarily for internal use indicating what has been achieved in the year and by whom. It is hoped that the timing of this Report is such that the RAL Annual Report entry can be constructed from the Divisional Report.

## 2. INFORMATICS DIVISION

The Computing Division was split into two separate Divisions in July 1984 for a number of reasons. The Computing Division had been growing in size and had a complement of over 200. The decision by the Computer Review Working Party to return control and funding of the Interactive Computing Facility and Single User System programme back to the Engineering Board meant that a Division of viable size could be formed whose interests were in the information systems area in the widest sense and which was funded completely by the Engineering Board. It was similar in role and purpose therefore to the Science Board funded divisions such as Laser and Neutron.

At its formation, the transfer of funding back to the Engineering Board was still in progress but by April 1985, Informatics Division was almost completely funded by the Engineering Board from the following projects:

1. Alvey IKBS/SE/MMI Directors: to provide coordination, support and some research and development activities in the three areas.
2. Alvey Infrastructure: to provide and develop the infrastructure, both hardware and software, for the IKBS/SE/MMI areas.
3. Interactive Computing Facility: to continue the provision of interactive facilities for the Engineering Board users via PRIME and GEC multi user minis.
4. Single User System Common Base Programme: to continue the provision of a common hardware and software base for Engineering Board users with PERQ1 and PERQ2 as the initial systems in the Common Base.

As the MMI work had only just started, the initial Group Structure was:

1. Software Engineering: R W Witty
2. IKBS
3. Distributed Interactive Computing

Neither of the last two Groups had a group leader and it was necessary to get approval for posts to be established before recruitment could take place. In the meantime, Bill Sharpe acted as head of the IKBS Group, and the Distributed Computing Group ran as three separate sections:

1. Interactive Computing Facility: M R Jane
2. Single User Systems: K Robinson
3. Alvey Infrastructure: R E Thomas

Ken Robinson was responsible for developing the activities in the MMI area.

Major management changes during the period were the resignation of Bill Sharpe, and the move of Cliff Pavelin to Informatics to take charge of the IKBS/MMI area.

By July 1985, the structure was:

1. Software Engineering : R W Witty (deputy D A Duce)
2. IKBS/MMI C J Pavelin (deputy K Robinson)
3. Distributed Interactive Computing: M R Jane (acting) (deputy R E Thomas)

The format of this Report is based on the structure in position at the end of the year.

## 3. SOFTWARE ENGINEERING

### 3.1 The Role of Software Engineering Group

The role of the Software Engineering Group is as follows:

1. Programme Management and Support: the Software Engineering Group provides management and support for the Alvey Software Engineering Director at Millbank. In particular, R W Witty is Deputy Director of the Alvey SE Programme and has responsibility for the overall strategy, its infrastructure policy and the general academic contribution.
2. Technical Support and Development: the SE Group does specific developments required by the SE Programme and provides technical support in assessing grants and briefing the Director on specific technical issues.
3. Research: in line with the Alvey SE strategy, a small amount of research is done by the Group in collaboration with university and industry. This ensures that the technical quality of the Group and awareness of the research directions is maintained.

All but the Research activity is funded directly from the SE Director's budget, with 75% coming from DTI and 25% from SERC. The DTI funding is because these activities are services on behalf of both the academic and industrial communities.

The Research work is either funded by Alvey as part of the SE Programme or by SERC's Computing Science Sub Committee (CSSC) which is responsible for long-term research. The Alvey funded research is collaborative with industry, while the CSSC research need not be.

### 3.2 SE Programme Management and Support

Prior to the Alvey Programme commencing, SERC had started a Specially Promoted Programme (SPP) of research in SE (the SERC's Software Technology Initiative). Many grants had been awarded and an infrastructure started. R W Witty was the coordinator of this SPP. At the start of the Alvey Programme, these grants were included in the SE portfolio providing continuity and involvement of the relevant SE researchers in the Alvey programme.

The SE programme currently consists of 47 new academic awards of which 11 are fully collaborative with industry. There are 15 new awards to be announced shortly. Of the 40 projects included initially, 23 are still running.

Support for the Alvey Programme consists of interaction with academic groups to assist in the preparation of grant applications and coordination of the SERC/Alvey Directorate interface.

Research supported by Alvey differs from that usually supported by SERC in that the Alvey Programme is a directed programme. This involves much closer involvement in both the preparation of the grant applications and especially during the execution stage of the research. For this purpose all projects are monitored, both technically and financially. This involves preparation of a database on all projects, collation of reports, generation of summaries and spend profiles. Regular reports are required from Monitoring Officers for collaborative projects and from industrial Uncles for academic only projects. Any exceptions raised by this monitoring process are actioned quickly.

Support is provided also for the Alvey SE Office in Millbank by providing assistance in meetings, workshops, panels and presentations. Much effort is expended in maintaining the files and reporting procedures for the programme. To assist in maintaining continuity of research, a mailshot service is operated. An increasingly important aspect of the overall support as the programme develops is the analysis of the budget and preparation of data for forward planning. For this purpose a special procedure has been developed with the objective of minimising difficulties associated with over commitments of the budget.

R W Witty, F M Russell and D C Findley, supported by Lilian Valentine and Janice Gore, undertake the above work.

### 3.3 ACARD Working Group on Software Engineering

ACARD (the Advisory Council for Applied Research and Development) is a high level body which reports to the Cabinet on long term issues. ACARD is currently studying the state of the UK software industry, its future prospects and the role of software engineering in all aspects of UK industrial activity (ie Manufacturing and Services).

The study is being conducted by a working group chaired by John Coplin, the Design Director of Rolls Royce. R W Witty, through his Alvey role, is a member of this working group.

The study has been conducted on a part time basis for much of 1985 and a report is likely to go to the Cabinet in 4Q86.

### 3.4 SE Technical Support and Development

#### 3.4.1 Introduction

The period has been one of transition as the section completes previous involvements arising from DCS, STI and the Common Base and begins to build up its new research links. Day-to-day activities have concerned the completion of Cambridge Ring developments, conversion of ML/LCF to the new Standard ML, and the import and evaluation of theorem-proving tools both for our own use and on behalf of the Alvey SE infrastructure.

#### 3.4.2 Theorem Provers

Theorem provers are software tools to aid the process of proving theorems. In this context we are primarily concerned with theorems about programs, for example that a particular program possesses a particular property.

Three current systems, ML/LCF, IOTA, and Boyer-Moore, have been acquired and are being studied to varying degrees. A fourth system (Gypsy) that SEG would like to know more about is not available owing to a US embargo!

The Cambridge version of ML/LCF was mounted on RLVC and then ported to the Atlas 10 under UTS (A D B Cox and A J Kinroy before he left). The UTS version has demonstrated the benefit of mainframe power for large proofs and is already being used so by external researchers at Cambridge. Proofs that previously would have been run overnight on a VAX are now accomplished in terms of minutes on UTS.

IOTA is a modular programming system, built in Japan, which includes a significant verification capability and has many features of a prototype second-generation Alvey IPSE. Experience with the approach will be of particular value for the IPSE 2.5 project, a large industrial-academic collaborative Alvey SE project.

Investigations have continued into how best to make IOTA available in the UK. IOTA is implemented in an ancient dialect of Lisp which turns out to be a forerunner of PSL (Portable Standard Lisp). PSL runs on a variety of machines (DEC20, VAX, Apollo) and has now been acquired for VAX Unix. An assessment is being made of the work required to port IOTA to run on top of PSL. A few problems have inevitably been encountered but are gradually being resolved.

The latest version of the Boyer-Moore theorem prover has been obtained from the University of Texas. We have yet to work with this system ourselves but are acting as a UK distribution point. The system has been distributed to about a dozen industrial and university sites.

### 3.4.3 Standard ML

The section has actively followed the development of the new Standard ML. C P Wadsworth attended the Edinburgh meeting in May 1985 to finalise the language. The standard is a consolidation of tried-and-trusted developments in the ML community since the original language was designed for the Edinburgh LCF project. Principal additions are: the data constructors and pattern matching facilities of HOPE, exception values, a richer and more systematic set of definition constructs, a module facility based on the latter, and I/O handling. Final documentation from Edinburgh is awaited. The language has Alvey backing and SEG expects to use it for their theorem proving work.

P M Hedlund joined the group in January 85 and has been working on converting ML/LCF to Standard ML. The new parser and type-checker are complete and he is now working on the rest of the system (code generator and run-time support). It will remain then to transliterate the 20 or so LCF sources files written in old ML to Standard ML. The aim is to ensure that LCF, as the largest application of ML to date, is fully available for Standard ML. (The modules facility is not needed for LCF and is not being implemented in the first instance.)

### 3.4.4 Cambridge Ring

The plan for SEG infrastructure envisages a variety of Unix systems linked by Newcastle Connection. It was felt that SEG could achieve this quickest by using the Ring since SEG had one in place and common interest and a common machine range with Newcastle. A lot of effort has been consumed in the attempt.

PERQ BBP was at last completed, the VAX driver converted to BSD 4.2 (by Unix Systems section), and the LSI11 BBP driver has been upgraded to CR82 standard (by D R Gibson). A simple file transfer program that runs directly over BBP was quickly implemented (by D R Gibson) and tested successfully between PERQ, VAX, PDP11, and LSI11. The program provides file transfer similar to PERQ PUFTP, with a five-fold increase in throughput (despite the slowness of PERQ BBP!).

Release 1.1 of the Newcastle Connection for PDP11 was finally received after months of contractual wrangling and installed on the PDP11/34 and LSI11/23. D R Gibson did sterling work assessing the installation and feeding the results back to Newcastle.

The PERQ, VAX and LSI11 drivers were supplied to Newcastle to enable them to upgrade the Connection where necessary for interworking between dissimilar hosts. This has not had the expected results! Hopes of a distribution for interworking PERQ, VAX and PDP11 over the Ring have evaporated into the Ether (to coin a phrase). So near and yet so far.

## 3.5 SE Research

### 3.5.1 Introduction

The overall SEG research theme is Quality Certification of Software Products. Within this theme, the main research interest of the Group is in Formal Specification, the development and application of machine-assisted proof systems and the role of formal proof in software development.

### 3.5.2 Formal Specification

D A Duce and E V C Fielding hold a research grant under the Alvey Software Engineering Programme entitled Specification of the Graphical Kernel System (GKS).

GKS became an ISO standard on 15 August 1985, and has been a British Standard for some time. The document describing GKS is some 245 pages in length; the style of the description is mainly English narrative. It is difficult for a potential implementer to get to grips with the standard from this document. There is a major effort in Computer Science research to develop formal techniques for the description of system designs; the aim of this project is to apply such techniques to GKS. (D A Duce and D C Sutcliffe (CCD) were the editors of the standards document and produced the camera-ready copy from which the standard was typeset.)

Initial work has been carried out with the Vienna Development Method (VDM), and more recently comparative studies with other formal techniques have been started. This work has resulted in a number of publications.

A complementary activity, looking at the emerging 3D Graphics Standards, GKS 3D and PHIGS, has been approved by SERC's Computer Science Committee.

To get feedback on the approaches adopted and to disseminate the work done, seminars have been given at the universities of Oxford, Cambridge, Salford, Lancaster, East Anglia, Leicester and Imperial College, and at SRI and IBM Yorktown Heights in the USA.

### 3.5.3 Graphics Standards

D A Duce and E V C Fielding participated in the ISO computer graphics working group meeting in July 1985. Both are involved in the formal specification subgroup. The main work of the meeting was to draft the structure of an ISO Technical report which will look at the feasibility of using formal specification techniques in the development of graphics standards.

D A Duce is secretary of the BSI computer graphics panel.

### 3.5.4 Typesetting

Good typesetting facilities are essential to the smooth progress of the group's research projects, especially the Formal Specification and ERIL projects. E V C Fielding did an excellent job in developing software to couple the Unix titroff text formatter and the IBM 4250 electro-erosion printer. The help of C D Osland of CCD and H K F Yeung (DIC Group) is gratefully acknowledged.

### 3.5.5 Equational Reasoning

A J J Dick's research concerns theorem-proving with equations based on a technique called the Knuth-Bendix completion algorithm. In this approach, equations are considered as rewrite-rules, and can actually be used to perform computations. There are many important applications of such work in computer science, especially in proving properties of program specifications, modelling the execution of functional programs, transforming programs into more efficient but equivalent ones, and compiling techniques.

During the last twelve months, A J J Dick has built on theoretical and practical work achieved as a PhD student at Imperial College. His main practical goal has been to develop further a rewrite-rule laboratory (mechanical theorem prover) called ERIL (Equational Reasoning: an Interactive Laboratory) to the point where it can be made available as a tool on the Alvey infrastructure machines; this goal is almost complete. At the same time, he has been able to considerably clarify much of the theoretical basis for ERIL, particularly with regard to a special form of polymorphism

involving hierarchical types and overloaded operators. Experimenting with this has represented original research effort.

The following useful visits and contacts have been made:

- A seminar given to the Programming Research Group at Oxford University, resulting in an ongoing discussion of the application of equational reasoning to program transformation.
- A presentation of ERIL at the European Conference on Computer Algebra, Linz, Austria, in April, which was very well received and resulted in a further invitation: A three-day visit to the Centre de Recherche en Informatique de Nancy, France for an extended presentation of ERIL and its theoretical basis, combined with attendance at the conference on Rewriting Techniques and Applications, Dijon, France in May.
- A two day visit to UMIST to install ERIL for their experimental use; also gave a seminar on the Knuth-Bendix algorithm as implemented in ERIL.
- A presentation to the FOREST project (Alvey sponsored) at Imperial College.

A J J Dick holds the Atlas Fellowship which is in association with St Cross College, Oxford. This means that he is a member of the College as well as RAL and spends part of his time there.

### 3.6 Distributed Computing Systems Programme (DCS)

The DCS Programme formally terminated on 6 September 1984. The occasion was marked by a major conference at the University of Sussex. D A Duce was very heavily involved in the organisation of this, including the production of two books concerned with the tutorials and presented papers.

After the conference there were the inevitable tidying up activities, the major ones being the production of the DCS Final Report, disposal of the equipment pool and rationalisation of the associated maintenance contracts.

### 3.7 Staff Changes

SEG welcomed the following new members during the year:

| | | |
|---|---|---|
| Sept 84 | D C Findley | Alvey Management |
| Oct 84 | A J J Dick | Atlas Fellow with St Cross College |
| Jan 85 | P M Hedlund | Research Section |
| July 85 | A D B Cox | Research Section (transferred from RAL/ID/IKBS) |

Alan Kinroy left us in Dec 84 to return home to his native land.

In June 1985 G P Jones left us to be promoted to the post of ID/DAO (Department Admin Officer).

The staff structure at the end of September 1985 is given in the organogram in Appendix A.

### 3.8 Future Programme

#### 3.8.1 Alvey SE Management

The Alvey Programme has almost completed its first phase during which strategy has been developed and research projects established and funded to implement the Strategy.

SE Management is now changing course to concentrate on the management and direction of this portfolio of research projects to guide them to success and to prepare the way for transferring new technology into industrial use.

During 1986 an Alvey-wide committee will be revising the Programme's infrastructure policy and preparing advice for their successors in the After Alvey period.

To help the above activities the SE team will be developing a new strategy document to explain what the programme is aiming to achieve during its second phase.

### 3.8.2 SE Research

#### Specification

The current two specification projects will continue their comparison of the efficacy of specification notations and theories as part of the overall search for viable techniques to specify the forthcoming graphics standards such as GKS-3D.

#### IPSE 2.5

SEG is considering joining the IPSE 2.5 project. IPSE 2.5 is a major Alvey SE industrial-academic collaborative project to build an advanced support environment for formal methods. SEG is proposing to concentrate on the development of the theorem-proving capability for IPSE 2.5 allied to research into new approaches to proof construction designed for advanced interactive use on large, high-resolution displays.

#### Alvey CAD036

The Programming Research Group of Oxford University is undertaking a project, funded by Alvey VLSI/CAD, entitled the Development of Advanced System Description Language Transformation and Verification Tools. Inmos Ltd are the industrial Uncle. PRG has requested that A D B Cox of RAL/SEG should work on this project under the direction of Dr Roscoe of PRG. Authorisation of this SEG involvement is imminent.

#### Dimensional Design

Prof Miguel Bertran-Salvans from Barcelona University will be spending a sabbatical year (1986) with SEG. Prof Bertran has a long standing interest in the Dimensional Design idea developed by D A Duce and R W Witty of SEG. Prof Bertran will be working with SEG and DEC/IOSG of Reading in a small, collaborative project to build an interactive, graphical editor for Dimensional Design and evaluate its effectiveness in an industrial context.

### 3.9 Publications


1. D A Duce, E V C Fielding and L S Marshall, Formal Specification and Graphics Software , RAL-84-068.
2. D A Duce and E V C Fielding, Better Understanding through Formal Specification , RAL-84-128, accepted for publication in Computer Graphics Forum.
3. D A Duce and E V C Fielding, Formal Specification - A Simple Example, to appear in ICL Technical Journal.
4. D A Duce and E V C Fielding, 'Formal Specification - A Comparison of Two Techniques, RAL-85-051.
5. D A Duce, Concerning the Specification of User Interfaces, Computer Graphics Forum 4 (1985), 251-258.
6. F B Chambers, D A Duce and G P Jones (eds), Distributed Computing, Academic Press, 1984.
7. Information Processing Systems - Computer Graphics - Graphical Kernel System (GKS) functional description, ISO 7942, ISO Central Secretariat, Geneva, 1985.
8. D Gibson and D A Duce, GKS and Text Processing, Computer Graphics Forum, 4 (3), 1985.
9. F R A Hopgood, D A Duce, E V C Fielding, K Robinson and A S Williams (eds), Methodology of Window Management, Springer Verlag, to appear 1985.
10. D A Duce (ed), DCS Programme Final report, SERC, 1984.
11. R W Witty, Software Technology Initiative Final report 1981-84, SERC, 1984.
12. W P Sharpe, R W Witty et al, Alvey Directorate Infrastructure Policy, IEE, Sept 84.

13. R J Cunningham, A J J Dick, Rewrite Systems on a Lattice of Types, Acta Informatica, 22, pp149-169, 1985.
14. R W Witty, Sixth Annual Lecture of the C&CD of IEE Software Engineering , RAL-85-007, Dec 84.
15. C P Wadsworth, Report on the IOTA Programming System and other Japanese Advanced Research, RAL-84-090.

## 4. IKBS

### 4.1 Introduction

The section supports the SERC/Alvey programme in IKBS and is starting its own research programme. Funding is mainly from the SERC contribution to the Alvey Directorate, and partly from the Engineering Board's ICF Applications which support the Special Interest Group, Artificial Intelligence (SIGAI). The Alvey activities are similar to those of SE Group except that the IKBS Director, D B Thomas, is partially resident at RAL in the R1 Link and, consequently, the interaction with the IKBS Directorate staff requires less frequent access to Millbank.

The Alvey IKBS programme has seen substantial changes over the period. At the beginning the research programme was still being planned and major initiatives were being taken in certain areas (e.g. Logic Programming, Declarative system architectures). Now, nearly all the funds are committed and the effort is being put into getting the projects under way, supplying equipment, monitoring etc.

The issuing of research grants is one major aspect of the Alvey IKBS programme, and it is the support of this, and the associated computing infrastructure, which has occupied most of the group effort. However there is also an embryo in-house research programme. It is hoped that during the next year, and given more stable staffing, the support work can be consolidated, and more effort can be given to research and development.

### 4.2 Support Activities

This covers that work which is driven directly by the requirements of the Alvey programme.

#### 4.2.1 Coordination of Research Themes

The IKBS research programme was divided into themes - Expert Systems, Intelligent Front Ends, Intelligent Computer Aided Instruction, Inference, Natural Language, Image Interpretation and Declarative System Architectures. In each of these, industrial and academic coordinators were appointed and charged with the formation of research communities around the topics. This is done by organising workshops, etc. W P Sharpe set up this organisation and played a very active part in its running, issuing theme newsletters, identified research requirements of Alvey demonstrators etc.

#### 4.2.2 Logic Programming Initiative

Recognising the UK lead in Logic Programming, the IKBS Directorate at the beginning of 1985 created a special initiative in Logic Programming with a series of workshops aimed at creating a single balanced programme of relevant research projects. W P Sharpe launched and it was in an advanced state when he left and R Ennals (Imperial College) took over. The programme now consists of a range of project investigating Prolog development environments, better logic programming languages etc. It relates to the IKBS architecture programme part of which is developing hardware appropriate to logic programming paradigms.

#### 4.2.3 Infrastructure

Apart from the VAX and GEC infrastructure run by DIC group the section has itself contributed to the development of the infrastructure.

The major initiative was the introduction of the SUN single user computer system in large numbers (now more 60) in the community, together with arrangements for central support etc. This has involved (P Kent, A B Smith):

- defining a standard configuration SUN for users, based on the benchmarks that had been run on the SUN and other machines and information from the users;
- helping users to sort out their specific requirements and then progressing their orders;
- negotiating discounts on SUN hardware and maintenance charges;
- looking after the SUN and Whitechapel computers at RAL and arranging for dispatch and loan of equipment to grant holders in Universities;
- advising potential grant holders of the latest SUN equipment and the SERC policy on central purchase and maintenance of SUN equipment;
- benchmarking SUN equipment in order to update the standard configuration SUN as new SUN products were announced;
- trying to get the SUN's at RAL working satisfactorily on the ethernet;
- organising the first SERC SUN user group meeting at RAL.

The SUN responsibility is now moving to DIC group (with P Kent).

The group supports Whitechapel to some degree - 22 were purchased for assessment by the IKBS Director and the group manages the allocation and distribution of these (A J Lucas). It also handles central purchase of Orion (P Kent) and latterly ICL Series 39 for large IKBS architecture projects (C J Pavelin).

### 4.2.4 IKBS Software

Within IKBS, SIGAI is responsible for setting the software standards and insuring their implementation infrastructure equipment. The group (C J Pavelin, A D B Cox) is responsible for running SIGAI and associated development contracts, establishing the standards, benchmarking software, etc.

Contracts are run at Edinburgh for general AI support, and for development of NIP, a portable Prolog which can be optimised for specific systems. At Sussex, work on POP LOG (a widely used Lisp/Prolog/POP11 programming environment) is supported. There is substantial work in technically monitoring these and helping to prepare new proposals (C J Pavelin, A J Lucas).

(A B Smith) The languages Cprolog, XLISP, and Quintus Prolog (SUN Only) have been ported to the VAX, SUN and Whitechapel. OPS5 has also been implemented on the VAX (because it is currently the only machine running Franz Lisp). The Prolog demonstration programs CHAT and PRESS are running on all three machines.

A D B Cox has worked on the BSI Prolog standards working group.

A J Lucas represents IKBS on the Alvey/GEC Implementation Group which monitors the development of various GEC software packages, on the technical side.

Negotiations have or are taking place with software suppliers to give favourable terms to Alvey workers - in particular POPLOG and Quintus Prolog.

SIGAI has proposed that the research community have better access to advanced IKBS development environments (e.g. ART, KEE) which exist on contemporary LISP machines (e.g. Symbolics). The hardware and software are typically very expensive, and C J Pavelin has been investigating means of providing such facilities.

### 4.2.5 Monitoring IKBS projects

The group is responsible for organising monitoring officers a requirement for all significant projects with DTI involvement. A procedure has been defined, and the first monitoring officers (NCC) are being appointed. A J Lucas has been offered as MO for one of the Vision projects.

### 4.2.6 Research Area Clubs

The group is responsible for setting up research area Clubs. Now that most grants are committed, Clubs are being formed to enable projects to interact with each other, define infrastructure requirements etc. The themes will become Special Interest Groups within the Clubs. New Clubs in IKBS will be Knowledge Based Systems, Logic Based Environments and Declarative Architectures (Vision and Speech & Language already exist and are shared with MMI). The KBS Club has just been formed and the steering committee has had its first meeting.

#### 4.2.7 Other Awareness Activities

The group runs the IKBS mailshot (sent bi-monthly to more than 450 researchers in industry and academe). An electronic Bulletin Board is planned, in order to reduce the paper mail sent out. The group also maintains an on-line version of an AI Tools Catalogue whose production was an Alvey IKBS Initiative (Editor A Bundy) and which is published as a book by Springer-Verlag.

An additional task in this area was the setting up by A B Smith of an interface to large Expert system packages (such as EMYCIN) on the Imperial Cancer Research Fund DEC10. This is available to authorised Alvey users for pump-priming purposes. It has involved system setup, and administration and implementation of a command environment on the DEC20 which allows the user to access only the AI packages.

#### 4.2.8 Alvey IKBS Management

C J Pavelin attends Alvey IKBS advisory group, Alvey infrastructure steering group and introduced and organises Alvey IKBS management meetings.

The group thus becomes involved in general Alvey tasks - e.g. providing rapporteurs at the Alvey Edinburgh conference, organising Alvey contribution to Expert Systems '85 etc.

### 4.3 In-house Development Activities

As well as support tasks generated directly by the Alvey programme, the group has been involved in minor developments, is developing a research programme and is planning a local IKBS service.

#### 4.3.1 Paralfex Project

This is a research proposal in association with the Alvey IKBS Community Finance Club (Alfex). One of the goals is the investigation of Knowledge Segmentation on the functional transformation (Expert Advisor to Novice Tutor), modifiability and maintainability of Knowledge Based Systems.

This proposal has been supported by the IKBS Director and is going ahead. It has involved acquiring and using the Savoir Expert System package for initial prototype work. Subsequent work will be based on Knowledge Systems with modifiable control structures.

#### 4.3.2 Intelligent Front End to ESP

ESP is a total building environment simulation package produced by the ABACUS group at the University of Strathclyde. The group is interested in making the package easier for a designer to use. D McFarlane is investigating the possibility of an Intelligent Interface to the Building Plant suite in the package. A proposal is being produced.

#### 4.3.3 Expert System Configurator

An Expert System has been built that builds UNIX kernels for the SUN microcomputer. It is written in the OPS5 production system language and runs under Franz Lisp on the VAX 11/750 and Sun computers.

#### 4.3.4 Fault Report Database

As an introduction to UNIX and RLVD, A J Lucas helped DIC group set up a data base (using INGRES) to hold information about faults on Infrastructure computers reported through RAL.

#### 4.3.5 IKBS packages

Various inexpensive packages have been purchased for an IBM PC-AT with a view to setting up a service to increase awareness of IKBS techniques at RAL. The Alvey Expert Systems Starter Pack (cut down versions of standard commercial Expert Systems), Prolog2, Golden Common Lisp, and Savoir are all mounted.

### 4.4 Staff Changes

IKBS welcomed the following new members during the year:

| | | |
|---|---|---|
| Feb 85 | A J Lucas | |
| Mar 85 | C J Pavelin | |
| June 85 | D F MacRandal | |
| Aug 85 | C Y L Kwong | |

Other staff who have contributed:

- G A Ringland HEP (joins group Nov 85)
- S Chadha HEP
- J W T Smith CCD (joins group Nov 85)

W P Sharpe left in March 1985 to take up an appointment with Hewlett Packard. A D B Cox left in September 1985 to join SE Group.

The list above gives an indication of the staffing changes which the IKBS section has had to endure. At the beginning of November P Kent joins DIC group and A B Smith leaves to do a PhD at Kings College. There will then be no one who was in this area at the beginning of the year.

G A Ringland is expected to join shortly; his research proposal is covered above. J W T Smith has already begun taking over the mailshot, and has become secretary to the Knowledge Based Systems Club. S Chadha has been investigating research possibilities in IKBS but has now been awarded an HEP Fellowship and thus may stay in physics.

The staff structure at the end of September 1985 is given in the organogram in Appendix A.

The Group had regular meetings during the year and talks were given as follows:

| | |
|---|---|
| MBASE, MECHO | S Shadha |
| ACME | A J Lucas |
| OPS-5 | A B Smith |
| ML, LCF | A D B Cox |
| 1st Order Logic | C J Pavelin |

### 4.5 Future Programme

#### 4.5.1 Alvey Support

Most projects have now begun or are at least committed, and the programme moves into a different phase. There will be less involvement with coordination of proposals, much more with monitoring, running research clubs etc. On the more technical side, an electronic Bulletin Board is being set up to complement the mailshot, and software standards, distribution and support are just beginning to be organised. It is hoped to begin an assessment of Knowledge Based toolkits.

#### 4.5.2 Research

The PARALFEX project should be well under way shortly, and we hope to have submitted a proposal for an IFE to ESP within the next six months. This should help to build up a nucleus of expertise in Expert Systems, and their application in the design field.

### 4.5.3 Awareness

We expect to assess and publicise the availability of Expert System Shells etc within the laboratory with a view to establishing if any applications at RAL could gain from these techniques.

### 4.6 Publications

1. W P Sharpe, Alvey Directorate Infrastructure Policy, Sept 1984
2. C JP avelin, R D Mount, Surveys of Engineering Board Computing RAL-85-023

### 4.7 Conferences

1. AI Conference, Capri, May 1985 (C J Pavelin).
2. Alvey Conference, Edinburgh, June 1985 (C J Pavelin, session organiser, speaker, A J Lucas, D Mac Randal rapporteurs).
3. ACME: Advanced Production Machines, Including Robotics, Sept 1985 (A J Lucas).

## 5. MMI

### 5.1 Introduction

The section is new, and consists primarily of the SUS development team. Over the year, three new staff members have joined - C A A Goswell, A J Seaton and D F Mac Randal. (Damian Mac Randal is on loan from the IKBS section). Much of the year was spent on Common Base business; probably the major task being the Single User System evaluation which involved most of the section staff and not a few outside!

Three staff managed to get through the promotion system this year - A S Williams, J C Malone and R G Dancey.

Staff list:

- Ken Robinson
- Tony Williams
- Mark Martin
- Damian Mac Randal
- Keith Dancey
- Janet Haswell
- Janet Malone
- Chris Crampton
- Arthur Seaton
- Crispin Goswell

### 5.2 Object-Oriented Programming

The overall objective of the OOP project is to evaluate the methodology as a means of software production and user interface design for the highly interactive graphics environment. An investigation of available software has been undertaken by C M Crampton. Two aspects of the project are significant - Smalltalk and C++.

Smalltalk-80 is probably the best known OOP environment, and was developed at Xerox PARC. The first implementation of Smalltalk-80 on the PERQ (Pipsqueak) was initiated by E Miranda (a Summer Vacation student), and J C Malone got the first 1982 byte codes of the virtual machine working correctly. The implementation was very slow, due to lack of optimisation and poor virtual memory management on the PERQ. Janet Malone then spent some time porting the Berkeley SUN version, which has considerable optimisation, but VMM performance prevented effective use of the implementation. (The PNX5 general release should appear soon - this appears to have a reasonably effective VMM system.)

The other project relates to the C++ programming language, an extension to C containing classes, developed at Bell Labs by Bjarne Stroustrup. We have a pre-release version; this fact is confidential under our licencing agreement. A S Williams and C M Crampton have collaborated on the implementation of C++ on the PERQ; J C Malone did the implementation on rlvd. Experience is being gained with its use, and Stroustrup is being kept informed of progress/problems.

C M Crampton has investigated the Macintosh QuickDraw and the (RAL, see below) ww(3) systems. A set of simple C++ classes has been defined and implemented.

### 5.3 Window Management

A Window Management Workshop, held from 29 April to 1 May, was organised. Most of the Division seemed to be involved in note-taking and so on! The outcome of the Workshop was felt to be successful enough for a real book to be produced; the five co-editors were F R A Hopgood, D A Duce, E V C Fielding, K Robinson and A S Williams. D A Duce and E V C Fielding did most of the editing in their (copious?) spare time. A S Williams presented a paper at the Workshop, comparing several different window managers. One outcome of the Workshop has been the request for a standard Application Program Interface to a range of window managers; A S Williams, K Robinson and F R A Hopgood have been involved in discussions with UK manufacturers and A S Williams is preparing a draft specification.

The Window Manager research proposal, originally submitted to SERC two years ago, is now to be funded as a development by Alvey, initially for a Portable Window Manager. Discussions have also taken place between RAL (A S Williams, K Robinson) and Dr Donald Broadbent (Oxford University) on a joint proposal concerned with user interaction with expert systems. RAL would be particularly concerned with the impact of multiple window systems.

### 5.4 Graphical Toolkit

Experiences with spy (inter alia) indicated the need for a set of graphics-oriented tools, implemented by M M Martin as ww. (No-one, as usual with UNIX naming, knows the reason for the name). At the lowest level, this offers portable means for basic functions such as rasterop, mouse input and so on. Interfaces are available for Pascal (J Haswell), Fortran (C A A Goswell) and C. As a way of exercising ww, and also to provide input on the next level of the toolkit hierarchy, a series of projects using ww have been undertaken. These include a file tree wanderer and a program to help in selecting command line options in UNIX (M M Martin); a dynamic, graphical version of ps (C M Crampton); and a tool to permit window description files to be created (C A A Goswell). The system is in use outside RAL. A tutorial relating to an early version was given before the PNX User Forum in 1985. D F Mac Randal has undertaken a study of the problems involved in implementing a highly interactive post-processing system for finite element work, and an outline specification of the software has been produced.

### 5.5 SUS Evaluation

This was a major exercise, occupying most of the staff in the section for about four months, and K Robinson even longer. Prior to the period under review, over 120 manufacturers had been contacted with an outline operational requirement. Ten suppliers of those 80 replying to that requirement were identified as being likely to be able to supply equipment of the required power on the required timescales; the suppliers so identified were Apollo, DEC, Gould-SEL, Hewlett-Packard, High Level Hardware, ICL, Racal Electronics, Ridge, SUN, and Whitechapel. These suppliers received a detailed Operational Requirement (mainly the work of C J Prosser, now with ICL, and A S Williams). The detailed replies received indicated that Apollo, SUN and Whitechapel were in a position to supply evaluation equipment.

Most aspects of the systems were investigated, either qualitatively or quantitatively. A S Williams provided expert technical advice; J Haswell ran most of the virtual memory and AIM benchmarks,

as well as looking after the Apollo DN550; K G Dancey took care of the SUN2/120 and investigated some of the more arcane aspects of VM performance; A D B Cox evaluated the compiler and libraries performance; K J Fermor and P Tempest-Mitchell waded through the Comms and IPC mire; T A Watson kept the Whitechapel MG-1 going as well as she could (it was a pre-production machine) as well as preparing and running the graphics benchmarks; M M Martin ported spy, once to the SUN, once to the Apollo, and several times to the Whitechapel's different versions of the operating system and latterly, its window manager. All produced reports and so on. K Robinson tried to make sense of it all (with help!), coordinated with Edinburgh University (who were looking at the systems from an IKBS viewpoint), Technology Division (who were assessing the equipment from a CAD viewpoint), and had innumerable discussions with the suppliers and then wrote it up and presented it to Alvey and SERC representatives.

At the end of the day, no clear picture emerged: the Whitechapel was too early in its development cycle to base a service on, although the basic hardware impressed in terms of performance, apart from the graphics (which were abysmally slow and have improved markedly since); the Apollo, while fast, is very expensive and has an attitude to window management which can best be described as quaint; while the SUN, at similar cost to the PERQ2, had a graphics performance slower by a factor of about 6, but with a basic hardware/system software that impressed. Finally, the relevant committees decided that the SUN2 should be added to the Common Base. Alvey have purchased a large number of SUNs mainly for the IKBS community.

### 5.6 Management

#### 5.6.1 MMI Directorate Support

K G Dancey is secretary to the Alvey MMI Human Interface Club Committee. This has involved organisation (at short notice) of a one day Forum at King's College, London, as well as regular meetings.

K Robinson has discussed MMI section's involvement with the MMI Directorate on support in the MMI area, and has been chivying to get decisions/action.

#### 5.6.2 CBP

As usual, throughout the year there have been regular meetings of the Single User System Steering Group, involving paper preparation and presentation, finance, user discussions and meetings, talking to ICL, SUN etc.

#### 5.6.3 Alvey Survey of UK SUS Manufacturers

Following the SUS Evaluation already discussed, the Alvey Board asked that a survey be done of the UK capacity in this area. K Robinson, together with an outside consultant (who has learned a lot about SUSs in the past year), has drafted (yet another) operational requirement, discussed it with various (about 20) UK manufacturers, reported to Alvey, and subsequently begun discussions with various Government Departments about their SUS purchasing policy.

### 5.7 Other Developments

A number of other developments have taken place which do not fit neatly into any single heading. These are collected here.

#### 5.7.1 PostScript

An implementation of PostScript, a language used to describe documents in a non-device specific way, is being undertaken on the PERQ. The language looks likely to be a standard of some sort in this area, at least until ISO catches up (1990?). postprocessors for troff, TeX and Scribe already exist and are available from the supplier, Adobe Systems. At present the basic language has been implemented, and work is proceeding on the graphics. When the work is complete, the PERQ will be available for use as a preview device before sending output to the laser printer. In addition, the

implementation has been made object-oriented; not only does this ease the graphics implementation, but also experimentation will be possible in the area of user interfaces and graphics.

### 5.7.2 PADL

The PADL (Part and Assembly Description Language) implementation, received from Darmstadt, has been mounted (several times) on the PERQ, with varying degrees of success. Severe problems, not yet fully diagnosed, have been encountered with one or more of the paging systems, the compilation system, and the sheer size of the software: filestore corruption has been a constant problem.

### 5.7.3 Pascal Plus, Automated Makefile Generator

Pascal Plus has been ported to PNX, the VAX (BSD4.2) and the Whitechapel (BSD4.1), together with as much of the associated development system as possible. A tape has been sent to QUB for onward distribution to interested parties. A utility to generate makefiles reliably has also been produced.

### 5.7.4 Clocks

Later versions of PNX have more than one clock, each showing different times. In the short time he has been in the Division, A J Seaton has produced a utility to allow these different clock times to be reset to a single value.

### 5.7.5 Dental Health

K G Dancey, K Robinson and A S Williams had above-average problems in this area over the period in question, and have coped well in the distressing circumstances. Regretfully, the problems have not been totally cured and further treatment is likely to be necessary:-)

### 5.7.6 Macintosh Evaluation

A Mac was purchased to enable assessment of the style of working and toolkit provided, with the object of providing input for future Graphical Toolkit developments. Various bits of software, some free (Mac to Unix window package, kermit file transfer, fonts, and definitely no games) and some not (Pascal, Music Works, Filevision etc) have been obtained.

### 5.7.7 Apollo and Brown University Software

As well as a low-level activity on keeping the Apollo working and up to date, a study of the Brown University Workstation Environment has been made. Severe difficulties were experienced in building a system that worked at all (on the SUN!), and the end result has proved to be fragile.

## 5.8 Future Programme

Over the next year, work is envisaged in the following areas:

a. Longer-term development work for the SUS programme;
b. Coordination and support work for the Alvey MMI Directorate;
c. Research and development in window management, again for the Alvey MMI Directorate;
d. Research work (assuming funding is obtained) on Assessment Methods (with Oxford University Experimental Psychology Department), and on Greyscale Displays and Document Display (with Brunel University Computer Science Department).

## 5.9 Conferences

1. PERQ User Forums, Sept 1984, May 1985 (Organisation and talks: P J Hemmings, A S Williams, K Robinson mainly; M M Martin gave a tutorial on WW prior to the May Forum)
2. Cosener's House Workshop on Window Management, 29 April to 1 May 1985 (A S Williams, K Robinson, F R A Hopgood attended, and organised same. A S Williams gave talk A

Comparison of Some Window Managers)
3. BCS HCI Conference 'INTERACT 841, London, Sept 1984 (A S Williams, K Robinson)
4. SUN User Group Conference, Boston, Nov 1984 (A S Williams)
5. IEE symposium on MMI in Engineering Workstations, Glasgow, March 1985 (A S Williams - speaker)
6. ACM SIGCHI Conference, San Francisco, April 1985 (A S Williams,K Robinson, F R A Hopgood)
7. BCS HCI specialist Group on Window Management, London, May 1985 (A S Williams - speaker)
8. SERC/CB Town Meeting, Leeds University, July 1985 (K Robinson - speaker)
9. Conference on Problem-Solving Environments, Nice, June 1985 (K Robinson)
10. Designing Effective Man Machine Interfaces, London, Nov 1984 (J Haswell)
11. Advanced Workstations for Scientific and Office Use, London, Oct 1984 (J Haswell)
12. CADI85, Brighton (J Haswell, K G Dancey)
13. European Unix User Show, London, June 1985 (J Haswell)

### 5.10 Staff Changes

Crispin Coswell, Damian Mac Randal and Arthur Seaton all joined MMI during the period.

The staff structure at the end of September 1985 is given in the organogram in Appendix A.

### 5.11 Publications

1. F R A Hopgood, D A Duce, E V C Fielding, K Robinson, A S Williams, (eds) Methodology of Window Management, Proceedings of an Alvey Workshop on Window Management. In press - to be published by Springer-Verlag.
2. K Robinson, with D W Willis, IT Consultants, A Proposal for the Application of Government Procurement to stimulate the UK Capability in Single User Systems.
3. K Robinson, SUS Evaluation Report (SUSSG/P19/85), Nov 1984.
4. Common Base Assessment Notes relevant to SUS Evaluation:
    - 32 K G Dancey SUN2 Workstation
    - 29,30 T A Watson Whitechapel MG-1 Bulletins
    - 27 K G Dancey Floating Point Performance
    - 26 K Robinson Notes on a visit to Whitechapel Computer Works
    - 25 P Tempest-Mitchell IPC Report
    - 24 T A Watson Results of Graphics Benchmarks
    - 23 P Tempest-Mitchell/ K J Fermor Communications Report
    - 22 M M Martin Porting SPY
    - 21 K G Dancey Comparison of Filestore Requirements
    - 19 K Robinson SUS operational Requirement
    - 18 T A Watson Getting Started on the Whitechapel MG-I
    - 16 P Tempest-Mitchell Communications: Ethernet
    - 15 K J Fermor Communications Report 1
    - 13 K G Dancey A message from the Bunker (Intro to SUN)
    - 14 K G Dancey Further messages from the Bunker (More SUN Info)
    - 11 J Haswell AIM Technology Benchmarks
    - 10 J Haswell Results of Benchmarking UNIX Systems
5. K Robinson, with D W Willis, IT Consultants, A Strategy for the Development of a UK Capability for Single User Systems in Support of the Alvey Infrastructure Policy.

## 6. DISTRIBUTED INTERACTIVE COMPUTING - ICF

### 6.1 Introduction

The oldest project being run by the Division is the Interactive Computing Facility which provides interactive facilities for Engineering Boards' research workers via a linked set of GEC and PRIME computers spread across the country, plus, until 31 March, a Dec10 KL.

The long-term philosophy is for interactive computing for researchers to be provided by integrated design facilities consisting of single user systems connected to servers on a local area network. It is not envisaged that this will happen quickly.

The current plan is to have phased out the GEC systems by the end of the five year forward look period. The PRIME systems will continue to run throughout the forward look period but with an aim of moving existing software that currently runs under PRIMOS to a UNIX environment. To achieve this initially, PRIMIX (UNIX) is being mounted as an alternative operating system on the PRIME systems and a Pyramid system has been installed for assessment.

### 6.2 GEC Systems

#### 6.2.1 Hardware Changes

A large number of hardware changes have taken place on the GEC 4000 machines in the last twelve months. This activity was coordinated by M R Jane and G A Lambert.

During August 1984 a Benson plotter was installed on the Southampton 4070 workstation.

During September 1984 the Heriot-Watt and Glasgow 4070 machines were upgraded to 4180s, which are owned by the Universities, but the software is still supported by RAL. These upgrades took place with no problems.

Also during September the Bradford 4082 was closed down. The peripherals on the machine were used to enhance an already existing 4090 which was owned by the University. This machine also had a memory upgrade at the same time, which caused a number of problems, as the new memory was faulty.

At the end of September 1984 the Cranfield 4085 was closed down and the machine was brought back to RAL.

Towards the end of 1984 the London PSS Gateway was brought into service, as well as the JNT News Machine, both machines running RAL supported code.

In February and March this year further hardware changes took place. RLGB had an extra two 70MB disc drives installed plus another 112MB of memory installed. The Cardiff 4090 had two of its 70MB disc drives replaced by two 275 MB disc drives and an additional 1MB of memory installed. At the same time the Cambridge 4090 had an additional 1MB of memory installed as well as two 70MB disc drives. Unfortunately the changes at Cambridge did not go smoothly as problems occurred which were eventually traced to the hardware.

At the end of March this year the Queen Mary College 4070 was closed down and brought back to RAL. Also at the end of June this year one of our oldest machines, the Appleton 4070, was closed down.

#### 6.2.2 Systems Support

With the lack of effort available for GEC Systems Support the development work for the systems has been greatly reduced, with the majority of the available effort going into general day to day system support. Staff involved have included S A Wood, R Poole and N Davidson.

A facility to allow the dumping system to read a command list and tell the operators what discs to mount was installed on the GECs at Rutherford.

Due to increased numbers of Hackers abusing the network, network authorisation was installed on most GECs to stop the unauthorised use of the network from these machines.

The Pad Print Server was declared ready for service early in 1985. This service will provide the queue for all output waiting to go to SERC provided PADS and printers at remote sites. This facility should allow is to start replacing some of our workstations with PADS.

The latest NAG library has been distributed to all our MUMS. We have also distributed the latest version of the Pascal and Fortran 77 compilers from GEC (bugs and all).

During the summer of 1984 the HASP function on the 4000 machines was replaced with a process called FILECARD which emulated the HASP functions. This allowed a job output from the IBM to be FTPed to the 4000 machines. Problems are still being experienced at some sites with this facility.

### 6.2.3 GEC Systems Contracts

Special two year contracts have been arranged by G A Lambert to provide special facilities for GEC Systems. These are at:-

**Cardiff**
development of WS Editor
**Bradford**
PASCAL Compiler support and provision of additional facilities
**Glasgow**
Update of Operators Documentation
**Leicester**
Development of CPROLOG

### 6.2.4 User Support

The last User Group and the last Managers Meeting held earlier this year decided that in future the two meetings would be combined to produce a GEC Manager/User Group Meeting.

Support activities continue at a consistent level with most enquiries being responded to within a few hours. Considerable progress has been made in updating the HELP files and the provision of additional utilities, eg KERMIT has proved especially useful.

Support has been provided by B A Alson and M J Loach.

**GEC Systems at 31 August 1985 - ICF Service Machines**

| Site | Machine | AUs |
|---|---|---|
| Bristol University | GEC 4090 | 2482 |
| Cambridge University | GEC 4090 | 1097 |
| Cardiff University | GEC 4090 | 971 |
| RAL (RLGB) | GEC 4090 | 2358 |
| RAL (RLGK) | GEC 4090 | 837 |
| Birmingham University | GEC 4085 | 386 |

## 6.3 PRIME Machines

### 6.3.1 Hardware

All machines have been upgraded during the year with additional memory on all systems. The 9950 at UMIST now has 6 Mbytes, all the 750s have 4 Mbytes and the 550s 2 Mbytes. Extra disk capacity was added to every system although the introduction of the 600 Mbyte fixed disk proved difficult, especially at UMIST which experienced problems extending over 6 months and required the disk unit to be replaced 3 times.

Prime 2250s were installed at Hatfield, Imperial College, Bath and Middlesex polytechnic and these are all in the process of being networked.

All this activity was arranged by M R Jane and G A Lambert.

### 6.3.2 Software

Development activities have been restricted due to a severe shortage of trained staff. However, responsibilities were divided between RAL and UMIST and all PRIMES have been upgraded to Revision 19.3 of PRIMOS. Identification and removal of systems bugs has been a significant activity and it has been estimated that up to 80% of Systems Groups effort is taken up in this activity.

Benchmarking of PRIMIX, in association with Surrey University, has taken place and RAL will be involved during the Autumn in the final Beta testing.

Other software development work has involved additions to the Archiver software to support the 6250 BPI tape drive installed at RAL, extensions to the Mail Server to circumvent nameserver problems and additions to LPOST. Extensive modifications have also been made to the Software Distribution System such that this is now largely an automatic process.

Staff involved have included M E claringbold, L C Peckover and R Harris.

### 6.3.3 User Support

The majority of requests for help from users continue to be handled by the local MUM managers with assistance from RAL and UMIST staff as necessary. This was provided by S Nightingale and P C Phillips.

Work continues in the provision of additional HELP facilities, ie GKS has been added, and the NAG On-line supplement has been made available at UMIST. Work has also commenced on a Network Help System.

The full Applications Manual has been distributed to all Users, with the Archive section being added during the year.

Two new user courses were held during the year, plus a special course for the new RAL staff and for new Managers. In addition Support staff have been involved in giving lectures at the SERC Summer School.

### 6.3.4 Prime Systems at 31 August 1985 - ICF Service Machines

| Site | Machine | AUs |
|---|---|---|
| RAL (RLPA) | P750 | 5888 |
| RAL (RLPB) | P750 | 4791 |
| UMIST | P9950 | 15441 |
| Warwick | P550 | 3855 |
| East Anglia | P550 | 1919 |
| UCL | P550 | 1965 |
| City University | P550 | 2112 |
| Surrey | P550 | 2646 |
| Sussex | P550 | 845 |

Software support provided for Prime systems at Bath, Hatfield, Imperial College, Middlesex Poly, UMIST, Nottingham, and 7 systems at RAL.

## 6.4 Pyramid

A Pyramid 90X machine was purchased in August to provide UNIX cycles to enable ICF Applications Software to be transferred from the PRIME to a UNIX environment. The Pyramid is a novel architecture (Reduced Instruction Set Computer - RISC) machine with a unique dual port of UNIX (Berkeley 4.2 and System V). The major effort on this machine has come from I J Gunn, S T Frost, J R Aitken, P J W Randell and L Sheather). I J Gunn has performed the main role as System Manager.

### 6.5 DECIO

The DEC10KL service run under contract by the Edinburgh Regional Computer Centre, closed down for ICF users on 31 March 1985. The service continued for the Alvey community until it closed altogether on 30 September 1985.

B G Loach and M R Jane have been closely involved with the DECIO support contract for many years. The formal closing ceremony of the service was performed by B G Loach on 30 September.

### 6.6 Systime 8750

In August the ICF Systime 8750 (VAX 11/750 equivalent) was transferred to the ABACUS design group in Strathclyde University. This group was one of the largest users of the DECIO service at ERCC and the only way to provide sufficient resource for their needs was to allocate this Systime 8750 to them. This machine runs UNIX and is the first external ICF supported UNIX facility.

C Balderson, I J Gunn, J R Aitken and S T Frost were all involved in the transfer and installation of this machine.

### 6.7 Resource Management

The main staffing effort has come from P D Athawes and B G Loach, with N B M Calton providing programming effort in the development of the new automated procedures. R Parkes joined the section taking over as local MUM Manager and he will be taking over many of the routine Resource Management activities for the RAL Machines, releasing Pat Athawes for other activities.

### 6.8 Grant Applications

The level of activity has remained constant with 80-100 applications being processed each round.

Development of the allocation of usernames and creation and distribution of Pinks is now complete and full scale testing has commenced. It is intended that in the future these functions will be undertaken by the remote local MUM Managers with RM at RAL only acting in an advisory capacity.

### 6.9 Staff Changes

The last twelve months have seen a number of changes in the GEC Section. The section moved in May this year from Central Computing Division to Informatics Division. S G Birtles left the Laboratory in September 1984. B Alston and M J Loach joined the GEC section towards the end of last year to work in the User Support Technology area. K Duffey left the GEC section at the beginning of 1985 to work in Technology Division. The beginning of the year also saw the arrival of K Poole to work on the systems side. During August and September C D Rust and N Davidson joined the systems team. The only member of the Section throughout the year was S A Wood.

The year has been one of change, both for staff and the configuration of machines. With two exceptions, M E Claringbold and L E Peckover, all staff are new, to those which were in post at the beginning of the year. In addition to the two mentioned the following have been involved with the Primes systems activities, R Harris, M H Roberts, User Support, S Nightingale and P C Phillips. In addition, I J Gunn, L Sheather and P J W Randall have been involved with preparations for the introduction of a UNIX service in the future.

The staff structure at the end of September 1985 is given in the organogram in Appendix A.

### 6.10 Future Developments

Work is in progress to release a new version of the GEC Operating System 4.15, expected to be made available by mid 1986. This will be the final version and no further development work will be undertaken.

The major effort on the Prime systems will be the development and introduction of the Prime UNIX (PRIMIX) facility, expected to be available early in 1986.

Further rundown of the GEC systems is planned, Newcastle at the end of October 1985 and Birmingham at the end of the year.

### 6.11 Publications

R Harris, Final Report on PRIMIX Beta Test at University of Surrey, April to October 1985.

## 7. DISTRIBUTED INTERACTIVE COMPUTING - SUS

### 7.1 Introduction

The Single User System project started as an Engineering Board initiative to provide a Common Base of hardware and software for the use of EB researchers. The Engineering Board's view was that this would be a major area of development in the future and it was important that some measure of standardisation took place to ensure that resources were not wasted in duplicating activities on a number of systems. Later the project was taken over by the Central Computing Committee as a Council-wide programme. More recently, it has been returned to the Engineering Board as a result of the Computing Review Working Party's recommendations.

The past year has seen the distribution to the user population of the full range of Common Base hardware and software - PERQ, PNX.2, Fortran 77, Pascal, GKS, NAG, and 20 sites now have X25 software. The same period has also seen the acceptance of the SUN2 range into the Common Base, and the beginning of the establishment of the SUN Support mechanism.

Many of the activities this year have been reported in the MMI report (see Section 5). This section concentrates on the support activities associated with the Common Base programme. P J Hemmings ran the Support Service, with T A Watson and M J Prime as the main software support staff. K M Lewis and D C Frith provided hardware and documentation and supplied software.

### 7.2 ICL

#### 7.2.1 ICL Collaboration

Testing of PNX4 has been completed and distribution will commence shortly. This release provides, for PERQ2s, the fast ERCC Fortran compiler, shared code and data, fork available for processes over 128KB, dual disk support, swap area bad block handling, and Newcastle Connection (over Ethernet) as well as the proprietary ICL C03 product.

#### ICL customer Service

The hardware upgrades for the PERQ1s, ie the addition of the 16K Writeable Control Store, have been added to 92 machines as an essential prerequisite to PNX/SR.

P J Hemmings has had a number of discussions have been held on various aspects of Customer service, mainly concerned with ordering equipment and hardware maintenance. Overall agreement has been reached to enable faults to be reported directly to the customer engineers.

### 7.3 SUN Microsystems

The 7 January meeting of CFSC approved SUSSG's recommendation that the SUN2 be added to the Common Base. Since then negotiations have taken place with SUN involving P Kent, F R A Hopgood, K Robinson and M R Jane on a whole range of activities (central purchase, software supply, hardware and software maintenance and so on), and agreement has been reached on most of these items.

### 7.4 Common Base Developments

#### 7.4.1 Communications

The prototype Cambridge Ring implementation by C P Wadsworth (see section 3) has been tested at Newcastle University. The Z80 upgrade programme has been completed but only slow progress has been made in producing a viable Cambridge Ring connection; in fact there is a fundamental problem due to major interference with tablet operation on PERQ1 which makes the Cambridge Ring connection unusable.

#### 7.4.2 Support

In spite of a serious shortage of staff the usual round of support activities continues. All routine enquiries are handled via the support office which has been manned by rostering members of staff from DIC Group and MMI Section for a fixed period each day. When a member of staff cannot be present queries can be handled via an answer-phone facility. GKS sets - some 90 of them - have been distributed and performance problems been tackled with the co-operation of the CCD graphics section.

User Notes on the NAG Library have been issued to all users.

#### 7.4.3 User Meetings

A User Forum organised by P J Hemmings, attended by some 80 users, was held at RAL on 14 May. The opportunity was taken to hold a Graphics Toolkit Tutorial given by M M Martin the day before.

Contact with the SUN UK User Group has been established and a SERC SUN User Group has also been set up by P Kent. It is intended that meetings will be held 3-4 times a year.

#### 7.4.4 Computer Board Collaboration

Further meetings involving RAt and QMC have taken place when matters of common interest have been discussed. K Robinson and P J Hemmings attend these.

### 7.5 Staff Changes

Resignation: P Tempest-Mitchell

The staff structure at the end of September 1985 is given in the organogram in Appendix A.

### 7.6 Future Programme

Responsibility for central support and software development on the SUN workstation is moving into the SUS section of the DIC group and as a result the section will be responsible for both the Common Base machine ranges and will be doing this on behalf of the Engineering Board's computing programme and the Alvey programme. The support arrangements will be reorganised, using the opportunity of the addition of SUN to the Common Base, the reorganisation of DIC group, and the move to R1.

Assessment of upgraded versions of machines already in the Common Base will be carried out, but a full-scale assessment on the scale of the 1984/85 exercise, would be entered into with extreme caution! This would be necessary when the market-place for high-performance workstations has altered.

Following the reorganisation of the DIC group, the section has a software development team and there are some major areas of work:

- to improve existing Common Base software, by making it available on both ranges of hardware and by improving its performance and resilience;
- to extend the range of Common Base software, both to improve the potential high quality interaction inherent in the Common Base machines, and also to provide access to facilities that are missing when compared with multi-access machines - access to high speed computing, good interworking, good hardcopy, reasonable size filestore, application libraries etc.

### 7.7 Publications

1. K Robinson, Future of the Common Base Programme - Recommendations by the SUSSG .

## 8. DISTRIBUTED INTERACTIVE COMPUTING - ALVEY INFRASTRUCTURE

### 8.1 Introduction

The Project initially involved the purchase of 10 GEC Series 63/30s and 5 Systime VAX 8750s for installation at sites selected by the Software Engineering and IKBS Directorates. Software development on these machines was the subject of a Memorandum of Understanding between Alvey and GEC (MOU. The GECs were intended to provide a UNIX service, once the Operating System had been mounted, and the VAXes (running BSD 4.2) were given to those sites whose function was to generate software, in order that they might have a reference machine, and also be able to import and export software. The sites were:

- Cambridge
- Department of Artificial Intelligence, Edinburgh *
- ERCC
- Essex
- Imperial **
- Oxford *
- RAL *
- Sussex *
- UMIST

Those marked with * had a VAX as well. Imperial, with active departments in both SE and IKBS, were assigned two GECs as well as a VAX.

Subsequently, it was decided to add Newcastle to the set of sites. They had obtained a GEC for the ASPECT project, but are now treated as a standard Infrastructure site.

Each site had a Site Manager appointed to look after the machine and to contribute to the Programme in other ways. These Managers varied considerably in their level of expertise and their willingness to participate.

During the first few months, the remaining machines were installed and Contracts signed. However, as will be seen from the subsequent report, the delays in software production on the Series 63 have affected everything. Those with VAXes have been able to run a service on them, but some other sites have yet to get started.

The following have been involved in the project from the start:

- R E Thomas, project manager
- C Balderson, I Vollmer, management
- R A Day, UX63 and communications
- J R Aitken, communications
- S T Frost, UNIX systems

M I Woods joined the UX63 team in August 84. A M Jackson joined the Management team in October. P J Overy and I Harding have recently joined (Communications and UNIX systems respectively). On the debit side, P J Smith left in August 84, A S Dunn in January and K J Fermor in April. All three took with them a considerable amount of expertise which was difficult to replace. S Harrod helped R A Day for a couple of months, and D Hicks has been with the Section for a year, first on UTS and later on Communications.

UTS (UNIX on the IBMs) has come to be regarded as part of the Infrastructure. The work has been done almost exclusively by H K F Yeung. There is considerable potential in providing powerful UNIX, especially to the Software Engineers and this has been borne out by experiments with Cambridge. H K F Yeung has recently been joined by N B M Calton.

Recently, the scope of the Project has been expanded to include SUN single user systems. Over 50 have been distributed to University users. Work is in hand to implement the Network File System and to connect these where appropriate to existing machines.

### 8.2 Installation and Contracts

The first quarter saw the completion of the installation of most of the computers. Two Cifer terminals per machine were delivered to each site. Toshiba printers for the GECs were delivered to sites, although (because of the software problems) these sometimes migrated to VAXes. pragma Laser Printers have also been delivered to Cambridge, EdAI, ERCC, Sussex and RAL, following a survey by C Balderson. Printers for the remaining sites will be ordered when problems over the ability to support postscript (software provided by Adobe) have been resolved.

Wide Area communications (covered in more detail below) were provided initially by the York Box on both machine ranges. Subsequently, all the 63/30s have been upgraded to 63/40s. Provision was made for one Local Area connection to each machine. The only option on the Series 63 is an Ethernet, with software written by ERCC (LLCI). As yet, there is little that can talk to it (but VAX and SUN implementations are imminent). The VAXes have been provided with Interlan Ethernets, and most are running TCP/IP (the appearance of SUNs running BSD 4.2 has made this protocol popular).

The Management costs of the sites, including the salary of the manager, are met by SERC. This cost is based upon an initial Estimate for the coming year, followed by a reconciliation exercise at the end. As expected, the first reconciliation proved difficult. Various short cuts taken earlier (in order to speed up the agreement) led to problems (such as the assumption by some sites that they would receive the total amount of the estimate regardless of whether they had actually spent it!).

C Balderson and R E Thomas spent most of February sorting this out, and final agreement with the last site has still not occurred.

Until May, RAL was responsible for Systems support on both sets of machines. However, the difficulty in recruiting suitable staff, and other related problems, caused RAL to seek Series 63 support elsewhere. ERCC replied to the tender, and the support handed over from May, following agreement on the Contract. As a component of the transfer of support it has been necessary to move the support computer to ERCC, thus leaving RAL without a Series 63.

### 8.3 General Management

C Balderson, I Vollmer and A M Jackson have been involved with the general management of the equipment, with help from other members of the section as required. Work involved operation of the local GEC and VAX, preparation and distribution of Operating Systems (for both machine ranges), dealing with site queries and operating the GEC SIR database (set up by A S Dunn on one of the ICF GEC 4000 machines!). This involves the monitoring of submitted error reports (SIRs) for their suitability for submission to GEC, and updating the database after replies from GEC have been received. Operational documentation has been produced and distributed.

The state of software on the official service machines meant that it took some time to be able to declare a 'Start of Service' date. Eventually this was taken as May 1st. As part of the necessary provision of management software, work was undertaken to set up an acceptable accreditation procedure, accounting and extension of the GEC fault reporting system to cover other areas.

The Fault Reporting system is intended to cover software faults in all Infrastructure supported systems and application software. The system is known as the Fault Reporting And Monitoring Environment (FRAME) and provides for fault reports from Site Managers to be sent to a central coordinator using full-screen input forms and FTP. The coordinator distributes the faults to the relevant Support agency for the software involved, enters the fault report into a database, establishing a Status record and history for the fault.

### 8.4 GEC System Software - UX63

Work on the GEC System has been undertaken by A S Dunn, R A Day and M I Woods, with S Harrod (a student) assisting for the first few months. A S Dunn left the group in January. The intention of the exercise was to assist GEC in providing UNIX on the Series 63, helping with the porting of utilities, providing accounting and distributing the software supplied by GEC to the sites. The work was covered by the MOU mentioned above.

Initially, GEC decided to mount System III UNIX. During the Autumn of 1984, GEC changed to System V, which became available in January. This had two effects: first, since porting utilities to System V was much easier, GEC no longer required RAL help in this area: second, it was necessary to undertake a major upgrade of all sites at the start of 1985.

Problems were experienced with the GEC releases (both their frequency and their inconsistency), which meant that sites saw a considerable delay between GEC announcing the release of a version and its subsequent appearance at the site. Much effort was expended in repeating jobs (such as sorting out the release tape) each month. There were also occasions when GEC informed us that they had mounted software themselves which either M I Woods or R A Day were in the process of mounting (as previously agreed). All this made the job of working on the Series 63 somewhat unhappy, and it was with considerable relief that the whole effort was passed to ERCC.

Turning to specific activities, R A Day and A S Dunn set up procedures for providing system releases to sites, including the extensive checking needed to prevent problems appearing remotely. A spooler and driver were written for the Toshiba high-quality printers, much of the work for this being done by S Harrod. R A Day spent some time investigating ways of organising the discs to suit the requirements of the users better, but this was hampered by the changing characteristics of different system releases. M I Woods began by porting system III utilities (such as "bfs" and "regcmp"). He also attempted to port the screen editor vi but stopped after GEC announced they had done it. He then worked on the journal logging utilities and on the accounting system (with S T Frost).

During the Autumn, GEC decided to hold a site audit. This involved going to each site and asking questions about problems, use etc. Almost all members of the section were involved. As mentioned earlier, the switch to System V meant a considerable amount of effort in converting the RAL software mods, and then visiting each site in the first quarter of 1985 to install the system and convert the filestore. Sussex proved impatient, so GEC installed a system for them without the RAL mods (which involved another visit later). Having installed System V, GEC's next release (the bug-fixed version) had also to be distributed, and this was completed in March.

### 8.5 VAX Systems - BSD 4.2

Most of the work has been done by S T Frost, assisted by J R Aitken and K J Fermor. As well as providing accounting and journal facilities, systems were prepared for release to sites. Since the operating system was well-known, the VAXes have been heavily used, and some problems have occurred (eg, sites changing their configurations without informing RAL, so that subsequent

releases fail to work). Various versions of the York software have been released, but it is still proving unreliable. Systems are therefore released on tape rather than over the network.

The version of emacs for 4.2 had some initial problems with windows and checkpointing files and these were sorted out by J R Aitken. S T Frost ported 'sees' to BSD 4.2. A tape of bug fixes for BSD 4.2 has been received from Mt Xinu. These have been implemented by S T Frost and P J Overy, and the new version distributed.

BSD 4.2 continues to be the favoured operating system because of its Virtual Memory and the software available over Franzlisp. However, BSD 4.3 is due shortly, and the latest releases of System V have Virtual Memory. S T Frost is investigating these systems to determine which should be provided for the sites. There would be some merit in moving to System V (to be compatible with the GECs) once the required functionality is present.

### 8.6 UTS

H K F Yeung has continued to look after the system and enhance the facilities available. In July 84, UTS (at the level of UNIX Version 7) had been mounted on the IBM 3081, but there were few users and it had to compete with CMS. During the year, various enhancements have been made, more users put on (a number of them new to UNIX) and the whole system has been moved to the Atlas 10 (where it does not compete with another interactive system). While this last move has been beneficial in general, it is difficult for UTS to obtain enough store to operate to best advantage (MVS being the major batch system).

One of the enhancements provided by H K F Yeung has been the extension of utility programs to access the 4250 and the 8700 printers. Franzlisp and CPROLOG have been mounted, and the ML/LCF system was successfully implemented (tested by A J Kinroy and A D B Cox). Recently, a user from Cambridge succeeded in running a program on UTS (with 12Mbytes virtual memory) 18 times faster than on a VAX (with 6 Mbytes real memory).

H K F Yeung has been ably assisted by D Hicks, who has worked on several projects. These included modifications to allow UTS output to be spooled to the 8700, provision of hhmail to allow UTS to use FTP to communicate with remote users (including mapping CMS ids to UTS identifiers) and an interface to the CMS Archiver to allow UTS files to be stored.

H K F Yeung has just been joined by N B M Calton. The new version of UTS (to System V standard) should arrive shortly, and work will be needed to incorporate the RAL modifications. This version provides a full-duplex facility which should allow some of the UNIX editors (such as vi) to operate successfully. Work can then begin in earnest to encourage users and to enhance the text processing facilities (at present, the 4250 is the best device available for high quality text at RAL).

### 8.7 Communications

This report covers those aspects of the Communications work which relate to the Infrastructure. Most of the effort has been provided by K J Fermor and J R Aitken. P J Smith worked on the Cambridge Ring. When K J Fermor left, R A Day took over Management responsibility for the section. Recently, P J Overy has joined. Work done by the section for the Common Base Programme is described elsewhere.

While the wide-area needs of the Sites were well defined, few had plans for local area networks. Subsequently, the needs of most sites are being met, with the exception of Essex, who, almost alone among Universities, run an LLC2 Ethernet. Connection to this is some way off.

#### 8.7.1 Wide Area Network

Most of K J Fermor and J R Aitken's effort has gone into bug-chasing in the York software, and distributing versions to sites. Debugging is made difficult by the non-repeatability of the faults, and the lack of debug aids in the front end. Problems ranged from call failures, security breaches, and the general reluctance of the user interface to provide what is expected (according to the

documentation). The security holes were found by the VAXes in the distribution; it just goes to prove how useful universities are in security testing code! General problems of X25 user interfaces concerned i/o when network utilities were in background mode, or were defined in command pipes. All problems have been reported to York via the SPR mechanism.

A new version of the code is expected in December, and it is hoped that this will be more reliable. The GEC upgrade has meant that the Infrastructure is less dependent on this code, and steps are being taken to find alternatives for the VAXes.

Other mail interfaces are also being reviewed. A copy of mmdf (a US system in general use at Imperial and UCL) has been obtained, and P J Overy is mounting it (when a complete version is supplied!).

### 8.7.2 Cambridge Ring

The Cambridge Ring has not featured very highly in the list of Infrastructure needs. GEC do not provide an interface, and have withdrawn the only hardware which might have been modified to provide this function. Only Oxford, Cambridge and Newcastle showed any interest. However, the appearance of SUNs (also without a ring interface) caused Cambridge to withdraw their request. Oxford decided to request an interface for the VAX only, and the same interface was provided for a (non-Infrastructure) machine at Newcastle.

A ring driver for BSD 4.1 existed on RLVC. P J Smith started to port this to BSD 4.2, and the work was completed by K J Fermor, with assistance from SE group. The UMCZ80 and access logic unibus cards were moved from the SE VAX to the IKBS VAX. Only BBP is provided. No TSBSP implementation is envisaged (Oxford have their own software, and Newcastle merely require Datagram for the Newcastle Connection).

### 8.7.3 Ethernet

This has been the more popular LAN, and has required much investigation (since there was little previous experience at RAL). BSD 4.2 comes with a driver for TCP/IP, and hence this protocol (non-standard) was available on the VAXes, and later on the SUNs. GEC provide an Ethernet interface for the Series 63, but their software (written by ERCC) supports LLC1 and Class 4 (so-called connectionless protocols).

Connecting various manufacturer's machines to the Ethernet has caused a few problems, which were made more difficult by the lack of suitable monitors. The problem has been partially solved by obtaining a Spider Monitor, but the best buy, an EXCELAN Nutcracker, proved too costly. Following the connection of SUNs and VAXes, it was found that a great many collision fragments were being generated by some (several?) interfaces. The development VAX (RLVF) was found to have a bad connection and after replacing the braid picks, most collision problems disappeared. VAX to VAX connections proved a problem until it was discovered that a fault in a transceiver was putting a voltage onto the Ethernet! This was discovered after much crawling under floors. Finally, one of the SUNs decided that almost every packet was colliding. This was traced to switch settings within the SUN.

As an aid, a portable Ethernet produced by DEC (a DELNI) has been obtained, and has proved so useful that another will be ordered. The first came on immediate delivery via Technology Division (who had ordered one by mistake!).

Following K J Fermor's attendance on the ad hoc Ethernet meeting which assisted the JNT in their decision to support a connection orientated network service over Ethernet, he became an active participant on the JNT Ethernet Advisory Group investigating the proposed service.

Future plans include the mounting of the ERCC code on the VAXes, (and possibly the SUNs if someone else does not do it first), and the implementation of the JNT-recommended connection-oriented LLC2 (with X25 above it).

### 8.7.4 Camtec Products

There are three areas of interest:

- Reverse Pads. Experiments were conducted to see whether a reverse pad could be used to supplement the York box on the GECs. This work was interrupted when it was discovered that the pad needs a 6-wire connection to the host. The GEC has subsequently moved from RAL, and been upgraded to a 63/40. Further investigation of reverse pads with UNIX will be carried out.
- X25 Board. Camtec are in the process of producing a Unibus board which will handle X25, thus removing the need for the York box. We have asked to be a test site for this equipment.
- Ether Pads. Camtec intend to produce a range of products for Ethernet. We are tracking this development.

### 8.7.5 Uucp

Uucp is the UNIX protocol which provides access to USENET. The USENET facility was setup on RLVD by P J Smith, connected by an ACU to Quantime, with whom we had an agreement to receive the news. J R Aitken has mounted various versions of uucp since, together with associated software. The latest version works over X25, and so is much more reliable. Uucp has also proved useful in connecting to other UNIX systems which have not had any network connection provided.

## 8.8 Staff Changes

New members:

| | |
|---|---|
| Aug 84 | M I Woods (from CCD) |
| Sep 84 | D G Hicks for 1 year |
| Nov 84 | A M Jackson (from CCD) |
| Apr 85 | P J Overy |
| Jun 85 | I Harding |
| Jul 85 | N B M Calton (from ICF) |

Resignations:

| | |
|---|---|
| Aug 84 | P J Smith |
| Sep 84 | S Harrod |
| Jan 85 | A S Dunn |
| Apr 85 | K J Fermor |

## 8.9 Future Programme

Our plans can be considered under the following headings:

a. GECs. Now that ERCC provide the systems support, RAL's role is mainly managerial. The fault reporting system will be installed, and may be extended to cover other machines as well. The major tasks will be the provision of LANs, laser printers and suitable high-level software (when the users decide what they want). Interconnection with SUNs will become important.
b. VAXes. We will continue to support the Operating system. BSD 4.3 will be obtained and issued if it meets the requirements. System V will be investigated with a view to considering changing to this more standard system once it provides the necessary features.
c. Text Processing. As well as investigating laser printers and typesetters, there is much interest in Postscript. This will be investigated.
d. UTS. The System V version will be mounted and a concerted effort put in to make the system acceptable to the potential users. Possible LAN connections will be investigated.

e. SUNs. These are new devices, and it is not clear yet what will be needed. The Network File System will be installed.
f. Communications. Replacements for the York box will be evaluated. LLC1 will be mounted on the VAXes, and an implementation of LLC2, with X25 above it, will be attempted. SUN's NFS and Newcastle Connection will be mounted.

Informatics
Informatics Department

# Informatics Annual Reports



## Informatics Annual Report 1985-6

## 1. INTRODUCTION

The Annual Report covers the year ending September 1986. Its main purpose is for internal use in the Division indicating what has been achieved and by whom. Hopefully it gives new members of the Division some idea of the work programme and its objectives.

Informatics Division was formed in July 1984 when the single Computing Division was split into two parts with Central Computing Division being responsible for the mainframe computer services and wide area networking. The responsibility of the new Informatics Division was to support SERC's Engineering Board's activities in the information systems area, namely:

1. Interactive Computing Facility: to continue the provision of interactive facilities for the Engineering Board users via PRIME and GEC multi user minis. The facility started to provide a service in 1976 and is the most mature of the Division's projects.
2. Single User System Common Base Programme: to continue the provision of a common hardware and software base for Engineering Board users initially with PERQ1 systems but more recently with PERQ2, SUN2 and SUN3 systems. This project started to provide a service in 1982 although work on single user systems started in 1979 as part of the ICF project above and in support of the Distributed Computing Systems programme which was being coordinated at that time.

**PERQ2**

**Large View**

3. Alvey IKBS, SE and MMI Support: to provide coordination, support and some research and development activities in these three areas of the Alvey programme.

   The Alvey Programme started in 1983 and was aimed at providing a significant impetus to cooperative pre-competitive research in the enabling and underlying technologies of Information Technology. Funding is provided by DTI, MoD and SERC via the Engineering Board.

4. Alvey Infrastructure: to provide and develop the infrastructure, both hardware and software, for the IKBS, SE and MMI areas. This started in 1984 providing multi-user support via a distributed set of GEC Series 63 and SYSTIME VAX systems. More recently support has also been provided for SUN2 and SUN3 systems.

The major change in funding this year is in the non-Alvey area where the decision has been made by the Engineering Board to merge the ICF and SUS programmes into a single programme called the Engineering Computing Facility (ECF). The motivation for this is to recognise the trend towards single user systems and the need to provide relevant server facilities for clusters of single user systems. It was felt that this could best be done by a single project having less rigid constraints between the two activities.

The internal organisation of the Division has remained static during the year, comprising three Groups:

1. Software Engineering R W Witty (deputy D A Duce)
2. IKBS/MMI C J Pavelin (deputy K Robinson)
3. Distributed Interactive Computing K F Hartley (deputy M R Jane)

Ken Hartley joined the Division near the start of the year as head of DIC Group. Appendix A gives the internal Divisional Structure with people in post in September 1985 and September 1986. Rob Witty was Deputy Director of the Alvey Software Engineering programme for most of the year and took over as Director in August. Both functions have entailed considerable interaction and time spent at Alvey Headquarters in Millbank, London.

The format of the report corresponds quite closely with the main project structure and the associated Group structure.

For those unaware of the prevailing jargon in the Division:

| | |
|---|---|
| ACARD | Advisory Council for Applied Research and Development |
| ALFEX | Alvey Financial Expert Systems Club |
| Alvey | Alvey Programme funded by DTI, MoD and SERC |
| ASPECT | Alvey-sponsored 2nd generation IPSE |
| CFC | Computing Facilities Committee of EB |
| CO | SERC Central Office at Swindon |
| CSI | Client Server Interface |
| CSSC | Computer Science Sub Committee of IEC |
| DCS | Distributed Computing Systems SPP |
| DTI | Department of Trade and Industry |
| EB | Engineering Board of SERC |
| ECF | Engineering Computing Facility (funded by CFC) |
| ECLIPSE | Alvey-sponsored 2nd generation IPSE |
| ERCC | Edinburgh Regional Computer Centre |
| FLAGSHIP | Functional, Logic And General Software-Hardware Implementation Project. Large Alvey project including ICL, P1essey, University of Manchester and Imperial College, London. |
| GRE | Government Research Establishments |
| ICF | Interactive Computing Facility (part of ECF) |
| IEC | Information Engineering Committee of EB |
| IKBS | Intelligent Knowledge Based Systems |
| IPR | Intellectual Property Rights (the rights to market the results of a particular piece of research) |
| IPSE | Integrated Project Support Environment |
| IPSE 2.5 | Alvey-sponsored 2nd generation IPSE |
| Millbank | Location of Alvey Directorate in Central London |
| MMI | Man Machine Interface |
| MoD | Ministry of Defence |
| NC | Newcastle Connection |
| NFS | SUN's Network File System |
| NRS | Name Registration Scheme |
| RFS | AT&T's Remote File System |
| SE | Software Engineering |
| | |

| | |
|---|---|
| SERC | Science and Engineering Research Council |
| SIGAI | Special Interest Group for Artificial Intelligence (originally an ICF group but now part of Alvey IKBS) |
| SPP | Specially Promoted Programme of SERC |
| STI | Software Technology Initiative - SPP that became part of the Alvey SE programme |
| SUS | Single User System |
| SVF | Senior Visiting Fellow |
| Swindon | Another name for Central Office |
| Uncle | An individual who oversees a non-collaborative academic research project in Alvey to ensure awareness of industrial relevance both into and out of the project. |
| VLSI | Very Large Scale Integration |

## 2. SOFTWARE ENGINEERING

### 2.1 The Role of the Software Engineering Group

SEG's role is four-fold:

1. Alvey SE Programme management, ie the Millbank function, with special responsibility for the academic SE Component, SERC/RAL finance and liaison with SERC Central Office at Swindon.
2. Technical Support to the Alvey SE Programme. This involves advice to the Millbank staff on technical issues (eg Wadsworth's briefing to Oakley on Japan), compilation and distribution of the SE Mailshots, refereeing project applications, information gathering (eg cellular radio, 3270 emulation).
3. Development work on behalf of the Alvey SE programme. This can be on behalf of specific projects (eg BSD 4.2 Ring driver for Newcastle/Aspect) or for the Alvey SE infrastructure generally (eg ML/LCF on UTS, Newcastle Connection). Some Development work of the specific project variety will be on behalf of SEG' s own research projects (see below).
4. SE research, in line with Alvey SE strategy, IEC/CSC policy and in collaboration with industry, GREs and Universities.

Management, Technical Support and Development work are funded directly from Millbank to SERC/RAL. They attract 75% DTI funding because these activities are services on behalf of both academic and industrial communities.

The research work is funded differently. This must either follow normal Alvey rules, ie a complete, collaborative project must be constructed, approved and awarded or go through the peer review system of IEC/CSC. At any given instant SEG aims to have more than one project under way with successors in the pipeline. SEG aims to have both Alvey and CSC funding simultaneously because some work will be more suited to CSC.

### 2.2 Alvey SE Programme Management

#### 2.2.1 SEG's Contribution to Alvey Management

The software engineering component of the Alvey Programme is a significant part of the total, amounting to about £65M, of which about £16M is for the academic part of the SE programme. An existing portfolio of academic research grants in SE (the SERC's Software Technology Initiative) has been included in the Alvey Programme to ensure continuity and involvement of all relevant SE research in the UK. The Alvey SE programme currently has 87 projects; 32 are fully collaborative and 55 are smaller uncle projects and SVFs etc.

Support for the Alvey Programme consists of interaction with academic groups to assist in the preparation of grant applications and coordination of the SERC/Alvey Directorate interface.

Research supported by Alvey differs from that usually supported by SERC in that the Alvey Programme is a directed programme. This involves much closer involvement in both the preparation of the grant applications and especially during the execution stage of the research. For this purpose all projects are monitored, both technically and financially. This involves preparation of a database on all projects, collation of reports, generation of summaries and spend profiles. Regular reports are required from Monitoring Officers for collaborative projects and from industrial Uncles for academic only projects. Any exceptions raised by this monitoring process are actioned quickly.

Support is provided also for the Alvey SE Office in Millbank by providing assistance in meetings, workshops, panels and presentations. Much effort is expended in maintaining the files and reporting procedures for the programme. To assist in maintaining continuity of research, a mailshot service is operated. An increasingly important aspect of the overall support as the programme develops is the analysis of the budget and preparation of data for forward planning. For this purpose a special procedure has been developed with the objective of minimising difficulties associated with over commitments of the budget.

The RAL Software Engineering Group has continued to provide management support to the Alvey Programme. Since the major part of the programme is now in place attention has concentrated on monitoring the individual projects and installing a procedure for disseminating the information generated by the programme.

General support is provided for coordination of industrial and academic proposals in the area of software engineering. In addition to processing new proposals to the directorate the directed nature of the programme results in necessary changes to existing Alvey projects. These changes result from the dynamic nature of the collaborative projects, reflecting changing industrial positions and the evolving nature of the research to ensure that the products continue to have industrial relevance.

The monitoring programme now is well established and is generating vital information on the progress of all SE projects. Especially important is the rapidity with which problems are identified in particular projects. Remedial action then can be taken or planned to minimise disruption to the main R&D thrust of those projects. The reports produced by the monitoring officers, and Uncles for non-collaborative academic projects, are used regularly for overall programme reviews. These reports form the basis for detailed assessments by the directorate staff in the various speciality topics within SE.

An essential part of the Alvey programme is the dissemination of information generated by the many research projects. These results are presented in the form of discrete deliverables for each project. To meet this part of the Alvey programme a procedure for disseminating information about the SE deliverables has been established. As the deliverables become available abstracts are provided, edited and collated for publication as a supplement to the bi-monthly Alvey News, thereby reaching 7000 potentially interested parties. Further information about the deliverables can be obtained from the relevant project manager or owner of the IPR.

Other general support activity includes continuation of the SE Mailshot service and generation of numerous reference data relating to the SE programme. Lists of participants in the programme giving their electronic mail addresses and current interests are maintained. Also, detailed analyses of the financial position are provided to permit optimisation of commitment of the residual funds in the SE division.

R W Witty, F M Russell and J Cheney, supported by Lilian Valentine, undertake the above work.

**Alvey Conference, Sussex, Left to Right: Tony Dignan (Ferranti), Mike Falla (Software Sciences), Hui Chiu and Mike Russell (RAL) who were part of the Software Engineering team run by David Talbot and Rob Witty. In the white suit behind is Geoffrey Pattie Minister for IT who took over from Kenneth Baker.**

**Large View**

As Deputy Director of the Alvey SE Programme RWW had responsibility for the overall strategy of the Programme, its infrastructure policy and the general academic contribution. On 1/8/86 RWW succeeded Mr D E Talbot as Director of the Alvey SE Programme.

### 2.2.2 ACARD WG on SE

ACARD (the Advisory Council for Applied Research and Development) is a high level body which reports to the Cabinet on long term issues.

An ACARD working group, chaired by John Coplin, the Design Director of Rolls Royce, spent the period Jan 85-March 86 studying the role of software in the manufacturing and service industries, the role and future of the UK software industry and the future impact of software on the UK economy. RWW was a member of this working group through his position in the Alvey Directorate.

The working group produced a report called Software: a vital key to UK competitiveness. RWW, John Coplin and Sir Francis Tombs (ACARD Chairman) launched the report at a Press

Conference in June 86. The report has caused some continuing public debate. The official government response is due towards the end of 1986.

### 2.3 Alvey SE Technical Support and Development Work

#### 2.3.1 Introduction

The section has now completed its work for the DCS, STI and Common Base programmes and has spent the year concentrating on aspects of specialist infrastructure for the Alvey SE programme such as the conversion of ML/LCF theorem proving system to use the new version of Standard ML.

This section has also handled the relocation of the Group's computing facilities from the Atlas building to R1 in Dec 85.

#### 2.3.2 Standard ML/LCF

ML is a functional programming language which was designed and first implemented at Edinburgh as the metalanguage for the interactive theorem proving system LCF. ML soon attracted interest quite independently of LCF with the result that a number of dialects appeared.

Standard ML is a consolidation of tried-and-trusted developments which has been agreed by the ML community. The final definition of the new language was completed by Edinburgh in the summer of 1985 with Alvey backing. The principal additions for Standard ML are: the data constructors and pattern matching facilities of HOPE, and exception mechanism which enables values to be passed with exceptions, a richer and more systematic set of definition constructs, a module facility based on the latter, and I/O handling.

Mikael Hedlund started work on converting the old ML/LCF to Standard ML in March 1985. The project has two aims:

1. to ensure that LCF, as the largest application of ML to date, is fully available for Standard ML, and
2. to widen the group's expertise in the implementation of functional languages.

The new implementation follows the same structure as the original, although much of the detailed code has had to be completely rewritten since the new language has a completely new syntax and a richer semantics. The new compiler for Standard ML was completed and tested in June 1986, and the 20 or so LCF source files which were written in old ML have now been transliterated to Standard ML.

The implementation is written in FranzLisp and has been developed on a VAX under UNIX BSD 4.2. FranzLisp is also available on several other machines at RAL (SUN and Pyramid under BSD 4.2, and Atlas 10 under UTS) and the new system will be moved to some or all of these when final integration and testing is completed on the VAX. The system will then be made available for distribution to the Alvey community.

#### 2.3.3 Theorem Provers

Theorem provers are software tools to aid in the process of proving theorems. In the software engineering context we are primarily concerned with theorems about programs, for example that a particular program has a particular property.

Beside the LCF system mentioned above, the group has continued its involvement with two other current systems, the Boyer-Moore theorem prover from the University of Texas and the IOTA system built at Kyoto University in Japan. We have not been working with the Boyer-Moore system ourselves but have continued to act as a UK distribution point for the Alvey SE infrastructure.

Investigations into how best to make IOTA available in the UK are at last nearing a successful conclusion. An attempt to port the original Standard Lisp implementation of IOTA encountered greater difficulties than had been anticipated (differences between early and current versions of Standard Lisp) and was eventually abandoned when a simpler option became available. A version

of IOTA ported to Kyoto Common Lisp (KCL) was received from Kyoto in April, together with distributions of KCL for VAX and for SUN. Installation and testing have been undertaken by a research student at Manchester, with assistance from Chris Wadsworth, and a more or less complete system is now running in Manchester on a VAX. The same system also loads successfully for KCL on the SUN but fails when attempting to save the IOTA core image. At the time of writing this is unresolved but it is thought to be due to minor differences between SUN2 and SUN3.

It is hoped to make the KCL version of IOTA available for distribution for the VAX shortly and for the SUN when the problem with saving core images is resolved.

### 2.4 SEG Research

#### 2.4.1 Introduction

The overall SEG research theme is Quality Certification of Software Products. Within this theme, the main research interests of the group are in formal specification, the development and application of machine-assisted proof systems and the role of formal reasoning in software development.

#### 2.4.2 Formal Specification

David Duce (DAD) holds two research grants, one from the Alvey Software Engineering Programme entitled Specification of the Graphical Kernel System (GKS), the second is from SERC's Computing Science Committee entitled Theoretical Studies of Emerging Computer Graphics Standards. The latter project was due to start in October 1985, but staff shortages have meant that the technical work has been slow in starting.

Pictures in GKS are described in terms of basic building blocks termed output primitives. GKS allows primitives defined in different coordinate systems to be composed and for different regions of the resulting picture to be viewed on different workstation display surfaces. GKS also provides elegant mechanisms for controlling the appearances of primitives in such a way that the capabilities of different workstations may be exploited to the full, for example a polyline primitive might be displayed as a solid co1oured polyline on one workstation and as a dotted polyline on a monochrome workstation. The technical work in 1984/85 was mainly concerned with specifying the appearance control mechanism in GKS. During this last year, the problem of specifying the geometry of all the GKS output primitives has been tackled and resulted in a paper which was accepted for the Eurographics 86 conference. In essence primitives are represented by the set of points in the real plane which they cover. Primitives as displayed on a workstation are represented as relations between points and colour values.

The 3D extension of GKS, GKS-3D uses the same primitives as GKS itself, and the definitions given are not limited to 2D. This is an essential step in finding a structure for the GKS specification that will encompass GKS-3D also.

The main thrust of the technical work now is to produce a reasonably complete specification of the output side of GKS. Essentially this involves integrating the specifications of the output primitives with the control mechanisms, though in reality this is far from straightforward because without due care the specification rapidly becomes cluttered and unreadable. For this reason the Z specification language (developed by Programming Research Group, Oxford) is being explored. One of the major strengths of Z is the facilities it provides for structuring specifications. One paper has already been written which describes, in Z, a simple model GKS system consisting of a single output primitive and describes the geometry and transformation control for this primitive. The structure of specification closely follows the GKS viewing pipeline model. This has formed the basis for a number of seminar presentations. A more substantial paper including appearance control is in preparation.

The project suffered a major setback with the departure of Elizabeth Fielding at the end of December 1985. At the time of writing, her post had not been filled.

The second project is concerned with two standards currently under development, GKS - 3D and PHIGS. The latter is a standard aimed at the needs of highly interactive applications where the ability to manipulate highly structured pictures is important. PHIGS essentially defines a graphics database which can be edited by the application program. Traversal of the database generates output primitives for display. One of the aims of the project is to define a specification structure that will accommodate GKS, GKS-3D and PHIGS and bring out the conceptual integrity of these systems. So far one paper has been produced, which is an annex to a UK position paper on PHIGS for the ISO Graphics Working Group meeting in September 1986. This paper gives an OBJ specification of a model of the PHIGS structure store, traversal of which generates a sequence of GKS functions which are defined in an OBJ specification of a model GKS system. At this time, PHIGS cannot be defined on top of GKS, the paper explores some ideas for extending GKS and reinforces the UK view that certain extensions would then enable PHIGS to be defined on top of GKS.

Seminars have been given at the Centre for Mathematics and Informatics (CWI) , Amsterdam; the University of Queensland and the Australian National Defence Academy. A paper was presented at a one-day seminar on OBJ, held at Imperial College.

### 2.4.3 Graphics Standards

David Duce participated in the ISO computer graphics working group meeting in February 1986. He is secretary of the BSI computer graphics panel. Bob Hopgood and David Duce gave tutorials on graphics standards at CERN in December 1985 and at AUSGRAPH 86 in Sydney and at Perth in July 1986.

**David Duce and Liz Fielding at the Graphics Standards Meeting at INRIA, Sophia Antipolis**

**Large View**

### 2.4.4 Equational Reasoning

Jeremy Dick's research continues in the field of Automated Equational Reasoning, and has been centred around the theoretical and practical development of his Prolog implementation, ERIL (Equational Reasoning - an Interactive Laboratory). Based on a polymorphic extension of the Knuth-Bendix algorithm which allows a rich form of sub-sorting, ERIL is a useful tool for experimenting with the specification and prototyping of abstract data-types, and can be configured for various models of computation, including functional rewriting, resolution of horn-clauses with defined functions, and narrowing.

During the last twelve months, ERIL has been enhanced in the following ways:

1. by compiling rewrite-rules into a shared structure, the efficiency of matching and unification has been increased by an order of magnitude;
2. the flexibility of the syntax has been considerably improved by allowing mixfix operators, which is a generalisation of prefix/infix/postfix allowing, for instance, single operators of the form if_then_else_;
3. translators between OBJ and ERIL allow ERIL to be used directly with OBJ specifications (but not yet with associative/commutative operators).

Jeremy Dick has been active in promoting the use of ERIL in other departments. It was used as an integral part of an algebraic specification course at the university of Stirling, where it is also being evaluated as the basis of a simple Pascal program verifier for 1st year undergraduate students. It is also in use at two sites connected with the Alvey-sponsored FOREST project, at AERE Harwell and IST, Cambridge.

### 2.4.5 IPSE 2.5

IPSE 2.5 is a major Alvey project to research and develop an Integrated Project Support Environment based on advanced distributed systems and man-machine interfaces, and incorporating support for both the practice and organisation of design tasks. A major objective is the development of an integrated framework for supporting the use of formal methods in software development, including formal specification and theorem-proving techniques.

The project began in October 1985 with three initial collaborators (ICL, STC and Manchester University) and had a successful first review with the Alvey Software Engineering Directorate in July 1986. RAL applied to join the project from April 1986 and, after some delay, received its grant allocation at the beginning of July 1986. Three additional industrial partners have also recently joined the collaboration.

The project as a whole emphasises the generic nature required of IPSE 2.5. This introduces a key distinction between a generator for an application system and a generated application. This is essentially a conceptual distinction, rather than a rigid division, which is important in understanding the tools to be provided. A generic IPSE may be viewed as a collection of specific generators and other tools together with an integrating framework.

The project thus consists of two main tasks:

1. to specify and implement a generic prototype on which specific supports environments can be constructed;
2. to construct some such specific support environments for demonstrations that stress formal reasoning and the integration of the practice of design with the organisation of design.

The latter process may be understood as one of instantiating the generic system through the application of relevant generators.

Work to date has mostly concerned the detailed requirements and initial work on the system architecture. Concept studies have been completed for the six main areas of the project. Three of these (design support, management support, and formal reasoning) concern the specific

requirements in these areas, while the other three (databases, man-machine interface, and languages) concerns the infrastructure needed to meet the requirements.

Chris Wadsworth has participated in these activities since March 1986 and jointly authored the study of requirements and concepts in the area of formal reasoning. He also represents RAL in the regular project meetings and has contributed to the technical reviews, both internal to the project and with the Alvey SE Directorate.

### 2.4.6 Transformation and Verification of Occam

Tony Cox (ADBC) has spent almost all his time working on the Alvey (VLSI/CAD) funded research project The Transformation and Verification of Occam Programs, which is a collaboration between Inmos Ltd and Oxford University; at Oxford the project has consisted of Dr Bill Roscoe, supervising, and two research officers, in addition to ADBC. ADBC is one of the SERC facilities requested by Oxford on their RG2!

Occam, a language for concurrent systems, was derived from the language Communicating Sequential Processes, and inherits its clear semantics; in Roscoe, A Denotational Semantics For Occam, a model is given which accounts for both the purely parallel and the internal and store-based aspects of the language. This semantics readily gives rise to a set of laws between Occam programs (Roscoe and Hoare Laws of Occam programming) which can be used as the basis of an automated transformation system. A semantics preserving transformation system offers various possibilities: deciding the equivalence of programs (through transforming to a normal form); improving efficiency; transforming to restricted syntax for VLSI implementation.

A prototype system has been written in Edinburgh Standard ML which is able to parse Occam Programs, apply any of the transformation laws and, most recently, to convert a program to normal form, including infinitary programs to a specified number of communication steps. ADBC has done almost all the programming on the project, while other members have contributed ideas on concurrency theory and the user-interface.

Future work on the project will aim to extend the system to full Occam Syntax, develop useful transformation strategies in collaboration with Inmos and improve the user interface.

ADBC has remained a member of the BSI working group producing a Prolog Standard, taking an active interest in the Semantics sub-group.

### 2.4.7 Dimensional Design Editor

SEG has been honoured to have Prof Miquel Bertran-Salvans from UPC Barcelona as a visiting researcher for the year beginning March 86. MBS has been interested in Dimensional Design, a graphical technique for presenting software designs originated by RWW and DAD for use in the FR80 Driver and Roots toolset.

A collaborative project between members of SEG (MBS, Duncan R Gibson (DRG), RWW) and DEC(UK) (Tom Povey) was established to build a syntax-driven compiler/compiler/editor system to be called the Dimensional Design Editor (DDE).

A requirement specification, user interface prototype and initial design work had been completed by July 86 when DEC posted Tom Povey to the USA and thus had to withdraw from the collaboration.

MBS has been working on the design of a syntax-driven editor for Dimensional Designs. A document collecting some ideas about the user interface is available.

Basing the approach on the re-use of the same type of display structure, namely the Dimensional Design (DD) itself, the document discusses the interface objects and proposes concrete layout forms for them. The following are examples: Global event sequences or menus, Library Dimensional Design Grammars (DDG's), and the edited DD's. The display of all these objects as DD's is proposed.

The reuse strategy has implications on the internal design since the same data type, namely the DD, is used to represent most of the objects.

Special attention is given to DDG's. They correspond to a possible extension of grammar notation (BNF) to allow the definition of dimensional structures (DD's). An example of their use in the definition of a Simple Dimensional Pascal (SDDP) language is included. As another example the structure of the library is defined with a DDG as well.

DRG did some investigative work on the 4-labelled cuboid model of Dimensional Designs. This involved taking some existing design work by RWW, and producing a translator using the TreeMeta compiler-compiler system. This translator took a simple linear representation of a DD as input, and output the necessary commands to draw it, then a simple pascal program took these commands, interpreted them, and drew the result on a PERQ screen.

Since then DRG has been experimenting with a Pascal program which is the prototype for the user interface of the Dimensional Design editor. This prototype tests ideas and the algorithm used to manipulate trees, both internally to the program and what is presented on the screen to the user. Experience gained here will be invaluable when it comes to building a more complete system.

Other odd jobs have been: sorting out Cambridge Ring equipment (still ongoing!) and distributing copies of the Boyer-Moore theorem prover. DRG has also been responsible for the installation of software on several PERQs. DRG now represents the SE Group at the Unix Service meetings.

### 2.5 Staffing

SEG welcomed Brian Ritchie to the Research Section in August 1986, and Jill Cheney to the Alvey SE Management section in July 1986.

Elizabeth Fielding left us in December 1985 to go to Holland, and Donald Findley left in March 1986 to return to social work in London.

The staff structure at the end of September 1986 is given in the organogram in Appendix A.

### 2.6. Future Programme

#### 2.6.1 Specification Research ( D A Duce)

The two current projects will continue their comparison of the efficacy of specification notations and theories as part of the overall search for viable techniques to specify the forthcoming standards such as GKS-3D and PHIGS.

#### 2.6.2 Theorem-Proving Research (A J J Dick)

Future work will revolve around a new SERC-funded project entitled An Assessment of Knuth-Bendix Techniques in Theorem-Proving. The basis of the research is to compare the scope and performance of a polymorphic predicate calculus theorem-prover based on the Knuth-Bendix technique with existing resolution/paramodu1ation-based methods, and assess the long-term potential of this new approach to theorem-proving.

The three-year research programme will be in three phases:

1. The extension of the existing ERIL system to treat the full Predicate Calculus. Two major tasks are involved in such an extension:
    i. The implementation of a unification algorithm capable of treating associative-commutative functions.
    ii. The implementation of the Recursive Decomposition Ordering with Status for proving the termination of set of rewrite rules.
2. Given a working model of the extended ERIL system, the second stage is to apply the theorem-prover to test cases to assess the capabilities of the Knuth-Bendix approach. This is

the major part of the project; its main aims are as follows:

i. To compare results with those reported in the literature for resolution-based methods.
ii. To gain experience in applying the prover to a range of problems in theoretical computer science (eg the processing of algebraic program specifications, the solution of domain equations, etc), with a view to identifying design criteria for a tool, especially use/tool interaction.
iii. To gain a deeper understanding of the strengths and weaknesses of the Knuth-Bendix approach.

3. The final stage will be to produce a feasibility report and design study for a fully-fledged theorem-prover tool providing the full power of the Knuth-Bendix techniques for use in a formal methods environment.

### 2.6.3 IPSE 2.5 Research (C P Wadsworth)

RAL is funded for the duration of the IPSE 2.5 project to September 1989. The grant application to RAL provides support for Chris Wadsworth as project leader and two other posts. Brian Ritchie joined RAL in August 1986 to fill one of the posts. An offer has been made to fill the other post from October 1986.

The project at RAL will continue the work that has begun on the formal reasoning aspects of IPSE 2.5. The long-term aim is to enable humans and machines to work together effectively in the accomplishment of formal reasoning tasks. Particular objectives within the context and time scale of the overall IPSE 2.5 project are:

i. to develop the theorem proving capability for IPSE 2.5,
ii. to extend the scope, practice, and acceptability of theorem proving techniques in the production of verified software,
iii. to understand the requirements for integration with other components both in the generic IPSE 2.5 system and in specific support environments,
iv. to investigate new approaches to proof construction designed for advanced interactive use on large, high-resolution displays equipped with windows and pointing devices,
v. to consider evolution to the IPSE 2.5 distributed delivery environment in which the computational power and storage capacity of mainframes is linked with the interactive convenience and flexibility of advanced terminals or single-user workstations, and
vi. to achieve a design which is readily portable between alternative delivery environments.

Much of the detailed work will be undertaken jointly with project staff at Manchester University, with whom we already have good working links.

## 2.7 Publications

### 2.7.1 Publications - External

i. D A Duce and E V C Fielding, Towards a Formal Specification of the GKS Output Primitives, Proceedings of Eurographics '86, A Requicha (ed), North Holland 1986.
ii. F R A Hopgood, D A Duce, E V C Fielding, K Robinson and A S Williams (eds), Methodology of Window Management, Springer Verlag, December 1985.
iii. D A Duce and E V C Fielding, Formal Specification - A Comparison of Two Techniques, accepted for publication in the Computer Journal (revision of RAL-85-051).
iv. F R A Hopgood, R J Hubbold and D A Duce (eds), Advances in Computer Graphics II, Springer Verlag, August 1986.
v. F R A Hopgood and D A Duce, Graphics Standards Introductory Tutorial, Australasian Computer Graphics Association, 1986.
vi. F R A Hopgood and D A Duce, Computer Graphics Programming - Professional Seminar, 1986. Australasian, Computer Graphics Association,
vii. A J J Dick, ERIL-Equational Reasoning: an Interactive Laboratory, RAL-86-0l0.

viii. A J J Dick and R J Cunningham, Using narrowing to do isolation in symbolic equation solving - an experiment in automated reasoning, in Proceedings of 8th Int Conf on Automated Deduction, Oxford, July 1986, LNCS Vol 230, pp 272-280.

ix. Theorem Proving Concepts Paper, IPSE 2.5 project paper, June 1986.

x. F R A Hopgood and D A Duce, Graphics Standards The Current State, RAL-86-08l.

### 2.7.2 Publications - SEG Notes

| SEG Number | Title | Author | Date |
|---|---|---|---|
| 95 | Alvey SE Visit to USA Oct 85 | R W Witty | 04.11.85 |
| 97 | Progress Report on the Implementation of Standard ML | P M Hedlund | 10.02.86 |
| 101 | SE Research at RAL | D A Duce | 13.02.86 |
| 116 | DD - A Layout Algorithm for the Labelled Cuboid Model Draft 2 | D R Gibson and R W Witty | 14.04.86 |
| 117 | Notes on a visit to CADCAM8 9.4.86 | D A Duce | 17.04.86 |
| 119 | SEG Development Software on RLVC SML, KCL, IOTA | C P Wadsworth | 23.04.86 |
| 121 | Notes on Lancaster Conf on SE | M Bertran | 06.05.86 |
| 122 | Conf on Text Processing and Document Manipulation | D A Duce and N Calton | 12.05.86 |
| 124 | Progress Report on the Implementation of Standard ML | P M Hedlund | |
| 130 | Chinese Univ Development Project SCIT April-May 1986 | R W Witty | 10.06.86 |
| 137 | Trip Report | A J J Dick | 23.06.86 |
| 140 | Trip Report Australia 86 | D A Duce | 21.07.86 |
| 142 | Dimensional Design: Requirements Specification for Prototype Draft 3 | D R Gibson | 20.08.86 |

**Bob Hopgood and David Duce on the right with Lena and Wendy Olive at Noosa. Bob and David visited Queensland University on way to Sydney**

**Large View**

### 2.8 Conferences, Visits, Seminars

RWW conferences, seminars

1. Ada Conference, York Univ, January 86
2. Cellular Radio, London, February 86
3. Lecture to Sussex branch, IEE, February 86
4. USA, Various sites, October 85
5. China, SCIT, April-May 86.

Conferences attended by CPW

1. Conference on Software Engineering Environments, Lancaster University, April 1986 (Formal Methods Panel member).
2. Course on Domain Theory, Laboratory for Foundations in Computer Science, Edinburgh Univ, May 1986 (joint course tutor).
3. CADE-8 Conference on Automated Deduction, Oxford, July 1986.

ADBC visits include:

1. IFIP International Conference on Functional Languages and Computer Architecture, Nancy, September 1985.
2. Occam User Group, University of Kent, September 1985.

Conference attended by DRG:

- Software Engineering Environments, Lancaster, April 86.

MBS has attended the following conferences:

1. Programming Support Environments, Univ of Lancaster, April 1986.

2. OBJ Tutorial, Imperial College, April 1986.
3. CSP Tutorial, Oxford Univ, April 1986.
4. Domains, Edinburgh Univ, May 1986.
5. International Conference on System Arrays, Oxford Univ, June 1986.
6. International Congress, Automated Deduction, Oxford Univ, July 1986.

AJJD made the following visits:

1. Stirling University Computer Science department to install ERIL, demonstrate its use, and give a seminar on Equational Reasoning.
2. Two day tutorial on Domain Theory at Edinburgh in May 86.
3. One day workshop on OBJ, Imperial College, June 86.
4. Seminars on Artificial Intelligence in Software Engineering at Frieberg, Germany in June 86.
5. Eighth International Conference on Automated Deduction (CADE-8), Oxford, July 86, to present paper on narrowing.

Conferences and Courses attended by PMH

1. Functional Programming and Computer Architecture, Nancy, France, September 85.
2. Domain Theory Workshop Edinburgh Univ, May 86.
3. Technical Writing Course, Harwell, June 86.

### 2.9 Miscellany

#### 2.9.1 China

In April-May 86 RWW spent four weeks visiting the South China Institute of Technology in the People's Republic on behalf of the World Bank. RWW acted as an advisor to the World Bank's Chinese Universities Development Project which is investing some millions of dollars to improve China's academic computer science teaching and computing services. Whilst at SCIT, RWW gave a course of lectures on software engineering which are to form the basis of a new undergraduate course.

#### 2.9.2 Committees

RWW currently serves on the Computing and Control Division Board of the IEE and IEE's Software Engineering Action Group.

## 3. IKBS

### 3.1 Introduction

#### 3.1.1 Staff List

Current staff are as follows. They are referred to in text by initials.

- C J Pavelin (CJP)
- M B Dunn (MBD) (seconded from Central Office 3/86)
- M K Jackman (MKJ) (joined 11/85)
- C Y L Kwong (CYLK)
- A J Lucas (AJL)
- D F Mac Randal (DMR)
- G A Ringland (GAR) (joined from HEP 11/85)
- J W T Smith (JWS)

#### 3.1.2 Objectives

This section has three objectives.

1. Promotion and support of SERC's research programme in AI/IKBS.

   This is principally funded through the Alvey programme at present, so most of the work is connected with the coordination, management and technical support of Alvey/IKBS. We work very closely with the IKBS Directorate based at Millbank. As post-Alvey plans become clearer we would expect non-Alvey work to increase, and already some work has begun for committees of SERC's Engineering Board.

2. Investigate the application of IKBS techniques to other parts of the RAL programme. This is considered essential for the long-term needs of the Laboratory's scientific and administrative programmes.
3. Build up a small funded collaborative IKBS research programme. This is required in order to maintain the effectiveness of the technical support and coordination role. The general theme is knowledge representation.

### 3.1.3 Progress Summary

The support effort is going very well and the work has adopted rapidly to the changing nature of the requirements with the monitoring of the programme. The new staff appointments during the year have had a very significant impact on the effectiveness of Alvey support.

The R&D effort has suffered because of shortage of effort and the large learning requirements. However the group is now almost up to complement and the technical expertise has rapidly increased, we are in a good state to make progress over the next year.

## 3.2 Program Management and Support (CJP, MBD)

The Alvey programme has moved, during the period, from a phase of project selection to one where projects are running. Thus the RAL activity in helping coordination of proposals has moved to one of monitoring projects and setting up and running clubs. But the section takes on a vast number of support activities, only the more significant of which can be mentioned in this report.

The last major IKBS round was at the beginning of the year; CJP prepared the cases for the Alvey Board. Since then the group has set up all the IKBS-only clubs, and monitoring is almost totally under way; the arrival of MBD has proved crucial in this. SIGAI, organised by AJL and CJP has become very influential in setting standards for IKBS software, and in initiating new support initiatives. The mailshot under JWS's very active editing is regarded, by the research community, as a questionnaire showed, as a very valuable medium. To sum up, the Alvey IKBS support operation from RAL has been very proactive during the year: we believe this is appropriate for the highly directed Alvey IKBS programme.

In the IKBS/architecture area there is a problem in coordinating work at three different sites (RAL, Swindon and Millbank) on many different aspects of the programme. To combat some of the problems, monthly 'IKBS Management meetings' have been held involving all the key people in the programme. MBD has acted as Secretary to these meetings, which have served as a useful focus for providing early warning of problems and for ensuring a fairly rational distribution of tasks.

Among the plethora of tasks that flow from the IKBS Management meeting, it is worth mentioning that some work has been done on planning a revision of the original IKBS Architecture Study (the blueprint for the Alvey IKBS programme). The Laboratory took the lead in putting together the original study and it is likely that the revised plan will play a significant role in determining whether or not there will be life after Alvey.

### 3.2.1 Research Clubs

#### (1) Architecture Club (MBD)

A significant amount of time has been spent getting the Alvey Systems Architecture Club under way. The Club comprises those 23 projects funded as part of the (IKBS) Systems Architecture programme together with others (eg ANSA, Design to Product Demonstrator) with a major

architectural component. Projects range from the huge (eg FLAGSHIP, the most expensive Alvey project) to the relatively modest. Project descriptions were obtained from the project managers and bound to form the background to the first meeting of the Club held on 3 June 1986 at the Institution of Civil Engineers in London. Some 45 people attended. A Club Steering Committee has now been set up of which MBD the Secretary and Colin Haley (Director of External Technical Relations, ICL) is the Chairman, to plan future Club events. The Committee proposed that the next full Club meeting (probably in November) should focus on benchmarking new architectures as a theme, and plans are being made to set up various Special Interest Groups and workshops. Additionally, links are being established with the KBS, Logic Programming and High Performance Silicon Structures Clubs, which all suggests a fairly busy programme during the coming months.

**(2) Knowledge Based Systems Club (JWS)**

JWS has set up, and is Secretary of the KBS Club.

This has involved close liaison with the Alvey IKBS Directorate at Millbank and the Chairman of the Steering Committee.

Since the publication of information about the Alvey clubs in Alvey News there has been an increase in general liaison with the public and the press.

Four KBS Club Steering Committee meetings have been organised since last October, three at Millbank and one at Sussex University. A two day meeting of the full KBS Club was organised in January at Milton Hill House, near Abingdon. There were nearly sixty delegates from twenty-one projects. Eighteen papers were delivered plus other discussion sessions. A limited edition of the proceedings was also produced.

Preliminary arrangements have been made for another two-day Club meeting in January 1987.

Two open sessions and one closed session were organised for the Alvey Conference at the University of Sussex in June.

**(3) Logic Programming Club (CJP)**

The Logic Programming Club, comprising the Alvey projects in the Logic Programming Initiative and others interested, was set up in the middle of the year. Robert Worden (Logica) is Chairman. An initial business meeting was held in July; it is planned to hold the first technical meeting in late September at Imperial College. CJP is secretary of this club during the set-up phase.

### 3.2.2 Special Interest Groups (MBD)

As indicated under the Research Clubs heading, an important feature of the Club activities (arguably one of the most valuable aspects of Alvey!), is the formation of Special Interest Groups and the holding of technical Workshops in developing research areas. MBD has been responsible for ensuring proposals for SIGs/Workshops are technically respectable and serve a useful purpose, and for arranging their funding, dissemination of their results, etc.

### 3.2.3 Monitoring Alvey IKBS Projects

**Organisation (MBD)**

Now that the Alvey IKBS programme is essentially in place, the emphasis has switched to monitoring its success and the effectiveness of individual projects. MBD is responsible for completing the task of appointing Monitoring Officers (usually external technical specialists, in many cases from industry). The Monitoring Officers are contracted to ensure that projects involving substantial DTI funding (often projects costing a few Mpounds and involving several industrial and academic partners) are properly managed and achieve technical targets. With a few exceptions (eg where difficulties remain in starting the projects themselves) the appointment of Monitoring officer is now complete. What remains is the job of monitoring the Monitoring Officers. This is no trivial task and we shall need to ensure that the Alvey Directorate establishes appropriate systems to achieve value for money from its Monitoring Officers. In projects (mainly longer term ones) where

no DTI funds are involved, industrial 'uncles' have been appointed to steer the project in the direction of industrial relevance and to act as an interface with the Alvey Directorate. During the period covered by this report, contact has been made with all the uncles and the role expected of them, particularly in monitoring, has been more clearly spelled out.

**In-House Monitoring Effort**

In some cases the section supplies monitoring effort directly. AJL monitors one of the large Vision projects; CJP has just become Monitoring Officer for a Logic Programming Environment project, and monitors all the SIGAI contracts.

Related to monitoring is the Alvey representation required for the IKBS Community Clubs. MKJ provides this function for the RICS and WIESC Clubs this has involved attending Committee meetings and discussion with project staff.

### 3.2.4 SIGAI (AJL, CJP)

The Special Interest Group AI, supported and run from this section, has continued to meet over the year to advise the Alvey IKBS Director and SERC Committees on the Infrastructure requirements of the AI Community. A significant piece of work commissioned by SIGAI has been a contract with IST to investigate existing Prolog Benchmarking tasks to discover exactly what aspect of Prolog they are able to measure, and to propose a definitive Prolog Benchmark suite that SIGAI could endorse.

Arising out of SIGAI are a number of support and development Contracts which the section normally initiates, administers and monitors (CJP, AJL). The current set is:

- Prolog support at Edinburgh
- Lisp support at Edinburgh
- POPLOG developments (2 contracts)
- Prolog benchmarks (complete)
- Lisp developments at Bath (Computing Facilities Committee)
- KRSTL at Edinburgh

The latter is a Knowledge Based Toolkit Trials Laboratory, jointly funded with other facilities by DTI and SERC. The initiative came from SIGAI; CJP is on the DTI/SERC Steering Committee for the combined facility.

### 3.2.5 NIP (CYLK, AJL)

NIP, the New Implementation of Prolog from Edinburgh, is now complete. It has been distributed by RAL to 29 research groups for use on a large range of UNIX based systems. A range of utilities and tools developed on the DEC 10 at Edinburgh are distributed with NIP and are available independently over the networks for users of other Prologs.

Release 1.1 of NIP was received from AIAI at the end of January. This was unloaded onto the following machines:

- SUN2: fileserver, richard and harold
- VAX: rlvd
- Pyramid: rlya
- Atlas-10

The installation of NIP required a few alterations to a Makefile which determined where the NIP executable files were to be found after installation. Then they were compiled and linked (all with the supplied makefile) . The compiled binaries were then copied to the destination directories for general access. All but the Pyramid were relatively straight forward; the Pyramid was most frustrating due to compiler problems. (Similar problems have prevented a Whitechapel installation).

There have been two new releases of NIP. Release 1.2 arrived at the beginning of February and was successfully installed on the SUNs, VAX and Atlas-10.

Release 1.3 arrived at the end of April (24th) and has been installed on the SUNs, Orion and VAX.

Release 1.3 manuals were received from AIAI and 10 copies of these were made and set to various Prolog users within the Division.

### 3.2.6 POPLOG (CYLK, AJL)

The development of Poplog, the AI development environment, has continued with the improvement of the Lisp sub-system to the standard of Common Lisp (itself the de facto international standard). It is now commercially supported by System Designers on a wide range of computers. This commercial support is being made available to academics working on Alvey projects through special agreements with the University of Sussex, who are developing Poplog, and a contract between the SERC and System Designers.

POPLOG is run here; we upgraded from V9.2 to V11 during the period. It was discovered that V11 did not work under Release 3.0 of SUNs operating system, after all the Lab 11 machines had been upgraded to run Release 3.0. A SUN 2/50 (edna) which had not been upgraded was set-up in Lab 11 to enable POPLOG to run.

CYLK has incorporated additional modifications from Sussex, to enable POPLOG to be used from Cifer terminals.


**POPLOG Stand at the Alvey Conference, Sussex**

Large View

### 3.2.7 AI Software List (AJL)

The list of AI software that is available on Alvey Infrastructure computers has been updated 6 times this year to reflect the varying status of the software packages. This is published in both the paper mailshots and on the electronic IKBS Bulletin Board. Its impact on the community has been the increased demand for software especially developed for and packaged for the Alvey programme.

### 3.2.8 UK AI Toolkits (JWS)

Both SIGAI and the KBS Club have been concerned about the lack of any UK source of advanced IKBS toolkits seen as essential for the next generation of Expert Systems.

As a result of discussions at the January meeting of the KBS Club plus further meetings during the Alvey Conference it was decided to form a small group to consider the production of a UK AI Toolkit, both in the medium and long term.

JWS organised the first meeting at Systems Designers Ltd in August, and another is scheduled for mid-September. Although JWS attended only as an observer it was requested that he act as Secretary and Alvey/RAL liaison.

### 3.2.9 IKBS Mailshot (JWS)

As the result of a questionnaire sent to the subscribers the IKBS mailshot was reduced from 470 to approximately 360. However with the growth of interest in IKBS in general and Expert Systems in particular the mailing list has grown to over 400 again.

There have been four mailshots so far this year containing sixty-three items in all. Most were volunteered but some were solicited from various people including members of the Laboratory.

A new item was instigated. This is a list of new publications in the area of Expert Systems and Knowledge Based Systems. This list is based on an online search carried out by the library. This does require some additional clerical effort but it is hoped to automate the process in the near future by down-loading records from the remote database. The IEE, producers of the most important database in this area (INSPEC), have bean contacted as we need their permission to re-use the down-loaded material and we are awaiting a response.

In addition publishers have been contacted to request advance information on the latest publications in IKBS and AI. This has led to the possibility of including reviews in the mailshot as some publishers have sent us advance copies of new books.

There has been some contact with European organisations and JWS is currently negotiating with the editor of the ECCAI Newsletter to include it with the mailshot.

During the period covered the collation and mailing of the mailshot was placed with an external mailing company. This required an investigation of the company and a modification of the production procedures. Although this has caused some small delay in one case it has saved a considerable amount of clerical effort on the part of Laboratory staff.

### 3.2.10 IKBS Bulletin Board (JWS, AJL)

This is an electronic mailshot distributed through USENET and directly. It was set up by AJL, and JWS took over the running in June.

It has not yet achieved the impact we hoped for. JWS intends to increase both the size of the mailing list and the range of contents. This will involve more use of some of the Mailshot material including reviews and other articles. This will not lead to much duplication as there is little overlap between the readers of the Bulletin Board and the Mailshot.

### 3.2.11 Prolog Standards Meetings

CYLK has represented us on the BSI meeting since the beginning of September 1985.

### 3.2.12 Benchmarking Prolog (CYLK)

When the different machines were running NIP successfully, they were tested with a set of benchmark programs to have an indication to their relative performances. Also the other Prologs (POPLOG-Prolog, Quintus) were included in the test.

The benchmark suite used was that from Portland State University. These were written by students who were new to Prolog. The advantage of this was that there would not be any optimised Prolog code which might take advantage of certain aspects of different implementations.

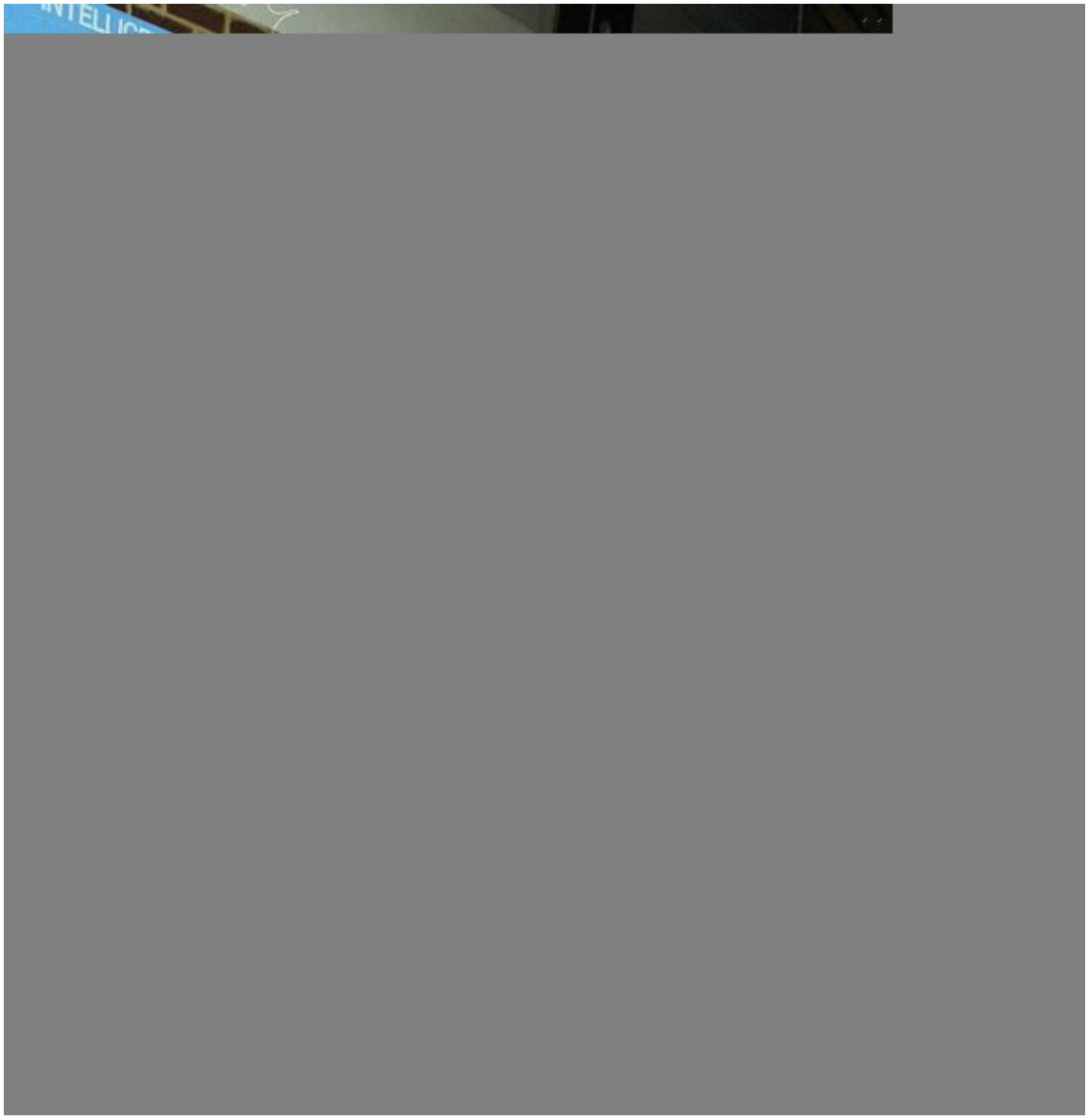
The benchmarks were run on:

- NIP: Atlas-10, VAX-d, SUN2
- Quintus: SUN2
- POPLOG-Prolog: SUN2

The results of these tests can be found in IKBS Technical Note 2.

### 3.2.13 Alvey Conference (CJP)

CJP was actively involved in the organisation of the IKBS demonstrations in this, contacting the projects, providing equipment and giving a summary to the visiting VIPs. (Tony Rush, RAL Administration Division, was responsible for organising displays.) CJP was rapporteur for two IKBS Club sessions, these write-ups to appear in Alvey News.



**Cliff Pavelin (centre) at the Alvey Conference, Sussex. IKBS Community Clubs Stand behind**

**Large View**


**Cliff Pavelin (right) at the Alvey Conference, Sussex. IKBS Community Clubs Stand behind**

**Large View**

**Alvey Conference, Sussex: Cliff Pavelin talks to Geoffrey Pattie, Rob Morland, Alvey VLSI Director looks on**

**Large View**

### 3.2.14 Equipment/Infrastructure

Responsibility for SUN purchase etc moved into DIC with Peter Kent, although CJP has been much involved with allocation of IKBS infrastructure systems. The major central purchase has been 7 ICL Series 39 machines for some major architecture projects. This involved the usual end of financial year scramble. AJL has continued to be responsible for Whitechapel loans.

**IKBS SUNs waiting to be tested, software loaded and shipped**

**Large View**

The section (indeed the group) relies heavily on the services of DIC group to provide the basic system and infrastructure support. However certain products used by the section are looked after by section members. MKJ is responsible for looking after our IBM PC software, and has produced a folder for the IBM PC XT. NIP and POPLOG are used within the group and provided by AJL/CYLK.

### 3.3 Research and Development

The group has the objective of increasing its R&D capability by building up a funded research programme and by embarking on IKBS applications within the Laboratory. These activities are at an early stage at present.

#### 3.3.1 Paralfex (GAR, CYLK)

The PARALFEX (Alvey IKBS approved proposal 077) formally started on 1 November 1985. The goals of the project are to take a real-world knowledge base (KB) - (in the first instance provided by the ALFEX community club) and

1. segment the knowledge source to facilitate the modifiability and functional transformation of an expert system

2. to identify different problem solving strategies in the financial sector.

Effort on the project so far has been divided into approximately two halves:

i. Setting up the advanced AI-toolkit, ART, on the Symbolics and investigating its applicability to our problem. This has progressed satisfactorily.
ii. Investigating the ALFEX market assessor expert system. Here progress has been less satisfactory. The original plan was based on the delivery of a large working knowledge base from ALFEX in February 1986. This did not happen and we had considerable difficulties with a buggy and unstable KB. The final release of the ALFEX market assessor is now targeted for October 1986 and we intend to have results by January 1987.

We also have an expert loan advisor, based on the knowledge elicitation transcripts provided by the contractors. This was built into an expert system using the shell Savoir (by GAR) and works. We are working on this knowledge base prior to receipt of the market assessor.

GAR was appointed to the Steering Committee of the ALFEX Community Club. A project summary of PARALFEX was submitted to the first Alvey Knowledge Based Systems Club meeting, and invited talk was given at Expert Systems '85. A position paper was submitted to the Surrey workshop on Explanation and subsequently an invited position paper was given at the workshop.

**Gordon Ringland (left) at the Expert Systems Community Club Stand at the Alvey Conference, Sussex**

**Large View**

A Symbolics 3670 and the ART Knowledge Based System were installed to a functional level with the help of CYLK.

### 3.3.2 Intelligent Front Ends (DMcR)

This is a collaborative project with the University of Strathclyde.

It is proposed to develop an interactive front end to converse with the user in the appropriate terminology, understand what analysis they require, and drive a back-end, in this case an energy simulation program, to obtain the relevant information. The proposal was rejected by the SERC Environment Committee in the April round, but with encouragement to rework and resubmit. This is being done.

### 3.3.3 Travel Regulation Expert Systems (JWS, MKJ)

To gain familiarity with both shells and to compare different Expert System techniques, two attempts have been made to build a system to advise on the SERC Travel Regulations.

MKJ wrote an Expert System with about 220 rules on a section of the Conditions of Employment Memorandum (claiming travelling expenses). This used the Expert System shell Xi. A full report will be written on this.

JWS is taking another approach using the ESP Advisor shell - the full version of this was obtained after using it in the Alvey starter pack. As the full text of the Travel CEMs is available on the IBM3081 a novel full text database plus expert advisor system is being developed. Although originally envisaged as a comparison with the application of the Xi shell to the same problem this approach (provisionally called Interactive Annotation) is so different that it cannot be directly compared. In this approach the user is shown the relevant text from the CEM and then asked if a dialogue is required to clarify it. This dialogue takes the form of a series of questions and a final decision on the applicability of the rules contained in the text to the users current problem.

### 3.3.4 Scheduling EBL Facility (MBD, CJP, GAR)

Another trial exercise arose from discussion with Technology Division, and was used particularly to give CJP and MBD more Prolog familiarity. It was a planning task concerned with the scheduling of the EBL machine. A 'core program' was written by CJP using a very simple algorithm for comparing jobs in a job queue; it was written in (Edinburgh) PROLOG, which proved its worth as a tool for writing elegantly brief logical conditions and its disadvantages in trying to understand control procedures. MBD extended the program to cover the characteristics of real job queues on the EBL and, in the process, have had valuable experience of the SUN workstations and PROLOG. The problem is interesting in that a simple algorithm seems to work quite adequately whereas a 'true' AI approach leads rapidly to a combinatorial explosion and the need for heuristics elicited from the expert human schedulers. Sadly this has become a solution in search of a problem because the introduction of a new Electron Beam Lithography facility has eradicated job scheduling problems!

Some work has been done on identifying fruitful areas for the application of expert systems in administration in the Laboratory and these will be pursued further.

### 3.3.5 Internal 'Knowledge Representation' Club

GAR formed and coordinated this research club internally, attracting interest outside the section. It consists of a series of meetings with talks from participants on a certain KR theme.

GAR persuaded most participants in the Knowledge Representation Club to agree to write up their contributions for inclusion in a book. Currently he is negotiating with a publisher to produce an introductory text on Knowledge Representation from the IKBS/MMI Group.

Talks so far have been:

- Introduction: GAR
- Object Oriented Programming: ASW
- Semantic Networks: DMcR
- Rule Based Systems: ASW
- Frame Based systems: GAR
- Logic in KR: CJP
- Dreyfus on the Limits of AI: JWS
- Lehnert - Understanding Narratives: MKJ
- Representation of Time: CYLK
- Computational Tractability: ASW

These have been most valuable in improving the technical awareness of the group.

GAR and DMcR are organising a workshop/topical research meeting to look at the field of knowledge representation. This will take place in December. The topics for consideration include logics of knowledge and belief, temporal logic, qualitative reasoning and deep versus shallow knowledge.

### 3.3.6 Internal Natural Language Group (MKJ, DMcR)

MKJ has been responsible for initiating a natural language group. Part of this has involved getting trainees and sandwich course students in order to initiate the building of some systems. MKJ has supervised Arif Hussain (a trainee) who has now implemented three programs in common lisp illustrating various aspects of natural language understanding. MKJ also supervises Owen Benson who is implementing a more complex natural language understander. This uses Sowa' s conceptual graphs as the basis of the approach.

DMcR supervises two students who are examining Prolog databases, with the intention of devising a query language based on conceptual graphs. The intention is to use the students to lay the foundation for a serious research proposal sometime next year.

The work conducted so far has allowed us to come to grips with some of the fundamental problems of language processing. As a result we know have some ideas for a project (based on the idea of parallel processing systems) . RSRE have shown some interest in these ideas and MKJ is currently pursuing the possibility of funding from RSRE. Also, MKJ has established some contact with the psychology department of Reading University who are interested in submitting (for external funding) a joint proposal on natural language.

## 3.4 Other Work

### 3.4.1 IPSE for Energy Modelling Community (DMcR)

DMcR has been involved with the SERC Building Committee's initiative to develop an IPSE for the Energy Modelling Community. This involved supplying expertise for the proposers, and a trip to the USA to discuss the American equivalent with the people at LBL. It is hoped that this will lead to a significant research project at RAL.

### 3.4.2 Environment Committee AI Facility (CJP)

The Engineering Board Environment Committee has asked RAL to set up and run for it a small facility of AI systems to be made available to its research community for short term trials. It is to consist of (a) an IBM PC plus expert system shells, (b) a standard SUN with LISP, Prolog etc, (c) a machine to support the advanced toolkit KEE. JWS is responsible for (a) and is setting this up. CJP has sent out an operational requirement to workstation (mainly LISP Machine) suppliers for (c), and has asked Edinburgh to assist in the evaluation.

### 3.4.3 AISB Quarterly - Reviews Editorship (JWS)

After attending the AGM of the AISB, JWS has been appointed Reviews Editor for the AISB Quarterly. This should help raise the profile of RAL as a centre for AI research.

### 3.4.4 Demonstrations - CHAT, PRESS (AJL, CYLK)

There are now demonstrations of AI techniques available which can be run by any member of the group. They have been used on visiting parties of school children and VIP's.

They involved getting CHAT and PRESS to run on POPLOG which has a few minor syntactic differences from C-Prolog. Both the demos were originally for C-Prolog. Also they were modified to run under NIP. The demos were therefore targeted to be run under C-Prolog, POPLOG, NIP and Quintus prolog. This was achieved but there were still some problems.

In CHAT, not all the questions in the supplied demo files were satisfied. This was closely examined and with a little help from MKJ a couple of bugs were identified. further work by CYLK subsequently solved all the bugs and got all the supplied demo questions answered. Also, one or two additions have been included to correct inconsistencies. CHAT knew about American, African, Asian, etc but not Australasian. This has been corrected.

In Press, there is a lot of sample input to the system and not all of them are answered. It is not known if the building and design of PRESS is good enough to handle ALL the A-level questions that are in the demo files.

The state of both these demos is that now anybody can log into a machine in Lab 11 using the id - ikbs with password - demo, and run them by typing chat or press.

## 3.5 Staff Changes

Peter Kent moved to DIC group and Andrew Smith left to do a PhD at the very beginning of the period. Since then there has been steady growth (see 3.1.1).

In addition new recruits joining at the end of the period are:

- S C Lambert
- B Bainbridge
- M D Wilson

GAR wrote the advert and took part in a successful recruiting exercise which has led to three more recruits for the section joining shortly.

## 3.6 Future Programme

### Coordination/Support

Much of this work will continue as now, with rather more emphasis on research clubs and monitoring. A major new initiative is expected to be the revision of the IKBS strategy. The After Alvey plans are likely to become much clearer over the next year, and it is hoped that the IKBS section can have some involvement in them. The environment committee AI facility should be under way.

### Research & Development

It is hoped that the funded research effort increases. The current firm plans are:

- Follow up to PARALFEX (expert systems architectures)
- Intelligent front-end proposal
- Collaboration on expert systems with ICRF

It is planned to explore the area of knowledge representation further with an implementation of (part of) Sowa's conceptual studies; this could unify some of the above project and the natural language interest of the group.

In-house applications are still at the purely exploratory stage.

### 3.7 Publications

A large amount of paper is produced in connection with the support role, eg SIGAI papers (CJP, AJL) , Alvey Board papers (CJP), IKBS Management meeting (CJP, MBD) , Mailshot (JWS etc), Alvey Infrastructure Committee (CJP) and four series of IKBS notes within the group.

#### Technical Notes

Those with some external impact are as follows:

1. Prolog Benchmarks (CYLK): SIGAI paper
2. The Application of IKBS in Building Design (DMR): SERC grant proposal
3. PARALFEX: Research into Expert Systems in the Financial Sector (GAR). Proceedings of Alvey IKBS Workshop on Explanation Surrey, March 1986.
4. UK IKBS research programme (CJP). Proceedings of SEAS Spring meeting Heidelberg, April 1986.

### Conferences and Visits

1. Workshop on Expertech Xi, (MKJ)
2. Alvey KBS Club meeting, January 1986, (MKJ,JWS, CJP, GAR)
3. ECAI Brighton, July 86 (MKJ, DMR, GAR, JWS)
4. Explanation Workshop, March 1986, (GAR)
5. AI in Engineering, (DMR)
6. Trip to California to Discuss Energy Modelling, (DMR)
7. Symbolics User Group Meeting, Washington, (GAR)
8. Hanover Fair, March 1986, (GAR)
9. Hanover for discussions at University, January 1986, (CJP)
10. SEAS meeting, Heidelburg, April 1986, (CJP)
11. Alvey Conference, Brighton, July 1986, (CJP, MBD, GAR, JWS)
12. Alvey Computer Vision and Interpretation meeting, September 1985 (CJP)

## 4. MMI

### 4.1 Introduction

Overall the section aims to contribute to the general area of Human-Computer Interaction, both by direct research and development activities, and by support for relevant research work elsewhere. These aims are supported by the following means:

1. Support of the Alvey MMI (primarily the Human Interface) community. The relationship between the section and the MMI Directorate is not nearly so close as for the SE and IKBS activities, however.
2. Research and development, primarily in the window management/user interface design areas, again on behalf of the MMI Directorate.
3. Investigation of the more advanced techniques of possible use to the SERC Common Base programme, funded by the Engineering Board's Computing Facilities Committee.
4. Direct research grants from Engineering Board committees via the usual (not the) RG2/peer review route.

The section membership has remained relatively stable over the year, with the exception of the two Janets (Haswell and Malone) who transferred to the SUS Applications section, leaving an all-male (but not chauvinist) MMI section. Tony Conway, a psychologist from Bristol University, joined in January. Helen Jenkins joined the group in January and acts as secretary to the section. C M Crampton ably managed the SO to HSO transition through the Group C promotion mechanism at the first attempt the system does seem to work sometimes!

Staff currently in post:

- Ken Robinson (KR)
- Tony Williams (ASW)
- Tony Conway (TC)
- Damian Mac Randal (shared with IKBS) (DMR)
- Mark Martin (MMM)
- Keith Dancey (KGD)
- Chris Crampton (CMC)
- Arthur Seaton (AJS)
- Crispin Goswell (CAAG)

**Tony Williams and a PERQ2**

**Large View**

### 4.2 Window Management

The book of the Workshop on Window Management held at Coseners in April/May 1985, was finally published in January 1986. Partly as a consequence of the Workshop, but also after much chivvying of the MMI Directorate, approval was obtained from the Alvey MMI Directorate to proceed with this project. The objective of the project is to specify the software interface between graphical applications and window managers. and to implement the interface on selected workstations.

Graphical applications which use the interface will then become portable to all workstations which provide it. This will accelerate production of applications with good quality user interfaces, and increase the availability of such software.

Following several rounds of refinement of the specification, and comments by the participating manufacturers, a version has been distributed to some potential users for their comments, prior to distribution throughout the community. Work has commenced on the design of window systems providing the CSI, to be implemented on the ICL Perq and SUN workstations. The team is experimenting with software providing terminal emulation and layout management services, which will ultimately be provided along with the CSI. A comparison of the CSI with the X window manager developed by MIT's Athena project is under way. X is beginning to emerge as a de facto standard for Unix workstations in the USA, despite its limitations.

ASW, CAAG, and CMC are carrying out this project. FRAH and KR have been involved in the discussions also, with further comments from most of the section. An eye has also been kept on the budding standards activity in the USA.

### 4.3 WW - Graphical Toolkit

The graphical toolkit, WW, designed to facilitate the development of highly interactive software, has been substantially enhanced by the addition of new facilities at several levels of abstraction, mainly by MMM. These include, at the lowest level, primitives for circles, bitmaps and cursors; at an intermediate level, support for icons, text manipulation, and external files representation; and at the highest level, a full terminal emulator, interactive filename and directory selection, etc. The complete package has been ported onto most of the workstations available in the Division. The screen editor SPY and the file transfer utility PUFTP have been rewritten to make use of the new facilities.

A utility, MON, for monitoring system activity was written last year for the Perq by CMC using WW. MON has since been ported to the Whitechapel and SUN. An early version was given to ICL, and a more recent version was distributed on the RAL floppy with the PNXS/SR release, as was TED (written by AJS), a graphical time editor also built on top of WW. It displays an analogue clock face and a calendar, so that the user can set the time and date using the mouse. It is intended to genera1ise these and incorporate them into WW.

In order to allow conventional engineering applications built using a mainframe/plotter philosophy (GKS level 0a) to be easily converted to a single user workstation, it was decided to develop a minimal subset of GKS which would reside on top of WW. Since the intention is to aid conversion, not to offer an easy porting path, adherence to the defined GKS levels was not considered essential. However, as far as practicable, the level 0a subset of GKS will be provided. An initial specification has been produced and KGD is doing the coding.

As a full-scale test for the graphical toolkit, WW, it was decided to build a form fill utility. This will handle dynamic, multi-mode forms, allowing the user to input, in any order, to the defined fields. These fields may be text, numeric (integer or real), buttons (eg on/off toggle), popup menus, special (eg date, filename). Data verification is carried out by the form utility, to application - supplied criteria. The form will also be dynamic, that is, the input of a value to one field may cause other fields to (dis)appear, or change their contents. Currently, coding is at an advanced stage. Although the design received comments generally from the Section, most of the design is the work of DMR, AJS and KGD; AJS is doing the implementation.

### 4.4 PostScript Interpreter

PostScript is a general-purpose programming language, incorporating a powerful set of graphics functions. It is used for description of printed documents, and for communication between document formatting systems and printing systems such as laser printers and typesetters. PostScript was developed by Adobe Systems Inc in the USA, and while the language definition is publicly available, implementations are not.

This project has produced an interpreter for PostScript, which runs on several workstations, and produces images of the document on the display. The interpreter implements the full language, and

almost all of the graphics functions. A version has been sent to several user sites for testing and evaluation.

PostScript printers can only produce bilevel output, and use half-tone techniques to simulate colours or grey shades. This interpreter has successfully been used on a greyscale display. Additionally, an experimental distributed processor version permits the language interpreter to run on a different processor from that driving the display.

CAAG wrote the interpreter. He has written a paper about it for the BCS conference on Workstations and Publications Systems, but acceptance has not yet been notified.

### 4.5 Coordination

The Alvey MMI Mailshot, which has CAAG as the coordinator, is now well established with nearly 2000 subscribers. Three issues have been generated (on a quarterly basis). The contributions to the mailshot come from the four Alvey MMI areas (Human Interface, Image Processing, Speech Processing, and Displays). Each of these areas is intended to have an editor who stimulates, collects and vets contributions; however the HI area as yet lacks such a person and the work is undertaken by RAL.

AJS has been working on the establishment of a Who's Who in the MMI areas. After initial experiments with shell scripts, it was considered necessary to use a real database to handle the volume and complexity of the data required. Accordingly, a system built round the INGRES relational database package was designed and implemented. A simple front-end has been written for end-users. The data collection form was redesigned and the data input partially automated. KGD is responsible for arranging the final form layout (following comments from a group of guinea pigs), and for distribution and data entry.

The Videotape library, managed by CMC, is established, but mainly consists of the SIGGRAPH tapes very few videotapes seem to be available from the community at large. Obviously encouragement is needed to spur investigators into recording real usage of their newly-designed interfaces. KGD has also acted as secretary to the Human Interface Club Committee. As well as organising meetings of HICC (sic) and the writing of minutes and so on, articles have been prepared for Alvey News (one of which received the black hole treatment at Millbank). A one-day seminar on Evaluation was organised at the LSE, attended by 57 people from 31 organisations. Latterly the HICC has been a somewhat moribund organisation following a number of resignations (including the chairman!).

### 4.6 Common Base Programme

MMM has spent some time implementing SPY and WW on the (never-announced) ICL Perq3. Following ICL's withdrawal from the SUS manufacturing scene, the results of his labours are unlikely to see the light of day (in a commercial sense at least).

CMC was involved with the PNX-5 field trial which finished late in 1985, and ten days were spent at ICL Kidsgrove validating PNX-SR during October. Some liaison with the PBC at ICL has been necessary since. A paper was produced describing the success of the validation.

The official AT&T release of C++ has been brought up on a Vax, and ported to the Perqs, the Pyramid and a GEC-63 at Edinburgh (C M Crampton). Bjarne Stroustrup, the designer and implementer of C++ at AT&T, has been advised of all changes made in order that later versions can be made more portable. Bjarne Stroustrup visited the Laboratory in August, and gave a seminar on What is Object-Oriented Programming?.

Several Perqs have been united with an ethernet and the Perq Newcastle Connection software tried. CMC has also been working with Robert Stroud from Newcastle on adding and testing his UDP driver for the Perq. This is now working sufficiently well that two way communications (via ethernet) are possible between Perqs and VAX and SUN machines (CMC and CAAG).

CMC has also established the ICL tape streamer on the ethernet, and configured the Perq fileserver so as to be useful (since ICL didn't!).

KR has attended meetings of the Single User System Interim Management Panel after handing over the CBP Management to JRG in November, as well as other meetings where a good memory for early events in the Programme was needed!

### 4.7 SPP in the Foundations of the Design of Interactive Systems

At the end of October 1985 the Computer Science Sub Committee decided to invite proposals for Specially Promoted Programmes, one of which was to be in some aspect of HCI. For a variety of purely administrative reasons, the agent appointed to prepare the proposal - William Newman was not appointed until just before Christmas. He set up a small panel consisting of M A Norman (Heriot-Watt MMI Unit), M J Underwood (MMI Directorate) (later N Bevan, and later still M Tainsh), and FRAH and KR from Informatics. After soliciting contributions from the community, the panel produced a draft proposal (also supplied to the February meeting of CSSC) for consideration at a Workshop held at the Abingdon Guildhall in March. The Workshop, which ASW and TC also attended, was very successful and a good proposal was prepared. At present the proposal is working its way through the funding mechanisms. Competition is stiff and there is no guarantee that the SPP will see the light of day. Nearly all of the Panel support, including the Workshop organisation, was the responsibility of KR [although H Jenkins did most of the work:-)].

### 4.8 Research Proposals

A proposal to develop a document preview system on a greyscale display was put before CSSC, who so far have been unenthusiastic. The proposal involves developing and evaluating (both for legibility and fatigue aspects) anti-aliased line generation algorithms, using a PostScript implementation on the HLH Orion. Both static and dynamic effects are to be investigated. KR and M Pitteway (Brunel) have written the proposal, with the help of comments from FRAH, , TC and ASW mainly. CAAG has implemented an initial version of PostScript on the Orion in Lab 11.

Following discussions and drafts prepared in the MMI Section, a number of outline proposals for both short and long term projects were developed. Two of these are to be submitted to SERC Committees for funding one on Extensible Graphical User Interfaces, prepared principally by ASW. The other, a joint project with the Chemical Engineering Department of Leeds University, is being prepared by TC and KR, on the use of advanced graphics techniques in a complex, multi (>3) dimensional CAD problem area - chemical plant design.

### 4.9 Other Developments

As usual, a number of things don't fit too well elsewhere and are treated here.

#### 4.9.1 Finite Element Post Processor

A post-processor for a finite element package is being developed to demonstrate the improvement in the user interface made possible by using single user graphical workstations. A specification of the system has been produced by DMR and a start made on the necessary infrastructure. However, progress has been rather slow due to too many other commitments.

#### 4.9.2 Intelligent Interfaces

In this area, there are strong links to the IKBS section's Intelligent Front End proposal. Also, there is a collaborative project with IKBS (M K Jackman) and SE (A J J Dick), and involving 4 students (0 R K Benson, J Barnsley, A Hussain, K Tarling), looking at natural language understanding. Two have already produced a system for text understanding, based on Schank's conceptual dependencies, and are looking at Sowa's conceptual graph formalism. The other two are looking at Prolog databases, with the intention of devising a query language based on conceptual graphs. It is hoped

that this work will lead to a serious research proposal some time next year. DMR and 'TC are involved in this area.

### 4.10 Future Developments

1. Longer-term development work for the SUS programme;
2. Continuation of the coordination and support work for the Alvey MMI Directorate;
3. Further R&D developments in the Window Management area for the MMI Directorate;
4. Research projects (given funding) described in the previous section.

### 4.11 Publications

1. F R A Hopgood, D A Duce, E V C Fielding, K Robinson, A S Williams, (eds) Methodology of Window Management, Springer-Verlag, 1986.
2. A S Williams, C M Crampton, C A A Goswell, Unix Window Management Systems, Client-Server Interface Specification, RAL-86-?, August 1986.
3. A S Williams, An Architecture for User Interface R&D, IEEE Computer Graphics & Applications, Vol 6 No 7, July 1986 pp 39-50.
4. C Prosser, K Robinson, A S Williams, An Operational Requirement for Assessing Single User Systems, RAL-86-028, April 1986.
5. K Robinson, Evaluation of Single User Systems, RAL-86-050, June 1986.

### 4.12 Conferences

1. Workshop on SPP in the Foundations of the Design of Interactive Systems, The Guildhall, Abingdon (organisation by HJ, TC, ASW, FRAH, KR).
2. October 1985 meeting of ANSI X3H3 committee and window management subgroup (ASW).
3. IEEE Conference on Workstations, November 1985 (CMC).
4. ACM Conference on the History of Personal Workstations, January 1986 (ASW).
5. Denver Usenix Conference, January 1986 (ASW).
6. Third meeting of the Object-Oriented Programming Society, March 1986 (CMC).
7. Atlanta Usenix Conference, June 1986 (CAAG).
8. Eurographics Conference, August 1986 (ASW).
9. BCS Electronic Publishing Specialist Group (ASW - speaker on PostScript).
10. IEE MMI Special Interest Group (ASW speaker on Window Management).
11. CHI '86, Boston, April 1986 (TC).
12. SIGGRAPH, Dallas, August 1986 (KR).
13. Eurographics 86, Lisbon, August 1986 (ASW).

## 5. DISTRIBUTED INTERACTIVE COMPUTING - ALVEY INFRASTRUCTURE

### 5.1 Introduction

### 5.1.1 Objectives

The objectives of this project are

1. To provide a computing infrastructure for Alvey projects in IKBS, MMI and SE Directorates. This includes managing the project, supporting users, and developing Unix-based systems and communications.
2. To provide and operate an in-house Unix service both to support local users and as a test bed for software and hardware developments, particularly in the areas of distributed file systems.

### 5.1. 2 Overview

The project has reached a level of maturity, with people actually using the machines. The implementation phase is now complete, but development of local area communications will

continue. Funding of the current machines is assured until March 1989 and discussions have started on the evolving role of the Infrastructure into the post-Alvey period.

The main components of the infrastructure are 11 GEC 63/40s and 5 Systime VAX 8750s located at:-

- Cambridge: 2 × GEC
- Department of AI Edinburgh: GEC and VAX
- ERCC: 2 × GEC
- Essex: GEC
- Imperial College: 2 × GEC and VAX
- Newcastle: GEC
- Oxford: GEC and VAX
- RAL: VAX
- Sussex: GEC and VAX

The only change this year has been the move of a GEC from UMIST to Cambridge.

The GEC 63/40s are now running a version of AT&T Unix System V, Release 2 and the VAXes BSD 4.2 A DEC VAX running ULTRIX and an AT&T 3B2 running the reference version of AT&T System V were installed at RAL during the year.

The Infrastructure Project is also responsible for providing a Unix Service on the Atlas-10 mainframe, for supporting over 100 SUN workstations and, since August, for running the Alvey Mail machine.

It will be clear from what follows that the Infrastructure is heavily committed to Unix systems and their communications requirements. The following systems are either fully supported, or impinge on the work of the project:

| | |
|---|---|
| VAX | BSD 4.2 (to be upgraded to 4.3)<br>ULTRIX<br>SYSTEM V 2.0 |
| IBM | UTS/Version 7<br>UTS/System V 2.0 |
| 3B2 | System V 2.1 (to be upgraded to 3.0) |
| GEC | UX63 (Sub-contracted to ERCC) |
| Pyramid | BSD 4.2/System V (for ECF) |
| Prime | PRIMIX (Benchmarking/evaluating for ECF) |
| SUN | BSD 4.2 (for Common Base Programme) |
| PERQ | PNX and PNX/SR (for ECF) |

The variety of systems in this list demonstrates how far we are away from a single, universal operating system. It also gives a hint at the problems of providing leading edge local area network facilities both on this site and all the other sites around the country.

### 5.2 Management

Ken Hartley (KFH) took over as project manager on his arrival, with Eric Thomas (RET) handling all the development work and Cyril Balderson (CB) responsible for site contracts and operational matters. KFH is also responsible for the formal link with Millbank through the Alvey Infrastructure Steering Committee, of which Bob Day (RAD) is the secretary, and the Alvey/GEC Implementation Project meetings. CB attends meetings with ERCC and GEC on operational issues (GECOPS) and RET meets with ERCC to discuss GEC support. Site Managers Meetings are organised by Ines Vollmer (IV) and attended by half the Division.

As well as the systems out in the field there is a growing in-house Unix service. The service evolved as systems were acquired but during the year it became clear that a service was being provided which needed the kind of management associated with a mainframe. Consequently a Unix Support Office was established, run by Brian Alston (BAA) and Martin Loach (MJL) , and Systems Administrators appointed: IV for the VAXes and Andy Jackson (AMJ) for the Pyramid and for the LAN service; Tony Lowe (ABL) is responsible for the hardware of the ID LAN.

Towards the end of the year KFH carried out a survey of equipment being used by Alvey projects, on behalf of Keith Bartlett. Janet Smith (JRS) entered the two hundred responses into an INFO database designed by CB. Analysis of the results is not yet complete.

### 5.3 UNIX Systems

#### 5.3.1 UTS

Francis Yeung (HKFY) and Neil Calton (NBMC) have been working on UTS, the UNIX system which runs on IBM mainframes under VM. At present, there are two versions. UTS 2.3 is UNIX Version 7 compatible, and has been running as a service for some time. UTS/V is a UNIX System V compatible version, which was received at the start of the year.

The current UTS service runs on the Atlas 10, in competition with MVS. Users have found that it does indeed provide powerful UNIX facilities, once the problems of the IBM interface have been overcome. However, it is proving difficult to come to some agreement with CCD on the method of accounting: both the actual algorithm and the parameter values. In addition, various attempts by CCD to improve the performance of MVS have had considerable adverse effects on UTS. UTS/V will provide a much better service. The local modifications have been included, and CPROLOG has been successfully tested (with the help of A J J Dick). However, the main stumbling blocks to introduction of a service are Franzlisp and the IBM 4705 controller. The old Franzlisp will not run under the new UTS, and we do not have the source. We have been trying for many months to buy a version for UTS from Franz Inc in the USA, but have run into contractual difficulties. The 4705 is the new communications front-end for the IBMs. One of the advantages of UTS/V is its ability to handle full-duplex ASCII terminals (UTS 2.3 really only works with IBM 3270s). This will allow editors such as vi or emacs to be used. New software is required in the 4705, which has only just come into service. CCD hope to mount this software later this year.

#### 5.3.2 Text Processing

NBMC has been working on three projects in this area: implementing a 6670 backend on UTS, providing support for the 4250 on UTS and VAX, mounting and testing Transcript on VAX and Pyramid.

The tolaser program has been enhanced to allow greater control of output from the 6670 laser printer by the user. Facilities for printing manual pages and obtaining output in a variety of fonts have been provided and will be extended.

NBMC has now assumed responsibility for maintenance of the code produced by Liz Fielding for obtaining titroff output on the 4250 erosion printer. A second 4250 has been obtained and installed in R1. Following discussions with CCD, it was agreed that Informatics should be responsible for the virtual machine which drives this. NBMC has improved the user interface for the software, provided documentation and also given access to the 4250 from the SE VAX (as well as from UTS). NBMC has installed and tested the Transcript software package on the VAXes. The system transforms UNIX documents and graphics files into Postscript format. The package has also been installed on the Pyramid where its full usefulness required the porting of the titroff software. This was done, to the extent that it exhibited the same bugs on the Pyramid as it did on a VAX! Access has been provided from all these machines to two Apple LaserWriters, enabling good quality documents to be produced. Two papers have been written; the first outlines the available software and how to use it, and the second provides a font catalogue for Transcript on the LaserWriters.

#### 5.3.3 VAX

There have been various upgrades to the existing VAXes during the years, mostly to the discs. In addition, the old PDP 11/70 was upgraded to a VAX, leaving only a couple of peripherals from the original. One of these, the tape deck, is proving unreliable, and is likely to be replaced. This machine is being used to study Ultrix, the DEC supported version of UNIX.

A DEC Delua ethernet controller has been ordered for the Ultrix VAX. This is a new product, which, apart from making the machine 100% DEC, will offer better performance than the Interlan controller. The major changes to the system have been the conversion of the SE VAX from BSD 4.1 to BSD 4.2, and the incorporation of a considerable number of bug fixes received from Mt Xinu. The former required the porting of the titroff suite to BSD4. 2. In addition, much effort was expended in preparing for, and solving the problems caused by, the move of the VAXes to R1. As well as the VAXes in house, the team is responsible for the support of the Alvey Infrastructure VAX network and the ECF VAX at Strathclyde. Most of the support work is done by Simon Frost (STF) , with help from Jim Aitken (JRA) and Ian Harding (IH). Bugs are usual

Informatics
Informatics Department

# Informatics Annual Reports



## Informatics Annual Report 1986-7

## 1 INTRODUCTION

The Annual Report covers the year ending September 1987. Its main purpose is for internal use in the Division, indicating what has been achieved and by whom. Hopefully it also gives new members of the Division some idea of the work programme and its objectives.

The main responsibility of Informatics Division is to support SERC' s Engineering Board's activities in the information systems and CAD areas. This splits into two main areas:

1. Computing Facilities Committee: CFC provides an infrastructure support to the various Engineering Board subject committees. Applications software of interest to more than one committee is supported centrally. The Committee is establishing an Engineering Applications Support Environment (EASE) which provides support from the application level down to the hardware that it runs on.

   A recent initiative has been to provide support for transputer related activities in the university and industrial environment.

2. Alvey: The Alvey Programme started in 1983 and was aimed at providing a significant impetus to cooperative, pre-competitive research in the enabling and underlying technologies of Information Technology. The Division has been responsible for the development of a hardware and software infrastructure for the IKBS, SE, and MMI areas. This started in 1984 providing multi-user system support via a distributed set of GEC Series 63 and SYSTIME VAX systems. More recently support has also been provided for SUN systems.

   The Division also provides coordination and support in the areas of IKBS, MMI and SE.

   A third major interest in the Division is:

3. Research: Research projects exist in the areas of IKBS, MMI, SE, VLSI and CAD. Funding comes from three main sources, the Engineering Board Committees, the Alvey Programme and the European ESPRIT programme.

The Division's aim is to keep a good balance between the research, development and support activities believing that omitting anyone area weakens the overall quality of the Division's expertise.

The internal organisation of the Division has changed significantly during the year. At the start, the Division comprised three Groups:

1. Software Engineering: R W Witty (deputy D A Duce)
2. IKBS/MMI: C J Pave1in (deputy K Robinson)
3. Distributed Interactive Computing: K F Hartley (deputy M R Jane)

The Applications activities of CFC were part of Technology Division, as was the support for the Image Processing and Speech/Vision part of the Alvey MMI activities.

During the year, a number of major changes have taken place which has meant several reorganisations. It is hoped that the instability of the current year will not be repeated in future years. The major changes have been:

**Rob Witty, the new Alvey Software Engineering Director, in his Millbank Office, September 1986**

**Large View**

1. R W Witty: Rob Witty was made Alvey Software Engineering Director in August 1986 and continued in that role until the beginning of 1987. In April 1987 he left for a one-year sabbatical at Xerox PARC. After several years managing IT Research, this is aimed at giving him an opportunity to get up-to-date in his research areas.

2. C J Pavelin: In July 1987, Cliff Pavelin decided to leave the laboratory to take up a post with Active Memory Technology, the company that markets the mini-DAP.
3. Computer Applications Group: As part of a general reorganisation in the Laboratory, the Technology Division Computer Applications Group moved to Informatics Division in July 1987, so that all support for the Computing Facilities Committee's activities resides in one Division.
4. Image Processing: The Image Processing section of Technology Division moved to Informatics Division on 1 September 1987. This rationalised the Alvey activities so that all support for IKBS, SE and MMI was in a single Division.

The loss of two senior members of the Division in a period when the Division expanded significantly in size has put a severe pressure on the organisation of the Division. A Staff Review is in progress to ascertain the number of senior posts necessary to run the Division. The current interim Group structure is:

1. Software and Knowledge Engineering: D A Duce (deputy G A Ringland)
2. Infrastructure (including MMI): K F Hartley (deputy R E Thomas)
3. Engineering Computing: M R Jane (deputy J R Gallop)

Organograms showing the Divisional structure at the start and end of the year are given as Appendix A.

Due to several changes in structure during the year (some quite recent), it has been difficult to provide a report that closely matches the Group structure. The main sections are as follows:

1. Introduction
2. Software Engineering: Reports on the research and development activities that currently form part of the SKE Group and the coordination/management activities that are now part of Infrastructure Group.
3. Knowledge Engineering: Similar to Software Engineering.
4. Infrastructure: The Systems Section of the Infrastructure Group provides systems and communications support for both the Alvey Infrastructure programme and the CFC activities. The Infrastructure Group provides a number of management functions for the Division and Alvey.
5. HCI: The Human Computer Interaction Section of the Infrastructure Group provides support for some of the Alvey MMI activities as well as having an active research and development programme funded by both Alvey and the Engineering Board.
6. Engineering Computing Facilities Executive: This chapter deals with the management aspects of the Engineering Computing Group and the support for Computing Facilities Committee and its Advisory Groups.
7. Computing Applications: Describes the activities of the Computing Applications Group transferred from Technology Division in July 1987.
8. Single User Systems/Applications Section: Describes the activities concerned with Single User Systems support and development.
9. Engineering Computing Operations/Support: Describes the operations and support activities associated with the systems run by the Division on behalf of CFC and Alvey.

Due to the recent arrival of the Image Processing Section, their activities are not reported in this Annual Report.

## 2 SOFTWARE ENGINEERING

### 2.1 Main Functions

The main activities in the Software Engineering area are:

1. Alvey SE Programme Management, with special responsibility for the academic SE Component, SERC/RAL finance and liaison with SERC Central Office at Swindon.

2. Technical Support to the Alvey SE Programme. This involves advice to the Millbank Staff on technical issues, compilation and distribution of SE Mailshots, and Abstracts of Deliverables, refereeing project applications, and information gathering.
3. Development work on behalf of the Alvey SE programme. This can be on behalf of specific projects (eg yacc/SML for Forsite) or for the Alvey SE Infrastructure generally (eg SML(LCF).
4. SE Research in line with IEC/CSC policy, Alvey SE strategy and in collaboration with industry, GREs and Universities.

Management, Technical Support and Development work are funded directly from Millbank to SERC/RAL. The research work is funded differently. This either follows normal Alvey rules, or goes through the peer review system of IEC/CSSC. At any instant the aim is to have more than one project underway with successors in the pipeline. SKE aims to have both Alvey and CSSC funding simultaneously. It is hoped that funding via ESPRIT can also be obtained.

### 2.2 Alvey SE Programme Management

The Division has continued to provide management support to the Alvey Programme. Since the major part of the programme is now in place attention has concentrated on monitoring the individual projects and installing a procedure for disseminating the information generated by the programme.

An increasingly important aspect of the overall support as the programme develops is the analysis of the budget and preparation of data for forward planning. For this purpose a special procedure has been developed with the objective of minimising difficulties associated with over commitments of the budget.

Now that the results of the programme are becoming available, attention is turning to plans for exploitation of these results. All industrial and academic participants in the SE programme have been asked to provide the Directorate with their outline plans for possible exploitation of their products generated under the Alvey programme.

Attention is also being fixed on the evaluation of the programme and this end information is being gathered arising from the dissemination of information programme.

F M Russell, J M Cheney and T Mawby supported by Lilian Valentine, undertake the above work.

### 2.3 Alvey SE Technical Support and Development Work

#### 2.3.1 Introduction

The section undertakes specialist infrastructure work for the Alvey SE programme. The way of working that seems most satisfactory is for the section to work alongside a specific Alvey project to provide a piece of infrastructure needed by that project, but to do,so in such a way that it will be of use to the whole community. An example of this is the project to provide a yacc-1ike tool for Standard ML.

#### 2.3.2 Standard ML/LCF

ML is a functional programming language which was designed and first implemented at Edinburgh as the metalanguage for the interactive theorem proving system LCF. ML soon attracted interest quite independently of LCF with the result that a number of dialects appeared.

Standard ML (SML) is a consolidation of tried-and-trusted developments which has been agreed by the ML community.

Mikael Hedlund (PMH) worked on converting the old ML/LCF system to SML under the guidance of Chris Wadsworth (CPW). The SML implementation was completed in June 1986. During this year the LCF source files written in old ML were transliterated to SML and the new system was tested. Larry Paulson at Cambridge University kindly assisted with evaluation of the new system and suggested some changes to the system to make the object language (PPLAMBDA) more

consistent with SML (the metalanguage). These changes have now been completed. A code optimizer was also built which improved the performance by a factor of 10. The work has been documented and the Rutherford SML/Cambridge LCF System is now ready for distribution to interested researchers. Brian Matthews (BMM) is handling distribution of the system.

Valuable feedback was also obtained from Anthony Clair at East Anglia who ran his benchmark programs through the compiler.

The old LCF system (still being used by Cambridge) and the Edinburgh SML compiler were mounted on UTS in collaboration with Stanley Ooi in Infrastructure Group.

### 2.3.3 SML-Yacc

The aim of this project is to produce a yacc-like parser generator written in SML which produces output code in SML. This project is being undertaken on behalf of the Alvey FORSITE project.

FORSITE is a collaboration project between the University of Oxford, Racal ITD Ltd, the University of Surrey and System Designers Plc. The FORSITE project is producing an environment to support the development of formal specifications in the Z and CSP notations. Both are products of Oxford's Programming Research Group. At the present time the main components of the environment are a multi-font WYSIWYG editor for mathematical texts and a type checker. The latter is written in SML. Current research in FORSITE is concerned with a proof checker for Z.

SML/yacc system is needed by FORSITE to provide a Z parser that will integrate neatly with the other components of the environment.

A specification for SML/yacc system was drawn up by PMH and BMM, and has been approved by FORSITE. The system has been designed for general use and not just to meet the requirements of FORSITE and is consequently very flexible.

Coding and testing are now well in hand.

### 2.3.4 Concurrency Workbench - Graphical Interface

In February 1987, the Laboratory for the Foundations of Computer Science at Edinburgh asked if the Division would collaborate with them in developing graphical user interfaces for software tools being constructed.

Edinburgh are developing a number of tools for supporting formal software development methods that would benefit greatly from graphical user interfaces. One such tool, the Concurrency Workbench, seemed particularly appropriate for a pilot study. The Concurrency Workbench is a suite of tools for manipulating and ana1ysing concurrent systems described in their CCS (Calculus for Communicating Systems) notation. The first prototype, with a simple textual interface, is now completed, and the aim of the collaboration work is to develop a graphical user interface for these tools. The tools are written in SML and the project will be organised in such a way as to produce a general purpose user interface toolkit for SML.

HCI section of the Infrastructure Group will be providing the people for the project, funding comes from the Alvey Software Engineering programme.

### 2.3.5 Theorem Provers

Theorem provers are software tools to aid in the process of proving theorems. In the software engineering context we are primarily concerned with theorems about programs, for example that a particular program has a particular property.

Beside the LCF system mentioned above, the group has continued its involvement with the Boyer-Moore theorem prover from the University of Texas. We have not been working with the Boyer-Moore system ourselves but have continued to act as a UK distribution point for the Alvey SE infrastructure.

## 2.4 Software Engineering Research

### 2.4.1 Introduction

The overall software engineering research theme is Quality Certification of Software Products. Within this theme, the main research interests of the group are in formal specification, the development and application of machine-assisted proof systems and the role of formal reasoning in software development.

### 2.4.2 Formal Specification

In September 1986 David Duce (DAD) held two research grants, one from the Alvey Software Engineering Programme entitled Specification of the Graphical Kernel System (GKS), the second from SERC's Computing Science SUS Committee entitled Theoretical Studies of Emerging Computer Graphics Standards.

The Alvey grant terminated in March 1987 and a Final Report was duly submitted to the Alvey Directorate.

The main thrust of the technical work during 1986/7 was to produce a reasonably complete specification of the output side of GKS. The major piece of work during the year was to devise what seems to be a general framework for the GKS output specification. Dr David Arnold and Graham Reynolds at the University of East Anglia have an SERC funded project on configurable models of graphics systems. Graphics processing pipelines provide a convenient conceptual model for many graphics systems and the UEA project is exploring this idea further by trying to identify general classes of processes and connectivity in such models. In November 1986 DAD was invited to spend a week at UEA trying to give formal specification of these models. It turned out that this could be done very neatly in the Z specification language using partial functions to model primitives, Z schemas to define the operations in the pipeline and the schema piping combinator to describe the composition of operations in a pipeline. This scheme is described in a joint paper accepted for the Eurographics 87 conference. This work has been applied with very encouraging results to the specification of GKS. Michael Parsons (MSP) has worked on this and a draft paper has been produced which describes the polyline, polymarker and fill area primitives in this framework. There are some difficulties fitting GKS into the framework, but we are of the opinion that these are due to inherent problems in GKS. These views have been recorded in a position paper submitted to the Eurographics GKS Review Workshop to be held in September 1987.

In November 1986, the PHIGS review provided the opportunity to look again at the GKS input model. The led to proposals made jointly with Bob Hopgood for extensions to the PHIGS input functions to allow multiple logical input values to be returned from a single trigger firing in REQUEST mode. A simple example of the need for this facility is the cross hair cursor input on Tektronix devices, where a single key press returns the position of the cursor and the identity of the key hit. The obvious mapping of this onto GKS is to a pair of logical input devices, a LOCATOR for the cursor position and CHOICE for the key hit.

In subsequent discussions with Clive Ruggles and Yee of the University of Leicester, a formal specification of the GKS input queue was developed which fits nicely with this model, and from the insights gained in this exercise a paper was written containing a range of proposals for extensions to the input model. This is about to appear as an RAL report. The proposals were refined further in discussions with Robin Langridge of the CAD Centre and Graham Reynolds, and were submitted as a UK Experts paper to the PHIGS review in May 1987. The proposals have also been submitted to the GKS Review Workshop.

DAD also wrote review papers on formal specification of graphics software for the CIL 87 Conference (invited paper) and the NATO ASI on Theoretical Foundations of Computer Graphics and CAD (invited contribution).

Progress on the second project concerned with PRIGS and GKS-3D has been slower. The work on extending GKS to enable PRIGS to be defined on top of GKS, reported in the last Annual Report was taken further in the light of the discussion of those ideas at the PHIGS review in September

1986. Work started on proving properties of the extensions using Jeremy Dick's ERIL system, but this work is yet to be completed. We have also had some preliminary thoughts on how to accommodate GKS-3D and PHIGS in the specification structure described above for GKS and to work this out in detail will be the subject of the next year's work.

Following the PHIGS review meeting in May 1987, a short paper has been written which analyses the PHIGS nameset concept and shows that it is, in some sense, a bad thing. These results are influencing the functionality to be provided in the Incremental Spatial Search capability recently incorporated into PHIGS.

### 2.4.3 Graphics Standards

DAD and MSP both participated in the BSI Computer Graphics Panel and in the PHIGS international review. DAD retired as secretary of the BSI Panel in November 1986, but did not escape the call of duty, being appointed secretary of the PHIGS meeting in May 1987!

### 2.4.4 Equational Reasoning Research

Jeremy Dick's (AJJD) research continues in the field of Automated Equational Reasoning. The ability to reason with equations (for example, to deduce conclusions from a set of equations), is important in a number of areas, for example specification of abstract data types and their validation, program transformation, synthesis of programs, program optimisation and solving equations.

AJJD has over a number of years developed a rich theoretical framework for equational reasoning and has developed a practical tool, ERIL (Equational Reasoning an Interactive Laboratory) based on this framework. ERIL is a useful tool for experimenting with the specification and prototyping of abstract datatypes, and is used by several research groups in the UK and abroad.

ERIL is based on the use of rewrite rules for computing and reasoning with equations. One of the potential applications of this approach is to theorem proving, and the aim of the present research is to compare the scope and performance of a theorem prover for a particular logical system (polymorphic predicate calculus) with traditional approaches, and assess the long- term potential of this new approach to theorem proving.

There are two main thrusts to the present stage of the project:

1. understanding and implementing several reduction orderings which the present version of ERIL does not have, including the Recursive Decomposition and Recursive Path orderings (both with Status) and an extended form of the Knuth-Bendix Ordering. The learning curve in this area has quite a steep initial gradient and considerable time was required for reading, understanding, explaining and discussing research papers.
2. developing ideas for the implementation of E-unification in ERIL. This is based on the observation that all extensions of unification can be expressed as solution-preserving transfunctions on the set of equations to be solved, as in the Martelli-Montonari unification algorithm. This would appear to be an excellent route to a highly configurable unification algorithm.

John Kalmus (JRK) joined the project in January 1987 and the combination of AJJD's computer science and JRK's Mathematics background is proving very useful.

A new variant of the Knuth-Bendix algorithm by Jieh Hsiang (Stony Brook, New York) was implemented in ERIL. This version overcomes some of the cases where the original algorithm fails because an axiom cannot be oriented into a rule. Initial experiments suggested that Hsiang's method is not really satisfactory for handling permutative axioms, and it is necessary to proceed with the implementation of an association - commutative unification algorithm.

A fruitful collaboration has developed with Dr Ursula Martin of the University of Manchester (soon to move to Royal Holloway and Bedford New College). A draft of her paper for the Second International Conference on Rewriting Techniques and Applications on a new means of orienting

rewrite rules was studied and her ideas were expanded sufficiently for an implementation in ERIL. This work will form the basis of a full research paper, jointly authored with Ursula.

Discussions held at the First Workshop on Unification will help towards the achievement of the second goal, the extension of unification in ERIL from the empty equational theory (standard Robinson) to arbitrary equational theories.

AJJD is also working on a technical report on data structures for the representation of rewrite rules. Current progress warrants considerable optimism for another paper by the end of the year. The ERIL system was used by Professor Bertran-Salvans, a Visiting Scientist from the Polytechnical University of Catalonya in Spain, for studying a model and semantics for a notation for parallel computation. It extends the familiar context-free grammar notation for the definition of a type of two dimensional strings, to model parallel and sequential execution. In addition, grammar rules are parametric. ERIL has been used to experiment with a set of transformation laws and a normal form for expressions in the notation. The results are described in an RAL report.

### 2.4.5 IPSE 2.5 Research

IPSE 2.5 is a major Alvey project to research and develop an Integrated Project Support Environment based on advanced distributed systems and man-machine interfaces, and incorporating support for both the practice and organisation of design tasks. A major objective is the development of an integrated framework for supporting the use of formal methods in software development, including formal specification and theorem-proving techniques.

The project began in October 1985 with three initial collaborators (ICL, STC and Manchester University) and had a successful first review with the Alvey Software Engineering Directorate in July 1986. RAL applied to join the project from April 1986 and, after some delay, received its grant allocation at the beginning of July 1986. Three additional industrial partners have also recently joined the collaboration.

At RAL, Juan Bicarregui (JB) and Brian Ritchie (BR) are now engaged in the project. Chris Wadsworth managed the project until joining the Transputer Initiative in January 1987. DAD is now the RAL representative on the Project Review Board.

The work at RAL is carried out in very close collaboration with the University of Manchester. JB and BR spend a fair proportion of their time at Manchester.

At the start of the year a lot of time was spent in familiarisation with the project and formal techniques in general. BR wrote a review of his Interactive Proof Editor (developed at Edinburgh) for inclusion in the IPSE 2.5 Deliverable, Theorem Proving Review paper.

The Manchester/RAL part of the IPSE 2.5 project is concerned with the support of formal methods of software development and in particular with aiding formal reasoning itself. The intention is to build tools which enable a user to construct proofs at the workstation; modern workstations such as the SUN3 should make it possible to design proof assistants which are much more usable than earlier tools developed around 'glass teletype' interfaces.

Initial work was concerned with generating a scenario of usage for a hypothetical system supporting construction and refinements of VDM specifications, and extracting requirements from this for a "VDM store" (database) of specifications and proofs.

BR and JB have also commented on the specification of Muffin, a prototype interactive theorem proving system being built at Manchester as a test bed for ideas.

BR used SML to build a rapid prototype of a part of the Muffin prototype formal reasoning tool. Tests on this revealed a flaw in the initial Muffin specification. This has now been superseded by the subsequent complete implementation of Muffin in Smalltalk-80 at Manchester.

One of the major problems being tackled by this part of the project is how to build a formal reasoning tool in which the logic with which the tool operates is in some sense a parameter. The

idea is to have a very general tool which can be instantiated to produce a tool for reasoning in a particular logic, say predicate calculus or temporal logic (a bit like a compiler-compiler). JB is working with Peter Lindsay from Manchester on the theoretical underpinnings of this idea.

BR is working on specification language instantiation with Cliff Jones at Manchester and with JB on theory stores. In the latter area BR has been working chiefly towards the production of a requirements document by generating scenarios of specification development in several languages (primarily LARCH and VDM) and attempting to draw general results from these. This document is due to be reviewed by the project at the end of August 1987.

### 2.4.6 Transformation and Verification of Occam

Tony Cox (ADBC) has spent almost all his time working on the Alvey (VLSI/CAD) funded research project The Transformation and Verification of Occam Programs, which is a collaboration between Inmos Ltd and Oxford University; at Oxford the project has consisted of Dr Bill Roscoe, supervising, and two research officers, in addition to ADBC.

A prototype system has been written in Edinburgh Standard ML which is able to parse Occam Programs, apply any of the transformation laws and to convert a program to normal form, including infinitary programs to a specified number of communication steps. ADBC has done almost all the programming on the project, while other members have contributed ideas on concurrency theory and the user-interface.

The basic ideas of implementing transformation rules as SML functions are being reviewed. The inspiration for this came from a paper by Larry Paulson (Cambridge) on his Isabelle system for constructive type theory, where inference rules rather than theorems are the central data type. The idea is that derived rules should be more efficient with this approach, but it is not yet clear how readily this applies to the Occam transformation system.

The prototype transformation system was used in earnest in the development of the floating point transputer and proved to be of real value in the development of a very complex system.

ADBC has remained a member of the BSI working group producing a Prolog Standard, taking an active interest in the Semantics sub-group.

### 2.4.7 Dimensional Design Editor

We were honoured to have Prof Miquel Bertran-Salvans from UPC, Barcelona as a visiting researcher from March 1986 to March 1987. MBS has been interested in Dimensional Design, a graphical technique for presenting software designs originated by R W Witty (RYW) and DAD for use in the FR80 Driver and Roots toolset.

A collaborative project between members of the section (MBS, Duncan R Gibson (DRG) , RYW) and DEC(UK) (Tom Povey) was established to build a syntax-driven compiler/compiler/editor system to be called the Dimensional Design Editor (DDE).

A requirement specification, user interface prototype and initial design work had been completed by July 86 when DEC posted Tom Povey to the USA and thus had to withdraw from the collaboration.

By the time the project terminated in March 87 the kernel of a generator of DD syntax-driver editors had been completed. This comprises a set of Pascal functions and procedures.

Grammars for the definition of Dimensional languages can be input to the kernel in order to obtain syntax-driven editors for different languages. An editor for a simple Pascal type language was developed. Grammars can be edited with the syntax-driven editor itself.

The kernel is described in an RAL report. Coding the system required a large amount of work by DRG.

### 2.4.8 Formal Specification of Spy

We are honoured to have Mario Martins (MM) from the University of Minho, Portugal as a Visiting Scientist from March 87 to December 87.

Text editors are the most widely used software components of any interactive computing system and in the last few years a new generation of editors has emerged based on sophisticated interactive techniques. Spy is a prime example of such an editor. Formal specification of text editors has received very little attention, given the number of text editors in use.

MM has been developing a specification of Spy in Oxford's Z specification notation. To increase the modularity and readability of the specification the editor was divided into four subsystems, the Editing System, the File System Interface, the Display Control System and the Window System. The schema notation in Z allows complex specifications to be presented in manageable chunks and this facility is used to great advantage in this specification. The editor specification is developed in easy stages, corresponding to increasing richness of functionality. The specification starts to get difficult when the UNDO facility is introduced. One suspects this is an experience shared with the implementation!

A report describing the specification has been produced, but has not yet been circulated.

### 2.5 Staffing

Brian Matthews was welcomed to the SE Section in September 1986 and Juan Bicarregui in October 1987; John Kalmus and Michael Parsons in January 1987. Terry Mawby was welcomed to the Alvey SE Management Section in June 1987.

Chris Wadsworth moved to EC Group in January 1987 to play a leading role in setting up the Transputer Initiative. Duncan Gibson transferred to EC Group in April 1987 to work on text processing.

Professor Miquel Bertran-Sa1vans returned to his university in Spain at the end of February 1987. Mario Martins, a Visiting Scientist from the University of Minho in Portugal joined us in March 1987. Professor Lockwood Morris is a Visiting Scientist on the IPSE 2.5 project from July 1987 for nine months.

Mikael Hedlund left us in June 1987 to return to his native Sweden.

Dr Stuart Robinson, a Visiting Senior Lecturer from Brunel University joined the group in April 1987. He spends one day per week at RAL. His initial work at RAL is transputer related and is described elsewhere in this report. He is also advising BMM on the yacc-SML project.

### 2.6 Future Programme

Funding wise the year has been a time of relative stability and it is hoped this situation will continue for the next year. Our aim now is to produce good quality research and strengthen our links with other research groups in academia and industry both nationally and internationally. We hope to be able to set up joint projects with some of the Institutions we are now working with informally. We will also be looking carefully at ESPRIT II as a possible source of future funding.

### 2.7 Publications

#### 2.7.1 Publications - External

1. D B Arnold, D A Duce and G J Reynolds, An Approach to the Formal Specification of Configurable Models of Graphics Systems, EUROGRAPHICS '87, G Marechal (ed), North-Holland, 1987.
2. D A Duce, Formal Specification of Graphics Software, Proceedings of CIL '87, Barcelona, Spain, March 1987.
3. D A Duce, Formal Specification of Graphics Software, in Theoretical Foundations of Computer Graphics and CAD, R A Earnshaw (ed), Springer-Verlag (to appear).

4. D A Duce, F R A Hopgood, C L N Ruggles and S T Yee, Input in GKS A Discussion Paper, RAL-87-057.
5. D A Duce, Graphical Kernel System (GKS) - ISO 7942, Computer Compacts, September/October 1986. (Also reprinted in Computers and Standards), pp 235-237, 1987).
6. F R A Hopgood and D A Duce Future Development in Graphics and Workstations
7. D A Duce and F R A Hopgood The Graphical Kernel Systems (GKS), Computer Aided Design (to appear 1987)
8. M Bertran-Salvans A Linguistic Semantics for Parallel Computation RAL-87-023
9. M Bertran-Salvans A Kernel for a Generator of Syntax Driven Editors for Dimensional Designs RAL-87-024
10. B Ritchie, Interactive Proof Construction, Proceedings of IEE Colloquium, March 1987.

### 2.7.2 Publications - SEG Notes

| | | | |
|---|---|---|---|
| SEG Number 145 | IPSE 2.5 Note 4 - Visit Report Tim Griffin, Edinburgh | B Ritchie | 02.09.86 |
| 151 | Trip to USA | R W Witty | 27.10.86 |
| 154 | The Incorporation of Standard ML in the Cambridge LCF System | P M Hedlund | 27.11.86 |
| 156 | Trip Report USA 6-22.12.86 | P M Hedlund | 09.01.87 |
| 157 | Edinburgh Standard ML | P M Hedlund | 13.02.87 |
| 159 | SML-Yacc A Compiler-Compiler in Standard ML | P M Hedlund | 18.03.87 |
| 160 | Trip Report - Barcelona 17-25.3.87 | D A Duce | 01.04.87 |
| 161 | The Incorporation of Standard ML in the Cambridge LCF System | P M Hedlund | 27.05.87 |
| 162 | Trip Report - NATO Study Institute 11 Ciocco, Italy, 4-17 July 1987 | D A Duce | 20.07.87 |
| 164 | Trip Report - NATO Study Institute 11 Ciocco, Italy, 4-17 July 1987 | M S Parsons | 20.07.87 |

M Martins, Formal Specification of Highly Interactive text Editors - The SPY example, June 1987.

### 2.8 Conferences, Visits, Seminars

DAD

1. CIL 87 Conference, Barcelona, Spain, March 1987
2. Eurographics UK Conference, East Anglia, March 1987
3. NATO ASI, Lucca, Italy, July 1987
4. Eurographics '87, Amsterdam, The Netherlands, August 1987
5. Seminar to Queen Mary's College, December 1986
6. ISO WG2 Meeting, Valbonne, France, May 1987
7. IEE Colloquium, 'Formal Methods in Human-Computer Interaction', London, January 1987
8. Z Course, Oxford, August 1987
9. Graphics Systems and Formal Specification, RAL, June 1987

MSP

1. ISO WG2 Meeting, Valbonne, France, May 1987
2. NATO ASI, Lucca, Italy, July 1987
3. IEE Colloquium, 'Formal Methods in Human-Computer Interaction', London, January 1987

4. Graphics Systems and Formal Specification, RAL, June 1987
5. Z Course, Oxford, August 1987

AJJD

1. Seminar to Queen Mary's College, October 1986
2. Seminars at SRI and Xerox Pare, USA, November 1986
3. The First Workshop on Unification, Le Val d' Ajo1, France, March 1987
4. Second International Conference on Rewriting Techniques and Applications, Bordeaux, May 1987

JRK

1. The First Workshop on Unification, Le Val d' Ajo1, France, March 1987
2. Second International Conference on Rewriting Techniques and Applications, Bordeaux, May 1987

BR and JB

1. VDM Course, STL Harlow, November 1986
2. BCS-FACS Workshop on 'Classical and Non-Classical Logics', December 1986
3. User Interface Design Course, Coseners House, March 1987
4. VDM-Europe Symposium, Brussels, Belgium, March 1987
5. IEE Colloquium, 'Theorem Provers in Theory and Practice', London, March 1987
6. Smalltalk-80 Course, Manchester University, July 1987
7. Workshop on Programming for Logic Teaching, Leeds, July 1987 (BR only - talk and demonstration)

PMH

1. 'Practical Software Support Environments', Palo Alto, December 1986

BMM

3. BCS-FACS Workshop on 'Classical and Non-Classical Logics', December 1986
4. IEE Colloquium, 'Theorem Provers in Theory and Practice', London, March 1987
5. Z Course, Oxford, August 1987

### 2.9 Miscellany

BMM is taking an MSc Course at Imperial College London in the Foundations of Advanced Information Technology (FAIT). This is on a part time basis, two days a week for two years. This course is intellectually very demanding, but gives a very good foundation in theoretical computer science. BMM is now engaged in a group project with other part time students. The project involves the implementation of optimisations to Prolog programs using Abstract Interpretation of of those programs. This is based on work by Jones and Sondergaard, Mellish and others into the abstract semantics of Prolog and alternative interpretations of those semantics to find significant properties whilst ignoring other attributes irrelevant to the analysis in hand. It is hoped to optimise Prolog for such things as groundness analysis, circulatory analysis, and help in solving the occur check problem.

DRG acted as secretary to the Alvey SE Staff Meeting from January until June 1987, and as the section's representative to USM until June 1987.

AJJD is secretary to the Alvey SE Formal Methods Advisory Group. He has been secretary since January 1987.

DAD assisted William Newman of the Alvey Directorate in organising a meeting on Formal Specification and Graphics, held at RAL on 12 June 1987.

DAD continues as Vice Chairman of Eurographics, participates in the Executive and Professional Board activities and is Programme Chairman for the Eurographics 88 event in Nice.

DAD produced the camera ready copy for a volume in the Eurographics Seminars series (Springer-Verlag) entitled GKS Theory and Practice. This is a collection of published papers on GKS which should be of particular interest to anyone implementing GKS. DAD is now editing a book on Knowledge Representation with Gordon Ringland, which contains contributions from many members of the Division.

## 3 KNOWLEDGE ENGINEERING

### 3.1 Introduction

#### 3.1.1 Staff

There were four recruits during the year and one loss.

- C J Pavelin (CJP) (left 8/87)
- M B Dunn (MBD)
- A J Lucas (AJL)
- J W T Smith (JWTS)
- K M Tarling (KMT) (joined 10/86)
- D F MacRandall (DFM)
- M K Jackman (MKJ)
- C Y L Kwong (CYLK)
- M D Wilson (MDW) (joined 10/86)
- G A Ringland (GAR)
- B G Bainbridge (BGB) (joined 10/86)
- S C Lambert (SCL) (joined 9/86)

Sandwich students

- R Benson (ORB)
- J B Garland (JBG)

**Cliff Pavelin Leaving Presentation, with Bob Hopgood**

**Large View**

Helen Jenkins was secretary other than for a period of sick leave when Jacqui Smith substituted. During September 1987, Jacqui Smith had an exchange for one month with Liu Catena of Italy.

### 3.1.2 Section Objectives

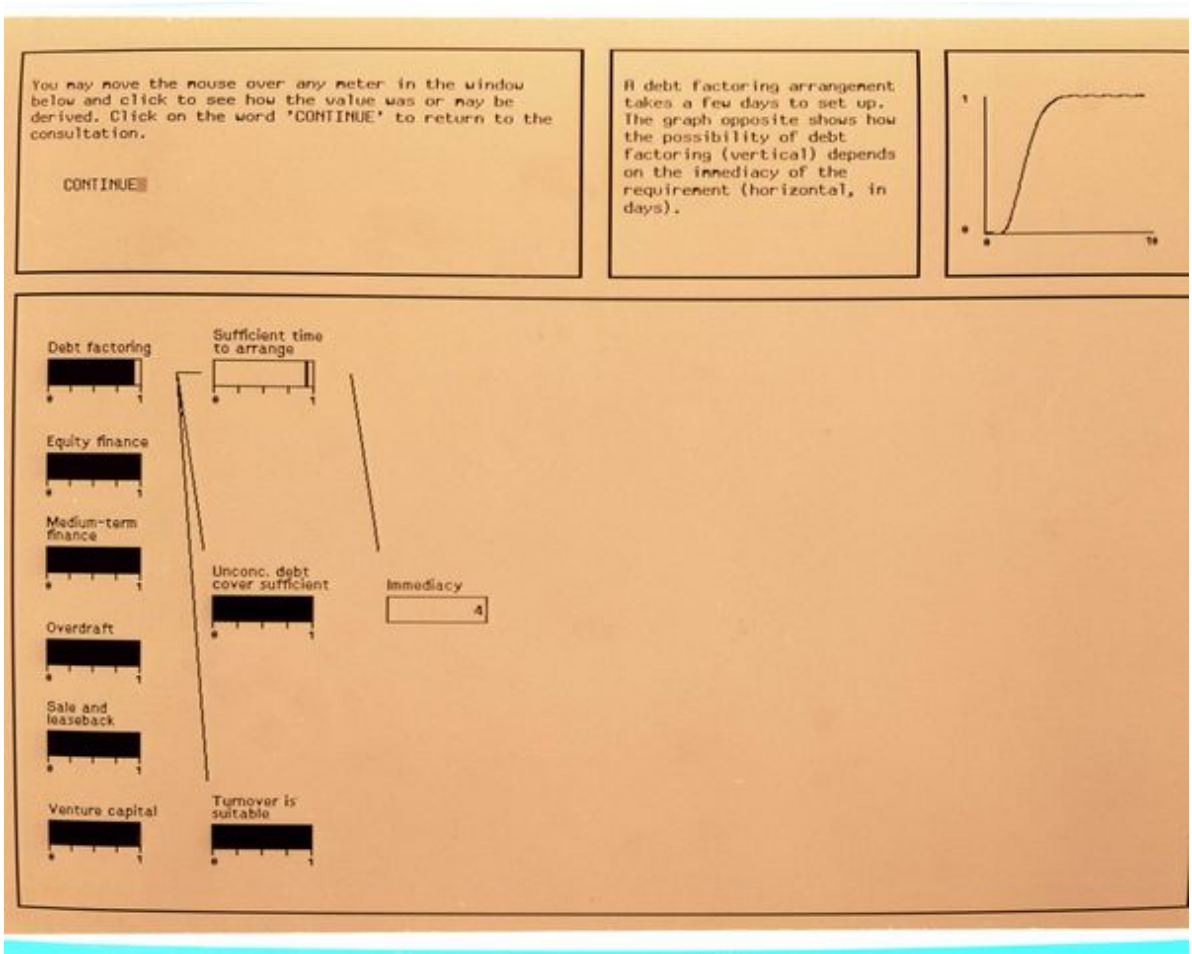
Knowledge Engineering section has the following objectives.

1. Promotion and support of SERC's research programmes in AI/IKBS. This is principally funded through the Alvey Directorate at present and most of the work is thus concerned with technical support and management of the Alvey IKBS and Architecture programmes. However there is some work both for the Engineering Board's Environment Committee and Computing Facilities Committee.
2. Establishment of a funded R&D programme in AI. This is required as an element in maintaining the effectiveness of the division.
3. Investigation the application of Expert Systems techniques to other parts of RAL or SERC programme. There should be useful applications of Expert Systems in SERC's scientific or administrative programmes, and in a small way (there is no specifically funded effort for this task) this technology is promoted by the section.

### 3.1.3 Progress Summary

The support effort is going very well and helped to preserve continuity over the change in IKBS Director at the beginning of the period. In some areas - monitoring, research clubs and SIGs, software support, and mailshot - the work has grown considerably with the maturity of the Alvey programme. New initiatives now successful have included the launching of the Logic Programming club, the AI facility for the Environment committee (termed ARTIFACE in subsequent sections), organisation of the IKBS/Architecture exhibition and various meetings at the Alvey conference, contribution to and organising the production of the IKBS strategy for IT92, collection of abstracts for IKBS and architecture projects and organising a Knowledge Acquisition workshop on behalf of the Computing Facilities Committee. Some time has also been spent in discussions about LOOKALIVE, a potential post Alvey project in Health.

On the R&D side, PARALFEX (GAR), a funded Alvey Project, has produced some impressive demonstrations and application has been made for a year's extension. DFM obtained SERC support for the 'Intelligent Front End' project and preparation of a proposal for an Energy Kernel System is well advanced. There is now a large amount of software implementing Conceptual Structures and a paper (MKJ) has been accepted for ES87. Various initiatives are giving the group a technical visibility, including a shortly to be published book on Knowledge Representation (Eds DAD and GAR) numerous external talks and book reviews by members of the group, and organisation of a workshop on KR (GAR, DMR) attended by prominent international figures.




**PARALFEX**

**Large View**

There has been little effort left for much activity in in-house applications; the major task has been the attempt to build an expert system in ion-source conditioning for ISIS. It is hoped that a RAL

report on expert system shells shortly to be produced (MBD) will help to promote this technology in the laboratory.

### 3.2 IKBS/Architecture Programme Support (MBD)

As the Alvey programme matures, the emphasis has switched towards assessing the achievements of projects and publicising them. The balance of work in the support area has thus slowly changed, although the total seems to continually increase, given major events like the Alvey conference. MBD has continued to act as Secretary to the monthly meetings held to ensure that the disparate parts of the Alvey organisation (RAL, Swindon and Millbank) continue to move in step. CJP attends the Alvey IKBS and Architectures Advisory group and the Alvey Infrastructure committee. AJL is secretary of SIGAI.

#### 3.2.1 Research Clubs (CJP, MBD, JYS, SGD)

A two day meeting of the KBS Club (secretary JYS) was organised in January at St Anne's College, Oxford. The format was a combination of reports and tutorials. There were many positive comments from the 56 attendees on the meeting, especially for the quality of the tutorials. The sessions on Deep Knowledge were led by Ken Forbus from the USA. Selected papers from this meeting were distributed in the May issue of the IKBS Mailshot. There was a one day open meeting of the Club at the Alvey Conference. This included nine presentations on the the theme Results - what has been learned. There were over 70 participants. A report on the session will appear in the Conference Supplement to the September edition of Alvey News. St Anne's has been booked for the next two day meeting planned for 11/12 January 1988. The KBS Club steering committee has met twice.

During the period, the Architecture Club (Secretary MBD) has begun to take a more active role in providing a focus for the Systems Architecture projects. In November 1986, the Club held a meeting on benchmarking new architectures; some progress was made in beginning to establish a suite of benchmarks. In March 1987 the Club held a meeting on exploiting parallel machines. A useful exchange of views was held; in particular, experience on Esprit and other projects proved a very valuable input. The activities of the Club has continued to be controlled by a Steering Committee (Secretary MBD). The Steering Committee has been responsible for establishing Special Interest Groups covering Knowledge Manipulation Engines and Systems Architecture on Silicon (jointly with the High Performance Silicon Structures Club); these SIGs have been very active. A SIG is also being established on Parallel Declarative Systems, and a meeting has been supported on Persistent Information Architectures.

The Logic Programming Club (secretary BGB) has had two technical meetings, organised with the help of Steve Torrance (Middlesex Poly) who was appointed as Logic Programming coordinator at the beginning of the year. A workshop is now being planned to consider the future directions for logic programming. An occasional Logic Programming mailshot has been sent.

The workshops supported by Alvey in IKBS and Architecture have been a highly successful part of the whole programme, bringing together academics and industrialists (often with a foreign visitor) to discuss specific topics in some detail. About 15 such workshops have been supported over the last year. MBD (and SGD) are responsible for ensuring that proposals to hold workshops are properly vetted and form part of a coherent programme and for overseeing the administrative arrangements.

#### 3.2.2 Alvey Project Monitoring

MBD is responsible for appointing and overseeing the work of Monitoring Officers (and uncles) to the projects. Apart from occasional changes, the MOs are now fully in place and the emphasis has switched to obtaining feedback from the MOs on, for example, technical progress, exploitability, milestones, etc. This may well have put a greater load on some of the MOs than they had anticipated.

Members of the group personally monitor certain projects in the infrastructure and Vision areas as well as three Alvey community clubs RICS, WIESC and TRACE. GAR was a member of the ALFEX Steering committee for most of the period.

### 3.2.3 Abstracts/Deliverables(MBD, SGD)

Arrangements have been made (MBD and SGD) for collecting abstracts of reports produced on IKBS and Architecture projects and publicising them as a supplement to Alvey News. About 100 abstracts have already been received and a selection of them should be published shortly.

### 3.2.4 IKBS Software Infrastructure (CYLK, AJL, KT, CJP)

The AI/IKBS Community is supported through the provision of software by the group; through the provision of support by University groups under contract to RAL; and through the commercial provision of software. Information on this can be found in our publication AI Software available on Alvey Infrastructure Computers now in its seventh edition.

The Special Interest Group in AI was established by the SERC to advise the Alvey IKBS Director and SERC Boards that support AI on the software, hardware and standardisation needs of the research/R&D community and the projects that might someday enhance the UK AI industry. I t is comprised of Industrial and Academic suppliers, developers and users of AI products. RAL organises the group, provides an interface between SIGAI and the groups it advises and, where appropriate, places contracts or encourages applications for research grants to implement its recommendations. The contracts so placed are monitored by this group for SIGAI.

The contracts include those that provide for the support and development of NIP (at Edinburgh AIAI) and POPLOG (at Sussex and SD). They also provide support for Lisp users (from Edinburgh AIAI); and for some of the UK effort on the international committees developing standards for Prolog and Lisp. They have enabled the Prolog and Lisp libraries at Edinburgh to be made available to users over the electronic networks.

#### NIP

The New Implementation of Edinburgh Prolog (NIP) is distributed by this group to SERC and Alvey supported groups for research, teaching and evaluation free of charge. We are currently distributing a new version (1.5) that has an enhanced user interface for the Sun Workstation and an interface to the editor "GNU Emacs" which is distributed with it. There are 57 groups using NIP.

The continuing development of NIP is supported by a contract which is administered by this group with advice from SIGAI.

#### POPLOG

The development environment, POPLOG, which includes the main AI languages of Lisp, Prolog and POP is being developed by the University of Sussex and Systems Designers under a contract administered by this group with advice from SIGAI (see below). The systems is being supplied, with support, by Systems Designers to 29 Alvey funded groups under a contract placed and administered by this group. The upgrading of the Lisp system to Common Lisp has just been completed and the final full implementation will shortly be available commercially.

#### KRSTL

A SIGAI contract helped to initiate the Knowledge Representation System Trials Laboratory at Edinburgh AI Applications Institute this enable academic and industrial researchers to gain access to advanced Knowledge Representation toolkits. CJP and a DTI representative jointly monitor this and a related facility the Parallel Architectures Laboratory.

#### Benchmarking Prolog

As the result of a recommendation from SIGAI, Imperial Software Technology (IST) was commissioned to produce a new suite of benchmarking programs for Prolog systems. As part of

this development, existing suites were subjected to analysis by a group at Cambridge. The new suite, known as the "Alvey Prolog Benchmarks", has been used on a number of different systems by this group and the results subjected to the same analysis by the Cambridge group - with some very interesting results. The suite, the original report from IST, our results and a report on them, together with the report on the analysis of those results by the group at Cambridge, are available.

CYLK continued to serve on the BSI PROLOG Standardisation working group.

### 3.2.5 Information Services (JWS)

The Mailshot has grown steadily over the past year, both in size (from 20 items per mailing to nearly 40 per mailing) and in the number of recipients (from 400 to 480). The Mailshot has become well known in the AI community and is now an accepted place for advertising research vacancies and academic meetings of all kinds.

The Bulletin Board was re-launched at the beginning of February. It has grown rapidly and there is now an issue approximately every two weeks. Like the Mailshot it has gained a reputation as a good place to advertise research vacancies and to announce meetings. At present there are nearly 150 JANET addresses in the mailing list, some of these auto-mailboxes representing University research groups rather than individuals. In addition there are the USENET recipients but it is very difficult to estimate these. They could exceed the number of JANET readers.

The Catalogue of AI Techniques (formerly called the Catalogue of AI Tools) continues to be maintained in book and database form. References to commercial shells, etc, have been removed and the amount of detailed information on genuine techniques has been increased. The updated version of the database (based on the 3rd as yet unpublished edition of the Catalogue) is now available in database input form. A small amount of editing is still required before it can be installed.

### 3.2.6 UK AI Toolkit Committee (JWS)

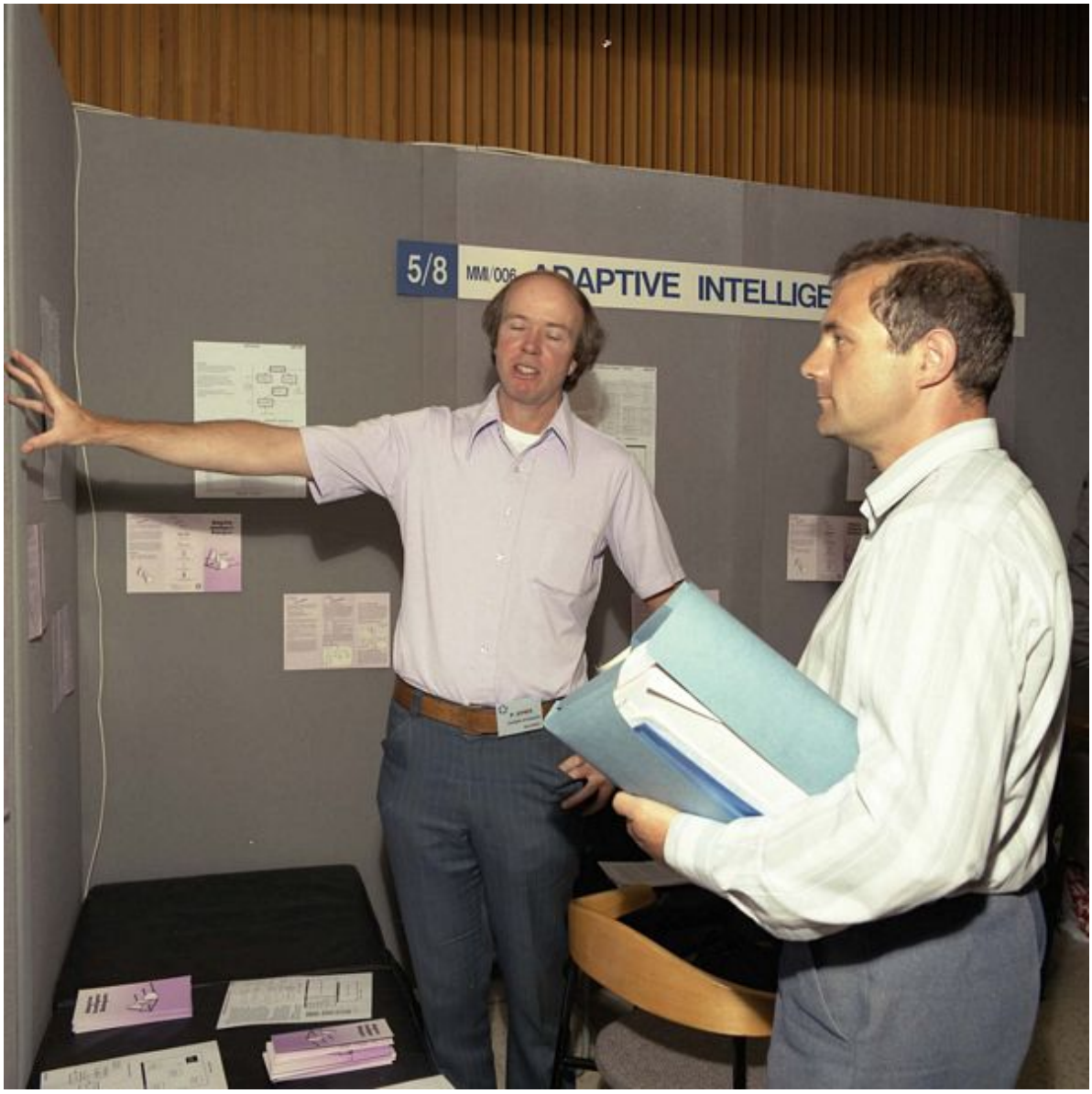
JWS acted as secretary of this group, set up by the IKBS Directorate following initiatives from the KBS Club and SIGAI. As a result, two short-term proposals received Alvey funding. After many meetings, including a two day session at Milton Hill House, a draft report covering long term recommendations has been produced.

### 3.2.7 Equipment (CJP, AJL)

There is still some work in allocating SUN equipment although it has reduced a lot. The group still administers a pool of Whitechapel computers and also the ICL Series 39 systems in the Architecture programme. There are preparations to replace one of these by a larger machine to meet the requirements of the Software Engineering IPSE 2.5 project.

### 3.2.8. Alvey Conference (CJP, JWS, CKYL, JWS, BGB)

The group were involved in organisation of this. CJP was responsible for the IKBS/Architectures exhibition; this meant planning the layout, organising the exhibitors, loaning SUNs, organising photographers etc. (Tony Rush from Scientific Admin gave invaluable help). JWS organised the KBS club session and BGB the Logic programming club. They both were official rapporteurs as was also CKYL in an Architecture session. CKYL was also responsible for configuring the SUNs loaned from RAL.




IKBS Stand at the Alvey Conference

Large View

### 3.2.9 IKBS Strategy for IT92 (CJP)

The IKBS Advisory Group asked Professor D Sleeman to prepare IKBS Strategy Recommendations for IT92. CJP contributed the infrastructure sections, took responsibility for production and did a small amount of editing. Both the main strategy document and a substantial Annex are produced and distributed to the community.

### 3.2.10 ARTIFACE (CJP, AJL, JWS)

The SERC's Environment Committee, as part of an awareness program, has funded an AI Artificial Intelligence Facility for Engineers. This includes a Sun 3 160M-4 workstation, and two IBM PCs equipped with AI software and tools by this group. They are loaned to Engineers in Universities for short periods for evaluation.

There was a substantial evaluation of LISP machines to run KEE (performed with the assistance of Edinburgh University AIAI), but the recommendation to buy Xerox was never followed up as the Committee concerned ran out of funds.

### 3.2.11 KA Workshop (MDW, CJP)

A workshop on Knowledge Acquisition was organised at Cosener's on behalf of the Computing Facilities Committee who wished to educate members of EB committees. The proceedings have been edited and will be distributed to every member of EB committees. MDW organised and spoke at the workshop, CJP helped with the editing, GAR, JWS, SCL assisted with note taking. HJ was conference secretary.

### 3.2.12 LOOKALIVE (CJP, MDW)

RAL was asked to assist with preparations for a possible Applications project in Health in a post Alvey programme. Meetings were organised at RAL with ICL and the project coordinator from the NHS; MDW was secretary.

## 3.3 Research and Development

### 3.3.1 PARALFEX (GAR, SCL, BGB)

Work has continued on this Alvey funded project to investigate knowledge representation strategies in the financial sector.

The Knowledge Base used is based on data provided by the Alvey finance community club ALFEX for their Source of Finance Advisor (SOFA). The project initially implemented this on an IBM PC in the shell Savoir, but the main task in this period has been the design and implementation of SOFA in the AI toolkit ART. The first stage was to duplicate Savoir's inference mechanism and to represent two of the six finance options. A graphical interface was added, based on a user-controlled display of the network of dependencies and the use of meters to show desirability of options. The interface is intended to allow immediately understandable and versatile explanations. After refinement of this interface, the remaining finance options were then added.

The system has been successfully demonstrated to the IKBS Director, to the ALFEX club (RAL hosted their final meeting) and many others. A poster was produced for the Alvey conference.

The knowledge engineering documentation from an early phase of the ALFEX SOFA has been examined with a view to an ART reimplementation which will make explicit the metalevel reasoning and possibly represent concepts of financial interest such as risk. Also a study of ART's viewpoint facility has been made, with the aim of determining its applicability to implementing functional changes in SOFA.

A proposal for a 1 year extension to PARALFEX has been submitted to Alvey.

### 3.3.2 Intelligent Front End (DMR, MDW)

An IFE proposal was accepted at the December round of the Building sub-committee, with a start date of April 87. This is a collaborative project with Strathclyde University, with 1 man for 2 years at Strathclyde and 1 man-year at RAL. The project has been divided into two, a MMI oriented development effort at Strathclyde, and an IKBS oriented research effort at RAL.

The research at RAL is looking at the designers and the packages, (or package developers) conceptual structure of the domain knowledge, with the objective of producing a mechanism to map between them. Project plans have been drawn up both for the research at RAL and the liasion with Strathclyde. A trial run for the acquisition of the domain knowledge was (and is being) conducted, and arrangements are being made for access to the experts. One spinoff was the development of tools to aid this task (see below).

### 3.3.3 Conceptual Graphs (MKJ, CKYL, ORB)

During the last year, this project has progressed from the early exploratory stage to an almost usable system. At the moment, working, and tested, software is available for:

- input/output and storage of conceptual graphs,
- handling definition and prototype graphs,
- performing copy, restrict and join operations

- accessing the above via a command driven user interface

Work on an inference mechanism for conceptual graphs is well under way. Close links have been established with other groups around the world which are working on CGs. There has been some spinoff from this project in the development of diagramming tool (see below).

### 3.3.4 Tools (MDW, ORB, MKJ)

In the course of the above research, and in response to external contacts, several useful tools have been produced, or are at advanced stages in development.

- Several simple word handling utilities were created to partially automate the task of eliciting concepts and relationships from experts.
- A tool for finding minimal spanning networks in the knowledge relationships was developed in collaboration with the MRC Applied Psychology Unit.
- An enhanced version of the MRC Psycholinguistic Database has been produced and is being distributed to research groups.
- An interactive diagram editor, roughly equivalent to pic, was developed to aid in the creation of simple diagrams for inclusion in documents.

### 3.3.5 Expert Systems Development (AJJD, MBD, MDW)

#### Job Applicant Shortlister

A small system has been built using the expert system shell SAVOIR to aid in short listing applicants for computing jobs at RAL at SO/HSO level. Huge numbers of such applications are frequently received in response to ' job of the month' advertisements and the aim was to provide a system which a clerk or secretary could use to help decide which candidates should be shortlisted. The completed system was rather limited in scope but undertaking it did provide useful experience both in the use of SAVOIR and in building expert systems.

#### High Energy Physics Project (MDW, AJJD)

A PROLOG program was built to configure devices in the OPAL experiment on the LEP ring at CERN at the request of members of High Energy Physics Division. This was reported in IKBS/TN11, and is being prepared as a RAL report by REP division personnel who have further developed the prototype which we prepared for them to show that the problem was comparatively easy to solve using AI techniques.

#### An Ion-Source Expert System for ISIS

MBD (together with some help from MDW on knowledge elicitation) has built an expert system to advise inexpert staff in running up (conditioning) a new ion source for ISIS. Ion sources are capricious devices and the expertise of the two experts involved was something of a moving target. Nonetheless a system was created, first of all using the Xi Plus expert system shell and finally using the Crystal shell. The use of Crystal proved an interesting experience because of its very high productivity, and it was this system which was eventually tested by the ISIS staff. It proved valuable except at a particularly difficult stage of the operation when events moved quickly; an on-line system would probably be needed to cope adequately with that stage.

#### SOFA in Crystal

The high productivity of Crystal was used by MBD (with GAR and SCL acting as domain experts) to build the Alfex Club's Source of Funds Advisor (SOFA) in Crystal. The task was undertaken extremely rapidly and successfully demonstrated to the Alfex Club when they visited RAL in May. Since that time MBD has added a fuzzy logic function to Crystal and the system now fully emulates the SAVOIR version.

### 3.3.6 Other Research (DMR, MDW, CKYL)

Throughout the year, several potential areas for future research were investigated. Some of these proved worthless, others were rejected by funding sources or collaborators, while others are still being looked at.

- The Props 2 system was evaluated as the basis for a 2nd generation expert system, but was felt to be too unstable. The idea was dropped.
- In collaboration with Salford University, a grant proposal to research a Methodology for Building Expert Systems was submitted to the SERC Computer Science Subcommittee. This was rejected.
- A grant proposal, in collaboration with Portsmouth, to produce a knowledge representation scheme/language for handling multiple viewpoints, will be submitted in October. This will probably go to the Environment Committee, to capitalise on the IFE and energy kernel (see below) work.
- A grant proposal is being submitted to produce the software for an energy simulation support environment that the SERC Building Subcommittee are considering. There is no, or very little, AI in this project. The chances of success seem fairly high.

### 3.4 Publications and Conference Talks

#### 3.4.1 Refereed

- Jackman, M. K., Inference and the Conceptual Graph Knowledge Representation Language, in Proc. Expert Systems 87, Brighton, UK. Dec 14-17 1987, to appear.
- Mac Randal, D. F., Some Trends in Computing - The Implications for Simulation, invited paper, to appear in special issue of Energy in Buildings on Energy Simulation.
- Mac Randal, D. F., The Application of IKBS Techniques to Building Design, in Proc. AI in Engineering International Conference, Boston, USA, Aug 4-7 1987, to appear.
- Barnard, P. J., Wilson, M. D. and MacLean, A. Approximate modelling of a cognitive activity: towards an expert system design aid in Proceedings of CHI GI 1987: Human Factors in Computing Systems and Graphics Interface, Special Issue of SIGCHI Bulletin, pp2l-26.

#### 3.4.2 Other

- MKJ: The conceptual graph Knowledge Representation Language Teeside Polytechnic, June 1987
- MDW: Task Analysis for Knowledge Acquisition, SERC Knowledge Acquisition Workshop, June 1987, Abingdon.
- MDW: Natural Dialogue Strategies and Intelligent Interfaces. BCS HCI SIG meeting, January 1987, London.
- MDW: User Models at Different Stages of the Design Process, ALVEY Human Interface Club, User Modelling SIG, June 1987, Cambridge.
- DFM: Intelligent Interfaces Alvey SIG on Intelligent Interfaces meeting, Abingdon, Dec 86.
- MBD, CJP, GAR, MDW: Artificial Intelligence, NERC One day Seminar, Swindon, April 1987
- CJP: Artificial Intelligence, Technology Division Seminar, April 1987
- CJP: AI Hardware, Computer Board Forum, Edinburgh, April 1987
- CJP: A Model is a Model AISB Quarterly, Jan 1987
- SCL, GAR: A Graphical Approach to Explanation and Question Answering for a Financial Expert System.
- GAR: Seminars on Expert Systems to Financial Institutions.
- GAR: Seminar to final ALFEX club meeting on AI tool comparisons.
- GAR, DMR organised a Topical Meeting on Knowledge Representation at Cosener's House 24-25th April. Ron Brachman (AT&T) and Bob Moore (SRI) were prominent speakers from the USA.

- BGB, MKJ, CYLK, SCL, DFM, CJP, GAR, KDW have all contributed to a book Approaches to Knowledge Representation, edited by Duce and Ringland and due to be published by Research Studies Press.
- As Reviews Editor of AISB Quarterly, JWS receives many books and CJP, KDW and MKJ have written reviews.

## 4 INFRASTRUCTURE

### 4.1 Introduction

The work reported here is carried out by what is now the Infrastructure Section together with Cyril Balderson working directly for Ken Hartley. The main objectives are:-

- to provide a computing infrastructure for the Academic component of the Alvey programme.
- to provide systems and communications expertise for ECF GECs. Primes and VAXes.

This is becoming an increasingly management dominated activity with support for GEC Series 63 being carried out at EUCS (formerly ERCC), the VAXes being stable on BVSD 4.2, UTS not moving to System V and Sun support being sub-contracted to the Common Base. Furthermore the systems expertise which was needed to support GEC 4000 and Prime machines has also ceased to be of importance as machines are phased out and support moved elsewhere.

However the UNIX and Communications expertise which has been built up in the early days of the programme continues to be of vital importance to the Division (through IDUS development work) and the wider community.

The staff currently in post are:

- R E Thomas
- P J Hemmings
- P A Jeffrey
- R A Day
- A B Lowe
- A P McDermott
- N B M Calton
- I J Gunn
- M I Woods
- P J Isserlis
- I J Johnson
- D F Smith
- H K F Yeung
- D G Hicks
- H Roberts
- B W Henderson
- M L Joseph
- C D Rust
- D Green

### 4.2 Systems

The Section suffered two major reorganisations during the year. In November, the Divisional reshuffle meant that Francis Yeung took over responsibility for both the GEC 4000 and the Prime Systems from Mike Claringbold. By this time, GEC systems support had dwindled to just one person, following Shirley Wood's promotion and move to the Network Executive. However, the decision to cease GEC support and to pass Primos support to UMIST caused another change in April, leaving the team very short of personnel. This is now being rectified by recruitment and internal transfers. Hopefully, we can now look forward to a period of relative stability.


**Informatics Machine Room in R1, June 1986, Shirley Wood and GEC 4090 System**

**Large View**

This year marks the end of an era, with support of Primos and OS4000 finally ending at RAL. These systems have served us well and have allowed large numbers of systems staff to cut their teeth over the years.

### 4.2.1 Prime Systems

The activity on Primes was split between Jeremy Isserlis (Primos) and Mark Roberts (Primix), with help firstly from Mike Claringbold and then Francis Yeung. Jeremy finished modifying and testing revision 19.4.10 of the Primos Operating system, which was passed to UMIST for distribution as usual. This work prompted him to produce a paper on the organisation and administration of the Prime computers at RAL, and action is now being taken on his findings. Revision 20.2.la of Primos arrived in December, and the SERC mods inserted. Just as this was done we received revision 20.2.2, which was modified similarly. Testing was longer winded than formerly as new disc partitions etc. were also necessary. Again, this work led to the production of a discussion paper, this time on the need for the modifications. As expected, this proved an emotive issue, and was discussed at length. Some progress was made in classifying the changes, but further work in this area will now be undertaken by UMIST, following the decision to hand over responsibility for Primos in April. Thus ended some 10 years of involvement with Primos, but sorrow was tempered with relief (particularly in respect of the SPARS (Prime error reporting)!)

Once version 19.4.10 had been completed, Jeremy and Mark installed the new system on Technology Division's new P9955II that replaced the two P750s, RLPG and RLPI; this work included merging the systems software of the two old machines and assisting operations and the local manager. Later, they helped install a floppy disc device in place of the old card punch machine used to transfer data to the wire wrap machine. RLPD, the Prime development machine, received a

streamer tape drive at last. The library wanted a demonstration of the PRIME INFORMATION database system (a version of PICK) and a library package, BOOKSHELF, on RLPA for a sales demonstration. Jeremy mounted this, with little help from Prime.

As well as helping with Primos, Mark completed the Primix beta test report on Primix 2.0. The effect of this on Prime was considerable, and involved going to Prime US to assist with the solution to some of the problems. This has proved to be very useful for both sides, and hopefully the contacts will be retained. Speed still gives the major cause for concern however. Mark made a number of suggestions which Prime have now included. The released version eventually arrived at the end of April, and was installed on the development Prime running with SERC Primos revision 20.2.2. Benchmarks using the Byte and Aim tests have been carried out, along with measurements intended to estimate the impact that Primix users will have on Primos performance. A number of bug reports and enhancement requests have been submitted to Prime. A trial user service on RLPA began in July. The Beta test version of Primix 3.0 with Primos revision 21 has recently been received. It is hoped that the performance and functionality will be sufficiently improved for a reasonable service to be offered on ECF Primes. It is planned to reconsider the whole issue at the end of September.

Last year, RAL commissioned Salford to provide an implementation of JTMP which would interface to the SERC networking code. This was monitored by Eric Thomas, with UMIST providing the necessary interface routines. After some delays (on both sides) it passed its acceptance tests, and is now available for release to sites. Note that it is a RJE implementation only; you cannot send jobs to a Prime via JTMP.

### 4.2.2 GEC Systems

Following the departure of Neil Davidson, Shirley Woods and Chris Rust continued to provide the general systems support for the GEC 4000 series. This included work on the NRS naming scheme. The move of Shirley brought the team down to a membership of one, and it was decided to plan for the freezing of the System. It had been hoped that the next version would be mounted, and the GEC X25 would be provided, but in the event neither proved possible (in spite of an attempt to use contract help).

It was finally decided to leave the main system alone, but to fix as many mail bugs as possible before April. Chris completed the work, and another era came to an end!

### 4.2.3 UTS

Most of the year has been spent on two activities: trying to get UTS/V into service and mounting TP4/LLC1. Stanley Ooi worked on these for the short time he was with us, along with Neil Calton and David Hicks, who carried on the work when Stanley left and Neil changed job.

A new version of UTS/V (1.1. 2) was mounted, and various packages ported to it. This was not always an easy job, with the 4250 backend proving troublesome. A new accounts program was introduced to correspond with the requirements of CCD. Much effort went into improving the documentation and in creating a proper boot tape. The discs were reorganised so that the minidisks were of a suitable size to be included in CCD's normal dumping schedule. Further changes were brought about by a new version of CMS, which affected the FTP and Mail system.

The two major hindrances to the introduction of UTS/V were the mounting of Franzlisp (only a binary version had been available under the old UTS) and the provision of full-duplex terminal lines. Franz has now been mounted, and Cambridge are being assisted in porting their code (HOL, High Order Language). Amdahl tell us that, at last, there is a version of UTS/F which coexists with the Compro software in the front-end which will allow local terminals to have full-duplex access. As yet we are unable to verify the above. This is at least a year late.

In order to provide better access to UTS, and to test out the ISO LAN protocols, the ERCC TP4 code was mounted over LLC1 via an Auscom box which links to a fibre optic link from the Atlas Centre to R1. The York Coloured Book software was used to provide file transfer and remote login.

The work was complicated by the need to share access with both CCD and HEP, and hardware problems with the Auscom. Finally, files have been transferred between UTS, a VAX and a SUN running ISO, but not before differences of interpretation of the standard had been encountered (and solved). Unfortunately, remote PAD login has proved more difficult, and is still not working correctly.

Attempts at getting UTS into a state where it will be more useful have been going on for a long time now. Regularly, the need for UTS is reviewed. There is one external project that has made extensive use of the software, but this is due to end shortly. It has been decided that UTS will be withdrawn by March 1988. The increased power of single user workstations and the availability of the CRAY X-MP makes a UTS service much less attractive than two years ago.

### 4.2.4 Text Processing

Neil Calton has been working on various text processing projects during the year. When he moved to Communications in April, Chris Rust (late of the GEC) took over. Neil has written shell scripts to enable UTS users to format documents with titroff and its preprocessors, and obtain the output on the IBM4250 erosion printer. A user's guide to the IBM4250 and formatting documents on UTS has been written and distributed. This includes information on fonts and character sets. The facility for accessing the 4250 from rlvc has also been enhanced. He has also adapted the UTS mv macro package to enable viewgraphs for foils and slides to be produced on the IBM4250. A user's guide to this mv macro package, with several examples, has been written.

Neil has installed, adapted and tested the TRANSCRIPT text processing package on UTS/V. As UTS/V is not yet connected to PostScript printers via the Ethernet various changes have had to be made. All Postscript output is redirected to the standard output channel. Facilities have been provided to assist users in transferring PostScript files to other machines for printing. A paper and a User Note have been prepared.

Neil helped connect a pragma QMS PostScript printer to rl.vf and tested it for compatibility with the Apple LaserWriters. He has also been trying to solve some of the flow control problems that have cropped up with the a13 LaserWriter. In addition, he installed and tested titroff and its preprocessors on rl.vm running Ultrix and tested them in conjunction with the Transcript software.

Chris has mounted the DWB 2.0 text processing package on UTS. Following this, he did the same on rl.vm, converting the package from a System V environment to a BSD environment. The most difficult part of this process was the conversion of two indexing programs which were particularly dependent on System V features.

### 4.2.5 VAX

Work on the VAXes has mainly been the fixing of bugs, reported locally and at the remote sites. The loss of both Simon Frost (at the end of last year) and Jim Aitken (November) was keenly felt, since they were the acknowledged experts. The team managed as best they could, and continued to improve their knowledge. Francis Yeung, Ian Harding and Neil Calton had the most involvement, with Ian and David Hicks specialising in Ultrix. Since April, Mark Roberts has begun to look at BSD Unix, mounting the latest version of C++.

Various versions of Ultrix have been mounted, and Ultrix 2.0 is awaited. Benchmarks have been run. Ultrix was successfully mounted on a Systime VAX, and might be considered a candidate for other VAXes if DEC can agree to quote us a price. Although DEC took over maintenance of the hardware, they are very reluctant to agree to running DEC software on a 'modified' machine. However, since we seem unable to obtain BSD 4.3 (because of the US export clause problem), Ultrix may be the only way of getting the VAXes to run faster. The longer we leave it, the less likely it will be, since the VAXes are becoming less important.

### 4.2.6 Pyramid

The VAX team also provide support for the Pyramid, including the addition of various SERC mods to the standard OSx (we must take care not to get into the Prime position here!) and updating the

operating system twice in the period. An accounts presentation program has been written by Mark to assist in the introduction of accounting to what is part of the Gold service.

#### 4.2.7 3B2

The 3B2 has proved very useful as a System V reference machine. Francis has installed Sys V Release 3 on 3B2 with a borrowed 5620 terminal (the original one has to be sent back to Olivetti for repair!). There are a number of new features in the new release including remote file sharing, streams, AT&T Transport Interface, shared libraries, AT&T windowing utilities etc. It has so far proved impossible to allocate any time to SVR3, but there is still a hope that we will be able to evaluate the new facilities. Access will be considerably improved when the machine is connected to the ethernet.

#### 4.2.8 IBM 6150

The Division has obtained an IBM 6150 Unix PC. Francis has been involved in the evaluation. The work was concentrated on three main areas user/administrator commands, system calls and library routines. A paper which compared the system calls between the 6150 and AT&T 3B2 (a reference machine for System V implementation) was produced. A plan to produce a similar paper on library routines was withdrawn because there are not enough discrepancies between the two systems to warrant it. The differences in the administrator commands are to a certain extent the results of the trend that everyone is trying something different nowadays to make the interface more user friendly. The absence of the shl (shell layer) facility is more fundamental as the 6150 chooses to have its own 'virtual terminal' facility instead. The printer spooling system on the 6150 is also different from that on the 3B2 and that appears to be a deliberate decision too. One interesting command that is not available on other systems is confer which provides the users with an on-line conferencing facility.

The main problem with the 6150 at the moment is communication as it is not connected to other machines by any means. However. with the cartridge tapes, there have been some successes in transferring files from the Sun3 workstations to the 6150. The problem should be resolved when the 6150 is connected to the Ethernet.

A quick comparison of the Byte Benchmark results between the Sun3 and 6150 shows that the Sun3 is faster executing function and system calls but the 6150 is faster running shell scripts. It would be interesting to compare the performance of the two systems with some genuine application programs.

Recently, IBM have expressed an interest in a joint project with the Division. Francis will lead the team which will look at connecting a Transputer, and using the resulting system to run some of the standard packages used by the Magnet Design team.

#### 4.2.9 Online System Activity Log

As part of the RAL A.S.O training scheme, Duncan Green has been given the task of providing an Online System Activity Logging facility. Before departing Stanley Ooi had proposed and devised a scheme where all changes to development systems would be logged in separate binders on a standard form. Envisaging a large growth of paper and the benefits of holding all the information in online relational format, it was decided that a better system should be provided. Duncan is using the Ingres Relational database, which is not the easiest database to get to use. He has successfully managed to develop a skeletal system via a C program interface which performs the basic operations such as retrievals, additions, perusal etc.

### 4.3 Communications

For much of the year, the Communications team has been seriously understaffed, reaching its low point when Jim Aitken left in November. The November reorganisation added Tony Lowe to the team, and now all the communications services, including basic wiring, are organised from within Infrastructure section. The April restructure changed things considerably by moving Jeremy Isserlis

and Neil Calton into the team. In addition, efforts have been made to arrange a sabbatical year for Danny Smith from the University of Queensland to work within the section on X.400 mail protocols. This has proved successful, and he will start at the end of August.

Mike Woods, having left the team in November, rejoined in April.

### 4.3.1 X25

Ian Johnson carried out extensive testing of the York X.25 code which he had ported to run with the Morning Star board on the Pyramid. This testing showed that the Morning Star board could provide a reliable X.25 connection, and a user service was introduced on pyr-a in early November. Shortly after this, he visited Brunel University and mounted the York X.25 code on their Pyramid. At both sites, the service provided is two-way FTP, and incoming terminal calls.

In December, Pyramid mounted a new revision of the X.25 Front End code, which runs on the Morning Star board. This revision totally destroyed the X.25 service to users, and prevented any further development or refinement of the York code, such as porting the York PAD program for outgoing terminal calls. Ian made extensive efforts, in conjunction with Pyramid technical staff, to pinpoint the OSx kernel problems which were preventing X.25 working. These problems turned out be due to a faulty upgrade procedure carried out by Pyramid. The Pyramid now runs a reliable X.25 service, including outgoing X.29 using the York PAD program. Pyramid UK have taken over support and development of the changes Ian made to the York netio routines.

Ian commissioned X.25 software on the Pyramid WorkCenter Central Server, nfs4.

In April, Jeremy Isserlis moved into the Comms team, working with Ian. Jeremy evaluated SUN's Coloured Books product for their X25 offering. Although a complete test cannot be made until version 4.0 of Sunlink X25 arrives (currently on order), it was possible to test enough aspects to confirm that the product would be a suitable recommendation for ECF and Alvey SUNs requiring stand-alone X25 access.

Jeremy is now installing software on one of the Division's fileservers, in preparation for moving the mail service onto this machine.

### 4.3.2 ISO TP4

The section has participated in a long-running project to provide ISO Transport Class 4 (TP4) protocols on to the Alvey Infrastructure VAXes. This was undertaken in conjunction with ERCC. Before leaving the section, Jim Aitken finally managed to remove some low-level bugs that were holding up progress, and produced a working system. He also ported the code to the Pyramid and demonstrated VAX-Pyramid interworking. Unfortunately, performance of the VAX system was much less than hoped for, typically achieving only 10-20% of the throughput of the equivalent application based on TCP/IP. This was found partly to be due to an unoptimised kernel implementation of the protocols, and partly due to the use of applications software tuned for WAN, rather than LAN, use.

The original reason for providing TP4 on the VAXes was to allow interworking with the Infrastructure GEC Series 63s. However, the recent appearance of TCP/IP on these machines fulfils this aim. Further development of TP4 on the VAXes has therefore been frozen.

Ian Johnson took part in a beta-test evaluation of SUN's Sunlink TP4 product. As with the VAX and Pyramid work, the York netio interface was put on top of the Sunlink code, allowing Coloured Book protocols to run over TP4. This proved successful, and Blue Book FTP gave throughput levels of 30-50% of those obtained using the TCP/IP equivalent. Ian also managed to interwork Blue Book FTP to the Pyramid, and to UTS (working in conjunction with David Hicks, reported earlier).

### 4.3.3 Pink Book

Ian Johnson assisted in the initial evaluation of Pyramid's Pink Book product. This attempt was ill-fated, due to problems with the Pink Book implementation on the VMS VAX in CCD. Another attempt has been arranged and hopefully a better result will be obtained.

### 4.3.4 Distributed Filesystems

Bob Day organised the introduction into service of NFS on the Pyramid, and the adoption of a "global user filestore" between Suns and Pyramid. This involved bringing the systems administrators up to speed on what NFS is about, and then getting them to do all the hard work in sorting out common Unix UIDs over the network. Once the licensing had been sorted out, rl.vd was added, and this meant a lot of work for Mike Woods in tidying up his implementation (despite fairly horrendous hardware problems). Neil Calton (having joined the team in April) looked after this work.

Ian Gunn attempted to implement the Yellow Pages distributed look-up system on pyr-a. This proved impossible to do with the current Pyramid implementation of NFS. Another attempt is planned when Pyramid deliver a more up-to-date version in August.

Bob gave two talks on NFS: one to the Alvey site managers' meeting and one to the computing Science Dept. at the University of Exeter.

Mike Woods' last work before his temporary stay in Software Engineering Group was to port SUN's generic NFS code to the Infrastructure VAXes. To prepare for this, Bob Day organised a one-off course from Instruction Set for Mike, Simon Frost and two people from ERCC, where a similar port to the GEC Series 63 machines was beginning. This took place at RAL, and resulted in an initial version being available very quickly. Mike spent some time in adapting existing utilities on the VAX to work under NFS, and in curing some low-level unreliability problems. The port is now in service on rl.vd, with Mike having provided 'consultancy' in getting this going whilst starting his RA work. The port is now being shipped to sites, with Oxford as the field test. Neil Calton has organised the logistics of the distribution. Ian Gunn and he will be doing the necessary site visits.

Neil has also written an introductory guide to NFS with particular reference to the steps that need to be taken prior to its installation at a site. This document was intended initially for Alvey site managers but its scope is being extended to make it of more general interest . Plans are also prepared for the introduction of NFS on rl.vc.

The main problem with the VAX NFS project turned out not to be technical but one of licensing. Negotiations between AERE Contracts and Instruction Set (distributors of the code) proved to be extremely protracted, and involved many people's time.

Ian has spent much of his time converting the news system to run over NFS rather than via daemons as was previously done. He has made available a version of rn which runs over NFS on Vax, Sun and Pyramid computers. He has also fixed many of the problems with news which have appeared over recent months. Ian has installed the Newcastle Connection on the Informatics Division Sun file-servers and has ported the Newcastle Connection to the Pyramid. There were several bugs, most of which have now been fixed. He has also put the Newcastle Connection on the Pyramid Central Server running a beta-test release of OSx4.0, the new release of Pyramid's operating system.

### 4.3.5 Pyramid Visit

Bob Day visited Pyramid Technology in Mountain View during May to discuss various communications issues. Major topics discussed were NFS (as it relates to the contract with Pyramid to supply Central Servers for the ECF) , X.25 (Pyramid are doing a new one to replace the "Morning Star"), Pyramid/CRAY communications, and Pyramid's ISO OSI planning. This was a very useful trip, allowing Bob to give Informatics' view of communications requirements to the team responsible for all Pyramid's communications products.

### 4.3.6 Divisional LAN

Tony Lowe joined the team in November, and has been kept very busy with the many and various communications requirements, caused by office moves, new equipment, additions to the Division (such as half of Technology!) etc. He has also been involved in installing etherPADs and thin wire ethernet. A Spiderport has been ordered so that it can be compared with the Bridge equipment

used so far. In addition, Tony has visited a number of the Infrastructure sites to discuss their Communications problems.

Bob and Tony undertook a series of measurements of traffic levels on the ID LAN and its servers. A number of interesting phenomena were discovered. This led to the purchase of a Hewlett Packard Ethernet monitor, which will be used to study what actually happens on the Informatics LAN. A joint study has been set up with Heriot-Watt University to attempt to construct a mathematical model of the LAN and servers, and to test it with data from our LAN. This should give a tool with which to predict what enhancements will be needed to the LAN as more clients are added, thus making long-term planning possible. Hopefully the model will be applicable to all LANs of this form.

### 4.3.7 RAL Site LAN

Bob Day and Tony Lowe have participated in discussions aimed at setting up a Rutherford site Ethernet. This would allow high-speed access to other LANs on site, and in particular to the central facilities in the Atlas Centre. This work led to Bob and Tony Lowe undertaking the evaluation of LAN bridges devices for LAN interconnection - an interesting task which looks set to continue for some time. So far two bridges have been evaluated. One, Bridge's 1B/2, seems to be a well-designed piece of kit; the other, LRT's Intracomm 6, unfortunately seems to be lacking in performance in its present form. It is possible that Tony and Bob will co-operate in a larger evaluation of bridges being conducted by Daresbury Laboratory on behalf of the JNT.

## 4.4 Management

In November, Ken Hartley was appointed Head of Alvey Infrastructure, on a half-time basis. Cyril Balderson assists him in these duties. The main function is to serve as a channel of communication between Millbank and RAL, and to try to bring together all Alvey Infrastructure activities. As they have been entrenched as separate activities for three years, little progress has been made. Ken and Cyril also serve the Alvey Infrastructure Steering Committee - Cyril is secretary - chaired by Laurence Clarke.

The most constructive effort during the year has been feeding back Informatics Division's experience of Alvey to those planning IT92 and to draft proposals for a new, broader based infrastructure.

At the November reorganisation, Eric reassumed the role of RAL Infrastructure Project Manager, assisted by Peter Hemmings. The main work has involved the running of Site Managers Meetings and the reconciliation of the spending at sites. This last has proved as difficult this time round as it was in the first year, and suggests that one should aim to avoid having site contracts which coincide with the SERC financial year. Peter has also taken over the liaison role with GEC, and as the chaser of other contracts (notably the one for NFS). At April, he was joined by Paul Jeffery, who has been learning fast. Paul has already produced time series graphs and histograms of the statistics from the sites, and has witnessed an Alvey first statistics from everywhere!

## 4.5 General

### 4.5.1 Access to Cray

With the implementation of the Forty Report recommendations going ahead (eventually, after a lot of hassle with the US), a Cray XMP 48 was installed in the Atlas Centre. Eric and Bob Day visited Cray UK and, following discussions with CCD, Technology Division and others, put together a couple of papers proposing ways in which Workstations running UNIX might be able to interface to the Cray without having to run JTMP and gaining batch access only. CCD plan to run UNICOS (UNIX on Cray) eventually, and there will be a Hyperchannel connection as well. After a slow start, work on providing a Unix interface to COS has just begun.

### 4.5.2 ECF Central Server

Bob Day has participated in the ECF Central Server project. From an earlier Operational Requirement a shortlist of machines was drawn up. Bob evaluated the communications abilities of these, including NFS performance tests on the Sun, Gould and Pyramid offerings. (He was ably assisted in this by Mike Woods and Lynton Jones-Ng.) From these, he and Julian Gallop drew up the final Tender Requirements, the responses to which led to the decision to opt for a mixture of Sun and Pyramid machines.

Bob is now involved, with Neil Calton, in a more extended evaluation of a Pyramid Central Server, purchased in March. To date this has involved progressing provision of Pink Book and TP4, as well as chasing Pyramid for performance enhancements for NFS.

Tony Lowe visited Warwick, the first external site due to receive a Central Server, to advise on LAN provision.

### 4.5.3 Informatics Divisional UNIX Service (IDUS)

Following various disagreements between Management and workers on what facilities could and should be provided in-house, it was decided to identify a Divisional Service. Bob Day played a major part in this, and will be the Technical Development Manager: this seems to mean being responsible for introducing new facilities; tentative plans are for a 'real' mail service, properly integrated text processing, and 3270 emulation from Suns. Bob has also advised on the provision of server and LAN capacity needed for the purchase of an extra 24 SUN workstations for Divisional use.

### 4.5.4 Ecstasy

Ecstasy is the name of a project set up by the Control Engineers to provide a common interface to a number of separate programs. Those with long memories will recall a package called DELIGHT-MIMO which tried to do the same thing. This was rejected by the community for a variety of reasons. RAL has been asked to help in two ways: to provide some advice and programming help on the Window Manager side of things and also to advise on Software Engineering aspects. Tony Williams supplies the former, and Eric Thomas provides the latter service. This has involved the provision of a definitive, quantifiable project specification. None of the other participants appear to have had any experience of writing such a document, and the stated objectives were originally very vague. The current document at least makes it clear what is being done (but there is a possibility that the community may not agree). The first version of the software should go to academic sites in January, with a final version (for handover to RAL) by June. It is still not clear how active a role RAL will play beyond this date. It could involve a large programme of work.

### 4.5.5 ASO Trainees

CCD again asked that the Division take the latest batch of ASO Trainees to introduce them to Unix. Eric Thomas and Neil Calton handled this. Eric acted as Customer, and provided the acceptance tests. As usual, this quickly demonstrated the need to plan tests so that errors are found (rather than merely throw one set of figures at the program). Neil also provided a set of twenty questions on UNIX for them to answer.

### 4.5.6 Compute Server

Mike Woods officially left the Group to join Software Engineering on his promotion. While there, he has begun to look at the possibility of working on a compute server which would locate the best place on the network to run a particular job. So far he has concentrated on the problems of setting up the administrative network needed to provide compute power at arbitrary places in the network. The work has been done using SUN workstations and SUN's RPC (Remote Procedure Call) mechanism as the underlying carrier. Lessons learnt from this include an appreciation of the limitations of SUN's RPC for this type of applications, and the need for a reliable underlying transport service to convey state information between servers. It is clear that a compute server is much more complex than a file server (such as for NFS) in these respects. The next stage of the work is to construct a proper 'worm' server using the facilities provided so far. Mike has decided to

recode his software in C++: this is to take advantage of the language's enhanced facilities for manipulating the complex data structures which seem to be a feature of this work. Mike returned to the Infrastructure Group in April.

### 4.5.7 3270 Emulator for SUN

Mike Woods has been supervising one of the ASO Trainees (Arif Hussain), who has been developing a 3270 emulator for the SUN. After the successful completion on the project, Mike did a small amount of work to bring the emulator to a state ready for distribution. This included tidying some of the code, altering the makefile to aid installation, and ensuring the documentation was complete. All work is done and the new release of the emulator is now available on the Suns.

### 4.5.8 OSST

Keith Bartlett, Alvey Infrastructure and Coordination Director, has set up a small team of industrial secondees to advise on the use of Open Systems for national R & D Programmes. OSST - Open Systems Support Team are mainly concerned with communications between industrial sites and interworking with JANET and other European networks. Ken Hartley, Bob Day and Eric Thomas had a fruitful discussion with them and have provided input to them on various strategy papers. Eric gave a paper, alongside OSST and the Network Executive at the UMIST meeting of the Alvey Networks and Communications Club, which discussed communications infrastructure for Alvey and similar programmes. It is hoped to continue this close collaboration in future. Cyril Balderson is preparing a paper on communications links between RAL and the outside world, as an example of the kind of problems they face.

### 4.5.9. Alvey Mail

During February, Cyril Balderson undertook the Project Managership of the Alvey Mail Service. Unfortunately, this has not always been held in the highest regard by its users, for various reasons. Although the service may have a limited period remaining with closure at present assumed for late 1988, it was felt worthwhile to specify a number of changes to the user interface to the service. The paucity of person-power however (10% of Shirley Wood!) has meant that these changes are still to be completed. A major activity was to reduce the user-base to those who had actually used the service within the last 6 months which caused a reduction of about 50% from those originally registered. There are now about 350 users registered, and among these there is a steady level of use.

A publicity piece for the Alvey Mail Service has been written for publication in Alvey News (probably October).

### 4.5.10 Finance Project

The Division has requested that an automated means be found to generate the financial reports received by Project Managers from the official RAL data. Peter Hemmings is undertaking this work, and has produced a user requirements specification. A functional spec will be produced shortly, and it is hoped to finish the system in time for the next end-of-year panic.

## 4.6 Staff Changes

i. Arrivals

- Stanley Ooi: October
- Arif Hussain (ASO Trainee): December
- Paul Jeffery: April
- Duncan Green (ASO Trainee): June
- Mei Joseph: July

ii. Promotions

- Shirley Wood: SSO
- Mike Woods: RA

- Ian Gunn: HSO
- David Hicks: HSO
- Mark Roberts: HSO

iii. Departures

- Simon Frost: September
- Neil Davidson: September
- Shirley Wood (to Network Executive): October
- Jim Aitken: November
- Ian Harding: March
- Stanley Ooi: April
- Arif Hussain: April

### 4.7 Publications

#### 4.7.1 External

C Balderson The Alvey Computing Infrastructure Project, Alvey News.

### 4.8 Conferences

- C Balderson
  1. Expert Systems '86 Conference, Brighton, December 1986
  2. MAP and TOP Seminars, Barbican, March 1987
  3. Alvey Conference, July 1987
- N B M Calton
  1. EUUG Workshop, September 1986
  2. ULTRIX SIG Meeting, October 1986
  3. UKUUG Winter Technical Meeting, December 1986
  4. USENIX, USA, January 1987
  5. UNIX User Show, May 1987
  6. NFS Overview Course, September 1987
- R A Day
  1. CIMAP - manufacturers display MAP and TOP products, Dec 1986
  2. Networkshop 15, April 1987
  3. Visit Pyramid, USA, May 1987
- I J Gunn
  1. Computer network Design & Protocols, December 1986
  2. EUUG, Helsinki, May 1987
- I Harding
  1. Writing Device Drivers, Instruction Set, December 1986
- K F Hartley
  1. Alvey Conference, July 1987
- P J Hemmings
  1. How to Get Results with People, Wembley Conference Centre, March 1987.
  2. Alvey Conference, July 1987
- D G Hicks
  1. Writing Device Drivers and Kernel OVERVIEW, December 1986
  2. USENIX, Phoenix, USA, June 1987
  3. Visits to Pyramid, Amdahl, AIM, June 1987

4. UNIX Kernel (IS course), September 1987

- P J Isserlis
  1. IFIP, Dublin, September 1986
  2. OCCAM Course, Edinburgh, January 1987
  3. Exeter X.25 Course, March 1987
  4. UKPUG, April 1987
  5. EUUG Helsinki, May 1987
  6. C Course, June 1987
- I J Johnson
  1. Computer Network Design and Protocols, December 1986
  2. Pyramid OSX 4.0 Seminar, March 1987
  3. Technical Writing for Scientists, March 1987
  4. Networkshop 15, April 1987
  5. USENIX, Phoenix, USA, June 1987
  6. Visit Pyramid, Amdahl, AIM, June 1987
  7. Exeter X.25 Course, September 1986
  8. EUUG Workshop, September 1986
- P A Jeffrey
  1. Advanced UNIX, Instruction Set, May 1987
  2. Alvey Conference, July 1987
- A B Lowe
  1. COMPEC, November 1986
  2. CIMAP, December 1986
  3. ICS Course, Computer Network Design and Protocols, December 1986
  4. Management of Data Communications Systems, January 1987
  5. Which Computer Show, February 1987
  6. Trouble Shooting Local and Wide Area Networks, February 1987
  7. Fibre Optics in Data Communications, IEEIE, April 1987
  8. Networkshop 15, April 1987
  9. Bridge Communications Seminar April 1987
  10. European UNIX User Show, May 1987
  11. CIM '87, June 1987
  12. International Workshop on LAN Management, W Berlin, July 1987
- S S L Ooi
  1. UNIX Course, Instruction Set, November 1986
  2. UNIX Kernel Course, February 1987
- M H Roberts
  1. UNIFORUM, January 1987
  2. C++, March 1987
  3. SERC Management Course, March 1987
  4. C Programming Course, Instruction Set, June 1987
  5. Networking UNIX Systems (IS course), August 1987
- C D Rust
  1. SERC Induction Course, January 1987
  2. Management Development Part 1, March 1987
  3. UNIX For Programmers, April 1987
  4. PostScript Language Seminar, May 1987
  5. Management Development Part 2, June 1987
- R E Thomas

1. UNIFORUM, January 1987
2. USA Visit DEC USA, January 1987
3. Project Management by Tom Gilb, March 1987
4. Networks '87 Exhibition
5. Alvey Conference, July 1987

- M I Woods
  1. EUUG Workshop, September 1986
- H K F Yeung
  1. Project Management by Tom Gilb, April 1987
  2. DECUS, September 1987

### 4.9 MSc

MIW continues to attend a MSc Course at Brunel University one day a week.

### 4.10 Future Work

Next year is bound to be a year of transition. There will certainly be a substantial run-down of Alvey activity; what remains unclear is whether there will be a follow-on programme of the kind envisaged in the IT86 report and, if so, what role RAL will be asked to play in it. KFH has been responsible for several drafts of an Infrastructure Strategy paper, each one modified by the Steering Committee. The end result is a rather different infrastructure from the Alvey one. One of the proposals is the setting up of a common base of software for the IT community, which would include everything from systems and communications up to environments and IPSEs. Creating and supporting it would bring together the contractual, managerial and technical skills of the Division. this should also fit in very well with work to establish EASE in the Engineering Board area.

Considerable effort has been expended in trying to ensure that Informatics does have a part to play in IT92. However, other avenues are also being explored to find work which is challenging, appropriate and above all, funded!

## 5 HUMAN COMPUTER INTERACTION

### 5.1 Introduction

The section's interests lie in the general area of user interface design on advanced workstations, undertaken both by doing R & D work in the area and by supporting relevant research work elsewhere. The major funding areas are:

1. Technical support, by work in the user interface/window management area mainly for the Alvey LDP/HR Directorate.
2. Programme support, primarily for the Alvey HI community, but also for the wider ex-Alvey MMI community.
3. Investigation of more advanced techniques of possible use to the SERC Engineering Board community, particularly with funding from the EB's Computing Facilities Committee.
4. Direct research grants from SERC committees, particularly the Computing Science Sub Committee.

Apart from Arthur Seaton, who has returned to Edinburgh for love and golf, section membership has been stable. Keith Appleby has recently joined us as a student working for Mark Martin. Staff currently in post are:

- Ken Robinson (KR)
- Tony Williams (ASW)
- Tony Conway (TC)
- Mark Martin (MMM)

- Keith Dancey (KDG)
- Chris Crampton (CMC)
- Crispin Goswell (CAAG)
- Keith Appleby (KA) (Student)

Both Helen Jenkins (HVJ) and Rita Hollington (RAH) have provided effective secretarial support during the year.

### 5.2 Window Management

Following the recommendations of the Workshop on Window Management that the section organised which was held in April/May 1986, approval was finally obtained from the ci-devant Alvey HMI Directorate for work to proceed at RAL. The project's objectives are two-fold: (a) define a low-level software interface (known as the Client-Server Interface or CSI) to window management functions imp1ementab1e on a range of workstations, and (b) implement the CSI on selected workstations as an existence proof. With vendor support for the CSI, application toolkits such as WW, which at present require extensive work to port to new environments would become much more widely available, easing greatly the work of applications programmers. Phase (a) is now complete with the publication of RAL Report 87-017 which has been widely distributed (CKC, CAAG, ASW). The implementation on the PERQ (with limited functionality) is complete. The SUN implementation awaits the arrival of X version 11, but some design work has been undertaken. A paper has been prepared comparing X and the CSI. Work on the design of a layout manager which runs on the CSI has also begun, with some prototyping of user interface ideas on X being undertaken.

### 5.3 Edinburgh CCS User Interface

Robin Milner's group at Edinburgh have a reputation for good formal methods work. Lately they have rea1ised that a good user interface is necessary for effective take-up of their work by ordinary software engineers. Following some discussions and presentations by RAL staff (ASW, KR, DAD) at Edinburgh, the Alvey Software Engineering Directorate agreed to fund work at RAL to provide a user interface for the CCS concurrent programming workbench. A limited amount of work has been done on this, mainly by ASW, HMM and CMC.

### 5.4 WW

MMM has continued to work on this graphical toolkit, aimed at applications programmers needing tools to write highly interactive applications. WW now supports colour, full screen access for reading and writing, and large cursors. Some of the work has been done in support of the porting of RAL GKS to SUNs. It has also been ported onto the CSI. Spin-offs from the Alvey Demonstration work (qv) into W include optimising window updating and bitmap access.


**Graphics Tools Stand at the Alvey Conference**

**Large View**

Experience with the SPY screen editor has led to MMM writing TEN, which gives more screen real-estate back to the user, as well as better functionality based on WW improvements such as files tore browsing, menus, cursors, small text areas and cut and paste with the window manager. Some optimisation has been possible to give dynamic feedback when sliding windows, and a simple experiment with gesture recognition was undertaken.

CMC has tweaked MON to fix a few bugs and add some facilities.

### 5.5 PostScript Interpreter

CAAG issued the first release of the PostScript interpreter near the beginning of this reporting year. Since then a number of improvements have been made, including non-integer scaling, arbitrary rotation of bitmaps, the setscreen function, fast area fill and complex clipping. Optimised text printing has also been provided - this gives a speed up of about four times. Ports have been done to Whitechapel, Orion, Vax and Pyramid (these last two permit remote viewing). The system has now been released publicly.

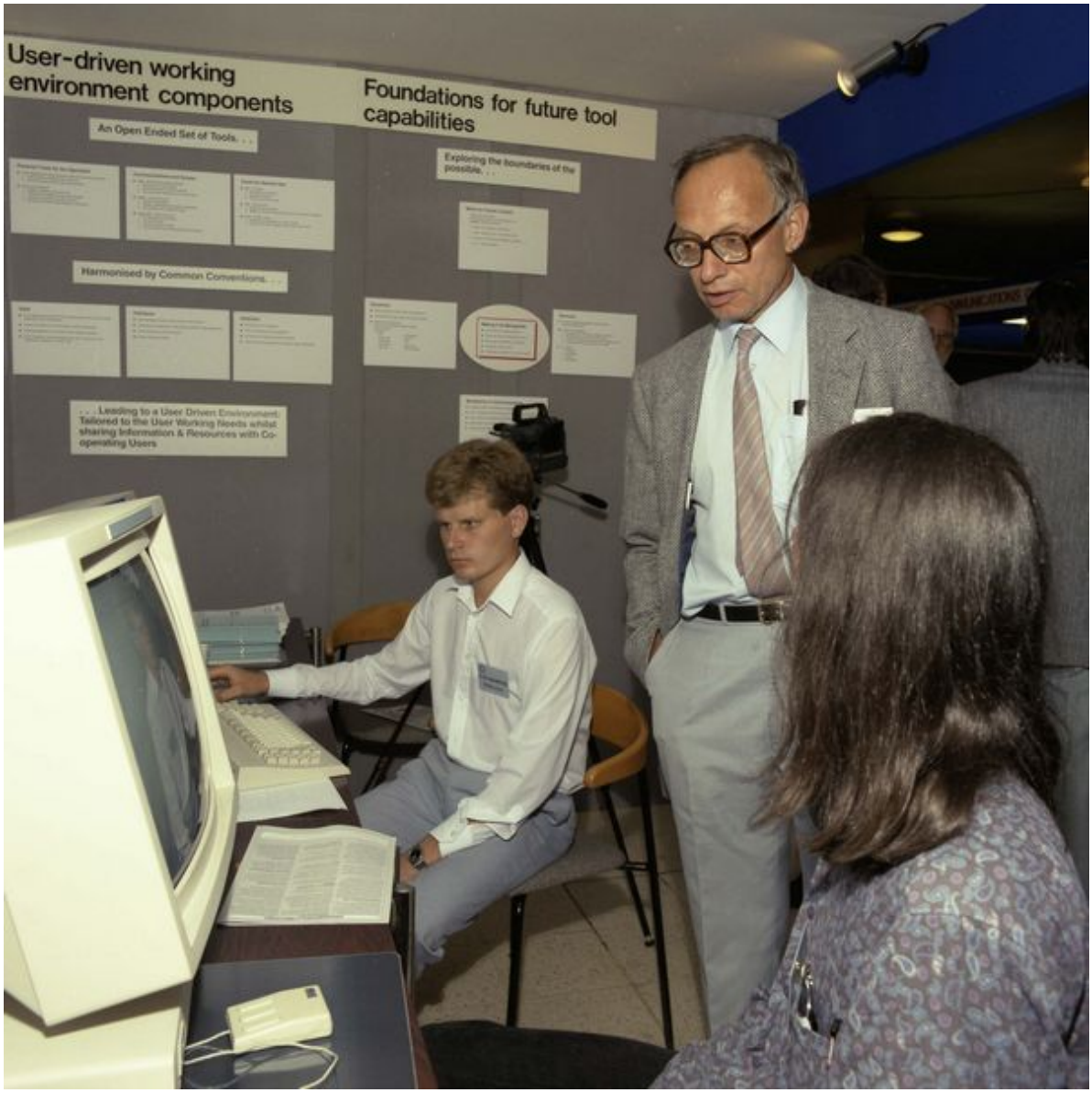
### 5.6 Alvey Demonstration

The whole section contributed to this activity a demonstration suitable for the Alvey Conference to show off our work. The demonstration consists of a small play, showing how a remote researcher can co-operate with a local technician on the design of a fairly complex laser facility (thanks to Denis Nicholas in Laser Division for providing the technical 'props'). The play requires two high bandwidth networked workstations, and assumes a voice channel is available. The major elements

of the demonstration include MUSK, a multi-user sketch pad which allows a number of users to construct diagrams, free sketch, and even input text, while sharing a common working area; DESED, a highly interactive laser design program; and PIXVIEW, which acts as a software video camera, enabling one user to see part or all of the screen of another (by consent, of course). ASW, MMM, CMC and CAAG did most of the software. The demo 'script' was handled by KGD and TC. The necessary PR material - display boards and handouts - were generated by ASW, TC and KR. Overall, everybody commented on almost everything. KR did a sterling job of worrying about the deadlines.


**Cooperative Working Demonstrator at the Alvey Conference. Crispin Goswell and Chris Crampton**

**Large View**




**Cooperative Working Demonstrator at the Alvey Conference. Demonstrating to Peter Kirstein**

**Large View**

Although this was a fair amount of work, the end-result, which is acceptably smooth, on its own justifies the investment. In addition, the opportunity was taken to explore in a small way problems associated with group working and communication; this has already resulted in work to be presented at a forthcoming conference, and bids to be a good research topic for the section in the future. As a final note, if WW had not been available then the project would not have been feasible.

### 5.7 Programme Support

#### 5.7.1 MMI Mailshot

CAAG continues to act as Mailshot Coordinator, with KR trying to sort out major problems as necessary and RAH providing the organisational back-up (arguing with Photo/Repro etc). Towards the end of the year an editor for the HI proportion of the mailshot was finally organised as part of the Loughborough LAMMIC contract. This has inevitably generated some discussion, particularly as LAMMIC would like to provide a monthly newsletter rather than part of a quarterly mailshot.

#### 5.7.2 Videotape Library

CMC looks after this; contributions and usage are currently at fairly low levels. Some 40 tapes are in the library.

### 5.7.3 Who's Who

This project aims to provide access to information on MMI research interests and services in the UK. KGD took over the project from Arthur Seaton and has done most of the direct database and form design work. 'Te has also spent time using awk and refer to ease the task of getting data into the system. Following comments from a number of experts, the original form was extensively redesigned and distributed to about 700 addresses. In parallel the database, using the INGRES DBMS, was designed and a set of image processing researchers' data input, partly as an exerciser and partly to satisfy a requirement for a paper copy by the Image Processing co-ordinator. This required writing a set of awk programs. Considerable difficulties were experienced both with the public-domain INGRES itself and the various implementations on the Vax and Pyramid. Occasionally the Pyramid version would disappear due to system vagaries, sometimes known as upgrades. The decision has just about been taken to purchase the (affordable) SUN version of INGRES; this would provide not only a more robust environment but also vastly improved front-end facilities.

### 5.7.4 Committee Support

TC now looks after the Alvey Human Interface Club Steering Committee, now revitalised under Vic Maller's chairmanship. As well as the usual secretarial duties, this has also required organising an HI Club meeting in London in March, and some support work for the nascent HI Special Interest Groups. The HI Professional Bodies Liaison Group is also supported.

### 5.7.5 IT86 Report - Alvey HI Response

Bide, IT86, IT92, Alvey 2 are all aliases for the same thing - the follow-on programme to Alvey for UK IT support. Following publication of the report, the Alvey Human Interface Committee set up two working parties to look at research requirements and organisational exploitation issues respectively. KR (as secretary) and FRAH attended the first-named working party, which met fairly frequently over a period of some few months at the beginning of 1987. The reports from the two working parties were merged and KR has a few copies if anyone is interested. As a document specifying research to be undertaken, it probably lacks a clear focus.

### 5.7.6 PUMs

PUMs are Programmable User Models these are things that the interface designer might have to program in future to see how good or bad his interface design is. (Think about an architecture which has memory which 'forgets' if you give it too much to remember). Richard Young at the MRC Applied Psychology Unit at Cambridge is undertaking this work with Alvey HI funding. KR is the Monitoring Officer for the project.

## 5.8 Research Projects

Two proposals have been submitted by the section to SERC - one to the Computing Science Sub Committee on Extensible Graphical Programming, and the other, collaborative with Leeds University Chemical Engineering Department, to Process Engineering Sub Committee B on the use of advanced user interface techniques for a complex plant design problem. Despite severe pressure on CSSC finances, the first proposal was mostly funded - a tribute to the skills of its writers (ASW, 'TC). The second was not fully understood by the Sub Committee, who to their credit did not reject it outright but appointed a panel to visit RAL. For various reasons outside the section's control and understanding, the visit planned for May/June never quite happened and is now scheduled for 25 September. This year, that is.

A meeting with staff at the Technische Hochschule, Darmstadt was held to consider possible topics for a European Twinning proposal. KR, DAD, JRG and CJP all attended, and a proposal on the

general topics of Theory and Practice of User Interface Design is being prepared, mainly by KR.

Some longer-term thinking has also been taking place on the future research directions for the section. These involve high-power workstations, multi-media input and output, and high bandwidth communications to remote multi-media resources. Various funding sources are being considered, including IT86, ESPRIT II, and so on.

### 5.9 Human Factors

There have been a number of delays in this area, some due to availability of suitable equipment, and some due to lack of space for a proper HF Laboratory (IGLM please note). MJP and 'TC have been working on some aspects of visual illusions, which are intended to lead on to investigations of different on-screen manipulation styles and 3D effects, related to exploration of complex spaces.

### 5.10 Eurographics 1987, Amsterdam

At the time of writing, four-sevenths of the section is in Amsterdam at this conference. There is an associated Workshop on Higher Level Tools for Window Management, of which ASW is programme chairman. MMM, CMC, and CAAG are all giving papers. ASW will also be acting as a panel chairman at the Conference to report on the Workshop.

### 5.11 Miscellaneous

The usual collection of things that do not fit neatly above are reported on here.

Exploitation of RAL Software. There has been much discussion but little actual progress with BTG on the exploitation of WW and associated software. KR has probably suffered the most. ASW did manage to persuade ICL to allow spy to be distributed to commercial companies (for internal use only), however.

Typesetter Service. KR and ASW were involved in discussions with Admin Division and CCD on the needs of the Laboratory for a high-quality typesetting service, and the subsequent purchase and installation issues. A Linotype Model 100 is being bought, which is a PostScript-driven device. The minor details of actually providing a service are now with RET and his section.

C++. Release 1.1 was ported by CMC to the PERQ and Pyramid, and some discussions with NBC have taken place so that Systems can do subsequent ports. CMC has ported release 1.2 to the SUNs and the Pyramid for HCI use.

PERQs and Communications. CMC has worked, with Robert Stroud's help and advice, on adding a UDP/IP driver to PERQ PNX5. This allows Ethernet links to the Divisional BSD machines using the Newcastle Connection. This has now been packaged and documented for use outside RAL.

Divisional Distributed UNIX Service. Both ASW and KR contributed to the policy document for what became IDUS. KR also attends ULM.

Know1edge Representation Book. ASW contributed two chapters to this, and TC one in collaboration with MDW.

UIMS Survey. ASW, TC and KR cooperated on the gathering of information for the ECF Programme. ASW is now working with M.1P in generating assessment criteria and a detailed assessment of the products.

ECSTASY. This is a project at UMIST on which ASW provides consultancy on user interface issues.

### 5.12 Future Developments

The following projects are envisaged for the coming year, given funding:

1. An object-oriented library for graphical user interface development funded by LDP/HI Directorate.
2. Continuation of the coordination and support work for the ex MMI Directorate.
3. Commencement of work on the Extensible Graphical Programming project.
4. If funded, beginning work on the Leeds University collaborative project.
5. Various projects of a longer-term nature for ECF.
6. Building up the Human Factors work.

### 5.13 Publications

1. G A Ringland, D A Duce (eds) , Approaches to Knowledge Representation (contributions by ASW, TC).
2. A S Williams, C M Crampton, C A A Goswe11, Unix Window Management Systems: Client-Server Interface Specification, RAL Report 87-017.
3. C M Crampton, A Portable Object-Oriented Toolkit, Workshop on Tools for Window Management, Eurographics 1987, Amsterdam, August 1987.
4. M M Martin, Foundations of a Toolkit, Workshop on Tools for Window Management, Eurographics 1987, Amsterdam, August 1987.
5. C A A Goswell, An Implementation of PostScript, BCS Workstation and Publication Systems Conference, October 1986.
6. C A A Goswell, Experiences in Implementing PostScript, Eurographics 1987, Amsterdam, August 1987.

### 5.14 Conferences

1. Alvey Conference and Exhibition, UMIST, July 1987 (KR, ASW, TC, CMC, CAAG).
2. Experimental Psychology Society meeting, UCL 5/6 January 1987 (TC) .
3. Workshop - Mental Models and HCI, Scharding, Austria, 9-13 June 1987 (TC).
4. EPS Meeting, Oxford, 1-3 July 1987 (TC).
5. IFIP 10th World Computer Congress, Dublin, September 1986 (KGD).
6. BCS HCI Group Meeting on HI Standards, London, November 1986 (KGD).
7. Eurographics 1987, Amsterdam, August 1987 (MMM, CAAG, CMC, ASW).
8. European Conference on Object-Oriented Programming, Paris, June 1987 (CMC).
9. USENIX Workshop on Graphics, Montery, California, November 1986 (CMC).
10. Object-Oriented Programming Society Meetings, London, 1986/1987 (CMC)
11. OOPSLA Conference, Portland, Oregan, September 1986 (ASW).
12. Alvey IPSE User Interface Workshop, Lancaster University, October 1986 (ASW).
13. Alvey QMC Workshop on User Interface Tools, June 1987 (ASW).
14. CHI '87, Toronto, Canada, April 1987 (MMM).

## 6 ENGINEERING COMPUTING FACILITIES EXECUTIVE

### 6.1 Introduction

The policy and budget for much of the work of the EC Group is determined by the Engineering Board's Computing Facilities Committee (CFC) . The latter is advised on technical matters by the Computing Facilities Technical Advisory Group (CFTAG), which was established in December 1986 and also met in February and May 1987. The ECFE is responsible for providing input to these groups and for executing their decisions.

The ECFE does not correspond to a particular branch of the group and the following staff participate:

- M R Jane

- A D Bryden
- F M Childs
- B Colyer
- J R Gallop
- G A Lambert

From the ECFE, MRJ and ADB attend CFC and MRJ, ADB, JRG, GAL (secretary) attend CFTAG.

The major concerns of CFTAG have been:

1. The evolution of the Common Base Policy for Single User Systems. This has resulted in a new (as yet, draft) policy for the wider issues of Engineering Computing, called the Engineering Applications Support Environment (EASE). JRG has written (and rewritten!) the various drafts. EASE has been announced in the EC Newsletter and input from Users has been invited. Comments are starting to be received.
2. The Application Software Review.
3. Engineering Board access to the Cray X-MP48.
4. Establishing guidelines for setting up and, controlling EMR contracts.

**Meetings**

CFC Meetings:- 10 October 1986, 11 March 1987, 3 June 1987 (MRJ, ADB)

CFTAG Meetings:- 11 December 1986, 18 February 1987, 7 May 1987 (MRJ, ADB, JRG, GAL)

### 6.2 Engineering Computing Facilities (ECF)

#### 6.2.1 Staff

Staff as at the end of August 1987:

- G A Lambert (GAL)
- F M Childs (FMC)
- L J Reed (LJR) arrived in April 1987 and transferred to Operations in July.

#### 6.2.2 Introduction

What the section lacks in numerical strength it makes up in quality! Linda Reed joined the section in April as a half-time mature trainee and has spent all her time in a training mode.

#### 6.2.3 Computing Facilities Technical Advisory Group (CFTAG)

GAL acts as secretary to the advisory group and in addition to the routine paper writing tasks associated with the role, has analysed the data and produced a report on the Applications Software Questionnaire which will be published as a RAL Report in the Autumn. Data on the use of International Networks by the research community is also being collected and a further report on the subject will also be produced.

As part of the Applications Software Review, a series of four Workshops are being arranged by GAL. The first, on User Interface Management Systems (UIMS), takes place in Glasgow in September, with a further one, on Database Systems, planned for November/December. Two further workshops are planned for early 1988.

#### 6.2.4 Esprit-962 (Everest)

GAL has now become involved in the management of the project and this is expected to take up to 50% of his available time.

#### 6.2.5 Grant Assessment

GAL remains responsible for the initial scan of all computer related grant applications referred to RAL for comment. After a successful visit to Central Office, Swindon by Chris Wadsworth, Peter Kent and GAL to comment on _a_l_l grant applications from the Computer Science Sub-

Committee, it is hoped to extend this practice to all committees as this achieves a significant time-saving for everyone involved compared with the current practice of grant applications being sent to RAL in a number of batches.

### 6.2.6 Engineering Computer Newsletter

Fran Childs (FMC) acts as editor of the Newsletter - with 4 editions produced so far this year. Contributions to the newsletter have been produced by members of the ECFE and from external members of the Engineering Board supported community. Production and distribution, against an exacting timetable, is a major task, as approximately 2,500 copies of each issue are distributed.

### 6.2.7 Transputer Initiative Loan Pool

Fran Childs (FMC) is responsible for the loan pool of the Initiative, which has seen a period of "frantic" activity during the past few months.

### 6.2.8 User Meetings

One meeting of the newly formed Engineering Computer User Group (ECUG), created from the ashes of the original hardware base committees, has been held (organised by FMC and GAL) with a further meeting planned for September. Attendance at the initial meeting was in excess of 100 which has been very satisfying as involvement with the original committees was declining rapidly. It is anticipated that the format of the ECUG will evolve to meet the changing needs of the user community.

### 6.2.9 Finance/Contracts

GAL still has some residual involvement with the management of the old ICF/UMIST site management committees and subsequent contractual work. Plans are now being made for the gradual reduction of the level of support obtained via the Support Contract at UMIST. All three contracts let to provide various software items for the GEC series 4000 systems have been completed.

### 6.2.10 Targets for this section

a. Take over management of Esprit 962 completely from ADB.
b. Complete organisation of workshops.

### 6.2.11 Courses

Semiconductor Materials and Devices, Davos, Switzerland. 31/8 - 4/9/87. (GAL)

## 7 ENGINEERING COMPUTING APPLICATIONS

### 7.1 Background

The Computing Applications Group (CAG) transferred from Technology Division to Informatics Division on 1 July to become part of the Engineering Computing Group under Mike Jane. Bill Trowbridge (CWT) , the previous leader of CAG, left RAL on 30 June to devote his efforts to Vector Fields Ltd, a company which he set up in 1984, and which has recently moved to new enlarged premises in Kidlington. Prior to his departure CWT, who held an individual merit appointment, had been employed half- time by RAL since June 1986. Most of the day- to-day running of the group was in the hands of Alan Bryden (ADB) as Deputy Group Leader as well as representing the Applications Software Programme at CFC and CFTAG. ADB also represents RAL on the Computational Fluid Dynamics Advisory Group (CFDAG), and is closely involved in the discussions about an IDF or Research Programme centred at Birmingham.

**Bill Trowbridge Retirement with Paul Williams (left)**

**Large View**

## 7.2 Engineering Applications Software Section

### 7.2.1 Introduction

The work of the section combines first-line support of a number of commercially provided packages, in-depth support of RAL written software and further developments to cover future requirements.

Staff list:

- Jim Diserens (NJD)
- John Collie (CJC)
- Subodh Chanda (SKC)
- Kevin Duffey (KPD)
- David Barlow (DSB)
- Chris Harrold (CSH)

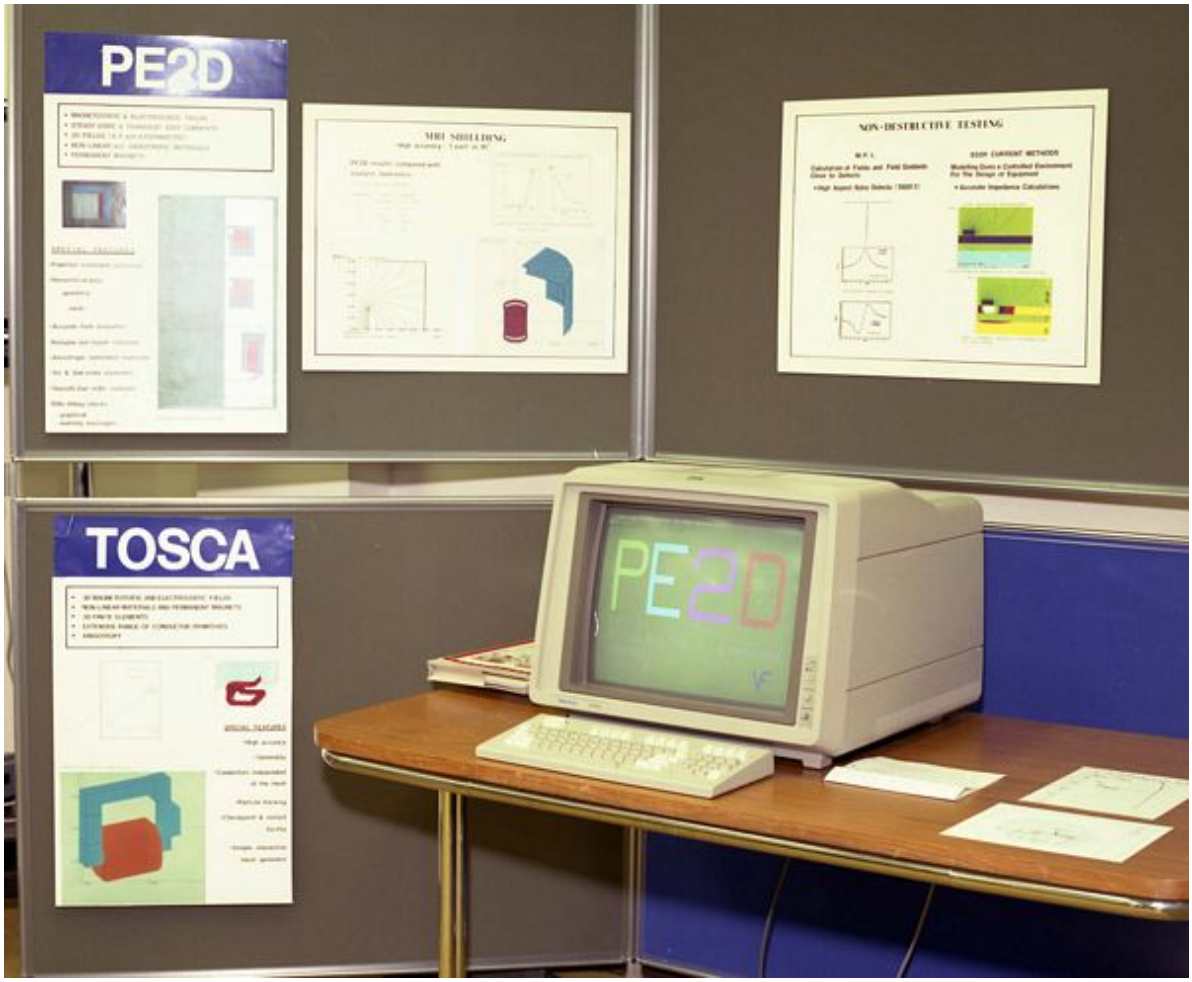
### 7.2.2 Electromagnetics Software (KPD, CSH, CJC)

**PE2D (2D Poisson Equation Solver)**

The PE2D package has been further developed by Vector Fields Ltd since John Simkin and Chris Biddlecombe left the group for this new company, and it is their version of the software which is now supported. The new versions of the analysis modules have been mounted on the IBM mainframe by the section.

### TOSCA (3D Poisson Equation Solver)

This package has now been mounted on the CRAY XMP by CJC with assistance from Alan Mayhook of CCD. Some of the improvements in coding have also been used to speed up the IBM version by about 30%.




**Computing Facilities Committee Visit :RAL/Vector Fields Software**

**Large View**

### 3D Eddy Current Package Development

Members of the section have taken part in the work to develop and test a suite of software for eddy current analysis in 3D. This is the subject of 3 different collaborations:

- The first of these is the research project between Imperial College, Bath University and RAL, of which the RAL coordinator is Chris Emson.
- The second is the series of international eddy current workshops, for which Chris Emson is also the RAL coordinator.
- The third is a collaboration with R L Ferrari of Cambridge University, to interface his HIFEM software to the FEGS pre and post processors.

A neutral file specification has been agreed between the various collaborators as a means of interfacing the packages with the pre and post processors. This means that benchmarks containing the same input data may be run on more than one package. The Alvey projects for process and

device modelling of silicon chips are adopting the same neutral file format. KPD has written a set of Fortran subroutines which read the neutral files and can be called by an interface program.

A post viewer program called HEXTET was written at Imperial College. This takes the output from a 3D finite element program and subdivides the mesh into tetrahedra and then allows the user to display results on any desired plane. CSH has tested this program and made a number of improvements to assure the reliability of the mesh subdivision process. For the international eddy current workshops a number of benchmark tests have been agreed. CJC has been solving some of these problems analytically. CSH has been running CARMEN and NJD has used PE2D for tests where appropriate.

#### Courses at RAL

Two courses for users of the RAL electromagnetics software have been held at the Laboratory. The first of these was in November and the second took place in July. Staff from Vector Fields Ltd and members of the Section, augmented by Chris Emson, provided the tuition. The November course was attended by about 17, comprising 8 from UK universities, 5 from commercial firms, 2 from CERN and 1 each from RAL and Milan University. For the July course there was an attendance of seven. Of these 6 were from UK universities and one from RAL. The reason for the drop in numbers is that VF now run their own courses at Kidlington.

### 7.2.3 Structural Engineering Software (SKC, DSB, NJD, CSH)

First Line Support is provided by members of the section.

#### NASTRAN

This package continues, on the IBM system, to be the main tool for structural analysis. Version 65 was delivered in August and includes a more efficient eigenvalue solver using the Lanczos method. We have considered the possibility of putting NASTRAN on the CRAY but the price quoted by McNeal Schwendler is unacceptably high.

#### BERSAFE

This package is provided free by CEGB and is particularly recommended for thick shell problems. It is installed on the IBM and interfaced to FEGS software.

#### LUSAS

This package is being mounted on the PYRAMID computer both as an assessment of its capabilities as a structural analysis package and also to gain some experience with implementation on a UNIX system.

#### FEMGEN and FEMVIEW

These pre and post processors are now renamed FAMBUILD and FAMRESULT and are sold as part of the integrated FAM system. This has been mounted on the PRIMEs, although a version for the SUN may be purchased soon. They are also being used for a number of applications in electromagnetics and device and process modelling. A demonstration of the new FAM system was given in the Atlas Colloquium in July.

#### MAVERIC

This is a module for error analysis which is being written by NJD. It will read a FEMVIEW input file and create an additional file for display of error estimates by FEMVIEW itself.

#### BEASY

CSH has carried out tests on the BEASY boundary element package to assess its suitability for inclusion in the structural software to be made available to users. It has been decided that it should not at present be supported.

### 7.2.4 Other Activities

NJD and KPD assisted in the evaluation of SDRC software for laboratory projects, particularly as a CAD system for the space programme. They provided benchmark problems and advice for laboratory engineers.

### 7.2.5 Publications

S K Chanda, N J Diserens. A Post Processor for Error Estimation in Static Analysis. RAL-87-?, September 1987.

C R I Emson, K P Duffey, J L Marsh. RALBIC Neutral File Read and Write Routines. RAL-87-?

C S Harrold. Using the Concept of Linkage of Closed Loops to Determine the Topological Invariants of a Cutting Graph. Paper to Compumag, Graz, Austria, August, 1987.

### 7.2.6 Conferences and Courses and the External Meetings

- A Short Course on Numerical Modelling of Electromagnetic Fields and Devices. Held at Russell Hotel, London. October 1986. (KPD, CSH).
- 3D Pre and Post Processor Seminar and Eddy Current Workshop, Lyon France. November, 1986. (NJD, Chris Emson).
- IUSC workshop on CAD/CAM software, Cranfield, January, 1987. (ADB, NJD, GAL)
- One day CRAY course, RAL January 1987. (CJC)
- SERC Initial Training and Management Course, February, 1987. (CJC)
- CRAY Conversion Workshop, RAL June, 1987. (KPD)
- SUN User systems course, Caterham April 1987. (CSH, DSB)
- NASTRAN Users Conference, Munich, West Germany, May, 1987. (SKC, NJD)
- Advanced CRAY Course, RAL July, 1987. (CJC)
- Eddy Current Workshop and COMPUMAG Conference, Graz, Austria, August, 1987. (NJD, CRIE, CSH)
- NJD represents SERC on the Inter University Software Committee's working party on CAD/CAM.
- Chris Emson is secretary and NJD represents the Group on the Special Interest Group in Electromagnetics (SIGEM).

### 7.2.7 External Study and Promotions

Subodh Chanda (SKC) is completing a PhD at the Mechanical Engineering Department, Birmingham University. The subject is Finite Element Analysis of Orthogonal Metal Cutting, and he hopes to finish this in May 1988.

Kevin Duffey (KPD) was promoted to HSO in December 1986.

## 7.3 Data Exchange/FE Processing

### 7.3.1 Staff

At present, the Section has 5 permanent staff:

- Bryan Colyer (Section Leader) BC
- Andy Irving ADI (transferred 1 April 1987 from Instrumentation Division.)
- Mike Mead MM (transferred 1 Dec 1986 from Laser Division)
- Debbie Thomas DT
- Jan Van Maanen JVM

**Brian Colyer demonstrating to the Computing Facilities Committee, October 1986. Doug Lewin standing at the front and John Wooton face on at the back**

**Large View**

In addition, for the whole period, we have had the assistance of a student from Sunderland Polytechnic, John Mountain (JBM).

### 7.3.2 Esprit Project: CAD Interfaces

This project occupies MM, DT and JVM for most of their time, and BC for 25% of his time. The Project, which started in November 1984, has as its main goal the specification and development of software interfaces between various CAD systems, and between CAD and Finite Element (FE) analysis systems. The present contract ends in October 1987; arrangements are under way for a two year extension. Twelve industrial and academic organisations from six member states of the European Community are involved. Much of the specification work has been completed, and interfacing software is now being developed. The Project has a high standards content, hence DT and JVM participate in International Standards Organisation committee meetings, and BC represents the Project at British Standards Organisation meetings on product data exchange.

### 7.3.3 SERC Building Committee

The second line of work, pursued by ADI in support of the thermal modelling community of the SERC Building Committee, is the analysis of multivariate time series systems and the development of an Energy Kernel System (EKS). The EKS is an example of what may be called generically "Design Environments" and is intended to test the hypotheses underlying such environments in one particular applications field; namely energy in buildings. Development of the EKS has been approved in principle and funding is being sought in the current grant application round to enable some six institutions to embark on this collaborative project. It is intended that the EKS development will have two phases. During the first phase different strategies will be explored using principles of rapid prototype development. This first phase should establish some best candidates for a working EKS. In the second phase a validated EKS will be produced. In both phases the EKS will be available to academia, the fuel supply industries, other government departments and industries for comment, appraisal and feedback; this should enable the information barrier between academic research and industrial use to be overcome.

It is anticipated that work on environments will expand into other disciplines, such as finite element modelling, analysis and results processing.

### 7.3.4 F E Processing

BC has spent about 40% of his time on this, with full time assistance from JBM. The intention of the effort is to develop CAE techniques on Single User Systems, with a view to their eventual incorporation into environments. The section acquired two SUN 3/160 M workstations at the beginning of the period, and thanks to the efforts of JBM on graphics interfacing we were able to port a large FE applications program from the ICL PERQ to a SUN in a few days. Agreement has been reached with Vector Fields Ltd of Oxford, which markets RAL FE software for electromagnetics, to develop jointly a new two dimensional potential modelling and analysis program for single user graphics workstations.

### 7.3.5 Publications

Stochastic sensitivity analysis of dynamic thermal models. CIB 86, Advanced Building Technology, Washington, Sep 1986. ADI

Covariance techniques in the detection of gravitational waves, in gravitational wave data analysis. NATO Advanced Workshop, 6-9 July 1987. ADI

Application of statistical techniques to the validation of multivariate time series simulators, 400 page contribution to the Validation Exercise Final Report, Sep 1987 ADI

Validation of dynamic thermal models, Energy in Buildings, Sep 1987 ADI

Building Energy Simulation, Energy in Buildings, Sep 1987 ADI

CAD*I Reports (unfortunately these are numbered in a manner similar to RAL Reports):

| | | | |
|---|---|---|---|
| RAL 0010/86 | 12 Nov 1986 | Report on visit to ISO TC184/SC4/WG1 | DT, JVM |
| RAL 0011/86 | 3 Dec 1986 | Syntax of the STEP Neutral File | JVM |
| RAL 0012/86 | 22 Dec 1986 | Syntax of CAD*I Neutral File | JVM |
| RAL 0001/87 | 12 Jan 1987 | Mapping of the new concepts of the Express language on the Physical File | JVM |
| RAL 0002/87 | 27 Mar 1987 | Specification for exchange of Product Analysis Data | DT, JVM |
| RAL 0003/87 | 21 Apr 1987 | Report on ISO Meeting at West Palm Beech, USA, 30 Mar-3 Apr 1987 | DT, JVM |
| 13 July 1987 | Report on ISO Meeting in London, | DT, JVM | |

| | | | |
|---|---|---|---|
| | 22-26 June 1987 | | |

### 7.3.6 Meetings

The following meetings were attended:

| | | | |
|---|---|---|---|
| Sep 4-12 1986 | Berkeley | EKS USA/UK | ADI |
| Sept 15-19 1986 | SERI (Colorado) | Validation Work | ADI |
| Sept 22-26 1986 | Washington | CIB 86 | ADI |
| Sept 25 1986 | Washington | W60 Building Performance | ADI |
| Sept 29 1986 | Washington | NBS, EKS Collaboration | ADI |
| Sept 30-Oct 2 1986 | Syracuse | Multivariate Statistics and Validation | ADI |
| Nov 3-7 1986 | Frankfurt | ISO TC184/SC4/WG1 | DT, JVM |
| Dec 2-3 1986 | Karlsruhe | | |
| Dec 11 1986 | London | British Standard AMT/4 | BC |
| Jan 26-27 1987 | Aachen | CAD*I Project Board and Review | BC |
| Jan 27-28 1987 | Aachen | CAD*I WG6 | DT, JVM, BC |
| Mar 19-20 1987 | RAL | CAD*I WG6 | DT, JVM, MM |
| Mar 30 - Apr 3 1987 | West Palm Beach | ISO TC184/SC4/WG1 | DT, JVM |
| Apr 27-28 1987 | RAL | CAD*I Project Board | BC |
| May 21 1987 | ICST | Robust Statistics | ADI |
| June 9 1987 | BSI | British Standard AMT/4 | BC |
| June 12 1987 | Polytechnic of the South Bank | Energy Flows in Buildings | ADI |
| June 22-26 1987 | London | ISO TC184/SC4/WG1 | DT, JVM |
| July 2-3 1987 | Copenhagen | CAD*I Project Board and Review | BC |
| July 6-9 1987 | Cardiff | Gravitational Wave Analysis | ADI |
| July 15 1987 | London | British Standard AMT/4 | BC |

## 7.4 Algorithms and Library Software

The section has the following staff:

- Chris Greenough (CG)
- John Ashby (JVA)
- Eitan Azoff (EMA) Research Associate recruited 3 November 1986
- Ian Collins (IMC)

- Chris Emson (CRIE)
- Raymond Fawcett (RJF) recruited 1 April 1987
- Ron Fowler (RFF) recruited 1 April 1987
- Chris Hunt (CJH)
- Tarang Patel (TKP) Research Associate

The section has grown from two to nine people during the last three years.

Two students, Phil Goodman and Janine Marsh left on 31 July 1987 after a year at RAL. This year there are three students - Karen Whitaker, Olivia Jane and Chris O'Mern. Also there is a long term visitor from University College Swansea, Dayal Gunasekera (DG).

The section is involved in Five Projects.

### 7.4.1 Esprit Device Modelling: Esprit 962 (Everest) (CG, TKP, CJH, DG)

**Project Description**

This has ten partners from five countries and 50% of the funding comes from the European Commission. Its objective is to extend the development of robust and efficient algorithms to simulate the behaviour of three dimensional semiconductor devices, to incorporate them in a computer code, and to compare the results against measurements on real devices. The project is funded for two years until April 1988, with the expectation of a further two years if progress is satisfactory.

CG is the Task Coordinator of Work Package 5, the Project Research Code. He is responsible for the specification and design of the software system, which is now being implemented at three sites. The software is divided into four parts, the Pre-Processor (Trinity College Dublin), Doping Profile Generator (University College, Swansea), the Analysis Code (RAL/GEC) and the Post-Processor (UCS). RAL is responsible for the kernel and for linking the modules together - initially this is using an extension of the neutral files used in the eddy current project, with the code implemented by KPD.

CJH and DG have integrated the modules from the different sites and are testing the program on various 3D benchmark problems. The project is being reviewed at the end of November by the Commission at which a demonstration of the working code will be made.

CG and CJH have also been involved in mesh generation algorithms which can be adapted to parallel machines. TKP is testing the GEC linear algebra package and integrating it into the RAL analysis code.

SERC is the Prime Contractor and RAL (CWT and ADB) is responsible for the management of the project as a whole. Vector Fields is contracted to provide CWT's services on one day per week at least until summer 1988, and from 1 July G A Lambert is assisting in the management of the project. At the last review in November 1986, the Commission requested some major changes which required a re-distribution of effort among the partners. This meant a great deal of discussion and visits to partners sites and Brussels before a new project plan prepared by ADB was produced in April 1987.

**Main Project Meetings**

**Work Package 5**
Agrate, Italy 4-5 Sept 1986 (CG, CJH, TKP)
**Full Project**
de Mierlo, Netherlands 28-29 Oct 1986 (CWT, AD.B, CJH, TKP)
**Project Review**
Brussels, 5-6 Nov 1986 (CWT, ADB, CG)
**Project Board**
Heathrow London, 26 Nov 1986 (CWT, ADB, CG)
**Work Packages 2,3,4,5**

Bologna, Italy, 14-16 Jan 1987 (CWT, CG, CJH)

**Work Package 5**

RAL, 16-17 Feb 1987

**Full Project**

Cork Ireland, 1-2 April 1987 (CWT, ADB,CG, CJH, TKP)

**Work Packages 2,3,4,5**

Swansea, 16-17 July 1987 (CWT, ADB, GAL, CG, CJH)

**Publications**

Project Deliveries due from RAL at end of Period 2 (April 1987)

**R5.1.1**

Project Code Overview Specification, C. Greenough (RAL) and P J Mole (GEC)

**R5.1.3**

Project Code Command Decoder Specification, J V Ashby and C. Greenough (RAL)

**R5.1.6**

Project Code Specification - delayed until next period

**R5.3.I**

Report on Command Decoder Implementation, J.V. Ashby and C. Greenough (RAL)

Work Package 5 Reports from RAL

**RAL/5.1**

Project Code Pre-Processor, C J Hunt

**RAL/5.2**

A Review of Graphics Systems, T.K. Patel

**RAL/5.3**

ESPRIT Device Modelling Project - Code Command Reference, C. Greenough and C.J. Hunt

**RAL/5.5**

Sparsity of Coupled and Decoupled Matrix Equations in the Modelling of Semiconductor Devices, T.K. Patel

**RAL/5.6**

Current Status of the Basic Linear Algebra Subprograms, T.K. Patel

**RAL/5.7**

RALBIC Neutral File - Definition, C.R.I. Emson, N.J. Diserens, P. Leonard, C. Bryant, N. El Khatib and C. Rajanathan

**RAL/5.8**

Project Code Overview, C. Greenough and P.J. Mole

**RAL/5.9**

Progress Report - Solution Module, C.J. Hunt and D. Gunasekerra

C. J. Hunt, C. Greenough, A novel method for the computation of the Delaunay triangulation with a view to efficient use of parallel architectures. RAL-86-090

**Overall Project Reports**

Consolidated Interim Reports are produced every 6 months for the Commission. Two reports were produced in October 1986 and July 1987. The Work Package 5 reports were edited by CG. The overall project reports are edited by ADB.

**(N.B. The Reports are produced in four sections - Management Report, and three technical reports - 'Work Package 1, 'Work Package 2,3,4, and 'Work Package 5. The complete second Consolidated Interim Report was 3 inches thick!)**

### 7.4.2 Alvey Process Modelling (VLSI 066) and Device Modelling VLSI 034) (CG, JVA, RJF, EMA, RFF, CJH)

It is convenient to treat the RAL section of these two projects as one unit. There is also a considerable overlap with the Esprit Project in such areas as Command Decoding, graphics, geometric specification, mesh generation, etc.

### Project Description

The role of the Process Modelling Project 066 is to design and implement a flexible software system for modelling of semi-conductor processes into which other partners can slot specific modules. One of these is the device simulator being produced by RAL Project 034. RAL provides the binding elements, including the control program, the data base, graphics, etc. Three modules are provided by university partners Implantation (Kent), Diffusion (Reading) and Oxidation (Swansea). Each module must be capable of intercommunication via the database, and of being intelligently controlled through the RAL-provided interface. The Moving Finite Element mesh used by the Diffuser Module is generated with the Implantation module.

The considerable problems of software integration, validation, etc in 066 are the responsibility of JVA, assisted by RJF. JVA has recently organised a Software Week at RAL on July 6-10 with members from the three universities to help to integrate the software components together. JVA is also looking into future needs of process modelling. EMA is producing the device modelling module in 034, and spends a small amount of time on research in semi-conductor physics. RFF is interfacing the geometry module to the data base. CJH has worked on the designer and development of the geometric modeller and mesh generation. IMC is currently developing graphical software. CG is directing the RAL effort and is involved in design of the device simulator for 034, and design of the software shell and integration of the modules into it for 066.

### Main Project Meetings

| | | |
|---|---|---|
| Alvey Device and Process Modelling Club, Edinburgh | 1-3 October 1986 | JVA, CG, CJH |
| 066 Software Integration Meeting, RAL | 18 November 1986 | CG, JVA, ADB |
| 034 Meeting, GEC | 21 Jan 1987 | CG, ADB |
| 066 Meeting, GEC | 29-30 Jan 1987 | JVA, CG |
| 034 Meeting, STL | 8 April 1987 | EMA, CA |
| 066 Meeting, Reading | 12 May 1987 | JVA, RJF, CG |
| 034 Meeting, RAL | 6 July 1987 | EMA, CG |
| 066 Meeting, RAL | 8 July 1987 | JVA, RJF, CG |
| 066 Software Week RAL | 6-10 July 1987 | JVA, RJF |
| 066 Meeting, Plessey | 23 July 1987 | JVA, CG |

### Project Reports

These are produced quarterly. In addition there is an Annual Report. Specific reports produced by RAL are:

E M Azoff, T K Patel and C Greenough, Specification for a General 2D Device Simulation Program, Alvey Project ALV-DMP-12, Jan 1987.

E M Azoff and C Greenough, Alvey Device Simulation - Command Reference, Alvey Project, ALV-DEV-13, March 1987.

J V Ashby, Alvey/RAL Software Integration Week, ALV-DMP-19, July 1987

E M Azoff and R E Fowler, Alvey Device Modelling Kernel Release 1.0 The physical model # and numerical method, Alvey Project. ALV-DMP-20 due end August 1987.

## 7.4.3 Eddy Current Project and Electromagnetics Research (CRIE)

### Project Description

CRIE has taken the leading role at RAL in this project, which involves both University and Imperial College, after CWT became part-time at RAL. This is a three year grant funded by Machines and

Power Committee. Specific items in the programme have been carried out by NJD, CJC, KPD and CSH but most of the code is generated by CRIE.

CRIE represents the UK on the International Committee for Electromagnetic Workshops. He organised the first workshop at RAL in March 1986 and attended other workshops. A list is given at the end of this section.

**Workshop and Project Reports**

Non-linear Transient Eddy Current Computation in 3 Dimensions - Project Overview C R I Emson Published in Eddy Current Seminar Proceedings, Editor C R I Emson, RAL Report RAL-86-088

Second Order Vector Potentials Applied to 3D Eddy Current Problems C R I Emson and C W Trowbridge Published in Eddy Current Seminar Proceedings, Editor C R I Emson, RAL Report RAL-86-088

A Simple Neutral File Definition C R I Emson Published in Electromagnetic Workshop Proceedings, Editor C R I Emson, RAL Report RAL-86-049

### 7.4.4 Finite Element Library (IMC, CG)

This activity has been given lowest priority and development has been very slow. Release 3, originally planned to be delivered to NAG in 1984, has been delivered and is undergoing final tests at NAG. The documentation will be completed by CG in early September 1987. IMC is implementing graphical output routines and providing support to the user community. The work on the library is part of the Application Software Programme funded by CFC.

### 7.4.5 Conferences and Workshops attended

(This excludes project meetings, which are listed with specific projects)

**1-5 Sep 1986**
Manning SERC Exhibit at BA meeting, Bristol. CRIE, KPD, CSH, DSB

**(NB The exhibit was requested by Central Office to highlight SERC's involvement with industry. The stand was shared with Vector Fields. ADB organised the loan of a VAX computer from Neutron Division and CAG provided a T4109 terminal to run the VF software. The exhibit with the same equipment loans was repeated at Techmart, NEC in November 10-15.)**

**22-23 Sep 1986**
Graz Austria - Symposium on Computational E1ectromagnetics. CRIE
**13-17 Oct 1986**
Tokyo, IUTAM CWT, CRIE
**20-22 Oct 1986**
Tokyo, Electromagnetics Workshop CRIE
**17-19 Nov 1986**
Lyon, Post-Processing in Electromagnetics workshop NJD, CRIE
**7-10 Dec 1986**
Los Angeles, IEDM EMA (visit organised by Sheffield)
**11-12 Dec 1986**
Los Angeles, NUMOS 1 EMA, TKP
**12-14 Jan 1987**
Atlanta, Georgia, International EM Workshop CRIE
**8-12 Jun 1987**
Athens, International Conference on Supercomputing CG, CJH
**15-19 Jun 1987**
Dublin, Short Course and NASECODE RFF
**17-19 Jun 1987**
Dublin, NASECODE EMA
**20-21 Aug 1987**

Graz, Austria, Electromagnetics Workshop CRIE
**25-28 Aug 1987**
Graz, Austria, Compumag CRIE, NJD, CJH
**25-28 Aug 1987**
Liverpool, Vector and Parallel Processing ADB

### 7.4 6 Publications

(This excludes project documentation, which is listed under the specific project)

E M Azoff, Closed-form method for solving the steady-state generalised energy-momentum conservation equations, in Procedures of NUMOS I Workshop, P25 Los Angeles, Boole Press, Dublin (1987) and in COMPEL 6, P25-30, 1987.

E M Azoff, Generalised energy-momentum conservation equations in the l6relaxation time approximation Solid-State Electronics, 30, pp 913-917, 1987.

Results From The 3-D Eddy Current Package CARMEN C R I Emson Electromagneto-mechanical Interactions in Deformable Solids and Structures, North Holland, Amsterdam 1987, P163-168, Editors Y Yamamoto and K Miya

Recent Developments in the Computation of Eddy Current Effects C W Trowbridge and C R I Emson Electromagneto-mechanical Interactions in Deformable Solids and Structures, North Holland, Amsterdam 1987, P15l-l62, Editors Y Yamamoto and K Miya

Methods for the Solution of Open Boundary Field Problems C R I Emson To be published in IE E Proceeding, Part A, 1987

## 8 SINGLE USER SYSTEMS/APPLICATIONS SECTION

The section is responsible for the support and development of Single User Systems for Engineering Board researchers and for the Alvey Programme; graphics on ECF machines; and text processing on ECF Unix machines. Some of these activities are also carried out for the divisional service, IDUS.

### 8.1 Staff in post at end August 1987

- Julian Gallop (JRG) Section Leader
- Peter Kent (PK) Head of SUS Support
- Kevin Lewis (KML)
- Morgan Chow (MC) (arrived 29 June 1987)
- Bill Hewitt (WJH)
- Mark Phillips (MP)
- Lynton Jones-Ng (LJJ-N)
- Dale Sutcliffe (DCS) Head of Basic Software
- Ruth Kidd (RMK) (transferred from Central Computing Division 1 December 1986)
- Predrag Popovic (PLP)
- Jan Malone (JCM)
- Duncan Gibson (DRG) (from 1 April to 4 September 1987)
- Trudy Watson (TAW)
- Janet Haswell (JH)
- Martin Prime (MJP)
- Peter Randall (PJWR)

### 8.2 Single User System Support

This team (led by PK) is responsible for support of centrally purchased and maintained Single User Systems funded through Engineering Board committees and the Alvey Programme. During the

year, the equipment has been for a rapidly increasing population of Suns and, as grants come to an end, a declining population of PERQs.

During the year, there have been a few staff changes. Fran Childs was in the team in September 1986, but was gradually taking on more work for the ECF as a whole. She therefore transferred to Geoff Lambert's section.

MDP joined from the ASO Training Scheme early in the year and MC joined the laboratory on 29 June 1987 after what could be a record for a work permit delay (he was originally interviewed in May 1986!). KML gained promotion to the post of Head of SUS User Liaison in May and, assisted by MC, WJH and MDP, has most of the user support responsibilities in the team.

### 8.2.1 Selection and Configuration

The first contact a user has with the Support team is usually when he/she is preparing a grant application. Although a proportion of grant applications fail, seeking advice is encouraged at this stage, so that fewer complications occur at the critical later stages. PK does this work. He is also expected to comment, when applications are actually received by a committee. This year, at the last round, all the comments for a particular subcommittee (Computer Science) were processed in a single visit to Swindon Office (others took part, but PK looked after the SUS requirements). This was successful as far as it went, but needs to be extended to other EB committees.

### 8.2.2 Purchase and Maintenance

The central purchase arrangements for Suns have been in place the whole year and are running more smoothly. However the difference this year is the much larger number of machines. Altogether there were over 200 installed during the year, including 33 at the University of York. The sheer numbers require some effort in organising purchases and maintenance contracts and some streamlining of this is needed. For SERC grants, Central Office order directly from Sun. This relieves the Support team of some administration effort, but difficulties can arise due to the team simply not being informed when a Sun is installed.

### 8.2.3 General Support Matters

The number of supported machines is (as at 31 August 1987):

```
333     Sun 3's
 54     Sun 2's
 48     PERQ 2's
 28     PERQ 1's
```

The target for the end of maintenance on PERQ 1's is end September. Only a small number of grants that were originally equipped with PERQ 1's continue beyond that date. A number of other PERQ 1' s were allocated to a variety of places through a variety of funding budgets. These people have been contacted by the Support team over the last few months and satisfactory arrangements have been made. Grant holders that continue to use PERQs after the grant has expired can make use of the coordination and distribution services provided by Queen Mary College and funded by the Computer Board. (KML,MDP)

A regular six-weekly progress meeting with Sun has been begun and new arrangements for the maintenance contract will begin on 1 October. Under the new arrangements, fault reporting (whether for software or hardware) will be through RAL and this will enable the Support team to have up to date information on the pattern of faults. Also RAL will have early copies of Sun software in order to advise Sun on software distribution.

A database for Sun 3's was set up during the year. It was found that information from several completed forms from different parties (SERC at Swindon, Sun, the users, etc) was needed in order to compile the records for any particular Sun. Most of the SUS Support Team were involved in the catching up exercise and Janet Smith is now responsible for the database upkeep.

The SUS Support office telephone has been staffed for most of the year by WJH.

One Common Base User Forum was held (KML, LJJ-N) before it was absorbed by the Engineering Computing Users' Group.

### 8.2.4 Software Distribution

Several software distribution rounds have taken place during the year.

Sun are responsible for distributing the operating system and most users are now up to version 3.2. The Support team distribute software added by RAL (or by contractors, such as University of Kent). Software distributed this year from RAL (by KML, MDP, WJH, LJJ-N) includes:

- RAL GKS, WW, tools based on WW such as mon and ted, Kent Software tools, Spy, tc tool.

**Computing Facilities Committee Visit :Peter Brown demonstrates Kent Software Tools, George Davies, Mike Hotchkiss, John Wooton, Doug Lewin**

**Large View**

LJJ-N produces installation scripts so that the user can move the software onto his/her Sun in a reasonably automatic way. Further basic software is being negotiated, of which the first example is Nag (the Nag library and and Nag Graphics) (PK, KML - also JRG, DCS).

On PERQ, there has been a maintenance release of operating system software for both PERQ 1 and PERQ 2 (PNX 5.3), which the Support team has distributed. In addition, a new optimising Fortran compiler, WW with Pascal and Fortran and Kent tools have been distributed (KML, WJH, MDP). The copying has been in co-operation with Queen Mary College. KML is setting up a machine (a Sun 2) to handle software distribution via the network. It will also make available up to date information about services available to users. Progress has been made, but some equipment is still awaited. It is expected that this will make software distribution far more convenient in the future.

### 8.2.5 Performance Testing

Some performance testing has been carried out this year.

- Virtual memory tests on Sun 2's with different amounts of physical memory. The tests (extracted from the 1984/85 SUS benchmark set) discovered how much user space was available before the virtual memory benchmark thrashed (LJJ-N)
- Some tests of the Sun graphics processors were established. This is to assist PK in advising users on their proposed configurations.
- Some AI benchmarks from IKBS Section were packaged and summarised and can be used to assess machine performance (WJH).

It is anticipated that performance testing will become a far more significant activity in the coming year.

### 8.2.6 Other SUS Support Activities

Currently no Sun we have produces colour permanent copy. Most equipment is designed to be attached to display equipment of lower resolution. The two main classes of output are photographic film (35mm or other) and colour output on paper or foil. A survey has been carried out and some demonstrations of colour output on paper and foil have taken place (KML with advice from DCS). The aim is to produce a report to guide future divisional purchases and to assist in advice to prospective grantho1ders. Some equipment that was spotted at Siggraph will be investigated before the report is produced.

During the year, SUS Support moved from offices in R32 into an open plan area. Although some aspects of the original scheme were not funded (for example, a small support meeting room for visitors), the open plan area has worked reasonably well for support activities, where information is frequently passed between members of the group (planning by PK and FMC with input from everyone).

The PERQ disc server has been put on the Ethernet. It is used to hold supported PERQ software for the support team and as additional work space for internal PERQ users (KML). This usage will need to be kept under review as PERQ activity drops further.

Support for the Transputer Initiative has been provided. MDP has tested and installed software on equipment in the loan pool.

## 8.3 Basic Software

During the early part of the year, this part of the section which was to become the Basic Software Team increased in size with the addition of several new faces. Andrew McDermott joined from the ASO Trainee Scheme, David Johnston joined from the ICL PERQ Business Centre and in December Pre drag Popovic from Yugoslavia finally received his work permit and was able to start. Dale Sutcliffe transferred from Central Computing Division Graphics Section on 3 November to lead the Team and in December Ruth Kidd also transferred from the same section. She brought with her the ICF Graphics work, so drawing together all the Engineering Board funded graphics work in the same team. This, together with the existing members, made a team of ten people by the end of 1986.

Early in 1987 it became necessary to restructure the team to carry out more effectively the tasks it had been assigned. The team was divided into three parts, namely ICF Graphics; SUS Graphics and Window Managers; and Text Processing and System Development led by Ruth Kidd, Trudy Watson and Jan Malone respectively. To reflect the work of the team more accurately, it was renamed the Basic Software Team, all the work being concerned with providing the basic software that users expect to find on a good system.

The purpose of the team can be summed up as developing, providing and supporting widely usable basic systems providing common interfaces on which higher level software and applications may be built. As time progresses, expectations will increase and the scope and functionality of basic software will increase.

Further staff changes took place during the year. David Johnston (DJJ) transferred to join the transputer coordinator team, and though Duncan Gibson joined the team in his place from Software Engineering, he was about to leave as this report was being written. Andrew McDermott (APMcD) transferred to the Communications team in Infrastructure Group in August 1987 to work on local area networks.

### 8.3.1 ICF Graphics

At the beginning of December 1986, the graphics work on the Primes and GECs, referred to as ICF graphics, moved from Central Computing Division when RMK transferred to Informatics Division. The opportunity was taken to place the whole of the Engineering Board funded graphics work together in Basic Software Team. RMK now leads a small team of PLP and (for most of the year) APMcD.

#### RAL GKS Upgraded to International Standard

The RAL GKS implementation project became a joint project of CCD and ID following the transfer of ICF Graphics - the master source of RAL GKS is held on Prime A. (NB: regular project meetings are held with CCD to monitor progress). The original implementation was of the Draft International Standard version of GKS and plans had previously been made to upgrade it to the IS version of GKS in collaboration with the Computer Board GKS Support Team who support RAL GKS (as GKS-UK) in the Universities. In late 1986 DCS and RMK planned,the upgrade with the GKS-UK Support Team culminating in a week of intense activity at Ross Priory on the shores of Loch Lomond in January 1987. The week was successful and the nine participants emerged at the end of the week with a completed set of edit files for GKS and all overweight!

The GKS-UK Support Team executed the edits and a joint period of testing followed. During the testing, the NCC validation suite was issued on beta test. RAL became a beta test site and was able to test the validation suite and RAL GKS simultaneously. Faults were found in each but overall the honours were even! All the workstation drivers in the RAL set were upgraded to IS status. The new master source was assembled on RL. PA and distributed to the SUN, CCD and the GKS-UK Support Team in July. This means that RAL GKS now matches level 2b of the International Standard and implements what will become the International Standard Fortran binding. This version is known as RAL GKS 1.00.

#### RAL GKS Installation

As well as development of the master source of RAL GKS, work has been done on its installation on different machines. RMK completed the installation of RAL GKS 0.10 (the DIS version) on the GEC in time for the ECUG meeting in April. This was well received by the user meeting.

With the change in recommended Fortran compiler from FTN77 (Salford) to F77 (Prime) on the Prime and the incompatibilities between the two, it became necessary to provide an F77 version of RAL GKS. This was completed and the library built using BIND to provide a shared library. The result was faster execution and smaller run files, but restricted the ability to add additional workstation drivers without rebuilding the library. Temporarily the shared library prevented the user replacing the error handler, though this last problem has now been solved.

Good progress has been made with configuring RAL GKS 1.00 for the Prime and it should have been released by the time this report appears.

#### RAL GKS Workstation Drivers

Provision of all requested workstation drivers continues to be a problem. However, a Printronix (a dot matrix printer) driver has now been added to the portfolio (PLP). Based on a VAX specific one from Starlink, the new driver is portable and uses a character heap in RAL GKS, a feature always anticipated but not before implemented. To assist in the provision of future workstation drivers, RMK gave a seminar on writing a workstation driver to CCD and ID staff.

#### GKS Hardware

A terminal from Ferranti implementing a logical GKS workstation was evaluated by APMcD. It has a mixture of good features and some peculiarities, and it was decided not to purchase the device.

#### NAG Graphics Chapter Mk2

The NAG Graphics Chapter Mk2 became available for the Prime. It was installed for use with both GINO-F and GKS by APMcD. A NAG Graphics Mark 2 library for use with GINO-F was also released on the GECs. This library will assist users to transfer their graphics applications from GKS to GINO-F.

### 8.3.2 SUS Graphics and Window Manager

TAW leads this small team which is responsible for graphics on the Single User Systems (currently PERQs and SUNs). Currently, this small team also looks after graphics on the Unix MUMs (Pyramid and VAX). The team members are JH, MJP and PJWR.

#### GKS on SUNs

By September 1986 it had become apparent the SUN's GKS had fundamental problems which were not going to be cured with a few bug fixes. There was an urgent need for GKS on the SUN. At the same time the Computer Graphics Unit at the University of Manchester had experienced similar problems with SUN's GKS and had entered into a collaborative agreement with SUN to sort out the problems. After discussion with all the interested parties, the best solution to all these problems appeared to be to install RAL GKS on the SUN and to implement a workstation driver for the SUN screen, with work shared between the Computer Graphics Unit at Manchester and Basic Software Team at RAL. The work was planned in a number of stages and was to use WW to access the SUN graphics facilities with a GKS workstation mapping onto a new window.

The first version was essentially complete at the end of March (TAW and PJWR) and Tony Arnold (UM CGU) gave a presentation on the work to the SUN UK User Group in April. A second version incorporating colour, extra input devices, and using RAL GKS 1.00 (the IS level 2b version) is well under way and will be complete before SUN OS 4.0 incorporating NEWS is available. At that time the interface to the SUN will need to be examined.

As the first version was completed, a completely new GKS appeared from SUN for beta test. Some testing was done (TAY) and this time the implementation appeared basically sound. It was a level 2c version but as yet the level c input features have not been tested. It may be a useful way of providing this facility on the SUN in the future.

York continued on the assessment of GKS-3D from GTS-GRAL. Some of the problems were solved on moving from SUN OS 3.0 to SUN OS 3.2. It is understood that the latest version works within a window rather than taking over the whole screen but delivery is still awaited. In order to gain more experience with GKS-3D an EMR contract has been placed with Owen Mills at the University of Manchester to carry out an assessment of GKS-3D on a SUN, in the area of molecular graphics. An order has been placed for limited number of licences for GKS-3D.

#### Other RAL GKS installations

With more direct control over the release of RAL GKS master source, it became easier to coordinate releases of RAL GKS on the Unix MUMs. RAL GKS 0.10 was successfully installed on the Pyramid and Vax (BSD4. 2) including reimplementing the system interface in the light of experience and to incorporate extensions with this release. (PJWR).

Assistance was given to those producing the RAL GKS 1.00 master source in detecting undeclared variables using both the SUN and Pyramid Fortran compilers. This work was helped in the installation of RAL GKS 1.00 on the UNIX MUMs, though this is not yet complete.

### NAG Graphics Chapter Mk2

In line with the aim of providing common basic software across the ECF machines, steps are being taken to provide the NAG Graphics Chapter Mk2 on top of GKS on the SUNs and Pyramid. NAG have been encouraged to carry out these implementations and were lent a SUN3 in order to test the Graphics Chapter with RAL GKS. They made good progress but there are a few items to be sorted out. The implementation on the Pyramid is also nearly complete.

### Other GKS Work

Testing of Visual Engineering's GKS was completed following delivery of the full Graph Cap system. This latter system, designed to reduce driver writing to filling in a table, worked reasonably well but had some peculiarities. A driver for the Sigma 5684 was nearly completed but this was output only - input was not attempted. There were also some shortcomings in the language used to describe the device. The implementation seemed satisfactory though the C binding was not the latest one (this may have changed since we received the software). (APMcD,PJWR)

Some experience was gained with the GKS from Precision Visuals on the SUN and a report was produced (MJP).

A Postscript driver for RAL GKS is an important requirement, given the use of Office Laserwriters on the SUNs and the increasing use of Postscript in text processing. Work has started on a Postscript driver received via Starlink and this will be made to adhere to the project conventions and to be machine independent (MJP).

### Pascal and Fortran interfaces for WW

Work was completed to provide access to WW from Pascal and Fortran (JH). Some problems occurred in keeping track of new versions of WW but a successful outcome was achieved when Pascal and Fortran interfaces were completed and distributed which matched the C version of WW distributed at the same time.

### Portable Window Systems

With the increased use of single user systems with high resolution displays, window systems are receiving more attention. Experience has been gained with both SUN News and X-windows during the year.

MJP coordinated the beta test of SUN News with the Universities of Sussex and Kent and QMC, with replies being received from the latter two. The first beta test version left a lot to be desired, while the second beta test though somewhat better did not match the expectations of a released version which it turned out to be!

MJP also installed X-windows versions 10.3 and 10.4 and the beta test version II, the latter still being in progress. He produced a report of this experiences but a future strategy still has to be agreed.

### High Performance 3D Workstations

Following the purchase of a Silicon Graphics Iris 2400 for evaluation at the Abacus Unit at the University of Strathclyde, it was decided to do a fuller evaluation of high performance 3D workstations. Currently on loan are an Apollo DN580, and a SUN3/260 (to be upgraded to a SUN4) and a Hewlett Packard 350 SRX is expected shortly.

Software was obtained from the University of Strathclyde for implementing on all the systems but is is not clear that this is a good test of 3D hardware. Some work on synthetic benchmarks has also been carried out but no results are available yet (JH). Harwell are also doing some work in this area to display results from the Cray and discussion of their experiences have taken place.

#### UIMS Survey

With A S Williams, MJP has carried out a survey of User Interface Management Systems on the market. He will be presenting a paper on his findings at the ECF Workshop on UIMS in September 1987.

#### Joint HCI Project

With A Conway, MJP has been investigating visual illusions on displays (see the HCI Section report for more details).

### 8.3.3. Text Processing and Systems Development

This small team, led by Jan Malone, is responsible for text processing and specific items of systems development that the team is called upon to do. For a set of unconnected reasons this small team has seen the most change in personnel. At the beginning of the year Jan Malone was assisted by David Johnston but following the approval of the Transputer coordination programme he transferred to that project from 1 April. His place was taken by Duncan Gibson transferring from Software Engineering but he is about to leave RAL as this report is being written.

#### Text Processing

The text processing work is carried out both for the ECF and on behalf of IDUS. On the Suns, it is also carried out on behalf of Alvey, Infrastructure. It is believed that the requirements do not differ enormously and that the same software can be used to satisfy each of these. A text processing plan for the division was approved at the beginning of the year (JRG). Whilst the formation of IDUS has changed the details in some respects, the overall plan remains valid.

The first components of forming a uniform text processing service are the provision of DWB 2.0 and Transcript 2.0, to drive the office laserwriters, on the Pyramid, under both universes, and the SUNs.

DWB and Transcript 2.0 were provided by Pyramid under the att universe but not the UCB universe. The Systems team in Infrastructure Group are to provide access to this software from the UCB universe.

DRG completed the implementation of DWB 2.0 on the SUNs, before he left, and Transcript 2.0 has just been received from SUN. DWB 2.0 will occupy a temporary position on the SUNs initially to enable users to change from using the existing troff software which has names in common with DWB 2.0, but cannot be moved because of lack of sources. After a suitable time the old software will be removed and DWB 2.0 transferred to its usual home.

Macro support for DWB 2.0 is currently under consideration and a survey on usage is about to be carried out in conjunction with Operations/Support section.

Transcript 2.0 has also been provided for the PERQ. The documentation is about to be completed. As no laserwriters are connected directly to a PERQ the despooling software has not been implemented (JCM).

#### Pascal Compiler for the Sun

It has become clear that not only has the Sun Pascal compiler not been validated as conforming to ISO Pascal, but has actually failed some of the validation tests. The importance of providing ISO Pascal has long been realised and a programme to evaluate third party validated ISO Pascal compiler for the Sun has begun. The compiler from Edinburgh Portable Compilers has been validated. Others will be tested before a decision on future provision is made (DJJ,JCM).

#### PERQ/SUN Compatibility Calls

With the need for users to transfer programs from PERQs to SUNs, some effort was put into providing transition aids. Depending on the software used, transition was not too difficult for some where the software was already available on both machines. For those using graphics system calls on the PERQ, an emulation package was written for the SUN. Documentation on its use and the restrictions was also produced (DJJ).

**PERQ/2 Networking**

Some effort was put into providing access to Sun and VAX filestore (including NFS filestore) from a PERQ/2. Investigation of providing blue book FTP over ISO TP4/LLC1 which existed on the PERQ/2 (Jan Malone) was carried out. Alternative strategies were also investigated but the final solution was to provide Newcastle Connection using the minimal UDP/IP driver on the PERQ provided by Robert Stroud at Newcastle. Chris Crampton in RCI Section completed this work.

### 8.4 Other Developments

#### 8.4.1 Central Server Facility (JRG, R A Day)

As a result of the operational requirement issued in August 1986 and the tender issued in November 1986, Sun were chosen for the small cluster of workstations and Pyramid for medium and large clusters, although it is expected that the boundary may be somewhat blurred at times. Bob Day has been heavily involved in this activity, especially the communications aspects.

The first system external to RAL is going in at Warwick as an intended replacement for the ICF Prime.

#### 8.4.2 Graphics Standards (JRG)

JRG has attended two ISO meetings, one of them the working group on computer graphics, ISO JC97/SC2l/WG2. JRG has concentrated on the programming language interfaces (or language bindings) and as a result of these meetings, the Fortran and Pascal bindings of GKS are now standards and GKS-3D and PRIGS language bindings are making progress. JRG is the ISO document editor for the Fortran language binding of GKS-3D.

#### 8.4.3 Contract with University of Kent

The University of Kent have an EMR Contract from the ECF to produce software tools for Single User Systems. In the past year, emphasis has been on refining the tools and porting them to the SUN.

### 8.5 Publications

J R Gallop: User Interface Management and Graphics Standards in Information and Software Technology, May 1987.

(M R Sparks and) J R Gallop: Computer Graphics Language Binding: Programmer Interface Standards in Computer Aided Design, October 1987 (to appear).

M J Prime: User Interface Management Systems - a Current Product Review paper produced for ECF Workshop on User Interface Management Systems, September 1987 (to appear).

SUN USER NOTES 5-10

PERQ USER NOTES 10,11

COMMON BASE TECHNICAL NOTES 36-85

GKS PROJECT MEETING NOTES

### 8.6 Conferences, Meetings

| | | | |
|---|---|---|---|
| NCC Seminar on TOP (DCS spoke on Graphics Standards) | NCC | Oct 86 | DCS |
| BCS Displays Group: Workstation Publication Systems | | Oct 86 | DCS, JH |
| BCS one day meeting on User Interface Management Systems | London | Dec 86 | JRG, JH, MJP |
| ISO TC97/SC2I/WG2 Rapporteur Group on Computer Graphics Language Bindings | Fort Collins, Colorado, USA | Jan 87 | JRG |
| usr/group seminar on desktop publishing and document preparation under Unix | | Feb 87 | DCS |
| NCC: National Technology Conference (JRG gave presentation on "Current Developments in Workstations") | Brighton | Feb 87 | JRG |
| European PERQ User Group | RAL | Mar 87 | Many |
| CHI 87 | Toronto, Canada | Apr 87 | MJP |
| Sun UK User Group | Manchester | Apr 87 | DCS, PJWR, TAW |
| NeWS Seminar | London | Apr 87 | MJP |
| Eurographics UK | University of East Anglia | Apr 87 | DCS, PJWR, DCS, TAW |
| BSC Displays Group: Parallel Processing for Displays | | May 87 | DCS, JH |
| Postscript Seminar | London | May 87 | DCS, JH |
| Seminar on Graphics Standards | London | May 87 | DCS (Chair) |
| ISO TC97/SG2I/WG2 Working Group | Valbonne, France | May 87 | JRG |
| ICS Computer Graphics: A comprehensive introduction | London | Jun 87 | APMcD, PLP |
| Sun UK User Group | London | Jul 87 | TAW |
| NATO Study Institute - Theoretical Foundations of Computer Graphics | Lucca, Italy | Jul 87 | JH |
| Siggraph 87 | Anaheim, California, USA | Jul 87 | RMK, DCS, CAD |
| Workshop on the future of NAG Graphics | Leicester | Aug 87 | JRG |
| Eurographics 87 | Amsterdam | Aug 87 | KML, PJWR, DCS |
| MSc Course on Computer Graphics at Middlesex Polytechnic (one day per week) | London | Ongoing | JH |

Members of the section have also attended various short courses during the year.

## 9 OPERATIONS/SUPPORT

### 9.1 Introduction

The purpose of the Operations Sub-section is to provide operational services, on whatever hardware, to the Engineering Computing community, to the Alvey community, and to the Division as a whole. In much the same way, the User Support Sub-section provides assistance and advice to users of these facilities.

The staff in post at September 1987, with three new permanent members recruited and two sandwich students taken on for six months each, is as follows:

- M E Claringbold (MEC) Leader (since 1 November 1986)
- Operations
  - P D Athawes (PDA)
  - A M Jackson (AMJ)
  - R Parkes (RP)
  - R Tillotson (RT)
  - L J Reed (LJR)
  - I Vollmer (IV)
  - A C Davis (ACD)
  - J R Smith (JRS)
  - A Jaroslawska (AJ)
- Support
  - B A Alston (BAA)
  - M J Loach (MJL)
  - N J Kennett (NJK)
  - P C Phillips (PCP)

(Prior to the divisional reorganisation of 1 November 1986, Cyril Balderson was in charge of Operations and Geoff Lambert was in charge of Support. Tony Lowe was also in Operations.)

During this period, both PDA and MJL gained promotion to HSO.

Apart from supervising the activities of the staff above in their work and personnel management, MEC has mounted the SLICE package on Prime, defined and implemented the functions of a system administrator, and been involved in the setting up of the Division Unix service becoming Service Manager.

MEC is Chairman of the Unix Service meeting held monthly, Chairman of the Prime Progress meeting held at 6-8 weekly periods and Chairman of the GEC availability meeting held every 3 months.

### 9.2 Operations

#### 9.2.1 ECF

The past year has seen the emergence of the System Administrator for the Engineering Computing Prime service and an associated set of duties and responsibilities. These have become an additional part of RP's workload and include full responsibility for resource management on all the RAL Primes. Other work which has arisen as a result of this concerns the need to provide accurate availability figures for the RAL machines. To this end he has been involved in discussions with CCD with a view to producing a specification and mechanism to provide such information via the Incident Report form used by CCD. Other activity has resulted from a decision reached by the Prime Coordination Committee to conduct a files tore audit of the RAL systems. This involves setting up information files describing software held in certain system directories, and maintaining these files. He has done extensive investigation and written a discussion paper to facilitate its introduction.

RP has continued to maintain close contact with the Operations staff of CCD responsible for operation of the Prime systems. In particular he has been involved with major hardware faults affecting RL.PF, continuing in his role as first point of contact for Prime Computer (UK) field service management. With the removal of the systems support staff at RAL he has found more demands

placed upon him when system software problems arise. Another problem, and one as yet unresolved, concerns the software for files tore backup used on all the RAL machines - this stopped working properly after a Primos update and he is now coordinating activity to establish the causes and then move towards the introduction of a later, correct version.

RP is secretary of the Prime Progress Meeting held at 6-weekly intervals, alternating between RAL and Prime at Hounslow.

PDA has spent a great deal of her time this year working on, and generally completing, special projects.

The merger of RL.PG and PL.PI into one machine was planned and completed by PDA involving the re-organisation of the filestores, machine configuration and the preparation of the SAD and Accounts database to reflect the requirements for handling the charging on the new machine.

This year PDA has handed over resource management tasks to local and remote site managers. A visit has been made to each site to present the database and to instruct the managers in its use. The Resource Management database which has been set up, to allow the managers to carry out their own resource management, has been generally accepted without too many problems. She needs to be available to consult with managers on problems relating to their new role and this is still very time consuming.

The streamlining of the Accounts database is still an outstanding project but much discussion has taken place and a draft paper produced, detailing the procedure for handling this database and the recording of the information. The ultimate aim is to make the Resource Management database interlink to the Accounts database. This will provide an automatic system of recording information which should reduce considerably the amount of manual effort that is currently required.

PDA has produced statistics and performance analyses as the need has arisen. Her experience has also been useful in relation to problems with the accounting procedures.

PDA is secretary of the internal Prime Co-ordination Meeting which is held at intervals of 6-8 weeks.

Primos Rev20 will be introduced on all the RAL Primes soon and this particular revision requires a conversion of the entire files tore . Both RP and PDA have done some preliminary planning to perform this.

ACD joined RAL in April 1987 from Technical College with little practical computing knowledge and is thus under training from RP. However he is able to assist in some of the system administration functions. He is also providing operational cover, such as dumping, for the development Prime RL.PD and the GEC RL.GK for MJL.

### 9.2.2 Unix Service

RT joined this Sub-section at the beginning of this reporting period as network system administrator for the SUN workstations within the Division. This includes the servers which provide user files tore accessible from any workstations with no local disk. There are 17 such diskless workstations and 20 with disks. The Ethernet LAN upon which clients and servers rely also includes the Division's MUMs, and the four laser printers attached to SUNs are available to them as well.

The network has become a service during the year and RT is in constant contact with users, and with owners of client machines. He has devised some of the tools, techniques and procedures used in administrating the service. These include the use of rdist to maintain file system mounts and local features across all the SUNs, the systematic incorporation of new users and new workstations, and a single point of contact for SUN hardware maintenance.

Particular events over this period have included the installation of SUN release 3.2 across the system, the addition of a further disk drive, the addition of the third server and several disked and diskless clients, the extension of NFS to the Division's MUMs, the transfer of some MUM load, eg news, laser printers, to the SUNs, and the introduction of automated server filestore dumping.

The network is expanding and he has been participating in planning the various phases in introducing the Yellow Pages shared user and password database.

IV is the system administrator for the Systime VAX rl.vd which, apart from being an Alvey Infrastructure machine is also the main Divisional mail machine and the host for the NeWS system. System administration has meant the investigation of machine performance problems, and peripheral problems. It has also included responsibility for filestore security through backups and installing software updates. Since July she has taken over system administration responsibilities for the Pyramid rl.pyr-a, the Pyramid workcentre nfs4, and the Software Engineering VAX rl.vc.

IV has participated in the conversion of rl.vd into the single filestore controlled by NFS which also includes rl.pyr-a, nfs4, three SUN fileservers, and the SUN single user systems. This is now used to provide all the user filestore for the Division's Unix service.

IV has written documentation for the local auto dump procedure which is being used by the CCD operators when performing overnight dumping of the VAXes and Pyramid.

IV is the local administrator of the News system, the worldwide bulletin board operated over USENET. This work involves the monitoring of disk space used by the system, the creation and removal of news groups,and liaison with other News administrators. She also administers the Divisional Arpanet registrations at the UCL gateway.

In a similar capacity to IV, AMJ served as system administrator for rl.vc and rl.pyr-a, and participated in the mounting of NFS upon the latter machine, until July. He was also responsible for the R1 Machine Room which entailed the planning for the arrival of new computers and the disposal of surplus equipment, the arrangement for services, such as electrical supplies, within that area, the co-ordination of the movement of computers, and the general arrangement of equipment. This has a bearing on his position as a building warden and the Divisional Safety Representative.

Two particular jobs in this period have been the evaluation of a Spiderport and the writing of a VMS format tape for use in Spain.

AMJ is secretary of the Unix Liaison Meeting which meets every 2 months.

Since July, when the Computer Applications Group of Technology Division merged with ID, he has been paving the way for a smooth merger for the two dozen or so people involved in the move. This has meant talking to each of them individually to find out what equipment they already have, what facilities they are using, and what they would like to have in becoming part of the Division's Unix service. Anticipating the need for workstations and networking facilities, he has been working sometimes with Tony Lowe to gain knowledge in this field.

AJ provides assistance to the system administrators and performs general machine operations. This is a long list which includes:-

1. checking the network status,
2. checking files tore status,
3. performing dumps on the SUN fileservers and the development VAX,
4. checking each morning that the overnight dumps are correct,
5. restoring files from backups,
6. maintaining tape library,
7. checking and maintenance of laserwriters,
8. upkeep of Unix manuals,
9. keeping Computer Room and Labs 10 and 11 tidy,
10. upkeep of computer stationery.

LJR joined the ECFE on 27 April on a part-time basis, 3 days/week, but it was decided to transfer her to Operations on 24 July as a more suitable place for training.

### 9.3 User Support

In order that the users can always receive assistance quickly, the aim has been that all members of the Sub-section should be able to support all machines. In practice, BAA supports Unix, MJL supports GEC and PCP supports Prime but all are capable of supporting other machines to some degree.

On the Prime, BAA has put up the long integer F77 version of the main NAG library fixing a bug in one of the routines. On the Pyramid, he is mounting Mk11 of the main NAG library since the version supplied by NAG does not work.

BAA is secretary of the monthly held Unix Service Meeting.

The staffing problems within GEC Systems Section became worse with the resignation of Neil Davidson and the transfer of Shirley Wood to JNT. An emergency meeting of the site managers agreed to abandon the intended upgrade of the operating system to version 4.17. Instead the current version was frozen with the known problems accepted. C D Rust (CDR) of GEC Systems Section and MJL continued with overall GEC support of ECF systems until April when CDR was moved. Since then MJL has taken sole responsibility for the day to day running and system management. He has produced and distributed revision to Volumes 1 and 2 of the Reference Manual, fixed all known bugs in KERMIT and made some improvements to the HELP system.

MJL is organiser and secretary of the GEC Manager/User meetings held twice a year, and secretary of the GEC Availability meetings held every 3 months.

PCP is responsible for the development, maintenance and operation of the Resource Management and Accounts databases. The former provides an interactive facility for site managers to enter grant and user details, the latter contains actual usage information for all users of ECF and TD Primes and GECs. Statistics are produced for Management and for publication, and bills are produced for Finance. He continues to develop these services in liaison with PDA. He performs the updating of software on all the RAL Primes, keeping the users aware of intended and actual changes.

PCP is organiser and secretary of the Prime User meetings held twice a year.

Two sandwich students from Brunel, namely B J Edwards (BJE) and P Sausman (PS), joined for 6 months each from 13 April. Working under BAA, they have produced an IDUS paper, introducing new members in the Division to the UNIX services available. With guidance and assistance from PDA and from UMIST, PS has been rewriting the Prime performance analysis package. BJE has been involved in benchmarking versions of Primos.

MJK joined on 22 June to support Unix users and is currently going through a training period.

### 9.4 Database Upkeep

The work of JRS covers both the Operations and the Support area and both the ECF and the Unix Service facilities. This is because she maintains and updates the many databases used by all concerned. Those which have been of most use in this period have been:-

1. users, location and details of SUN-2s,
2. users, location and details of SUN-3s,
3. addresses and telephone numbers of remote site contacts,
4. remote site contracts,
5. blue book report, ie, computer details, configuration, maintenance contracts, site contacts at Universities,
6. Alvey applications,
7. terminals owned by ID.

JRS has also liaised with many locations regarding the disposal of old ECF terminal on loan to them, and reporting those accepted to RAL Loan Pool.

# Informatics Annual Report 1987-8



## 1 INTRODUCTION

The Annual Report covers the year ending September 1988. Its main purpose is for internal use in the Department, indicating what has been achieved and by whom. Hopefully it also gives new members of the Department some idea of the work programme and its objectives.

The Divisional Structure in September 1987 was:

1. Software and Knowledge Engineering D A Duce
2. Infrastructure K F Hartley
3. Engineering Computing M R Jane

The funding for the first two Divisions came largely from the Alvey Programme. Software and Knowledge Engineering had research projects in the IKBS and SE areas and provided technical support to Alvey Directors in these areas.

The Infrastructure Division supported a hardware and software infrastructure for the IKBS, SE and MMI areas. This started in 1984 providing multi-user system support via a distributed set of GEC Series 63 and SYSTIME VAX systems. More recently support has also been provided for SUN systems. This Division also provided coordination and support in the areas of IKBS, MMI and SE for the relevant Alvey Directors.

Engineering Computing Division provided support for the Engineering Board's Computing Facilities Committee. This was a range of activities from application to hardware support aimed at providing support for research funded by the Committees of the Engineering Board.

The Alvey programme will be substantially complete by April 1989 and the last year has been one of running down the Alvey work as the programme comes to an end. In consequence, the Divisional structure became rather unbalanced. For this reason and several others, a new structure was introduced in July 1988 which is oriented more towards function than funding. The new structure has four Divisions:

1. Systems Engineering: R W Witty (Deputy D A Duce)
2. Design: M R Jane (Deputy B Colyer)
3. Computational Modelling: F R A Hopgood
4. Distributed Computing Service: K F Hartley (Deputy R E Thomas)

The major changes were to split Engineering Computing into its functional components, to move the Human Computer Interaction work of the Infrastructure Division into Design and to move the Image Processing parts into Computational Modelling.

The organograms at the start and end of the year are given as Appendices. The format of this report is largely that of the structure at the beginning of the year.

# 2 SYSTEMS ENGINEERING

## 2.1. Introduction

### 2.1.1 Reorganisation

After the enforced changes in structure and management which occurred during the previous reporting period, this period was relatively stable with DAD and GAR leading the combined Software and Knowledge Engineering Group from September 1987 -May 1988 when RWW returned from his American sabbatical.

In the July 88 reorganisation of Informatics Department the synergy between SE and KE was recognised more formally when SKE Group became Systems Engineering Division.

### 2.1.2 Staff to Initials Mapping

- R W Witty (RWW)
- D A Duce (DAD)
- A J J Dick (AJJD)
- J C Bicarregui (JCB)
- B Ritchie (BR)
- B M Matthews (BMM)
- J R Kalmus (JRK)
- M S Parsons (MSP)
- G A Ringland (GAR)
- B G Bainbridge (BGB)
- S C Lambert (SCL)
- C Y L Kwong (CYLK)
- D F Mac Randal (DFM)
- M D Wilson (MDW)

Visitors

- J E Galletly (JEG) (University of Buckingham)
- S K Robinson (SKR) (Brunel University)
- M Martins (MM) (University of Minho, Portugal)

Sandwich Student

- L N Woodhead (LNW)

## 2.2 Software Engineering

### 2.2.1 Main Functions

The main activities in the Software Engineering area are:

1. Development work on behalf of the Alvey SE programme. This can be on behalf of specific projects (eg yacc/SML for Forsite) or for the Alvey SE Infrastructure generally (eg SML/LCF).
2. SE Research in line with IEC/CSSC policy, Alvey SE strategy and in collaboration with industry, GREs and Universities.

Development work is funded directly from Millbank to SERC/RAL. The research work is funded differently. This either follows normal Alvey rules, or goes through the peer review system of IEC/CSSC. At any instant the aim is to have more than one project underway with successors in the pipeline. Systems Engineering aims to have both Alvey and CSSC funding simultaneously. It is hoped that funding via ESPRIT can also be obtained.

### 2.2.2 Alvey SE Technical Support and Development Work

#### 2.2.2.1 Introduction

The section undertakes specialist infrastructure work for the Alvey SE programme. The way of working that seems most satisfactory is for the section to work alongside a specific Alvey project to provide a piece of infrastructure needed by that project, but to do so in such a way that it will be of use to the whole community. An example of this is the project to provide a yacc-like tool for Standard ML.

#### 2.2.2.2 SML-Yacc

The aim of this project is to produce a yacc-like parser generator written in SML which produces output code in SML. This project is being undertaken on behalf of the Alvey FORSITE project.

FORSITE is a collaborative project between the University of Oxford, Racal ITD Ltd, the University of Surrey and System Designers Plc. The FORSITE project is producing an environment to support the development of formal specifications in the Z and CSP notations. Both are products of Oxford's Programming Research Group. The main components of the environment are a multi-font WYSIWYG editor for mathematical texts and a type checker for Z. The latter is written in SML.

An SML/Yacc system is needed by Forsite to provide a Z parser that will integrate neatly with the other components of the environment.

The specification for the system was drawn up by Michael Hedland and Brian Matthews (BMM). Following Michael Hedland's return to Sweden, Stuart Robinson (SKR) has become involved in this project. By December 1987, the system was in a sufficiently good state as a parser for LR grammars to be a practical tool. However the extension to full LALR parser generation proved technically very difficult and computationally very expensive.

During the winter period, the first version of the LALR lookaheads generation was implemented, the final computational problem to be overcome in producing LALR parsers. The algorithm given in Aho Sethi and Ullmann's book on parser construction was implemented. This proved computationally very expensive in ML so some time was spent optimising the code and doing as much precomputation as possible to get the run time to a reasonable level. Another lookahead algorithm as given by Pennello and DeRemer was implemented when further improvement in the ASU algorithm seemed impossible. This was claimed to be a better algorithm, but the efficiency of the ASU version has not been achieved. The project is now winding down and a final product is scheduled for October 1988. There is some tidying up of the code to be done. Example parsers will also be produced and tested including a parser for the FORSITE Z grammar.

The new methods developed in the project are being written up for publication, and a users manual is being written.

Working with functional languages has suggested a method for the production of parsers which is based on parser composing operations. This is completely different to the traditional table-based methods used in this project to date. Some exploratory work is being done in this area before the project terminates.

#### 2.2.2.3 Concurrency Workbench - Graphical Interface

In February 1987, the Laboratory for the Foundations of Computer Science at Edinburgh University asked if the Division would collaborate with them in developing graphical user interfaces for software tools being constructed.

Edinburgh are developing a number of tools for supporting formal software development methods that would benefit greatly from graphical user interfaces. One such tool, the Concurrency Workbench, seemed particularly appropriate for a pilot study. The Concurrency Workbench is a suite of tools for manipulating and analysing concurrent systems described in their CCS (Calculus for Communication Systems) notation. The first prototype, with a simple textual interface, is now completed, and the aim of the collaboration work is to develop a graphical user interface for these tools.

HCI section of the Infrastructure Group are providing the people for the project, funding comes from the Alvey Software Engineering programme. Technical progress is reported under the HCI entry.

#### 2.2.2.4 Theorem Provers

Theorem provers are software tools to aid in the process of proving theorems. In the software engineering context we are primarily concerned with theorems about programs, for example that a particular program has a particular property.

Some 30 copies of the Cambridge LCF/Rutherford SML system (described in the 1986/87 Annual Report) have now been distributed and more are in the pipeline. Much interest was aroused by Larry Paulson's (Cambridge) book on LCF. Larry Paulson has produced a SUN version of the system which is about ready for distribution by RAL.

The group also acts as UK distribution point for the Alvey SE Infrastructure for the Boyer-Moore theorem prover from the University of Texas.

### 2.2.3 Software Engineering Research

#### 2.2.3.1 Introduction

The overall software engineering research them is Quality Certification of Software Product. Within this theme, the main research interests of the group are in formal specification, the development and application of machine-assisted proof systems and the role of formal reasoning in software development.

#### 2.2.3.2 Formal Specification

In September 1987 David Duce (DAD) held a research grant from SERC's Computing Science Sub Committee entitled Theoretical Studies of Emerging Computer Graphics Standards.

DAD and Mike Parsons (MSP) worked on the project during the year, but progress was impeded by DAD assuming the role of SKE Group Leader and the diversion created by the Esprit II programme.

Three papers were prepared for the Eurographics GKS Review meeting in 1987. One covered proposals for improved input facilities in GKS. The second was a specification of the polyline, polymarker and fill area output primitive of GKS in the framework reported in the Arnold, Duce, Reynolds paper at Eurographics 87. The third paper recorded the lessons learnt from the GKS specification work so far and areas in which the GKS definition could be improved. The papers were well received at the Workshop and it is noticeable that, with the exception of the USA, there is

now considerable sympathy in ISO for the use of formal methods in the development and presentation of standards.

The GKS Review Workshop produced many interesting ideas for directions in which GKS could be simplified and at the same time provide richer facilities. A good example of this was the idea to replace the GKS segment store with a primitive store from which primitives could be selected using a name set/filter mechanism.

Many suggestions were made concerning output primitives: the current set of primitives in GKS is unsatisfactory for several reasons.

MSP subsequently looked at more fundamental and structured ways of defining primitives. The underlying philosophy is that the set of output primitives will never be fixed, people will always want to add new primitives to do a specific job, or to exploit particular hardware. To allow for this extensibility, a proposed framework approach for graphical primitives is proposed: as long as new primitives can be shown to fit the framework model, they may be considered to be primitives. The case of poly primitives has been looked at in some detail and a working paper using a functional specification style has been produced. This specification has been partially implemented using Miranda (a functional language developed by Turner at the University of Kent) and Postscript.

The subject of Reference Models for Computer Graphics Standards reared its head again during the year. It is a subject on which everyone has an opinion (and different expectations!), yet few are prepared to put pen to paper and produce drafts for discussion. DAD produced a document for discussion by BSI in February 1988. In revised form this was transmitted to a special SC24 advisory group meeting on future policy in April 1988. This meeting came out with a recommendation that the BSI reference model should be developed further, together with a recommendation that a Components/Framework model should be explored as a basis of the development and management of future graphics standards. At a subsequent meeting of the BSI Reference Model Group, it became clear that the BSI Reference Model could be integrated with a Component/Framework model, essentially by recognising a connection between abstract data types and components. A revised paper was produced which formed part of the BSI input to the SC24/WG1 meeting in July 1988.

The Component/Framework model was well-received by European nations, but met with considerable opposition from the USA. Further work to refine this model within Europe is being planned.

MSP did some joint reference model work with Clive Ruggles at Leicester University. This started from the recognition that in a graphic system there are two dimensions in which graphics data can be reified (made more concrete). The first is a data reification, the second a graphical reification. A working paper describing their ideas went through several iterations.

#### 2.2.3.3 Graphics Standards

DAD and MSP both participated in the BSI Computer Graphics Panel and in the GKS-3D international review. DAD attended two GKS Review meetings and the SC24 meeting in June/July 1988. DAD has recently been appointed document editor of the GKS Review.

#### 2.2.3.4 Equational Reasoning Research

Jeremy Dick's (AJJD) research continues in the field of Automated Equational Reasoning funded by SERC's Computing Science Sub Committee. The ability to reason with equations (for example, to deduce conclusions from a set of equations), is important in a number of areas, for example specification of abstract data types and their validation, program transformation, synthesis of programs, program optimisation and solving equations.

AJJD has over a number of years developed a rich theoretical framework for equational reasoning and has developed a practical tool, ERIL (Equational Reasoning - an Interactive Laboratory) based on this framework. ERIL is a useful tool for experimenting with the specification and prototyping of

abstract data types, and is used by several research groups in the UK and abroad. ERIL is based on the use of rewrite rules for computing and reasoning with equations.

AJJD and John Kalmus (JRK) have continued the development of ERIL.

Several more termination orderings in ERIL have now been successfully implemented. These include a version of the Knuth-Bendix Ordering that allows the user to assign weight to function symbols (userKBO); three versions of the Recursive Path Ordering, one which requires the user to assign the function precedence in advance (userRPO), another which automatically determines the appropriate precedence (RPO) and another which also determines appropriate function status (RPOS).

Initial experiments have been made with AC completion in ERIL.

A new version of ERIL is currently being designed in collaboration with the Royal Holloway and Bedford New College (RHBNC).

A joint paper of AJJD and JRK with Dr Ursula Martin (Royal Holloway and Bedford New College) is now complete, and awaits submission to an appropriate refereed journal.

AJJD's paper on structures for the representation of rewrite rules has been suspended pending the results of an MSc project that he is supervising on the subject at Imperial College.

A major task for AJJD and JRK during the period was the production of the ERIL users' manual, of which preliminary copies have been distributed for general comment. It has been registered as a laboratory report (RAL-88-055), and will be issued in September 1988.

Another RAL report on the prolog module structure used in the new version of ERIL is planned. AJJD's recently completed thesis will also be issued as an RAL report.

AJJD and JRK have held extensive collaborations with RHBNC, having held 5 one or two day meetings, which have at times included Dr Muffy Thomas from Glasgow and Stuart Matthews from Hatfield Polytechnic.

#### 2.2.3.5 IPSE 2.5 Research

IPSE 2.5 is a major Alvey project to research and develop an Integrated Project Support Environment based on advanced distributed systems and man-machine interfaces, and incorporating support for both the practice and organisation of design tasks. A major objective is the development of an integrated framework for supporting the use of formal methods in software development, including formal specification and theorem-proving techniques.

The project began in October 1985 with three initial collaborators (ICL, STC and Manchester University) and had a successful first review with the Alvey Software Engineering Directorate in July 1986. RAL applied to join the project from April 1986 and, after some delay, received its grant allocation at the beginning of July 1986. Three additional industrial partners have also recently joined the collaboration.

At RAL, Juan Bicarregui (JCB) and Brian Ritchie (BR) are engaged in the project. DAD is the RAL representative on the Project Review Board. The work at RAL is carried out in very close collaboration with the University of Manchester. JCB and BR spend a fair proportion of their time at Manchester.

The Manchester/RAL part of the IPSE 2.5 project (Theme C) is concerned with the support of formal methods of software development and in particular with aiding formal reasoning itself. The intention is to build tools which enable a user to construct proofs at the workstation; modern workstations such as the SUN3 should make it possible to design proof assistants which are much more usable than earlier tools developed around glass teletype interfaces.

During the period September-December 1987, the RAL work concentrated on the design of the theory store for the formal reasoning IPSE (FRIPSE) being designed and built by theme C. FRIPSE is split into a left hand side, providing specification language support, and the right hand side,

providing theorem power support. Initially it was intended that the left hand side and right hand side would communicate through the theory store, but this was eventually felt to be too complex an interface and a simpler interface was designed, and the theory store has been accommodated in the right hand side.

The requirements analysis work for the theory store is written up in an Alvey deliverable Theory Store Analysis.

Following a reorganisation of the IPSE 2.5 consortium in the theme B area, RAL has been charged with the design and implementation of a minimal left hand side for use by theme C whilst the fuller version from theme B is awaited.

Work began in January on the specification of the minimal LHS component of Theme C - a support system for VDM (as a design methodology as well as a specification language), whose main purpose in life is to provide interesting proof obligations for the RHS (theorem prover/theory store) to work on. Originally, the keyword for this design was minimal; however, in consideration of the present status of the theme responsible for a full-blown support system, RAL have come under some pressure to make the design less minimal.

Design and presentation of a preliminary formal specification of the LHS has been the major task over the first half of 1988. A VDM data model has been developed to encapsulate the construction of completed design developments, in accord with the process laid out in Jones 86 of specifications of varying degrees of abstraction linked by reification information (how one specification can be formally viewed as an implementation of another, both through reification of data models and through redesign of operations and functions upon them). This model went through numerous iterations.

Several working documents which were published in June, were amalgamated into the preliminary specification which was reviewed and has been released as a project document.

Since then, effort has been concentrated upon one of the largest gaps in the preliminary specification, namely how operation decomposition could be handled. The main task here is the design of a method for annotating statements in a Hoare-like fashion. A working document on this should be completed soon.

BR and JCB have also contributed to the rest of the theme C work, participating in informal discussions as well as more formal document reviews.

BR co-authored a paper with Paul Taylor (Edinburgh) on the Interactive Proof Editor (IPE the subject of BR's PhD thesis). The paper was presented by Paul at a workshop on Hardware Verification in Canada in June.

Jim Woodcock and BR initiated an attempt to use the IPE to prove a Z proof obligation. It was interesting that the proper structure of the proof obligation only became apparent during the construction of the proof. To BR's relief, the IPE coped quite well with this style of development and it is intended to write up the exercise.

#### 2.2.3.6 BSI-VDM

February saw the start of BR and JCB's involvement with BSI VDM. The intention is to make RAL's specification follow the BSI proto-standard as closely as possible, hence the involvement in the BSI committee. As work progressed through the following months, errors in the proto-standard were found and it became clear that certain choices that had previously seemed arbitrary could have complicating consequences on the theme C work. Thus contributions to these meetings have increased. BR has been persuaded to take over document control of the main proto-standard document from Cliff Jones (Manchester); so far, this has required little effort - the main changes to the BSI proto-standard so far seem to have arisen from the IPSE 2.5 work.

#### 2.2.3.7 Concurrency

Jim Woodcock (JCPW) continued his researches into the area of state-based concurrency. In collaboration with He Jifeng (PRG, Oxford) JCPW is working on the combination of the Z notation with CSP, the basic idea being to use Z to describe states, and CSP to describe concurrency and interaction. Jifeng has now fixed the theoretical underpinnings and has produced a complete set of rules for data refinement. JCPW has produced a case study which uses the new techniques. Part of the work was presented at the Z users meeting in Oxford in December, and at a series of lectures at IBM UK Laboratories, Hursley Park.

Working with material from the CICS formalisation project at IBM, JCPW has developed some case studies in specification and refinement. Current work concerns proof rules for event refinement, based on Jacob's rules for local replacement. This seems promising. The second approach to the description of state-based concurrency is Cliff Jones' extension of VDM with rely and guarantee conditions. Little work has been done using this extension since Jones published his D.Phil thesis in 1981. Working with a colleague at GEC Telecommunications, JCPW has produced the first draft of a report which investigates the applicability of the technique. In his thesis, Jones concentrated on operation decomposition, and in particular parallel decomposition. The report takes a more general view of development, where a development step may involve both a data refinement and the decomposition of an operation. The notions that Jones suggests for proving refinements correct are shown to have major shortcomings. The most important of these are the inability to change the degree of atomicity in a refinement, and the need to know how the environment of an operation is being developed in order to make a development step. The first problem militates against proper abstraction whilst the second militates against hierarchical design. The work has been presented at a seminar at the Hatfield Polytechnic on 20 November, and at RAL on 27 November.

In January JCPW completed work on a paper describing this work. The paper describes previously unknown incompleteness results for his notion of refinement. A summary of this work was presented at a workshop on refinement at York in January, a paper has been accepted at the VDM 88 Symposium, and a full report submitted as a monograph at the PRG, Oxford. In collaboration with Jifeng at the PRG, JCPW has a draft of a new set of rules for refinement, which is believed to be complete. The proof of this has yet to be discovered.

Work on verification of processes in the notations of CSP has also continued. Often small processes and simple specifications lead to surprisingly long proofs. Using ideas of fully abstract states, a normal form for such a specification has been developed so that it denotes the same behaviour as a corresponding normal form process. A proof rule for determining the correspondence has been verified. This reduced the burden of proof in the examples that have been studied. Proofs of satisfaction are replaced by chains of equivalences in the model. The normal form specifications are written in the readiness model for CSP, and are closely related to operations in concurrent Z.

JCPW has contributed to the work on a Standard for Z.

Working with Jim Davies, (JCPW's D.Phil student) a specification and implementation of the Ethernet protocol in timed CSP has been produced. This is the first application of the timed model, and it is revealing many interesting insights and theoretical problems. There seems to be much work to be done here.

JCPW has recently completed a book on formal methods.

#### 2.2.3.8 Visiting Scientist

Mario Martins (MM) from the University of Minho, was a Visiting Scientist from March 1987 to December 1987. During the period September 1987 to December 1987, MM's work was concerned with the specification of user interfaces. Two papers were produced during the period, one of which describes an extension to the production system formalism which can be used for the specification of concurrent systems. The second built on earlier work with Jose Oliverra and describes the use of constructive and algebraic specifications in formalizing some aspects of the user interface.

### 2.2.4 ESPRIT II

A Call for Proposals for Phase II of the ESPRIT (European Strategic Programme of Research in Information Technology) was formally issued in December 1987, with a response date set of 12 April 1988. From the first ESPIRIT II Proposers Day held at the end of the ESPRIT I technical week in September 1987 until 12 April 1988, DAD and many others were almost completely absorbed in endless rounds of European travel and meetings formulating research proposals for ESPIRIT II. The effort involved in ESPIRIT proposals is infinitely greater than that involved in formulating SERC RG2 proposals. AJJD and MSP gave very valuable assistance when the workload was at its peak.

### 2.2.5 Future Programme

The outcome of the ESPIRIT II proposals is not completely decided at the time of writing, but Software Engineering Group hopes to be involved in one project. Applications are also being formulated for the UK IED collaborative Programme.

The group now has a large number of links with other research groups, both national and international, and it is hoped that some of these will mature into formally funded projects. The following list is some of the organisations with which we have formal or informal collaborations.

- University of Manchester
- University of Edinburgh
- University of Oxford
- Royal Holloway and Bedford New College
- Brunel University
- University of Cambridge
- University of East Anglia
- University of Leicester
- University of Leeds
- Polytechnical University of Catalonia, Spain
- University of Minho, Portugal
- University of Glasgow
- Hatfield Polytechnic
- Imperial College
- INRIA, France
- CWI, The Netherlands
- Technical University of Darmstadt, W Germany
- IBM UK Laboratories

### 2.2.6 Other Activities

BMM is taking an MSc Course at Imperial College London in the Foundations of Advanced Information Technology (FAIT). This is on a part time basis, two days a week for two years. This course is intellectually very demanding, but gives a very good foundation in-theoretical computer science. BMM has now embarked on the project which will conclude MSc. This is on Strategies for Theorem Proving in an Equational Reasoning System, and is under the joint supervision of Jeremy Dick and Chris Hankin at Imperial College.

AJJD is secretary to the Alvey SE Formal Methods Advisory Group.

DAD continues as Vice Chairman of Eurographics, participates in the Executive and Professional Board activities and is Programme Chairman for the Eurographics 88 event in Nice.

DAD edited a book on Knowledge Representation with Gordon Ringland, which contains contributions from many members of the Division. The book was published in April 1988.

DAD and AJJD spent a week in Barcelona at the Technical University in November 1987, teaching a course on algebraic specification. This led to an opportunity to do a little bit of graphics research through a simplified system showing how PHIGS could be defined on top of GKS-3D.

The UK Term Rewriting Group, formed by AJJD and JRK jointly with Ursula Martin, has had several informal meetings. Two excellent formal meetings were held in Glasgow on Induction and Inductive

Inference, and in Manchester on Extensions to Term Rewriting.

AJJD and JRK are both involved in the organisation of the BCS FACS meeting in term rewriting to be held in September 1988 in Bristol.

## 2.3 Knowledge Engineering

### 2.3.1 Objectives

1. Establishing and maintaining a funded R&D programme in AI, where possible in collaboration with SE and HCI. This is required as an element in maintaining the effectiveness of the department.
2. Promotion and support of the SERC'S research programmes in KE/IKBS. This has been mainly funded by the Alvey Directorate and the work is concerned with technical support of the Alvey IKBS programme. There has also been work for the Engineering Board's Environment Committee and the Computing Facilities Committee.
3. Investigation of the application of KE techniques to Administration within RAL.

### 2.3.2 Research and Development (GAR, BEB, JEG, CYLK, SCL, DMR, MDW)

#### 2.3.2.1 Paralfex (GAR, CYLK, SCL, BGB)

Work has continued on the Para1fex project investigating architectures for know1edge-based systems. A number of extremely promising directions are being investigated, within the general framework of a unified architecture which is being developed to allow experimentation with the ideas. The possibilities for reusability of knowledge are being investigated, and it has been discovered that there is great potential here for making the process of building knowledge-based systems faster and more reliable. It has been found that there is a greater variety of approaches available than is found in reuse of conventional software. Knowledge-based systems, including the Source of Finance Adviser on which the Paralfex work is currently concentrating, may have different user roles with much knowledge in common but a certain amount varying. The reuse of the common knowledge would reduce the need for knowledge acquisition when building such complementary systems. There is also the idea of abstract generic tasks, applicable in specifying problem-solving strategies across domains, and of reusable packages of domain knowledge (for instance, the knowledge associated with the balance sheet/profit-and-loss account).

Another direction of work is concerned with the explicit representation of control knowledge by means of prototypical tasks. It is well-established that control or strategic knowledge must be made available to a knowledge-based system explicitly if the system is to be able to explain its reasoning adequately. At one level the representation of generic tasks contributes to this; another approach is to represent control knowledge as prototypes describing the typical sequence of actions associated with any entity in the domain from simple numerical quantities to the consultation as a whole and possibly including the request and generation of explanation.

Finally, a last theme is the integration of graphical explanation facilities aimed at the end-user.

The current version of the Source of Finance Adviser is Version 1.6 which works on the Symbolics Release 6.1/ART2.0. With the acquisition of ART Release3.x for both the Symbolics and the SUN which provides much improved facilities, the SOFA system is being reimplemented to make use of these enhancements. As a familiarisation exercise for CYLK, SOFA 1.6 has been ported to the SUN/ART3.I. This was to gain more knowledge of both the internals of SOFA and programming in ART. There is a great deal of difference between the Common Lisps on the two machines.

The Symbolics had its OS upgraded to Genera 7.1. This took a couple of days. First to back up the existing file-store (200MB to 40MB cartridges) and then the man from Symbolics did the actual installation of 7.1. In addition, the SUN 3/160 LIGNUM was upgraded to run ART. This required memory increase from 4MB to 16MB and the disk reconfigured to increase the swap space to 80MB. The purchase of Common Lisp had to be chased up due to a slip up of communication somewhere. We didn't get the documentation and tapes until late July. When the software arrived IDUS management had to be cajoled into providing 60MB of disk space to unload/install ART and

SUN Common Lisp. There was a problem of getting LIGNUM to realise 80MB of swap. There were also problems of installing ART due to incorrect version of SUN Common Lisp. This was rectified after the visit to Ferranti International.

A sandwich student from Teesside Polytechnic, (LNW), is now working on the project. Her first assignment is to port the Source of Finance Adviser into Goldworks, an AI toolkit running on a Compaq 386 machine. This will extend the range of comparative versions of the Adviser available to us, and put us in a position to experiment with forms of input and output other than the standard questioning of the user (e.g. the use of spreadsheet files). It is known that such a facility would greatly enhance the acceptability of the system and others like it to their intended users.

#### 2.3.2.2 Knowledge Acquisition Methods (MDW)

The review paper presented at last years SERC Knowledge Acquisition for Knowledge Engineering Workshop by MDW has been expanded to cover the variety of task models proposed by others for design systems in greater detail and will be published as a book chapter.

The RAL report produced last year describing a Machine Readable Psycholinguistic Database has been published as a journal article (MDW).

#### 2.3.2.3 Temporal Logic (JEG)

Temporal Logic has been studied, including:

i. The classical work of McDermott and Allen and more recent work by Shoham on applications in AI.
ii. The work of Barringer et al to the specification of complex systems and the execution of temporal logic statements.

A seminar was given to SE and KE on temporal logic.

#### 2.3.2.4 Knowledge Representation (GAR, BGB, CYLK, SCL, DMR MDW)

A book, Approaches to Knowledge Representation: An Introduction edited by David Duce and GAR was published in April 1988, containing contribution from the above Group members, together with colleagues from HCI and SE.

#### 2.3.2.5 Intelligent Front End (IFE) Project (DMR, MDW)

The SERC-funded Intelligent Front End (IFE) project addresses the difficulties that end users experience when attempting to use existing engineering appraisal packages. It tackles two issues, firstly the poor quality of the current user interface and secondly the high level of skill/knowledge required to drive the appraisal packages.

The IFE currently consists of a central blackboard, accessed by three knowledge bases - for dialogue handling, rudimentary user modelling and building the user conceptualization. The dialogue knowledge base uses a dynamic form-fill package, (developed in conjunction with Strathclyde University) together with other supporting packages such as a map utility (MDW), to obtain raw user input. The use of a knowledge-driven forms package enables a happy medium to be steered between application driven question/answer input and unstructured command language input and permits the intelligent use of inferred (ie context sensitive) defaults. It is expected to have a demonstrator system by mid October.

### 2.3.3 Technical Support (GAR, CYLK, MDW)

#### 2.3.3.1 Evaluation of Alvey Mechanical Health Monitoring Project (034) (GAR)

At the request of the Alvey Directorate GAR with Dr Roy Leach of Heriot Watt conducted an extensive evaluation of the MHM (034) project during November and December.

#### 2.3.3.2

During the year, project monitoring duties for Alvey have been undertaken by members of the group. MDW has been monitoring officer on IKBS 098, A Knowledge Acquisition Methodology for Research Associations in which role he has attended project management and technical meetings, assessing both aspects of the project's progress.

#### 2.3.3.3 SIGAI (MDW)

The secretaryship of the committee SIG AI has been undertaken by a member of the group (MDW) since July 1988. SIG AI has been an advisory committee on Artificial Intelligence to SERC and Alvey in the past, and is expected to continue in that role under the new DTI IED structure.

#### 2.3.3.4 BSI Prolog Standardisation (CYLK)

CYLK is a member of the Main Working Group representing the SERC. The representation also covers one of the sub-committee meetings, that of the Built-In Predicates (BIP) sub-committee. The BIPs work is concerned with the definition of what predicates and their behaviour are to be included in the eventual Standard Prolog. The main committee meetings discuss the contributions of all the sub-committees collectively.

The state of the effort at July 88 is that the definitions of modules in Prolog has to be included in the standard (as most of the current implementations have some module facility) and the discussions on the subject have re-started.

#### 2.3.3.5 Language Support and Benchmarking (CYLK)

Portable Common LOOPs (PCL)

This is a publicly available Object Oriented Programming system (OOPs) obtained via the network. A successful attempt to get PCL to work on top of Kyoto Common Lisp took about two weeks in November. The difficulty in this exercise was the lack of documentation. Although that was available free as well, it had to be ftp'd from the USA and at the time, the cost of this was too high.

Kyoto Common Lisp

Four weeks were set out just before Christmas last year with the aim of porting Kyoto Common Lisp to the Pyramid RISC architecture machine. If this was completely successful, a comparison of the performances of KCL on SUN and Pyramid would be done. The port was relatively straight forward as the documentation clearly laid out what source files needed to be re-written or altered and was completed right on target.

Performance Comparison

The main part of January was taken up benchmarking KCL to measure and compare the performances on the SUN and Pyramid. The bible of LISP benchmarking by Gabriel was heavily consulted during this process. The actual programs were kindly supplied by SUN Microsystems, UK.

### 2.3.4 The Application of KE Techniques to Administration within RAL (GAR, SCL, MDW)

Work has started on identifying appropriate areas within Administration at RAL where Knowledge Based support would be of value. It is intended to implement a demonstration system by April 1989.

### 2.3.5 ESPRIT

From October to April GAR, SCL and MDW were heavily involved in the formulation of proposals for ESPRIT II. Papers arising from these proposals have subsequently been submitted for publication. Proposal 2474 - MMI2, concerned with Multi Modal Interface for Man Machine Interaction with Knowledge based systems has been accepted and we expect to be involved with this project over the next five years.

### 2.3.6 IED

From July to mid-August GAR, SCL and MDW were concerned with formulating a number of IED1 proposals. The result of this activity is still awaited.

### 2.3.7 AIM

Initial contacts have been made and an outline proposal developed for submission to the CEC under the Advanced Informatics in Medicine (AIM) initiative. This proposal will be for a project to demonstrate that knowledge can be acquired from both medical and technical experts in different European countries and combined together with advanced sensor technology into a diagnostic KBS which can be used within the health systems of different European countries.

### 2.3.8 Honorary Positions

CYLK is a Member BSI Standards Committee on Prolog.

MDW has accepted to be European Representative on the Editorial Board of the journal Interacting with Computers and undertaken the relevant editorial duties. He has also accepted membership of the programme committee for the ACM conference CHI' 89 to be held in Austin, Texas in April 1989.

## 2.4. Staffing

### 2.4.1 Software Engineering

Mario Martins returned to his University in Portugal at the end of December 1987 after a very valuable 9 month visit to the Laboratory. Mike Parsons left the Laboratory in June 1988.

Mike Parsons, Brian Ritchie, and Jeremy Dick were awarded PhD' s during 1987/88.

Rob Witty was on sabbatical at Xerox PARC until May 1988 after which he resumed his role as Head of Software and Knowledge Engineering Group (aka Systems Engineering Division). At the invitation of Dr Bill Spencer, Vice President of Xerox's Corporate Research, RWW spent April 87-April 88 in the Intelligent Systems Lab of Xerox PARC, California. This allowed RWW to pursue his training goals in mathematical logic and IKBS through a combination of personal study and external courses run by Stanford, ACM, and the IEEE.

Residence in Palo Alto enabled RWW to appreciate the strategic factors contributing to the successful phenomenon (or phenominal success) known as Silicon Valley.

The senior management of PARC were kind enough to educate RWW about the challenges and rewards which arise in the pursuit of research from an industrial perspective.

RWW would like to record his heartfelt thanks to the Alvey Directorate, RAL and to Bill Spencer, John Seely Brown, Frank Squires and Ron Rider and their colleagues in Xerox for enabling RWW to partake of such a wonderful opportunity to improve and expand his understanding.

### 2.4.2 Knowledge Engineering

Brian Bainbridge left in December 1987.

Damian Mac Randal was transferred to Design Division in the July 88 reorganisation.

Lana Woodhead joined on 11 July 1988 for an industrial sandwich year as part of her Teesside Polytechnic BSc course.

## 2.5. Publications

### 2.5.1 Software Engineering

**Publications - External**

1. A J J Dick, Automated Equational Reasoning and the Knuth-Bendix Algorithm: an Informal Introduction, RAL-88-043

2. A J J Dick, M S Parsons and S C Lambert, The State-of-the-Art in Software Reuse RAL-88-052
3. A J J Dick, Order-Sorted Equational Reasoning and Rewrite Systems, PhD Thesis, Imperial College, 1988
4. B Ritchie and J Bicarregui, The FRIPSE LHS Spec", IPSE 2.5 document 060/00144/2.1, July 1988
5. B Ritchie, The Design and Implementation of an Interactive Proof Editor", PhD Thesis, University of Edinburgh, 1988.
6. B Ritchie and P Taylor, The Interactive Proof Editor: An Experiment in Interactive Proving, to appear in: Proceedings of Calgary Workshop on Hardware Verification 1988.
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8. J P C Woodcock, Using VDM with Rely and Guarantee Conditions, Proc VDM 88 Symposium, LNCS Springer Verlag 1988
9. J P C Woodcock, Grammar and Abstract and Concrete Syntaxes, Technical Monograph Oxford University Programming Research Group, 1988.
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11. J P C Woodcock, Software Engineering Mathematics Pitman, 1988 300pp.
12. J P C Woodcock, Using Z: Teaching How to Use Mathematics for Large-Scale Software Developments, FACS Facts Bulletin of the BCS Formal Aspects of Computing Science Specialist Group, July 1988.
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14. J P C Woodcock, Some Problems with Rely and Guarantee Conditions, Workshop Digest Workshop on Refinement, January 1988.
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19. D A Duce and M S Parsons, A Specification of the GKS Polyline, Polymarker and Fill Area Primitives, Proceedings of the GKS Review Workshop, Eurographics Association, 1987
20. D A Duce and M S Parsons, Some Lessons Learnt from Formal Specification, Proceedings of the GKS Review Workshop, Eurographics Association, 1987
21. D A Duce, Extensions to the GKS Input Model, Proceedings of the GKS Review Workshop, Eurographics Association, 1987
22. D A Duce, Configurable Input Devices A Discussion Paper, Proceedings of the GKS Reveiw Workshop, Eurographics Association, 1987
23. G A Ringland and D A Duce, Approaches to Knowledge Representation : An Introduction, Research Studies Press, 1988
24. M S Parsons, Application Languages and Graphical Data Structures, PhD Thesis, University of Kent, 1988
25. M S Parsons, Image Representations Using Miranda Laws, submitted for publication, May 1988
26. M Martins, Communicating Production Systems - A Formalism for Specifying the Behaviour of Concurrent Systems, University of Minho Technical Report, 1988

27. J N Oliveria and F M Martins, Archetype -Oriented CHI - A Formal Approach to User Friendliness, submitted for publication, 1987
28. F M Martins, Formal Specification of Highly Interactive Text Editors The Spy Example, RAL-87-093

**Publications - Internal**

1. B Ritchie and B Matthews, Trip Report:Refinement Workshop, York. SKE Group Note 187, January 1988.

### 2.5.2 Knowledge Engineering

1. B G Bainbridge, The Explicit Representation of Control Knowledge", in Ringland and Duce (1988)
2. J A Clark, A D Irving, S Lockley, D Mac Randal An Object-Oriented Approach to Building Performance Proc USER-I, Ostend Belgium, (1988).
3. A Conway and M D Wilson, (1988) Psychological Studies of Knowledge Representation. In Ringland and Duce (1988)
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16. G A Ringland (1988) Structured Object Representation - Schemata and Frames. In Ringland and Duce (1988)
17. A S Williams and B G Bainbridge (1988). Rule Based Systems. In Ringland and Duce (1988)
18. A S Williams and S C Lambert, Expressive power and computability, in Ringland and Duce (1988)
19. M D Wilson (1988) The MRC Psycholinguistic Database: Machine Readable Dictionary, Version 2. Behavioural Research Methods, Instruments and Computers, 20 (1), 6-11
20. M D Wilson, (in press 1988) Task Models for Knowledge Elicitation. In D Diaper (Ed) Advanced Knowledge Elicitation Chichester: Ellis Horwood
21. M D Wilson, D A Duce and D Simpson (submitted - 1988) Life Cycles in Software and Knowledge Engineering: A comparative review. Expert Systems

### 2.6 Conferences, Workshops and Courses Attended

### 2.6.1 Software Engineering

**JCPW**

1. Some Problems with Rely and Guarantee Conditions, Workshop on Refinement, York January 1988.
2. Software Specification and Design, 16 lectures, PRG Michaelmas term.
3. Structuring Specifications in Z6 lectures, Farnham Castle, 2-3 March 1988.
4. An Introduction to the Z Notation, 4 lectures, Department d'Informatique, University of Tunis, Tunisia, 25-26 March 1988.
5. A Save Area: An Industrial Application of Formal Methods, Conference d'Applications Intelligence Artificiel1e, Nabeul, Tunisia, 31 March 1988.
6. Specifying Protocols in Z, Lecture to IBM Design Group, Home Farm, Winchester, 12 April 1988.
7. Concurrency in a Model-Oriented Framework, lecture to visitors from University of Karlsruhe, Oxford, 19 April 1988.
8. Program Development Using CSP, Seminar, Oxford, 25 April 1988.
9. Specification, Data Refinement, and Operation Decomposition, invited lectures, Seminar on Formal Methods, Shell Research Laboratories, Amsterdam, 10 June 1988.
10. Z and CSP Combined Seminar, Oxford 21 June 1988.
11. Teaching How to Use Z, Workshop on Formal Methods Education, Manchester 29 June 1988.

**DAD**

1. Eurographics 87, Amsterdam, September 1987.
2. Esprit Technical Week, Brussels, September 1987.
3. ISO PHIGS Editing Meeting, Fort Collins USA, October 1987.
4. Algebraic Specification, Edinburgh, October 1987.
5. Lecturing on Algebraic Specification, Barcelona, November 1987.
6. ISO GKS-3D Editing Meeting, Amsterdam, February 1988.
7. Seminar at Opening of Haus von Graphische Datenverbeitung, Darmstadt February 1988.
8. NCGA, Anaheim, March 1988.
9. Eurographics UK Chapter Conference, April 1988.
10. Seminar at UCL, June 1988.
11. ISO SC24 Meeting, Tucson USA, June/July 1988

**Ann Mumford (loughborough, Andre Ducrot (INRIA) and David Duce at the ISO Meeting in Tucson**

**Large View**

12. Opening address Eurographics Portuguese Chapter meeting, July 1988.

**MSP**

1. Z Users Meeting, Oxford December 1987.
2. Eurographics UK Chapter Conference Brighton, April 1988.

**AJJD**

1. Algebraic Specification, Edinburgh, October 1987.
2. Lecturing on Algebraic Specification, Barcelona, November 1987.
3. BCS FACS Algebraic Methods, December 1987.
4. London Maths Society Term Rewriting Meeting, RHBNC, January 1988.
5. Second Unification Workshop, France, June 1988.
6. Seminars at Hewlett Packard, Brunel University, Praxis, Program Validation Ltd, Hatfield Polytechnic.

**JRK**

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1. Algebraic Specification, Edinburgh, October 1987.
2. BCS FACS Algebraic Methods, December 1987.
3. London Maths Society Term Rewriting Meeting, RHBNC, January 1988.
4. Second Unification Workshop, France, June 1988.

**BR**

1. Seminar on IPE, Oxford, March 1988.
2. Refinement Workshop, York, January 1988.

3. SERC Induction Course, May 1988.
4. Semantics of Formal Systems, Edinburgh, June 1988.

**JCB**

1. Algebraic Specification, Edinburgh, October 1987.
2. Technical Writing for Scientists, AFRC, 1988.
3. Semantics of Formal Systems, Edinburgh, June 1988.
4. Generic Logic Workshop, Imperial College London, 1988.

**BMM**

1. Algebraic Specification, Edinburgh, October 1988.
2. Refinement Workshop, York, January 1988.
3. Semantics of Formal Systems, Edinburgh, June 1988.
4. Programming in Miranda, University of Kent, June 1988.

### 2.6.2 Knowledge Engineering

**CYLK**

1. ART Training Course at Ferranti International Cwmbran, Wales, 7-11 March and 25-29 April.
2. European ART Users' Group Meeting, Newport, Wales - 19-20 May.
3. Reason Maintenance Systems Workshop Leeds University - 14-15 April. Wrote review of workshop for AISB Quarterly Summer 1988 issue.

**SCL**

1. Third Alvey Explanation Workshop, University of Surrey, September 1987
2. Course Introduction to SUNs, Rutherford Appleton Laboratory, November 1987.
3. Course in Knowledge Elicitation and Acquisition, Cognitive Applications Ltd, Brighton, April 1988.
4. European ART Users' Group meeting, Newport, Wales, May 1988.
5. UK IT 88 Conference, Swansea, July 1988.

**DMR**

1. Course in Knowledge Elicitation and Acquisition, Cognitive Applications Ltd, Brighton, April 1988.

**GAR**

1. Fourth Annual ESPRIT Conference, Brussels, September 1987.
2. UK IT 88 Conference, Swansea, July 1988.

**MDW**

1. First European Workshop on Knowledge Acquisition, IEE, London, September 1987.
2. MOD Ergonomics Guidelines Expert Systems meeting, RAE, Farnborough, September 1987.
3. BCS HCI Group Meeting, Formal Models in HCI, London, December 1987.
4. BCS HCI Group Meeting, Knowledge Elicitation for Expert Systems, London, February 1988. Presenting: M D Wilson, Task Models for Knowledge Elicitation.
5. Alvey HI Club Meeting on User Models, Cosener's House, Abingdon, June 1988

## 3 ENGINEERING COMPUTING

### 3.1 INTRODUCTION

The work of the Division has been split up into sections on Computational Modelling, Design and the Transputer Initiative which reflect the new structure in the Department.

### 3.2 COMPUTATIONAL MODELLING

### 3.2.1 Introduction

On 18 July, 1988, the reorganisation of Informatics brought together a number of activities into a new Computational Modelling Division. Most of these were previously part of the Engineering Computing Group.

### 3.2.2 Alvey Process and Device Modelling

RAL is involved in two closely related projects in two-dimensional modelling:

- VLSI066: Process Modelling
- VLSI034: Device Modelling

These are collaborative projects involving partners from industry and universities. The overall aim of the projects is to design and implement a flexible software system (called TAPDANCE) for modelling of semi-conductor processes.

Industrial and academic partners in these projects are:

**034**

- Rutherford Appleton Laboratory
- General Electric Company
- STC Technology Ltd
- University College Swansea
- Queens University Belfast

**066**

- Rutherford Appleton Laboratory
- General Electric Company
- STC Technology Ltd
- University College Swansea
- Queens University Belfast
- Plessey (Caswell)
- Reading University
- University of Kent
- Southampton University
- Edinburgh University

The system consists of a shell provided by RAL into which a set of modules or kernels fit. RAL's involvement is the production of the shell, a number of the infrastructure modules and, as part of VLSI034, the Device Modelling kernel, DEVMOD. Other kernels are being produced by Kent (Implantation), Reading (Diffusion) and Swansea (Oxidation).

The people involved with their main responsibilities are:

**C Greenough**
System Design and Overall Project Management
**J V Ashby**
TAPDANCE Shell and 066 Software Management
**R J Fawcett**
TAPDANCE Modules
**E M Azoff and R F Fowler**
DEVMOD
**K Whitaker**
TAPDANCE Shell (Sandwich Student)

#### 3.2.2.1 TAPDANCE Shell (J V Ashby, C Greenough)

C Greenough (CG) has been involved in both Alvey projects from the start and has been responsible for the overall concept and design of TAPDANCE. CG is the overall project manager and attends the Project Management Steering Committee meetings as director of software

development. As the Alvey team has grown, some of the day-to-day project management has been delegated to JVA.

J V Ashby (JVA)'s role has been partly managerial, planning and overseeing the day to day work of the 066 project as well as liaising with the university and industrial partners on the software aspects of the projects.

JVA has participated in the implementation of TAPDANCE shell with CG and the integration of the various kernels and directing RAL effort in those 066 kernels for which RAL has responsibility. In addition, he has worked on various elements of the shell.

The TAPDANCE shell comprises a database through which all data transfer is effected, a manager to handle it and to allow limited interaction with the operating system, a display module for post-processing of results and an overall controller. During the year several improvements have been made to the database, notably to extend its capability to handle such things as I-V graphs. At present the database is a single direct access file made up of several domains, each of which contains a 'snapshot' of the semiconductor device. This has the disadvantage that any changes to a domain are immediate and irretrievable. JVA worked on a version which uses a temporary copy of the current domain and works on that, thus giving greater flexibility.

During the year JVA has supervised a Sandwich Student, Karen Whitaker, in work on the simple command parser used within T APDANCE. They have changed the command tables to use an efficient sparse storage scheme and developed a rudimentary full-screen form filling mode of interaction which uses GKS to ensure portability.

Much time has been spent revising the DISPLAY module. JVA has introduced the capability to produce isometric plots based on a general triangular finite element mesh based on hidden line and hidden surface algorithms developed at University College Swansea. With the advent of RALGKS at level 2b zooming has been revised. An additional command has been put into the module to enable the user to draw results of simulations such as the I-V curves referred to above. Documentation of the DISPLAY module has been started.

TAPDANCE has now been released to four external sites, the universities of Kent and Swansea, STL Harlow and Plessey Caswell, where it is running on Micro-VAXes. The need for these releases has involved JVA in preparing a VMS version of TAPDANCE and feeding back knowledge gained on portability into the master version which is held on Prime-H.

Through the year JVA and CG have attended several Alvey 066 project meetings as well as the Alvey Layer Processing Club meeting in Edinburgh. In addition they organised a special software meeting at RAL for the 066 project. CG has attended the project management steering committee meetings.

#### 3.2.2.2 TAPDANCE Kernels (R J Fawcett, J V Ashby)

R J Fawcett has been implementing RAL's 066 kernels within TAPDANCE. Early in the year, RJF finished writing and testing the SIMPLANT kernel. SIMPLANT is a kernel which simulates ion beam implantation into any target made of semiconductor device fabrication materials. Such implantation is an important step in the manufacturing sequence of semiconductor devices. A typical target consists of irregular abutting regions of silicon, silicon oxide and silicon nitride. SIMPLANT incorporates some analytic results in order to speed its operation. It is a faster, more robust but less rigorous alternative to the IMPLANTATION kernel. SIMPLANT has proved its worth in the months which have followed its incorporation into the TAPDANCE package.

More recently RJF has undertaken major development work on the GEOMETRY modelling kernel. This kernel provides the TAPDANCE user with the means of specifying and modifying the geometric descriptions of semiconductor devices.

In its original form the GEOMETRY kernel (developed by C J Hunt and R F Fowler) accepted geometric data from the screen with minimal checking. More complete checks were made before geometric descriptions were written to the TAPDANCE database but an option was available to

store invalid descriptions. This option existed to ensure that the time spent in data entry should not be wasted because of an abrupt end to a session. The first piece of development work on the GEOMETRY kernel was to improve data checking and to place it at the moment of data entry. This proved to be rather complicated because of the need to check the dependents of any modified item. For example, movement of a point would demand that the point be checked along with any lines and regions incorporating it. Dependency tables therefore had to be generated and maintained. The changes made the GEOMETRY kernel much easier to use, with errors producing instant diagnostic messages, and removed the possibility of storing invalid data in the database.

RJF has continued the development work on the GEOEMTRY kernel by adding five new commands: to delete geometric objects, to clear a geometric description, to define or modify an electrical contact, to apply a mask to part of a device and to etch part of a device. The first three of these commands were fairly straightforward while the last two were particularly complex. Both the masking and etching commands allow isotropic or anisotropic operations to be simulated. They incorporate the automatic generation and deletion of points, lines and regions with the consequent modification of dependency tables.

RJF has produced a laboratory report on the SIMPLANT kernel and is currently writing user manuals and system documentation for the SIMPLANT and GEOMETRY kernels. The SIMPLANT user manual is close to completion and the GEOMETRY user manual is well on its way.

The integration of the university produced kernels and DEVMOD, RAL's device modelling kernel, has been a continual task through the year. The University of Kent delivered their full implantation code and JV A successfully installed it. Collaboration with Reading University and Swansea has made progress in the coupling of the Diffusion and Oxidation kernels, and under RAL's guidance Swansea have been developing their Oxidation kernel to cope with general geometries and to use a triangular mesh. DEVMOD is now fully integrated into TAPDANCE and simple examples passing from process steps through to device modelling have been run.

#### 3.2.2.3 DEVMOD (E M Azoff, R F Fowler)

The contribution of the Rutherford Appleton Laboratory to the 034 project is the production of a general purpose, two dimensional semiconductor simulation code, currently known as DEVMOD. DEVMOD solves the fundamental semiconductor device equations with the current transport given by the drift-diffusion model. The material model allows for varying semiconductor composition, and is a basis for future modelling of heterostructure semiconductor devices. The emphasis at present is in modelling silicon.

The device equations; Poisson's equation and the current continuity equations are solved by a simultaneous solution method, with a decoupled approach used for the initial solution guess. The program makes use of a number of state-of-the-art features: the device domain is discretised by a triangular finite-element mesh that possesses the DeLaunay property. This allows for arbitrary geometrical problems to be catered for. The linear system of equations make use of the ICCG and CGS solvers. (ICCG is based on one developed by CG and CGS was written by Dr P Mole of GEC.)

Through TAPDANCE, the user can define the geometry and mesh via the appropriate modules and access results, which are stored in the database, via the display module. The various process modelling modules can provide impurity distributions to DEVMOD, otherwise simple uniform and Gaussian doping profiles may be specified within DEVMOD.

Progress has been made during the past year and DEVMOD is now able to solve a range of basic problems. The most important development to the code in this time has been the inclusion of the ability to solve the on-state problem, ie when current is flowing in the devices.

EMA has been involved in the design of the module and in the derivation of the discrete algebraic system. EMA and RFF have been implementing these discrete equations.

RFF has carried out tests on a set of benchmark problems, ranging from finding the current flowing in a block of semiconductor material with uniform doping to the steady state operation of a MOSFET (a metal-oxide-silicon field effect transistor, one of the basic building blocks of modem large scale integrated circuits). Comparison with data from other sources has confirmed that the simulation code is giving satisfactory results.

RFF and EMA are currently improving the performance of DEVMOD, both in terms of speed and robustness, since it is intended to be a general purpose simulator that will be used by a wide range of users, rather than a research code.

DEVMOD has been written to run within the TAPDANCE shell that has also been produced at RAL. This system gives an integrated environment for running DEVMOD, along with other programs, or kernels, that calculate the structure of the semiconductor devices from the fabrication processes. The device modeller is able to use the information on the doping from the process simulators and predict how such a device will perform. RFF has written an interpolation routine to allow DEVMOD to use the dopant information within the data base of TAPDANCE.

During this period RFF has also spent some time porting the TAPDANCE system to run on the SUN/Pyramid UNIX systems.

#### 3.2.2.4 Other Device Modelling Activities (E M Azoff)

##### Non-Parabolicitv Effects in Semiconductor Transport Models

The effects of nonparabolic energy-wave vector dispersion have to date been ignored in the hydrodynamic modelling of charge carrier transport in semiconductors. In the case of some semiconductors this can be justified on the basis that the effect introduces only a small correction. However in the case of III-V semiconductors, non-parabolicity can introduce significant changes, for example the current density in InAs under degenerate conditions is reduced by 40% compared with a parabolic model. With the increasing technological importance of III-V semiconductors a revised transport model is required.

In order to make the problem tractable, a first order non-parabolicity approach was taken and a set of high-field transport equations derived by taking moments of the Boltzmann transport equation. The resulting model, which also accounts for heterostructure and degenerate semiconductors clearly reveals the influence of non-parabolicity. Furthermore, by taking the low field limit, the commonly used drift-diffusion current density can be corrected by a number of non-parabolicity coefficients.

This work is due to appear in J of Applied Physics, 18 August 1988.

##### Modelling High-Field Effects in Submicron Semiconductor Devices

The program HETEM has been written to solve the hydrodynamic transport equations, including the energy and momentum conservation equations. The energy transport model allows the possibility of investigating the hot electron effects in submicron semiconductor devices, including velocity overshoot and energy and momentum relaxation. The program has been applied to modelling the GaAlAs/GaAs heterojunction bipolar transistor.

### 3.2.3 ESPRIT Device Modelling (C Greenough, C J Hunt, T K Patel) (D Gunasekera - visitor from UCS)

RAL is involved in an important ESPRIT device modelling project. A primary aim of the project is to develop efficient algorithms to solve the drift-diffusion form of the device equations in three-dimensions. As semiconductor devices become smaller their three-dimensional nature begins to show itself. For European industry to predict the behaviour of sub-micro devices if of paramount importance. The project has ten industrial and academic partners:

- Rutherford Appleton Laboratory
- STC Technology Ltd (UK)
- Philips, Eindhoven (Netherlands)

- SGS-Thomson, Milan (Italy)
- University of Bologna (Italy)
- IMEC (Belgium)
- Trinity College Dublin (Ireland)
- University College Swansea (UK)
- NMRC Cork (Ireland)
- ADBV Limerick (Ireland)

The project is divided into five workpackages:

**Workpackage 1:**
Physical Modelling (SGS)
**Workpackage 2:**
Discretisations (GEC)
**Workpackage 3:**
Mesh Generation (UCS)
**Workpackage 4:**
Linear and Non-linear Algebra (Philips)
**Workpackage 5:**
Project Research Code (RAL)

RAL is the prime contractor and leads the whole project as well as directly the most important Workpackage, Workpackage 5 the Project Research Code.

RAL is also technically involved in Workpackages 2, 3 and 4.

Over the past year C Greenough, C J Hunt, T K Patel and D Gunasekera, have been working on the development of a comprehensive three-dimensional modelling system.

CG as well as being the co-ordinator of all RAL effort, is the director of the software programme within the project and co-ordinator of Workpackage 5, and is responsible for utilising the eight man-years of effort from four partner sites (RAL, TCD, UCS, STL). CG is responsible for the overall design of the system which consists of four major program modules coupled through a simple neutral file system. The modules are: geometric modeller and mesh generator (TCD), impurity profile generator (UCS), the analysis code (RAL) and the post-processor (UCS). STL have been involved in the evaluation of the system. RAL is responsible for the overall planning and control of the Workpackage, the development of the analysis module and the provision of the integration tools.

CJH and DG have been involved in the design and implementation of the solver module. The system can now solve the on-state semiconductor problem in three-dimensions. The complete integrate system was demonstrated at a successful Commission review.

TKP has been involved in the development of the neutral file system. This was based on the one design and implemented by C R I Emson et al. This work involved the conversion of the system from sequential ASCII files to direct access binary. This gave a speed improvement of a factor of two.

### 3.2.4 The Finite Element Library (C Greenough, C J Hunt)

The NAG/SERC Finite Element Library is now in the third release. Release 3 of the software has been with NAG Ltd since the autumn.

There are now over 100 licence holders of the Library world-wide and a large user population. Although the software runs to some 150 Fortran Sub-routines and 14 example programs, only two significant bugs have been reported since the release of Release 2.0 in 1984.

CG is in control of the whole project and has planned the developments and content of the next three releases of the Library.

CG and CJH have been involved in developing both new routines for the basic library and new example programs. Some work has also continued on developing the graphical output capabilities of the Library and the pre-processing has been enhanced with a simple mesh generator and bandwidth minimiser.

Release 4 is now in preparation for delivery to NAG Ltd. An important addition to the Library will be two example programs on the solution of the Navier-Stoker equations.

### 3.2.5 Other Research in Numerical Techniques (C Greenough, C J Hunt)

PARFEL - A Parallel Finite Element Library.

DAP-FELIB (C Greenough)

Fitted Finite Elements (C Greenough)

#### 3.2.5.1 Publications

- E M Azoff: Semiclassical high-field transport equations for nonparabolic heterostructure, degenerate semiconductors , J Appl Phys. To appear 18 August 1988.
- E M Azoff: Current Transport in Nonparabolic Kernel Structure Semiconductors, IEEE Colloquium 'Modelling and Analysis of Circuits and Devices', 4 December 1987.
- E M Azoff, R F Fowler: Alvey 034 6 Monthly Report, May 1988.
- E M Azoff and R F Fowler: Alvey 034 Device Modelling Kernel: 6 monthly report. Alvey Project: ALV/APP/VLSI/034 report no ALV-DMP-21, April 1988.
- R J Fawcett: SIMPLANT: Analytic Calculation of Ion Implantation within the TAPDANCE System, RAL-88-037, April 1988.

**Conferences/Courses**

**R J Fawcett:**

- 31 September to 2 October 1987 Alvey Layer Processing Club Meeting University of Edinburgh.
- 11 January 1988 Introduction to SUN Workstations RAL
- 15 to 17 February 1988 Ordinary Differential Equations Harwell Training Centre
- 25 to 27 April 1988 Partial Differential Equations Harwell Training Centre
- 12 May 1988 Expert Systems Harwell Training Centre

**R F Fowler:**

- 1-2 October, 1987 Alvey Process and Device Modelling Club Meeting University of Edinburgh.
- Various Alvey 034 Project Meetings (3 monthly).

### 3.2.6 Engineering Applications

The staff involved in these activities have been

- N J Diserens (NJD)
- C R I Emson (CRIE)
- C S Harrold (CSH)
- C J Collie (CJC)
- S K Chanda (SKC)
- D S Barlow (DSB)

#### 3.2.6.1 Structural Software (NJD)

NASTRAN has continued to be the main structural analysis finite element package supported, although use has been largely in-house.

LUSAS has been mounted on the PYRAMID, both to assess the capability of the software and to gain experience of operating applications packages in a UNIX environment.

#### 3.2.6.2 Pre- and Post-processing (NJD, SKC, DSB, KPD)

The Pre- and post-processors FAMBUILD and FAMRESULT (formerly FEMGEN and FEMVIEW) are now installed both on PRIMEs and SUNs.

A neutral file system RALBIC now facilitates the interchange of finite element data between these pre- and post-processors and users' programmes. It is anticipated that this will be superseded eventually by the CAD*I neutral file development.

#### 3.2.6.3 Electromagnetics Software (NJD, CRIE, CSH, CJC)

The latest versions of the RAL electromagnetics software packages, PE2D and TOSCA, upgraded by Vector Fields Limited, have been mounted on the PRIMEs, the SUNs and also on CMS. The solver module for the 3D TOSCA package has been modified to run on the CRAY-XMP/48. This executes at about 9 times the speed of the IBM in the solution of non-linear problems. C J Collie helped A R Mayhook (CCD) in this activity.

A study is being made of the solution of dense matrices using the AMT DAP with a view to its application to packages such as BIM2D, which is a Boundary Integral computer program for analysis of magnetic field problems.

A course was held in April 1988 for users of the PE2D package. This was attended by 9 people, all from UK universities.

C S Harrold has developed Hextet - a program which performs the automatic subdivision of a mesh of irregular hexahedral elements (8-node bricks with planar places) into tetrahedra without introducing extra nodes. The triangular faces of these tetrahedra need to be coherently matched. Surprisingly, there are 74 such subdivisions (2 using 5 tetrahedra and the rest being sextuplets) for a brick element. Such subdivisions only generate 64 triangulations of a brick surface. This allows us to place constraints on the choice of subdivision. In particular, the aim is to avoid tetrahedra with negligible volume. However, only random access to brick elements can be assumed, matching brick faces is a challenging problem but a working solution can be obtained by using group theory. Some more coding will be required before this program can be used in conjunction with a neutral file system.

#### 3.2.6.4 DAP (CSH)

i. Electromagnetics As an initial exercise in gaining experience on the DAP, a program was written to compute the electrostatic field in the space surrounding a charged surface. This problem has been re-formulated in a way which is suitable for the DAP, giving an improvement on the classical result based on Cagnoli's theorem. A report on this method will be detailed in a forthcoming edition of the DAP Newsletter.

ii. Linkage Calculations The determination of linkage of closed paths in space is of importance in the calculation of fields surrounding multiple connected conductors. An analytic solution to this problem has been derived. It relates linkage to the sum of the entries in a generalised matrix. A FORTRAN plus program is being developed to perform this task.

iii. Magnetostatics BIM2D is the only electromagnetics program to be transferred to the DAP. It solves linear magnetostatics problems in X-Y co-ordinates. Solutions are obtained by solving dense symmetric systems of linear equations. Currently, such systems are being solved using the AMT BIGSOLVE routine - a parallel form of Gaussian elimination. However, more efficient methods are being developed which manipulate block matrices as opposed to row or column vectors. Furthermore, alternative methods are now being investigated to exploit the symmetry of the problem.

#### 3.2.6.5 Eddy Currents (C R I Emson)

The main activity in the past year has been the completion of an SERC funded project involving RAL, Bath University and Imperial College on 3D Eddy Current analysis. The project has resulted in the production of a research computer program written at RAL capable of analysing 3D linear transient eddy current problems. Also as part of the project, the implementation of a Neutral File

can now be used to interface the eddy current package with commercial pre- and post-processors namely FEMGEN and FEMVIEW, as well as the Post-viewer written by Imperial College as part of the project.

As part of the activities in electromagnetics research at RAL, CRIE has also been involved in a number of other tasks. These include the assessment of a 3D eddy current code developed by the group at Electricite de France, the implementation of the RAL eddy current software on the SUN computer, and the organisation of another in a series of eddy current seminars held at Coseners House (see Publication list below). During the seminar, the first in (hopefully) a series of meetings was held to enable collaboration between a very active group in Italy and ourselves in UK on 3D magnetic field studies. The meeting was attended by 4 professors from Italy, who were also attending the seminar, as well as 3 professors from UK. C J Collie produced one of the test programs (eddy currents in a hollow sphere) used at the workshop.

CRIE has also been involved in the submission of grant applications to continue funding for the electromagnetic work at RAL. This has included 2 submissions for a project on high frequency electromagnetic device analysis, neither of which were approved. He was also involved in the preparation of a large grant proposal for ESPRIT II on electrical device design using knowledge based systems. This too was not funded.

#### 3.2.6.6 CHEST (NJD)

It is envisaged that SERC will make use of CHEST (The Combined Higher Education Software Team), who are based at Bath university, for supply of commercially available software for engineering applications. This will, of course, only be necessary in respect of those grant holders who cannot obtain the required facilities directly via their local computing centre.

#### 3.2.6.7 Publications and Conferences

**Publications**

**C S Harrold:**

Using the Concept of Linkage of Closed Loops to Determine the Topological Invariants of a Cutting Graph, IEEE Trans Mag, Jan 1988.

**C R I Emson:**

- Coupling Thermal and Eddy Current Effects in Two Dimensional Electrical Conductors, C R I Emson and C P Riley, Presented at ISEF'87, Pavia, Italy, September 1987.
- Transient 3D Eddy Currents using Modified Magnetic Vector Potentials and Magnetic Scalar Potentials, C R I Emson and C W Trowbridge, IEEE Trans on Mags, vol MAG-24, No 1, p86-89, Jan 2988.
- Problems and Workshops for Eddy Current Code Comparison. L R Turner, K Davey, C R I Emson, K Miya, T Nakata and A Nicolas, IEEE Trans on Mag, vol MAG-24, No 1, p431-434, Jan 1988.
- RALBIC - A Simple Neutral File for Finite Element Data - File Definition, C R I Emson, C Greenough, N J Diserens and K P Duffey, RAL Report No RAL-87-102.
- RALBIC - A Simple Neutral File for Finite Element Data Description of Read and Write Routines, K P Duffey and C R I Emson, RAL Report No RAL-87-103.
- Methods for the Solution of Open-Boundary Electromagnetic Field Problems, C R I Emson, IEE Procs, vo1.135, Part A, No 3, pp151-158, March 1988.
- Workshops and Problems for Benchmarking Eddy Current Codes, L R Turner, K Davey, N Ida, D Rodger, A Kameari, A Bossavit and C R I Emson, Presented at Intern Symp on Fusion Engineering Technology, Tokyo, 10-15 April 1988. (To be published in Journal of Fusion Engineering and Design.)
- Knowledge Based Systems Applied to the Design of Electrical Devices, D A Lowther, E M Freeman, C R I Emson and C M Saldanha, Presented at INTERMAG,

Vancouver, July 1988. (To be published in IEEE Trans, vol MAG.)

- Results for a Hollow Sphere in Uniform Field (Benchmark Problem 6), C R I Emson, COMPEL, vol 7, Nos 1 and 2, p89, March/June 1988.
- Eddy Current Seminar Proceedings - March 1988, Ed: C R I Emson, Proc of Seminar held at Coseners House, Abingdon, UK, 28-30 March 1988. (To appear as RAL Report.)

**Conferences and Courses**

**N J Diserens:**

- Compumag Conference in Graz (August 1987)
- UNIX for Programmers at The Instruction Set (November 1987)
- Workshop on Linear Accelerator Codes (San Diego, January 1988).

**C R I Emson:**

During the past year, CRIE attended a conference in Pavia, Italy, where he presented a paper on the coupled problem of the thermal effects of eddy currents (see Publications list). He has also given two invited lectures, one at Institute of Electrical Engineers (IEE), London, and one at Imperial College, London.

**C J Collie:**

- TOSCA Course at Vector Fields Ltd (15 October 1987). This was a 1-day course intended to bring users up to date with the latest release of TOSCA.
- UNIX for Programmers at The Instruction Set. (23-27 November 1987. )
- Advanced Optimization Techniques for Parallel Processors. Held at CINECA, Bologna (11-15 January 1988). The course was about FORTRAN processing on machines which have a vector processor, and in which all processors share a common memory. Machines in which the multiple processors have their own private memories were mentioned only in passing. However, differences between the various types of shared memory machines, such as the number of pipes to and from memory, the existence of hardware scatter-gather, etc, were covered in considerable detail. To the extent that a knowledge of machine details is relevant to writing optimal code, the differences will reduce the portability of programs. A large part of the course was devoted to particular details, for example, the proper ordering of the loops in a matrix multiply to obtain optimum vectorisation. A similar amount of detail was needed in considering microtasking. The differences between machines may become more transparent to users with the introduction of FORTRAN-8X, Mr Levesque however was sceptical on this point: he considers the right approach is exemplified by such products as FORGE, (which his company, Pacific Sierra, has produced), which permit interactive optimisation of codes on a particular machine. About a day was spent presenting and demonstrating.
- Electromagnetic Users Course, held at RAL (19-21 January 1988). CJC attended this as a demonstrator.
- ITMB, held at Urchfont Manor (8-13 May). This was the 2nd part of a 3-part management course run by SERC training.
- PE2D Users Course, held at RAL (23-24 May 1988).

### 3.2.7 Environment Committee Support (A D Irving)

The SERC normally has a relatively passive role in the selection of the research areas which it supports. However, recently the SERC has tried to concentrate some of the available research funds in areas perceived to be of national importance. This means that the passive role of SERC has been partly replaced by more selective mechanisms for enc0uraging research in these selected areas such as the setting up of Specially Promoted Programmes (SPPs). It has long been recognised that the success of any UK energy conservation programme is dependent upon reducing energy consumption in buildings and then associated services, since this accounts for approximately half of the total amount of prime energy consumed nationally for all purposes. Consequently during the 1970 's there was considerable growth in the number of Research and

Demonstration projects in this area, and it was against this background that the Energy in Buildings Specially Promoted Programme was set up by the Building Sub-Committee during 1979.

Although personnel at RAL have supported Energy in Buildings related activities for 8 years now this is the first year that Informatics Department has become involved. Two broad areas of research are being supported at present and it is anticipated that these areas will continue to develop.

Firstly a stated objective of the Energy in Buildings SPP was to increase the fundamental understanding of, and develop the methodology for, the prediction of the dynamic thermal behaviour of buildings. There was a need for further development of models for the prediction of the thermal dynamic behaviour of buildings and systems. In particular there is an awareness of the need to improve the confidence in, and the credibility of, thermal models if they are to gain widespread acceptance. Consequently from the inception of the SPP the establishment of a Model Validation exercise has been a central concern and RAL has been one of the four institutions participating in this validation exercise. The emphasis of RAL's contribution has been towards the identification, implementation and preliminary application of techniques which will identify the accuracy, sensitivity and range of appropriate use of simulation models and the algorithms contained therein. These objectives have been achieved by using existing time series analysis and statistical quality control techniques and where necessary refining them or developing new techniques. For example a stochastic sensitivity analysis technique has been developed which relates the non-linear system sensitivity functions to the response functions. Also the statistical vector $T^2$ test (telling test) originally applied to comparing the experimental against simulation model predicted time series output has been extended to perform vector tests on the correlation functions on power spectral densities. In addition a novel technique has been developed which should statistically test the eigenvalues of the impulse and frequency response matrices. It is recognised that these techniques will be sensitive to outliers in the data and a robust covariance estimation technique is being developed which examines the derivatives of the covariance. RAL and Cranfield are currently preparing a joint research proposal for submission which will not only continue development of the statistical validation techniques but also include them in the Energy Kernel System and apply them to a limited range of algorithms in the EKS.

Secondly RAL's initial involvement with the SPP was in the area of performance assessment. RAL is and will continue to support this area of research. For example at RAL in 1988 a non-linear theory of thermal transmission through the building fabric has been developed9 which is based upon a technique developed for the extraction of Volterra kernels from the data and the transmission theory is being tested in collaboration with the university of Newcastle. Performance assessment tools, based upon Volterra kernel extraction using central statistical moments, will be developed in collaboration with Bristol University and by using existing experimental data and simulation models the convergence, accuracy and range of appropriate use of such tools will be assessed before discrimination.

Finally the rest of this financial year is to be devoted to clearing the backlog of papers arising from the above work.

C J Collie has started providing A D Irving with support in these activities.

#### 3.2.7.1 Publications and Conferences

**Publications**

**Irving A D:**

- Application of Statistical Validation of Multivariate Time Series Thermal Model Validation Exercise Final, September 1987.
- Stochastic Sensitivity Analysis Feasibility Study, B Day, T Dewson, P Fitt, D Richardson and A D Irving, SERC Final Report for Grant GRJD/39238, May 1988.
- Validation of Dynamic Thermal Models, Energy and Buildings: Special Edition on Thermal Simulations Modelling, Ed: J A Clarke and A D Irving, January 1988.

- Stochastic Sensitivity Analysis of Dynamic Thermal Models of Buildings, A D Irving and J P Allen, cm 5th International Symposium, Bath, July 1986, p.95-99.
- Stochastic Sensitivity Analysis, A D Irving and J P Allen. Being revised before re-submission to Applied Mathematical Modelling.
- Applications of Stochastic Sensitivity Analysis, A D Irving, J P Allen, T Dewson, D Richardson, B Day and P Fitt. In preparation.
- Robust Covariance and Transfer Function Estimation. In preparation to Technometrics, 1988.
- On the Bias and Root Mean Squares Errors of Sample Covariance Estimates. In submission to Technometrics, 1988.
- Non-Linear Thermal Transmission. In submission Bldg Envir, August 1988.
- Analysis of Multivariate Non-Linear Systems with Stationary Boundary Conditions. In preparation.
- Building Energy Simulation: An Introduction, Special Edition on Thermal Simulation, Modelling, Ed: J A Clarke and A D Irving, Energy and Buildings, vol.10, No.3, January 1988.
- J A Clarke and A D Irving, Editors of Special Edition on Thermal Simulation Modelling, Energy and Buildings, Vo1.10, No.3, January 1988.

### 3.2.8 Visualisation - Image Generation

This is a new section which is to take responsibility for visualisation of complex data, which could be complex multi-dimensional results or complex models or one superimposed on the other.

Some preliminary work has been done in the old SUS/Applications section during the year by JH, who has been assessing workstations with added 3D graphics power. An assessment of functional capabilities has been carried out and a benchmark has been written. The benchmark is adjustable in the quality of rendering that it demands and in the complexity of the scene and is expected to be suitable for testing the new superworkstations becoming available.

Other work during the year has been done by RP on ray-casting on transputer systems and is described under Transputer Developments (3.2.9.3).

The new section will consist of:

- J Haswell
- R Popovic

### 3.2.9 Transputer Developments

Transputer Developments during the year have been in two main sections. Chris Wadsworth has run a small team concerned with technical developments involving the transputer. For the first half of the year these people were also involved in the co-ordination activities. The main goal now is to build up the Department's technical involvement in projects involving the transputer and parallel processing in general.

A separate activity, but now under the same management, has been assessing the ability to enhance the power of the IBM 6150 workstation by adding transputers to it. IBM have funded the hardware for this activity in return for access to the papers produced by the project.

The staff involved in the two activities are:

**Transputer Developments**

- C P Wadsworth
- G M Megson
- D J Johnston
- R Popovic

**IBM 6150**

- H K F Yeung
- M H Roberts
- B W Henderson

#### 3.2.9.1 Transputer Initiative Co-ordination (CPW)

CPW was Deputy Co-ordinator for the Initiative until this was handed over to Cyril Balderson in January 1988. This entailed involvement in all aspects of getting the Initiative started - the academic loan pool, establishment of the National and Regional Centres, priorities for initial development contracts, etc - and continuing publicity, presentations and demonstrations. Presentations about the Initiative were given to three conferences (Liverpool, Bangor, Bath), to several supplier companies, and to an assortment of meetings, including demonstrations to Council and to the Engineering Board in support of the case for the future funding of the Initiative.

CPW continues to liaise closely with the RAL Co-ordination Team, particularly in technical matters, and is a member of the Transputer Application Management Group (TAMG), the steering group established by Computing Facilities Committee to oversee and advise on the running of the Initiative. He also chaired and led the Workshop on Transputer Development Environments held at Coseners House in November 1987. The Workshop produced a detailed set of recommendations on suggested developments (not all of them short-term!), which have now been absorbed by T AMG into the Initiative's plans for development contracts for 1988/89.

#### 3.2.9.2. Transputer Centre

An interim Centre, with CPW as Head, was established at RAL as soon as the Initiative started in April 1987, in order to provide an initial focus for the Initiative until the National and Regional Centres became fully operational. During this period the interim Centre ran two courses given by INMOS staff and hosted a variety of users, mainly loan pool applicants whose needs are best met by access to Centre facilities. Following the confirmation of RAL as the permanent Regional Centre for London and the South East, Richard Parkes has taken over as Manager of the Centre.


**Transputer Course at RAL, August 1987**

**Large View**

Technical backup and support to the Centre is now provided mainly by the Parallel Processing Group in the new Department structure, with assistance from others as appropriate from time to time. Much of this work to date has consisted of initial discussions with, and technical advice to, prospective industrial customers of the Centre, some of whom are now booked to use the Centre facilities. It is also expected that some of these contacts may well lead to consultancy or joint development work with particular companies.

### 3.2.9.3 Transputer Developments (CPW)

One project has been worked on to date, and one probable future project is currently being discussed.

### Software Migration Aids

This general area covers anything concerning tools, advice, or other aids to assist users in porting existing software to transputer systems. An initial six-month development contract was placed with Professor Hey's group at the University of Southampton. The goals for the six-month contract, which ended in March 1988, were:

a. to produce a number of Occam harnesses for linking together programs written in other languages (typically Fortran and C) to run on suitable multi-transputer configurations.
b. to produce a paper to act as a User Guide, with advice on getting started with the transputer and on porting applications.

CPW collaborated with Southampton on part (b). A summary of the work given by Professor Hey at the Transputer Initiative Seminar on reports from the first round of development contracts, held at RAL in April 1988, was well received and it is likely that this work will be extended.

**Parallelising Fortran Compiler (DJJ)**

This was an EMR (in conjunction with Dr Stuart Robinson of Brunel University) to develop a parallelising Fortran compiler. An initial feasibility study was carried out and a report was produced. The long term aim is to take existing sequential Fortran code, automatically extract the parallelism and run it on a network of Transputers.

In particular, DJJ was involved with the development of a static Fortran analyser, that would produce statistics from Fortran source to reveal the nature of any parallelism present.

**Harness Development (DJJ)**

DJJ has produced a number of application independent harnesses that should simplify the task of moving code on to a multi-processor system. These harnesses were given built-in monitoring facilities so their design could be improved on an iterative basis.

**Hardware Accelerators Project (GMM)**

HAP involves research into parallel algorithms which can be used to accelerate and support an existing sequential package STABLE-H for $H^{+¥}$ design of finite dimensional, multivariable, time invariant feedback control problems. The first step has been a feasibility study to identify the main areas of the package where parallelism can be applied and a set of core algorithms defined. The result of the study appears in [4]. The remaining time has been spent on developing test algorithms using transputer hardware for the core algorithms identified above, this has included Ricatti (Lyapunov) equation solution, Singular Value Decompositions (SVD's), Model Matching problems, and Multivariable Frequency Response (see [6][7][8] and [9] for details). At this time the practicality of the accelerator has been demonstrated and the type of parallel algorithms required identified construction of the accelerator has been delayed until appropriate software and tools for developing a PC/package interface have satisfactorily evolved and become available (eg SUN interface and TDS Toolset). The Research for better algorithms and techniques is on going.

**Neural Networks and Control Systems (GMM)**

To complement the designs above, attempts have been made to formalise a general mapping technique for converting Feedback Control System models into Neural Networks. The idea is to map control problems into neural networks and train the weights of the network for a given control problem. An inverse transformation then yields the coefficients of the transfer functions for implementing the control problem. Other benefits such as fault tolerant designs, distributed control, and expert networks for CAD packages will result from a working model. So far a generalised framework has been identified but more analysis is required before the implications of the design in control and AI contexts can be fully analysed. Hence no significant results are available.

**SCRIP Ray Casting Machine (GMM, RP)**

RP and GMM have been developing a ray casting machine in OCCAM based on the SCRIP architecture. Most of the programming has been done by RP and a primitive system is almost working.

**3.2.9.4 6150 Developments (MHR, HKFY, BH)**

The IBM 6150/Transputer project was a project of two tales. It began with a joint study with IBM and the objective was to increase the processing power of the 6150 by interfacing it with the INMOS

transputer. This involved implementing a device driver for the transputer board and a server for the host/transputer communication. Software development on the 6150/transputer architecture could be done either in the Transputer Development System (with tools such as the folding editor) or the Unix System environment (with tools such as vi, make, sccs etc). Utilities were provided to facilitate transferring files between the two environments. Recent advances made it possible to dispense with the Transputer Development System completely which marked a significant change in the way the transputer could be used. The approach was, to a certain extent, novel at the time it was conceived, but was gaining wider recognition and acceptance as people started to appreciate the transputer was not the ends but only the means of computing. It was believed that a transputer acting as a master with a host acting as a slave peripheral (as in the early days when the host was dominated by the PCs) was extremely restrictive and in the long term more expensive. On the other hand, a suitable host with a suitable operating system environment would open up all other opportunities, such as networking, high quality graphics, windowing, program development and support environment, document preparation, database management etc to the users. It was clear that a good workstation with a Unix operating system would be ideal for the transputer. Conversely, the justification for having the transputer on the workstation is based on applicability, performance and cost effectiveness. Unless one was prepared to pay a hefty sum for a super-workstation, presently a workstation could deliver typically not more than 10 MIPS which would easily be dwarfed by a transputer system. In short, the performance of a workstation can be improved many times at an affordable price by equipping it with a transputer system which would allow it to be used in applications that are not possible today because of insufficient processing power.

With limited resources, it had always been our firm belief that research and development work should be driven by real applications. No matter how convincing our workstation/transputer architecture argument was, it would have to be proved by genuine demands for such a system. Therefore, in the second part of the project, we were very pleased to collaborate with Vector Fields in implementing BIM2D, an electromagnetic design package, on the 6150/transputer system. The implementation was designed to explore parallel processing as offered by the transputer system and high quality graphics, which would be essential for any CAD packages, as supported on the 6150 workstation. Apart from having a deliverable product, the main result of this part of the project was to assist in sharpening the requirements in the RAL/IBM joint study.

Vector Fields originally intended to move the Fortran code for the solver part of BIM2D onto the transputers, and rewrite it as a parallel program. However, because of delays in the release of the Inmos Fortran compiler, and subsequent delays in acquiring the Occam toolset (which is needed to run Fortran processes in parallel), MHR wrote a parallel Gaussian elimination algorithm in Occam, which has been interfaced to BIM2D. BWH installed a GINO graphics simulator to support BIM2D, this simulator provided graphics support on both the IBM 6150 and the SUN machines. BWH spent some time tracing an apparent fault in the graphics system on BIM2D through the BIM2D FORTRAN code. BWH finally isolated the error and proved that it was an error in the IBM FORTRAN compiler. As an aid to the graphics support BWH also installed BIM2D on the SUN, this allowed the debugging of the GINO simulator on the IBM 6150 to be checked against the GINO simulator on SUN and the real GINO package on the PRIME machines.

To demonstrate output from the transputer board producing graphics on the 6150 display, HKFY and BWH wrote a Mandelbrot program in Occam, linked via a Unix pipe to a C program running the display. Following the installation of an additional board with four transputers, a multi-transputer version was developed by BWH with assistance from MHR.

A more flexible interface, using System V Inter Process Communications routines, has been developed by MHR to allow client programs running on the 6150 to communicate with server programs on the transputer board.

To learn more about multi-transputer programs MHR rewrote the mandelbrot demonstration program to do dynamic load balancing using the farm approach. This produced a significant improvement in performance.

The Fortran compiler and stand-alone Occam toolset have since arrived and been installed. To support Fortran and the stand-alone Occam (which run without the Transputer Development System), the Inmos 'alien language file server' was ported to the 6150, and MHR added the RAL inter-process communication enhancements which allow a server process on the transputer to talk to a client application running under Unix on the 6150.

To enable the Occam toolset to be used on the 6150 MHR has written some interface programs which emulate the MS-DOS interface programs provided by Inmos. Source to a makefile generator is provided by Inmos; this determines the dependencies within the components of an Occam program and creates a makefile suitable for building the program. MHR made some changes to get this running under Unix, (the original is designed for use with Microsoft make under MS-DOS).

The stand-alone toolset integrates better with standard Unix development tools, (such as make and SCCS), than the Transputer Development System.

MHR has used a simple test program to show that multi-transputer can be built and run on Fortran programs the 6150 transputer system. The way is now open for Vector Fields to integrate some of their Fortran routines from BIM2D into the existing Occam Gaussian elimination program.

MHR made use of the Transputer Centre Inmos ITEM rack to connect an array of 32 T800 transputers to the 6150. The Gaussian elimination program was reconfigured and ran successfully on the larger system. Further tuning of the algorithm, to make more efficient use of the T800s needs to be done, but the initial test showed a speed up of around seventy times when compared with a single T4 transputer.

BWH worked during the year on the rtserver program. This program was very restrictive as it only allowed access to the Transputer Development System (TDS) editor or an IBM 6155 terminal. BWH initially provided a new help screen mechanism within TDS. He then converted rtserver to run under the curses terminal interface package, thus allowing rtserver to display on any ASCII terminal with a terminfo file. This still left rtserver with a user interface which relied on special keys found only on the IBM 6155 terminal. He then provided a standard user interface to allow users to access the TDS editor in a common fashion. This interface uses standard Alpha-numeric keys and the Escape key, the interface provides pop-up menus to aid the user to access the 37 functions available within the TDS editor. This interface allows users over the Ethernet to access the transputers on the IBM.

BWH has also been working on providing other utilities for the IBM 6150. These consist of a Screen-blank program and a suite of programs to help with the TDS system. The screen-blank program monitors the use of the console display and blanks the screen if the console is not used for more than 15 minutes. The TDS utility suite consists of four programs:

**encode**
which converts ascii files into TDS Occam format,
**decode**
which converts TDS Occam format into ascii files,
**insert**
which allows file to be quickly inserted into the TDS filesystem
**tdsed**
a shell script to handle entry into the TDS editor.

This suite provides a TDS/UNIX programming workbench allowing the user to move easily between the TDS filesystem and the UNIX filesystem.

BWH has been learning to program in Occam during the year. This was initially required to understand the TDS editor. BWH worked on providing a simple mandelbrot test to be used for benchmarks. This program helped to introduce Occam and parallel processing. A version which could run on one transputer was provided. When a 4-board transputer card was added to the IBM 6150 BWH extended his program to run under 5 transputers. Graphics using GSL {the IBM

graphics support package, were used to provide the graphics needed to display the Mandelbrot images.

BWH has supported the work on the IBM 6150 during the year by installing various packages. These packages have included PHIGS, X-windows, BWH assisted in installing TCP/IP and an Ethernet card. BWH has also helped install two new versions of the Operating System AIX 2.1.1 and AIX 2.1.2. Simple testing of the PHIGS and X-windows systems was carried out by BWH, these resulted in producing small demonstration programs to show the systems in operation. BWH has also taken part in the installation on three disk drives and two transputer cards on the IBM 6150.

BWH spent part of the year on the TRANSA program. This program could solve transient dynamic problems using an explicit method for the integration of equations. It was expected that since this package was written in Occam that it would be a relatively simple task to install it on our IBM 6150. This program for the transputer arrived in an early version of Occam 2 on DOS disks. But BWH transferred this to AIX, converted the Occam code into a format compatible with the current Occam compiler and placed it in the TDS system. BWH converted it from multi-transputer to single transputer format to simplify testing and debugging. Although the program was written for DOS operating system, BWH managed to provide read support for DOS in the rtserver. This support enabled the program to be started and a set of test data read into the transputer. Unfortunately the program would not progress any further and no calculations or results could be generated. It was found to be difficult to extract debugging output from the various parallel processes during execution of the program. Not enough time was available to insert a suitable debugging framework, so no further work has been carried out.

As an introduction to Curses on the Unix system BWH investigated the terminfo entries for various terminals. BWH produced a terminfo entry for the Cifer 2634 on the pyramid and IBM 6150.

BWH has provided a Device Driver to handle the Transputer card on the IBM 6150. The Unix structure on the IBM is quite different due to the inclusion of a Virtual Resource Manager (VRM) to isolate the Operating System from the Hardware. BWH created a character device which provides the transputer with a portable interface. The interface also provides security against multi-user access of the transputer. BWH has provided a version of rtserver using the interface to test the Device Driver.

BWH is currently writing reports on both the TRANSA and Transputer Device driver projects.

#### 3.2.9.5 Papers and Conferences

**Papers**

**G M Megson:**

1. A Systolic Array for the Quotient Difference Algorithm, D J Evans and G M Megson, IEE Proc, vo1.135, part E, no 1,1988, pp60-66.
2. The Systolic Control Ring Instruction Processor (SCRIP), G M Megson and D J Evans, Int Conf. and Exhib. on Parallel Processing for Computer Vision and Display, 12-15 Jan 1988, Leeds.
3. Systolic Array Implementation of Group Explicit Methods for Parabolic PDE's, G M Megson and D J Evans, to appear in Proc Int Conf on Systolic and Array Processors, California, USA, 25-27 May 1988.
4. Hardware Accelerators for STABLE-H. To appear in Control 88, Oxford 13-15 April 1988.
5. Improved Matrix Product Computation using Double Pipeline Systolic Arrays, G M Megson and D J Evans. To appear in the Computer Journal early 1989.
6. Transputer Implementation of Systolic Arrays for Model Reduction, IEE Computing and Control Division Colloquium "Recent advances in parallel for control" Digest 1988/94 UCNW Bangor, and RAL-88-048.

7. Implementing SVD Computation for Feedback Control Systems on Transputer Arrays, poster in CONPAR 88, Sept 1988, UMIST Manchester and RAL-87-090.
8. Efficient Computation of SVD's for Multivariable Frequency Response on Transputer Arrays, G M Megson and S D O'Young. In preparation.
9. Implementation of Ricatti Equations for Control Problems using Transputer Arrays. RAL-88-032 Rutherford Appleton Laboratory, UK.
10. Systolic Determination of Absolute Stability in Feedback Control Systems, Report No OUEL 1704/87 Dept Engineering Science, Oxford University, Submitted to IEE Proc-D.
11. A Complexity Transform for NP-Complete Problems, Report No OUEL 1708/87 Dept Engineering Science, Oxford University.
12. SERC/DTI Transputer Initiative Workshop on Transputer Development Environments, Ed: G M Megson, D J Johnston, R Popovic, C P Wadsworth, January 1988.
13. SERC/DTI Transputer Initiative Workshop Final Report, Eds: G M Megson, C P Wadsworth, R Popovic, J Major, D J Johnston.

**C P Wadsworth**

1. SERC/DTI Initiative on the Engineering Applications of Transputers, C P Wadsworth and M R Jane, IEE Conf on Parallel Processing and Control, Univ Coll of North Wales, Bangor, Sept 1987.

**M H Roberts**

1. Report on Primix Beta 3.0 (RAL Prime Systems Note 16).
2. IBM 6150/Project Progress Report 2 (Unix Subsection Note 25), H K F Yeung, M H Roberts.
3. IBM 6150/Project Progress Report 3 (Unix Subsection Note 25), M H Roberts, B W Henderson.
4. EASE Evaluation Tests (Unix Subsection Note 28), M H Roberts, H K F Yeung, B W Henderson.
5. USA Trip Report, Usenix Summer Conference, San Francisco, 1988, M H Roberts, I J Johnson.
6. USS28 EASE Evaluation Test
7. USS34 IBM 6150 Progress Report
8. USS36 TDS/UNIX-Utility Set
9. USS37 IBM6150 Configuration Report
10. USS38 Transputer Server Enhancements
11. USS39 Guide to TDS over network

**B W Henderson**

1. USS40: Introduction to graPHIGS on the IBM 6150.

**H K F Yeung**

1. IBM 6150 Project Progress Report
2. Decus Europe Trip Report
3. Evaluating Supercomputers Seminar Report
4. UTS Closure Plan
5. A Guide for EASE Benchmark (co-author)
6. A Comparison of the System Performance Between SUN/3 and IBM 6150.
7. Effects of the Window Systems on Program Performance
8. A Sample of Benchmark Results

**R Popovic**

1. IFIP Conference, Distributed Processing, trip report.
2. Evaluation of CSA (Computer System Architecture) PART .4B-420 Transputer Board, Transputer Initiative Note 15.

3. Evaluation of CSA (Computer System Architecture) PART.6-420 Transputer Board, Transputer Initiative Note 16.

**D J Johnston:**

1. Evaluation of Transtech's Four T800 Transputer Board for the PC, Transputer Initiative Note 20.
2. Graphics on a Transputer Network.

**Conferences**

**C P Wadsworth**

1. VAPPIII Conference on Vector and Parallel Processors, Liverpool, August 1987.
2. IEE Conference on Parallel Processing and Control - the Transputer and Other Architectures, University College of North Wales, Bangor, September 1987.
3. How to Deal with Difficult People, Career-Track Seminar, Birmingham, Sept 1987.
4. Parallel Processing Symposium, Bath, October 1987.
5. Expert System in Government, Gatwick Hilton, November 1987.
6. Transputer Initiative Workshop on Transputer Development Environments, Abingdon, November 1987.
7. CSELT Seminar on Parallel Declarative Systems, Alvey PDS SIG Meeting, London, December 1987.
8. Solving Scientific Problems on Multi-Processors, Royal Society, London, December 1987.
9. Transputer Initiative Seminar on Reports from Development Contracts, RAL, April 1988.
10. Apollo Computing Technology Seminar, London, May 1988.
11. TAMG Meetings, October and November 1987 and June 1988.

**G M Megson:**

1. Parallel Processing for Computer Vision and Display, Univ of Leeds, 12-15 Jan 1988.
2. 7th Occam User Group Meeting and Workshop on Parallel Programming of Transputer Based Machines. Grenoble, September 14-16, 1987.
3. Parallel Processing in Control - The Transputer and Other Architectures, Bangor, 20-222 September 1987.
4. Control 88 Intern Conf of IEE on Control, Oxford, 13-15 April 1988.
5. Recent Advances in Parallel Processing for Control, 7 July 1988, Bangor.

(Remark: Attendance at 1, 4 and 5 was to present papers.)

**R Popovic:**

1. 7th Occam User Group Meeting, Grenoble, 14-16 September 1987.
2. 'Distributed Processing' IFIP Conference, Amsterdam, 5-7 October 1987.
3. 'The Future of Graphics Software', London, 28 October 1987.
4. 'SERC/DTI Transputer Initiative Workshop on Transputer Development Environments', Abingdon, 30 November-l December 1987.
5. 'Parallel Processing for Computer Vision and Display', Leeds, 12-15 Jan 1988.
6. 'SERC/DTI Transputer Initiative Seminar', RAL, 26 April 1988.
7. 'The Future in Parallel', Micro Way Conference, Olympia, London, 28 June 1988.
8. 'GKS-3D Course', RAL, 19-20 July 1988.

**D J Johnston**

1. Took part in the joint SERC/MRC exhibit at UK/LA. This was a British arts fair, organised by the British Council, that took place in Los Angeles. On the last day DJJ actually got to shake hands with the Duchess of York!
2. Also manned the Transputer Initiative stands at a Royal Society Soiree and at the PC User Show held in Olympia. These produced a large number of enquiries - so much so that DJJ was kept busy for a fortnight answering all the specialised requests for information that he received!

3. Attended the 'Helios Developers Conference' at Bath on 7 and 8 July 1988. Helios is a novel distributed operating system that is particularly suitable for networks of Transputers.
4. SERC Induction Course, RGO, June 1988.

**M H Roberts**

1. Inmos Occam Course at RAL, November 1987.
2. X-Windows Tutorial at RAL, March 1988
3. Transputer Seminar at RAL, April 1988
4. Usenix Summer Conference, San Francisco, June 1988.
5. Visits to SUN, Pyramid and NASA Ames Laboratory in Calfornia, June 1988.

**B W Henderson**

1. C Programming Workshop Course - Instruction Set
2. Device Driver Course - Instruction Set
3. Induction Course - SERC, Swindon
4. X11 Tutorials - RAL
5. EUUG Conference - London
6. Transputer Seminar - RAL

### 3.2.10 Computational Fluid Dynamics (A D Bryden)

A D Bryden (ADB) was a member of the Computational Fluid Dynamics (CFD) Advisory Group which held six meetings during the year. The Group submitted an interim report to the Electro Mechanical Engineering Committee (EMEC) in February 1988 followed by a final report which was approved by EMEC in June 1988. ADB provided the computing background to ensure that the recommendations on computing are compatible with EASE. He played a major part in drafting the final report.

As a result of EMEC's acceptance of the report, ADB is planning some of the details for implementation of the report. A visit is being made to NASA Ames Laboratory to discuss acquisition of their computational data. A Workshop will be held in the Autumn to make more detailed proposals relating to the policy agreed by EMEC.

## 3.3 Data Exchange and Finite Element Processing

### 3.3.1 Staff

Before the reorganisation on 18 July 1988, the Section had the following staff:

- Bryan Colyer (Section Leader) (BFC)
- Mike Mead (MM)
- Debbie Thomas (DT)
- Jan Van Maanen (JVM)

DT was successful in obtaining promotion during the year.

### 3.3.2 Programme

Work has continued on ESPRIT Project CAD Interfaces (CAD*I), which was described in last year's report. This has occupied MM, DT and JVM for most of their time, and BFC for about 20% of his time. Except for a small involvement in standardisation activities, RAL's participation in this project is due to end on 31 October 1988.

During the past year the work on CAD*I consisted of finalising the reference model and the software, and also the writing of the final report. The reference model has been completed and is able to describe finite element modelling, analysis and results. Work is progressing well on the software. The programs now finished or nearing completion enable the transfer of data from a geometry neutral file to FAMbuild, from FAMbuild to neutral file, from neutral file to Nastran, and from neutral file to FAMview. Non-exclusive licences have been granted to a partner in CAD*I (GfS,

a company based at Aachen in West Germany) to incorporate some of this software into commercial products.

A successful International Workshop was organised by the section on behalf of CAD*I in Oxford, 21-22 March 1988. Out of 75 participants, 50 were from commercial and academic organisation not involved in CAD*I; most of the member states of the EEC were represented.

DT and JVM have continued to participate in International Standards Organisation committee meetings. This work enables us to influence the development of the STEP standard (STandard for Exchange of Product Information).

Progress has been made by MM on the development of a compiler for the data modelling language EXPRESS, which has been adopted by STEP.

BFC has spent about 40% of his time on work associated with finite element processing, interactive graphics and user interfaces for single user workstations. He wrote a GINO graphics emulator package for the SUN and, together with B W Henderson (Computational Modelling Division) produced a version for the IBM 6150. The SUN version relies on the ww interactive graphics library which was produced within the Division.

BFC has continued to collaborate with Vector Fields Ltd of Oxford. The GINO emulator has been used to implement the finite element electromagnetic programs PE2D, SCARPIA, TOSCA and OPERA (originally developed at RAL) on SUN workstations. Work is continuing on a new two dimensional potential modelling and analysis program, though progress has been slow due to the commercial success of the prorams just mentioned and consequent demand for improvements and support from customers.

### 3.3.3 Publications

**CAD*I/WG6/RAL Reports:**

| | | | |
|---|---|---|---|
| 006-87 | 9 Nov 1987 | Report on ISO meeting in St Louis, USA, 12-16 Oct 1987 | JVM |
| 007-87 | 20 Nov 1987 | Report on ISO meeting in St Louis, USA, 12-16 Oct 1987 | DT |
| 008-87 | 20 Nov 1987 | Current Status of CAD*I and PDES Specifications for FE data exchange | DT |
| 009-87 | 1 Dec 1987 | Interfacing geometry to FEM using CAD*I; examples of practical Problems | MM |
| 010-87 | 18 Dec 1987 | Minutes of CAD*I WG6 meeting at GfS Aachen, 3-4 Dec 1987 | JVM |
| 011-87 | 18 Dec 1987 | Specification of Exchange of Product Analysis Data. Version 2 (draft) | JVM, MM, DT |
| 0001-88 | 26 Feb 1988 | Specification of Exchange of Product Analysis Data. Version 2 | JVM, MM, DT |
| 0002-88 | 25 Mar 1988 | FE Analysis Control - IDEF1X Reference Model | DT |
| 0003-88 | 15 Apr 1988 | Report on ISO meeting in Washington DC, USA, 28-31 Mar 1988 | JVM |
| 0004-88 | 15 Apr 1988 | ISO TC184/SC4/WG1 meeting in Washington. FEM committee report | DT |
| 0005-88 | 17 Jun 1988 | Substructuring in CAD*I and FAMbuild | MM |
| 0006-88 | 17 Jun 1988 | Substructuring in CAD*I and Nastran | DT |

### 3.3.4 Meetings

The following meetings were attended:

| | | | |
|---|---|---|---|
| 7-8 Sep 1987 | Madrid | CAD*I WG6 | JVM, DT |
| 16 Sep 1987 | London | BSI AMT/4 | BFC |
| 8-9 Oct 1987 | Madrid | CAD*I Project Board | BFC |
| 12-16 Oct 1987 | St Louis | ISO TC184/SC4/WG1 | JVM, DT |
| 27 Oct 1987 | Nottingham | NAFEMS CAD/FE exchange WG | DT |
| 5-6 Nov 1987 | Aachen | ESPRIT Phase II Proposal | BFC |
| 26 Nov 1987 | London | BSI AMT/4 | DT |
| 3-4 Dec 1987 | Aachen | CAD*I WG6 | JVM, MM |
| 3-5 Dec 1987 | Abingdon | CFTAG Workshop | DT, BFC |
| 14-15 Jan 1988 | Aachen | ESPRIT Phase II Proposal | BFC |
| 25-29 Jan 1988 | Rotterdam | ISO TC184/SC4/WG1 | JVM |
| 8-9 Feb 1988 | RAL | CAD*I WG6 | JVM, MM, DT |
| 15 Feb 1988 | Birmingham | NAFEMS CAD/FE Exchange WG | DT |
| 22-23 Feb 1988 | Karlsruhe | CAD*I Project Board | JVM |
| 3-4 Mar 1988 | Aachen | ESPRIT Phase II Proposal | BFC |
| 21-22 Mar 1988 | Oxford | CAD*I International Workshop | JVM, DT, MM, BFC |
| 27-31 Mar 1988 | Washington | ISO TC184/SC4/WG1 | JVM, DT |
| 20-22 Apr 1988 | Leeds | CFTAG Workshop | BFC |
| 21-22 Apr 1988 | Madrid | CAD*I WG6 | MM, DT |
| 17 May 1988 | Brussels | CEN/CENELEC Conference | JVM |
| 18 May 1988 | RAL | NAFEMS CAD/FE Exchange WG | DT |
| 24 May 1988 | London | BSI AMT/4 | DT |
| 20-21 Jun 1988 | Copenhagen | CAD*I WG6 | JVM, MM |
| 27 Jun 1988 | Frankfurt | CAD*I Project Board | JVM |
| 20-21 Jun 1988 | Denver | ISO TC184/SC4/WG1 | JVM, DT |

### 3.3.5 Courses

| | | | |
|---|---|---|---|
| 6-11 Feb 1988 | Santa Cruz | Course on TIGER UIMS | BFC |
| 22-23 Feb 1988 | Uxbridge | METIS Tornado DBMS | DT |
| 28 Jun - 1 Jul | London | Relational Databases | DT, MM |

| | | | |
|---|---|---|---|
| 1988 | | | |

### 3.4 Engineering Computing Facilities Executive

#### 3.4.1 Infrastructure

The policy and budget for much of the work of the Engineering Computing Group is determined by the Engineering Board's Computing Facilities Committee (CFC). The latter is advised on technical matters by the Computing Facilities Technical Advisory Group (CFTAG). The ECFE is responsible for providing input to these groups and for executing their decisions.

The ECFE does not correspond to a particular branch of the group and the following staff participated:

- M R Jane (MRJ)
- A D Bryden (ADB)
- F M Childs (FMC)
- B Colyer (BFC)
- J R Gallop (JRG)
- G A Lambert (GAL)

From ECFE MRJ attends CFC and MRJ, ADB, JRG, GAL (Secretary) attend CFTAG.

The major concerns of CFTAG have remained

1. The definition of, and acceptance by the Engineering Board of the Engineering Applications Support Environment
2. The completion of the Applications Software Review
3. Engineering Board access and use of the CRAY X-MP48
4. Setting up and controlling EMR Contracts

**Meetings/Conferences/Publications**

CFC Meetings: 21/12/87, 29/6/88, 20/9/88.

CFTAG Meetings: 2-3/11/87, 3/3/88, 4-5/5/88, 5/9/88 (MRJ, ADB, JRG, GAL) .

Prime and the UK Academic Engineering Community 1976-1988 (MRJ) - a paper presented at the First World Congress of Prime Users held in Australia on 9-15 October 1988.

Engineering Computing Facilities (ECF)

Staff:

- G A Lambert (GAL)
- F M Childs (FMC)

**Computing Facilities Technical Advisory Group**

GAL acts as Secretary to the advisory group and in addition to the routine paper writing tasks associated with the role produced a report on the Applications Software Questionnaire which was published as RL 87-074. As an essential part of the Applications Software Review a series of four workshops were organised by GAL:

- User Interface Management Systems at the University of Glasgow on 19-21 September 1987.
- Support for Database Systems at Abingdon on 3-5 December 1987.
- Numerical and Mathematical Software at the University of Warwick on 1- 3 February 1988.
- Tools for Integration at the University of Leeds on 20-22 April 1988.

The reports from the workshops formed the basis for the software aspects of the EASE policy which was accepted, in principle, by the Engineering Board in July 1988.

### ESPRIT-962 (EVEREST)

GAL now has responsibility for the management of the project. RAL is prime contractor. Immediately after the project review meeting, held in November 1987, GEC indicated their intention of withdrawing totally from the project. This caused a period of feverish activity to find a substitute partner, STC Technology Ltd, and make all the necessary changes to the contract and forward details, before the end of the contract in March. In spite of all efforts final renewal of the contract was not completed until September.

### Grant Assessment

GAL remains responsible for the initial scan of all computer related grant applications referred to RAL for comment. It is noticeable that an ever increasing number are requesting SUN based workstations and that those requesting resources on the ECF multi-user-mini computers are reduced to a trickle.

### Engineering Computing Newsletter

Fran Childs (FMC) continues to act as the editor of the Newsletter, with editions being produced at quarterly intervals. Production, against an exacting timetable remains a demanding task with well over 2,500 copies being distributed in each edition.

### ECF Multi-User-Minis

The decision was taken to bring forward the closure of the ECF MUMs, at a meeting of the community held at RAL in December 1987. The following timetable was accepted.

**East Anglia Prime**
Close December 1987
**UCL Prime**
Close March 1988
**Surrey Prime**
Close March 1988
**UMIST Prime**
University responsibility: April 1988
**City Prime**
University responsibility: April 1988
**Warwick Prime**
University responsibility: April 1988
**Cardiff GEC 4090**
Close June 1988
**RAL GEC 4090**
Close June 1988

The responsibility and use of the RAL GEC community has been passed on to CCD.

### Transputer Initiative Loan Pool

Fran Childs (FMC) remains responsible for the loan pool of the Initiative. Activity has remained high with large injections of new equipment requiring check-out and distribution. FMC has also been involved in a series of displays etc publicising the activities of the Transputer Initiative.

### User Meetings

One meeting of the Engineering Computer User Group (ECUG) was held (organised by GAL and FMC), however a second meeting was cancelled, due to lack of attendees.

### Finance/Contracts

GAL now has responsibility for all the contractual activity of the ECF, including all the hardware, software and support contracts. In addition there are an increasing number of EMR agreements being offered as a result of the EASE activity.

### 3.4.2 Operations

#### Introduction

The purpose of the Operations Section is to provide operational services, on whatever hardware, to the Engineering Computing Community, to the Alvey community, and to the Department as a whole. In much the same way, the User Support Section provides assistance and advice to users of these facilities.

The staff in post at September 1987, the beginning of this period of report, was as follows:

**M E Claringbold (MEC) Section Leader**

Operations

- P D Athawes (PDA)
- A M Jackson (AMJ)
- R Parkes (RP)
- R Tillotson (RT)
- L J Reed (LJR)
- I Vollmer (IV)
- A C Davis (ACD)
- J R Smith (JRS)
- A S Jaraslawska (ASJ)

Support

- B A Alston (BAA) resigned 24/12/87
- M J Loach (MJL) resigned 12/1/88
- N J Kennett (NJK) later N J Watkins
- P C Phillips (PCP) resigned 4/12/87

#### ECF General

The major occurrence in this period, affecting the work of the Section, was the decision of the CFC, in December, to run down the use of the GEC and Prime multi-user-mini-computers, terminating the service by 31 March 1990. No new full 3-year allocations for such resources would be taken on and no new allocations beyond 31 December 1989 awarded. Closely following this decision, many machines were either closed or handed over to the University sites. It had already been decided to cease funding some uneconomic machines so that, during this period, GECs closed at Cambridge, in December and Cardiff in May; with Primes the dates were, East Anglia in December, City, Surrey and UCL in March, and UMIST and Warwick in May. These measures did not exclude RAL where both the Department's GECs went, one scrapped in December and the other transferred to CCD in May; the development Prime was transferred to UMIST in February.

The operating system on the GEC had already been frozen but now the same fate befell the Prime.

#### UNIX General

With the rapid growth of SUN workstations within ID and the imminent closure of the Alvey program, it was decided to close down the two DEC and two Systime VAX computers by March 1989. Already one of them, rl.vm, has been loaned, indefinitely, to NAG following the loss of their machine in a fire.

#### GEC Support

In September, MJL was the solitary person working on GECs. As System Manager, he had overall responsibility for the day to day running of the system, providing limited updates, hardware and software problem identification, and system security monitoring.

He provided user support by electronic mail, telephone and personal contact, and provided and maintained documentation.

He fixed all known faults in the Kermit file transfer protocol software.

He resigned in January, bringing to an end all GEC expertise and support within the Department.

### Prime Support

In a similar way, PCP provided support for the Prime computers and their users.

He also assisted in resource management by designing, programming and administering two databases providing information for finance and management.

When he resigned in December, the software updating was transferred to ACD and the general user support to UMIST. Local support was taken on by MEC and PDA.

### UNIX Service Support

The third member of the Support Office, BAA, also resigned in December. Although all three members had their own specialist area of support, each was able to cover the other areas to some degree. With the UNIX service gaining momentum, in contrast to the GEC and Prime service, there was a need to replace BAA immediately and, to this end, NJK was thrown in at the deep end.

She took over the UNIX support on SUNs, VAXes and Pyramid and, in doing so, mounted Mk11 of the NAG Fortran Library on the Pyramid.

Taking over the post of Secretary of the monthly held UNIX Service Meeting, she has been responsible for the production and distribution of the Service Notes. In this series, she has written one as a quick reference guide to the Unipress emacs V2.l0.

### Prime Operations/Resource Management

During November and December, RP passed the responsibility and experience of Prime Managership of RLPA to PDA. Before moving into the Transputer Initiative, RP worked together with PDA in two particular tasks, namely the upgrade of RL. PH from a 2655 to a 2755, and the reformatting of all the discs to conform with the new and SERC final major release of Primos, Rev20.

In her role as both Manager and Resource Manager, PDA has since been involved in the move of grant-holders from the remote sites to RL.PA, especially from UCL where a complete disc had to be transferred. A replacement 2250 on a grant at UCL required her assistance as there is no longer a Manager at that site.

One of Prime's newest and largest discs was installed on RL.PG and this required necessary reformatting.

An outstanding BRMS (dumping procedure) problem has been, and still is, giving cause for concern.

A pilot program to look at forecasting for the Engineering Board has been developed and PDA is assisting in the process.

ACD, who was assistant to RP, transferred to PDA when she became Manager.

### UNIX System Management

IV has been the System Administrator for the Pyramid, rl.pyr-a, the two production VAXes, rl.vc and rl.vd, and the Pyramid workcentre, nfs4. Apart from the overall responsibility for these machines with regard to performance, fault investigation, liaison with manufacturers for hardware and software faults, a major task was the installation of release 4.1 on nfs4 and rl. pyr-a. Due to the way in which Pyramid distribute their releases, involving the completion deletion of /usr, this was an undertaking with drastic repercussions for two weeks.

She has participated in the integration of rl.pyr-a and rl.vd into the Mail service.

IV has also handled the administrative maintenance of Netnews, updates of the NRS database, and Arpanet registrations and mail queries.

ASJ has assisted IV particularly in the operational support. When agreement was made to cease CCD involvement in machine dumping, ASJ took over the task to perform these with minimal disruption during prime shift. Subsequent file retrieval, on user demand, and files tore checking is her responsibility.

Analogous to IV, RT has served as System Administrator for the SUNs by maintaining user filestore, maintaining hardware and software through contact with SUN UK, installing new software, reconfiguring hardware and resolving operational problems.

Over and above the type of problems expected in an operational environment, he has been involved, generally in leadership of several related projects. These have been the major rearrangement to include additional server nfs5 and 24 clients, an upgrade to as to 3.4, installation of the ID Mail Service, the move of servers to comply with new Computer Room plan, and the addition of a further server nfs6. Preparations have started for the as release 4.0.

RT has been responsible for the day to day Lab 11 facilities.

Working on a part-time basis, LJR has been assistant Systems Administrator, primarily for the SUN workstations. This has included such tasks as helping to manage filestores, to check and maintain printers, to add discless clients and, on disc machines, to upgrade from 3.2 to 3.4, to install DWB software, and to install the DAP software. She has maintained the SUN on-line manual pages, added new users, and been responsible for issuing new user ids and group ids.

She has arranged in-house SUN user courses.

LJR has revised the IDUS Note on getting started for new users of IDUS.

MEC has been undertaking a survey of fire safes and of Postscript laser printers for attachment to the Ethernet.

### Prime Systems

Although Prime system work has been covered by a UMIST contract, the assessment of Prime UNIX (Primix) was made at RAL. Following user involvement from all sites and a summary by MEC, it was decided, on its performance, not to install the software.

The other major new software installed was JTMP.

### Technology Merger

AMJ, with assistance from ASJ and ACD on occasions, was responsible for linking the old Computer Applications Group of Technology Division into ID with regard to equipment needed individually and the merger of their partly owned terminal pool. An analogous exercise followed when the Image Processing Section was also merged, together with their Microvax computer.

He has, in effect, been the Systems Manager for the AMT DAP when this was purchased in December and eventually installed in Lab 11, linked to a SUN. He has served as liaison with AMT for hardware and software updates and queries.

Assistance has also been given with networking connections.

### Database Administration

JRS has been responsible for the maintenance and upkeep of the many INFO databases held for use by ID. These include -

- Details of SUN workstations with serial numbers, locations, users, contacts and maintenance.
- Remote site contacts.
- Remote site contracts.
- The blue book of computer details, configuration, maintenance etc at Universities.

- Alvey applications.
- ID terminals, location, users, model type, serial numbers and connections.
- A database of comments on the SERC/DTI Transputer Seminar held in April.
- The run-down of the ICF Terminal Loan Pool.
- Mailing list for Transputer Initiative.

**Courses attended**

| | | |
|---|---|---|
| Sept 7-11 | Prime System Principles & Tuning - Southampton | PDA |
| Sept 10 | CSMA/CD (Ethernet) Mechanism & Practice - London | AMJ |
| Sept 16 | Network File System - London | RT |
| Sept 29 | Managing Awkward People - Swindon | MJL |
| Nov 19-20 | AMT DAP Programming - London | BAA, MJL |
| Jan 25-29 | Pyramid System Administration - Farnborough | IV |
| Mar 7-10 | C Programming on Cray - Atlas | RT |
| Mar 23-25 | Introduction to UNIX - Harwell | ASJ |
| May 24-27 | Induction Course - Daresbury | RT |

**Off-Site Meetings and Conferences Attended**

| | | |
|---|---|---|
| Sept 14-15 | INFO User Group Conference - Sheffield | PCP |
| Sept 21 | UMIST Prime User Meeting - UMIST | MEC |
| Oct 22 | 21 Oct 22 Systems Industry DEC Seminar - Abingdon | MEC |
| Nov 18 | Compec Exhibition - London | MEC, MJL |
| Dec 14-15 | UKUUG Workshop on Networking | IV |
| Jan 7 | SUN Seminar - Oxford | PDA |
| Mar 4 | Pyramid Upgrade Seminar - Farnborough | MEC, NJK |
| Mar 16-24 | Assistance to UCL Manager to move Users - London | PDA |
| May 5 | Pyramid User Group Meeting - London | NJK |

### 3.4.3 Single User Systems/Applications Section

The section has been responsible for the support and development of Single User Systems for Engineering Board researchers and for the Alvey Programme, graphics on ECF machines, and text processing on ECF UNIX machines. Some of these activities are also carried out for the Departmental service IDUS.

**Staff in post during the year**

- Julian Gallop (JRG) Section Leader
- Peter Kent (PK) Head of SUS Support
- Kevin Lewis (KML)
- Morgan Chow (MC)
- Bill Hewitt (WJH)
- Lynton Jones-Ng (LJ-N) Until December 1987
- Mark Phillips (MDP)
- Dale Sutcliffe (DCS) Head of Basic Software
- Ruth Kidd (RMK)
- Predrag Popovic (PLP)
- Jan Malone (JCM) Until August 1988
- Trudy Watson (TAW)
- Janet Haswell (JH)

- Martin Prime (MJP)
- Peter Randall PJWR) Until January 1988

During the year, Mark Phillips gained promotion to SO, and Martin Prime to HSO.

On Friday 13 May, Bill Hewitt and Mark Phillips suffered injuries in a car accident and were eventually able to return to the Lab in August and November, after recovering from their injuries. By the time they returned, Informatics reorganisation had taken place.

The assessment project for Single User Systems in EASE started in June and Tony Lucas, Subodh Chanda and David Barlow joined the section briefly until reorganisation took them into a new Assessment Team.

**Single User System Support**

The team led by PK has been responsible for support of centrally purchased and maintained Single User Systems funded through Engineering Board committees and the Alvey Programme.

The team supports over 400 SUNs and a small number of remaining PERQs. PK took responsibility for advice to SUN people preparing a grant application and specifying SUN equipment for the committee secretariats. During the year some of this work was gradually handed over to KML.

All machine ranges are held online with the largest and most active set the SUN3s - being upkept by Janet Smith.

Maintenance is coordinated at RAL. The contracts procedure has been streamlined moving away from the old quarterly contracts to a long- term one, where the actual equipment lists are agreed between SUN and RAL on a frequent basis. PK and KML have been involved here.

The SUS Support Office telephone (with Atlas' Service Line screening out the hardware calls) has been staffed by WJH, MC and MDP.

Software distribution this year has mainly been concerned with providing new users with a standard software set and distributing new versions. NAG numerical library and NAG graphics has been licensed and distributed on request. New software expected to be distributed next year includes X-ll window system and the DWB text processing software suite.

With the large number of sites to distribute cartridges to, efforts have been made to set up a software and information distribution system accessible to any user connected to JANET (JAM or Janet Access Machine). Progress in setting up communication has been slow due to problems with the implementation of the X29 coloured books software.

MC and Jeremy Isserlis have spent much time testing SUN communication software and MC has set up file structures for allowing the user to find the information that is needed.

**Basic Software**

DCS led the Basic Software Team. The purpose of the team can be summed up as developing, providing and supporting widely usable basic systems providing common interfaces on which level software and applications may be built.

**Text Processing and Systems Development (JCM except where otherwise stated)**

The work of providing a uniform and useful text processing system on the UNIX machines has been continued during the year. Documenter's Workbench 2.0 and Transcript 2.0 are now in normal use on all the IDUS gold service machines.

A survey on the usage of text processing macros was carried out by Nicola Watkins and resulted in the choice of mm as the major set of macros. Also arising from the survey, were produced some Informatics macros and profiles (mid) ; this allows Informatics papers, notes, memos and letters to be conveniently created.

As the text processing system evolved, IDUS Note 14 was kept up to date.

The result of this work (except the Informatics macros) was packaged up for ECF distribution.

The policy of using manufacturer's version of Transcript 2.0 was thrown into question by two events. One was the arrival of psfig, which allowed Postcript files to be inserted into DWB documents. The effective use of psfig needed an alteration to Transcript. The other event was the test and use of new Laserwriters. The technical policy favoured was to adopt Transcript source, alter it and compile it for IDUS Gold and ECF machines. Unfortunately staff shortages meant that this is impractical for the time being.

Within IDUS, the text processing policy has been guided by a text processing meeting, chaired by the IDUS Technical Manager, Bob Day. Chris Rust also contributed to the text processing software.

### GINO to GKS Conversion

With the demise of the support for ICF Primes and GECs, conversion of graphics programs from GINO to GKS has achieved some prominence. DCS gave a talk on the subject to the special meeting of grant holders in December and wrote a letter to users, distributed with the Engineering Computing Newsletter. Little response was received from users despite their earlier worries. Some enhancements to RAL GKS have been included in the final release on the Primes to ease the transition (RMK).

### RAL GKS Development

Development of the master source of RAL GKS has continued this year, with several significant enhancements being completed.

PLP finished work on a driver for Tektronix emulators. This makes use of the scrolling text screen for all alphanumeric text, and also allows drawing in the background colour (ie erasing).

PLP added an extra choice input device to the Tektronix and Sigmex drivers to allow any printing character to be used for choice input. This ties in with the new ESCAPE functions designed and implemented by RMK. The purpose of these ESCAPEs is to associate GKS locator and choice devices, so that they can both be triggered by a single operator action. This allows the use of GINO CURSOR-style input, and has been implemented to ease the conversion of GINO-F software to GKS.

PLP has started work on a GKS driver which generates PostScript output. This is based on a driver written by a Starlink VAX/VMS user, which MJP converted to run on UNIX. PLP is correcting this driver and also enhancing it to make better use of postScript.

The new system interface routines for RAL GKS were designed and implemented on UNIX and Prime (RMK, TAW, PLP). These perform character and byte output to a file, and are already being used by the PostScript driver.

In August, RMK produced RAL GKS master source 1.20. This included all of the developments described above (apart from the postScript driver which has not been completed).

### RAL GKS - Installations

In addition to work on the master source of RAL GKS, libraries have been produced and released on various operating systems.

When PJWR left in January, RMK took over graphics on the Pyramid and released the Pyramid GKS library he had built.

RMK also released RAL GKS 1.20 on the Primes; this is intended to be the last GKS release on these machines.

### NAG Graphical Supplement Mark 2

In June, RMK released versions of the NAG Graphical Supplement for use with GKS and GINO-F on the Primes. These libraries allow a phased transition from GINO-based graphics to GKS.

Work is currently underway to provide NAG Graphics libraries for use with GKS on the SUNs and Pyramid.

### SUS Graphics and Window Management

Several diverse areas of work were covered during the year. The main areas of responsibility being GKS on SUNs, other graphics standard software on SUNs, emerging standard window management software and UIMS, and evaluation of high performance workstations. The team consisted of JH, MJP (half-time) and PJWR (until January 1988) and was headed by TAW.

### RALGKS on SUN Workstations

This is an ongoing collaboration with Tony Arnold of Manchester University, Computer Graphics Unit. The Draft International Standard version of RALGKS was upgraded to the International Standard on SUNs. Several improvements were made to the SUN workstation driver. TAW added support for colour workstations and fuller functionality for line drawing. PJWR wrote many speed and functionality improvements for the output and control of the SUN workstation driver. Tony Arnold made several improvements to the input functionality. This was packaged up and given to support for distribution.

PJWR wrote a SUN raster image to GKS metafile converter and documented it. There was a need for some performance tests for GKS. These were written and tested by TAW.

An X11 workstation driver for RALGKS is being written as part of the same collaboration. A Postscript driver was ported to UNIX by MJP and modified to conform to the International Standard. Some of the Postscript code production routines were altered so that they would produce correct Postscript code. MJP developed some new test programs to augment existing tests and so fully tested the driver.

### GTSGRAL GKS-3D and FIGARO

PJWR configured GKS-3D for use on SUNs at RAL. TAW then tested FIGARO and GKS - 3D and made them available for the Department. The new version now works within a SUNview window instead of taking over the whole screen. However this version still only corresponds to a very early version of the standard.

Towards the end of the year DCS organised a training course at RAL for potential recipients of the four licences purchased for external use and assessment. it was given by UIS, the suppliers of GKSGRAL-3D in the UK and was attended by five external users and two RAL staff. Just before the course, but too late to postpone, it was learnt that a new version corresponding to the DIS was imminent and would be sent to RAL when available. This version will be distributed to the trial sites.

### X11 for the EASE Community

Standard window systems are becoming important so work was needed to provide EASE users what they need and increase their awareness of what they can do. This work started in January with the trip to the X Conference at MIT. TAW wrote some XII benchmarks and ported an application to Xlib to be used by the EASE evaluation. Having gained some experience of using X11 TAW planned future work on XII needed to support EASE users. This was documented in a paper and a SUN user note informing users of our intentions. The MIT XII release 2 on SUNs was too slow to use so TAW implemented some speedups designed by CAAG and incorporated several known fixes to the code. This will be made available to EASE users.

### User Interface Management Systems (UIMS) Assessment

The UIMS assessment was instigated by the CFTAG workshop on UIMS held in September 1987. This recommended that two commercial UIMS (PASET and TIGER) should be evaluated for use in an engineering environment. The aim of the evaluation was to determine the ease of converting a reasonably sized (approximately 15,000 lines of FORTRAN) existing engineering program to use each UIMS and to determine the advantages and disadvantages of using the UIMS.

It was subsequently discovered that another UIMS under consideration, BLOX, had been purchased by a US graphics' software house and would be supported and developed. This was added to the evaluation.

DCS has managed the assessment which is being carried out by UMIST (PASET and BLOX) and RAL (TIGER) staff and MJP has coordinated the daily running of this evaluation.

MJP has continued work on the survey of UIMS, which compared proprietary systems and evaluated them against a set of criteria which he produced from papers in the subject area. He presented the conclusions as a paper at the CFTAG work shop and the survey provided a useful focus to the workshop's deliberations. The paper was then updated and published as a RAL report (RAL 88 -028) User Interface Management Systems a current product review.

**Evaluation of High Performance 3D Graphics Workstations**

This work carried out by JH is reported on elsewhere.

**SUN New Users Course**

TAW and MJP prepared part of this course, on using the window system and gave it a few times to members of the Department and UMIST.

**Single User system Assessment for EASE**

The Single User System Assessment project became a major project in June. This followed preparatory work by Eric Thomas (RET) who prepared the questionnaire with inputs from many people and JRG, DCS, PK and WJH. The project clearly needed more effort and AJL, SKC and DSB joined the section. Since reorganisation was known to be imminent both RET and JRG were actively involved. JRG chaired project meetings before the reorganisation and RET afterwards, with one standing in for the other during holidays, thus ensuring continuity.

DCS assisted in the design of the questionnaire and benchmarks. TAW prepared X11 benchmarks. PK produced initial filter mechanisms to remove the no-hopers and also advised on statistical methods.

After reorganisation, the assessment became the first project of an enlarged assessment team under Mike Claringbold/Bob Day, who became heavily involved.

Bob Day coordinated the paper, which Eric Thomas presented to the September CFTAG meeting.

**CFTAG and ECFE**

JRG participated in CFTAG and ECFE and took a major role in formulating EASE in response to inputs from many sources. He also presented the new plans to various bodies such as IUSC and CHEST thus starting what should be a useful cooperation with them.

**ESPRIT II Project ARGOSI**

With Bob Day and Dave Duce, JRG and DCS represented RAL in establishing the ARGOSI Esprit II proposal, which has been looked on with favour by the Commission, although they have said combine with another proposal and, by the way, there's only half the money you asked for!

### 3.5 Regional Transputer Centre

**Staff**

- R Parkes

The London and South East Regional Transputer Centre was set up on 1 April 1988, after existing as an interim facility since September 1987. The Centre is now located in Building R1, Lab 10. Day-to-day operation of the centre, and the overall provision of services to academics, laboratory staff and industry is the responsibility of the manager, R Parkes (RP). RP took over responsibility for the

move of the facilities from the previous accommodation in R32 and the opportunity was seized to upgrade the appearance of the centre. This was accomplished at minimal expense, in particular, a fortuitous flood in the area resulted in the laying of new carpet replacing the existing rather grubby covering. The centre has now been repainted and equipped with better lighting, fittings and furniture than existed in the interim facility. Given the financial restraints the area is now considered to be suitable for its purpose. The centre is equipped with 5 IBM PC computers containing a single T400 transputer together with development software such as the TDS (Transputer Development System) which includes a novel folding editor, and also sequential versions of the scientific languages, Fortran and C. Two of the machines are used as front ends to multi-transputer systems manufactured by Meiko and INMOS. These systems also have high speed colour graphics capability. A number of demonstration programs are also provided.

Much emphasis is placed on the search for customers from industry, who are particularly sought after, in view of their ability to bring funding into the centre, which is supposed to be self-sufficient by 1990. Progress has been steady, if not exactly spectacular, and much importance is attached to the value of advertising. The momentum is being maintained nevertheless. In July of this year our first seminar was run at the laboratory, with the aim of introducing Company Management into the idea of the Transputer, and parallel processing. The seminar was well received and it is expected that at least one other will be run later in the year, targeted at a similar group. it is hoped that lucrative activity within the centre will be generated as a result. The Centre also plans to run a more technical follow-up in the Autumn.

The Initiative exhibited recently at the User Show, which has resulted in a number of contacts in industry from which some new sponsorship deals should soon be concluded.

Usage of the centre has been sporadic; which is rather disappointing in view of the widespread advertising. Perhaps it is yet still too early to draw implications. The indications that industry will take up services offered by the centre are in evidence and uptake of services, should soon begin to accelerate. In expectation of this databases are being designed to provide the management information that will be required later.

Other general issues that concern the operation of any service such as this are slowly being addressed, such as bookings, security, technical documentation, the way machines are used and what sort of operating/usage procedures should be in existence. At the moment these are being developed according to the actual demands that are being made. It has certainly be necessary to introduce a booking scheme and the issue of software security is one that will be addressed as a priority.

Other areas of activity planned for the immediate future are the development of a standard user environment on the PCs for this centre consisting of standard utilities, compilers, development environments, eg TDS and TDT, packages, libraries, utilities and possibly online tutorials. The development of a business plan to produce an income of £100,000 per year is also a priority issue. The Centre is already in a position to charge for some of its services, some chargeable hands-on use has already been invoiced for.

### 3.6 Transputer Coordination

#### Staff

- M R Jane (MRJ)
- C Balderson (CB)

At the start of October 1987, CB moved from Alvey Infrastructure Coordination to the SERC/DTI Initiative in the Engineering Applications of Transputers. The envisaged role was that of Technical Administrator with responsibilities for contracts, loans of equipment, liaison with Transputer Centres etc. During this period, CB attended a small number of conferences and courses aimed at establishing a transputer background.

Initial activities were in supporting the Transputer Applications Management Group (TAMG) and the Support Centre Directors Meetings (SCDM). In addition a number of development contracts were established in support of the Transputer Software Base with various universities. A round of purchases and equipment upgrades added interest to the end of financial year, as did the opening of the National Transputer Support Centre at Sheffield, on which CB was a member of the organising committee.

In the new financial year, CB took on additional responsibilities as Deputy Coordinator for the Transputer Initiative and became involved with the marketing of the Initiative services. This has led to participation in and organisation of a number of shows and seminars in terms of the Initiative or the RAL Transputer Centre. Included in this has been participation in the Royal Society Soiree, involvement in the arrangements for a publicity video currently being made on behalf of the Initiative, speaking at events such as the Transputer Forum at the PC User Show, and the IEE Colloquium on Recent Advances in Parallel Processing for Control, and participation in the Enterprise 88 event in Newbury on behalf of the RAL Centre.

There have been several meetings with potential clients of the Centre based on follow-ups from these events and other publicity, with CB involvement. There have also been discussions with potential sponsors for the Initiative.

On the academic front CB is involved with universities and companies in setting up of development contracts aimed at adding to the base of transputer software. CB is also involved with the overall management of the Loan Pool, including assessment of new applications, and in production of the Initiative mailshot.

**Conferences/Publications**

A UK Initiative in the Engineering Applications of Transputers (MRJ) - a paper presented at the Prime International Conference on Computer Graphics held in Singapore on 15-16 September 1988.

### 3.7 Evaluation of High Performance 3D Graphics Workstations

**Staff**

- J Haswell

To evaluate the 3 top of the range workstations from Hewlett-Packard, SUN Microsystems and Apollo Computers JH designed some 3D graphics benchmarks aimed to stretch the capabilities of each. For each machine JH had to learn a new graphics language, and in the case of the Apollo, the language was also being extended during the evaluation. For HP and Apollo, the graphics package claimed to be based on PHIGS, whilst for SUN based on Core. In the case of the latter two machines JH suffered problems with unavailability of the necessary hardware and software. JH soon discovered that despite upwards compatibility trying to develop software on lower range architectures is not always easy or recommended.

#### 3.7.1 Hewlett-Packard

The HP 350SRX arrived mid-September, and proved relatively easy to work with - JH only suffered one upgrade to the operating system and one period when the machine was out of action due to hardware failure. After the upgrade the graphics package came with a good set of example programs and on reading the small print from an online manual. Apart from not succeeding to convert the tests to run within a window (which was the result of incompatible software for the given hardware) JH had reasonably completed the tests by January 1988.

#### 3.7.2 Apollo

The DN590T (though for most of the time a DN580 or DN580T). Throughout most of the evaluation JH had an Apollo on loan. However, only for a short period of time did it have the required 24 colour plane, with floating point coprocessor, for the rest of the time an 8 colour plane model was used.

The initial release of graphics software did not contain such things as shading and the machine, being one of their demonstration machines, was liable to disappear for a while and return in an unsuitable state for my evaluation. Problems included lack of example programs and lack of reasonable documentation.

### 3.7.3 SUN

SUN-4/260C (though for most of the time a SUN-3/260C). Again JH was hampered by lack of example programs, poor documentation, changes in operating system and unavailability of the desired hardware. Not being the only contact with manufacturers for this machine caused problems in knowing what state the machine is in.

### 3.7.4 Part-time MSc in Computer Graphics (Year 2)

Mondays, during term-time JH has attended Middlesex Polytechnic to study for an MSc in Computer Graphics. Since a term was used at the beginning of the course to bring everyone to the same level of competence in mathematics and programming the end of first year exams were part way through the second year, in December 1987. She passed in all subjects despite suffering from an abscess (as discovered in a later trip to the dentist) and obtained As for the courseworks. She has another set of exams in December 1988 then 2 terms to complete a dissertation on a chosen topic.

### 3.7.5 System Administration for Apollo Workstations

JH installs the latest software and assist users to the Departments Apollo DN3000 and other Apollo at RAL. She is the Laboratory contact with Apollo and keeps up to date with developments via the Apollo User Group, the Network news and the Press.

### 3.7.6 System Administrator for Macintosh PCs

JH maintains the Department's Macintosh Plus, assists users and advises on the purchase of hardware and software. She also keeps up to date with developments via the Macintosh User Group, the Network news and the Press.

### 3.7.7 Conferences/Colloquium

| | | |
|---|---|---|
| 28 Oct 1987 | London | The Future of Graphics S/W (BCS) |
| 26 Dec 1987 | London | Realism and Visualisation (BCS) |
| 26 Mar 1988 | London | Graphics Tools for Software Engineering: Visual Programming & Program Visualisation (BCS) |
| 5 May 1988 | London | Visualisation of Fields in Three Dimensions (IEE) |

### 3.7.8 Courses/Tutorials

1. Mondays during term-time at Middlesex Polytechnic (Year 2 of 3) Part-time MSc in Computer Graphics
2. 9 Oct 1987: SUN Microsystems with Instruction Set - X11/NeWS Seminar
3. 28 Mar 1988: Univ Surrey Easter School on Colour in Visual Displays

### 3.7.9 Internal Reports

1. CB Technical Note 83 - 13 Aug 1987 - Trip Report NATO Study Institute - Theoretical Foundations of CG and CAD).

## 4 INFRASTRUCTURE GROUP

### 4.1 Introduction

The Infrastructure Group which disappeared in the re-organisation of 18 July was led by K F Hartley (KFH) during the report period. Most of the work was funded by the Alvey programme under the headings of Infrastructure and Coordination and Support. Technical support of IKBS and Software Engineering was provided by SKE Group. Some research in HCI and Image Processing was funded by Alvey and Engineering Board. The other major responsibility was for Systems and Communications support of Engineering Board systems.

The following sections describe the work done during the report period, but 4.3 is somewhat different. It contains the full text submitted for the 1988 Alvey Annual Report. As it is understood that it is likely to be reduced substantially before publication the opportunity is taken to include it here for the record. It contains a review of the Department's support of the Alvey Programme throughout its lifetime. As the Alvey Directorate no longer exists and Informatics Department support will end in March 1989, though some Alvey research projects will continue for a further two years, it was felt that this was the right time for such an overview.

### 4.2 Management

KFH's main activities during the year have centred on the new joint SERC/DTI collaborative programme (still without a name, though IED are running a competition to find one). Comments were prepared on the draft strategy documents. Attempts have been made to persuade those responsible that the new programme must have an infrastructure, to define what it should contain and to try to ensure that the Department obtains a reasonable share of the funding. So far, all of these have proved to be frustrating and inconclusive. The decisions are expected to be made by December 1988.

Substantial effort has been needed to wind down the Alvey activities by re-deploying staff and redistributing or ending activities. This is never easy but reasonable progress has been made without too many casualties amongst the staff involved. For once resignations have actually helped, even though the skills could not be spared. Continued uncertainty over future funding probably contributed in some cases.

KFH has also contributed to management's response to the Management Services Review of Informatics Department. This started before, and will be completed after, the present report period. Hopefully some errors have been corrected; certainly some of the conclusions have been strenuously challenged. We await the outcome with interest and some patience.

KFH and the whole Group have been ably and loyally supported by Miss H V Jenkins, between bouts of injury and illness, and Mrs J Perkins nee Smith, between bouts of house purchase and marriage.

#### 4.2.1 Courses, Conferences, etc

KFH attended the IED conference at Swansea in July and a Bow Group conference on the Exploitation Gap.

### 4.3 Informatics Department Support of the Alvey Directorate

SERC's Rutherford Appleton Laboratory (RAL) has been providing support for the Alvey programme since its inception. As this may be the last Alvey Annual Report it is appropriate to review the origins, scope, achievements and lessons learned from this involvement.

#### 4.3. Origins

The Alvey Report was published in September 1982 and the Programme started in June 1983. During that period RAL was involved in several SERC initiatives which were directly relevant to Alvey. The most important of these were:-

- Distributed Computing Systems programme. This was a programme coordinated from RAL, whose main aims were to develop a research community in the areas of loosely and

tightly coupled systems, novel architectures and the theory of parallel computation.

- Software Technology Initiative. This was a Specially Promoted Programme of SERC's Computer Science Committee which started in 1981. Its co-ordinator was seconded into the Alvey Programme as Deputy Director and the entire SPP became part of the Alvey Software Engineering programme.
- SPP in IKBS. RAL was involved in formulating a Specially Promoted Programme in IKBS, which became the basis of the Alvey IKBS programme.
- Alvey Programme. RAL was heavily involved in the period January 82 to June 83 in the actual formulation of the Alvey Programme.
- Image co-ordination. SERC's Information Engineering Committee was starting to support co-ordination of research in the processing of image and other sensory data, including speech.
- JANET. The SERCNet was run from RAL and was at that time evolving into the Joint Academic Network (JANET).
- ICF and CBP. The Computing Facilities Committee of SERC's Engineering Board were funding the Interactive Computing Facility (networked multi-user minis) and the Common Base Programme (hardware and software standards for procurement and support of Single User Systems - the precursors of today's Workstations). Many of the staff involved were experienced in providing and supporting networked facilities and the issues of human-computer interaction which arise with such systems.

These activities meant that RAL had experienced staff in post who were able to give immediate assistance to the Directorate right at the start of the programme.

### 4.3.2 Scope

As the various Directors turned to SERC and RAL for extra effort different functions emerged and evolved over the years in the areas of IKBS, SE and MMI. RAL's work for the VLSI programme is described elsewhere. The scope of these activities eventually included:-

- Programme Management and Support. This was direct in the case of Software Engineering, with RAL staff occupying many of the posts in that area, and more indirect in IKBS where RAL took on several specific functions. Other SERC staff were seconded into the Directorate for more direct involvement in managing the IKBS programme.
- Co-ordination. This includes organising workshops and conferences, providing administrative and secretarial support for Clubs (including Speech, Vision, Architectures, Knowledge Based Systems, Logic Programming and HI), SIGs (eg SIGAI) and Advisory Groups on IKBS and Formal Methods, and membership of committees and advisory bodies such as the ACARD working group on software.
- Awareness. This includes running the SE, IKBS and MMI mailshots, setting up a Who's Who in MMI, a videotape library and an on-line version of the AI Tools Catalogue.
- Contracts. Numerous contracts have been let and monitored for central purchasing and maintenance of SUNs, ICL Series 39, HLH Orions and Whitechapels; software development and support contracts (Prolog support, Prolog benchmarks, Poplog development and support, Lisp support and so on); and user support (eg GEC Series 63).
- Monitoring and Deliverables. RAL is responsible for selecting and employing monitoring officers, for monitoring projects in many areas, and collecting and disseminating deliverables. In fact, the monitoring system was originally devised by RAL staff.
- Technical Support for the Community. Discussed below.
- Academic Computing Infrastructure. This was based on four different Unix machines - SUN 2/3, GEC Series 63, Systime Vax 8750 and UTS on IBM 3081 and Atlas 10 mainframe. Tasks included endeavouring to provide similar functions on four different versions of Unix and providing local and wide area communications. One of the main reasons for putting the GEC Series 63's into selected Universities was to speed-up provision of the software needed to make the machine a commercial success and a useful tool for the entire programme. The Vaxes were initially bought only for those sites with GEC's which were responsible for porting

software from Berkeley Unix. Progress was disappointingly slow and eventually overtaken by the upsurge of workstations. The machines were, in fact, becoming a valuable resource by the end of the project - but too late. Alvey Mail eventually became part of this project and was the only part directly to benefit the industrial community; the programme's regulations meant that more direct support for industry could not be provided.

- Site Managers. Contracts were let to provide site managers at the sites with GEC Series 63 - Cambridge, ERCC, Edinburgh, Essex, Imperial College, Newcastle, Oxford, Sussex and UMIST. The site managers' jobs eventually grew to include support of all Alvey users at their site.
- Pump priming. Resources were made available to supply hardware and software for evaluation and exploration of ideas prior to projects being funded.
- Other tasks. The staff in post were a valuable resource which could be called on to carry out any tasks which arose suddenly and were needed urgently. For example, a survey was carried out of the equipment (hardware and software) being used on Alvey projects.

### 4.3.3 Achievements

In many respects the achievements of this kind of work are invisible meetings happen, minutes appear, invoices are paid, mailshots arrive, contracts run and so on. They only become visible when something fails. However, the development work undertaken by RAL for delivery to the Alvey community has led to visible results; some of the highlights are discussed below.

a. ML/LCF Effort was made available to assist Edinburgh define a standard form of the functional language ML - this became Standard ML (SML). The ML/LCF package was converted into SML at RAL and made available to the Alvey community. The original implementation was on a Vax; it was subsequently ported to SUN, UTS and Pyramid. A code optimiser was then built which produced a tenfold increase in performance.
b. FORSITE Project The FORSITE project requested RAL to build them a parser for the specification language Z, which generates SML output code. The staff to build this parser were seconded to PRG Oxford for this task. The result will initially be used by FORSITE but should be more widely applicable.
c. The Alvey Prolog Benchmarks SIGAI believed that there was a need to improve upon the Portland State University Prolog benchmarks, which had been used to evaluate the performance of various Pro logs . A contract was placed with Imperial Software Technology to produce the "Alvey Prolog Benchmarks". Cambridge were asked to analyse both existing benchmarks and the new set, and the new set was run with various prologs on various machines. The software, the results and the Cambridge report are available on request.
d. Concurrency Workbench Edinburgh's Laboratory for the Foundations of Computer Science has built a set of tools written in SML - the Calculus of Communicating Systems _ but were aware that a proper user-interface was needed if the tools were to be used by non-expert users. A joint development project between the SE and HCI teams at RAL was initiated which will result in a generalised user interface toolkit for SML.
e. Window Managers The Alvey directorate asked RAL to organise a workshop on Window Management in the spring of 1985. The results were published as a book which was typeset at RAL. The book ended with a recommended work programme. Eventually it was agreed that an infrastructure project would be undertaken at RAL to define a low level interface between graphical applications and the window manager the Client Server Interface (CSI). Once defined it was to be implemented on a number of workstations, following discussions with manufacturers. This has now been done and a RAL-developed toolkit (WW) built on top of it. The toolkit was used to build several portable demonstrators, including the editor SPY, and by the University of Kent for a collection of Unix utilities such as a file comparator and a directory/file browser. It was also used for a major demonstration at the UMIST Alvey exhibition. The theoretical work underpinning of CSI has made it possible to carry out a critique of the de facto industry standard X.11.

f. Image Processing Algorithms Library Infrastructure effort at RAL is part of the MMI IPAL project. RAL's role is to assist NAG Ltd to pull together the best available image processing algorithms into a properly designed, coded and documented library in the style and quality of NAG's other libraries. A Fortran version is due for beta-testing later this year and a start has been made on a C version. Algorithms have been contributed from Alvey projects, other communities such as astronomy and some have been developed in-house.

g. ISO Communications GEC implemented low level ISO connectionless protocols (LLC1) for their Ethernet connection. ERCC received infrastructure funding to build the York version of JANET's Coloured Books code over ISO Transport Class 4. RAL then ported this code onto a Vax (running Berkeley Unix 4.2) and UTS (Unix Version 7). GEC eventually agreed to provide the Arpanet protocol set (tcp/ip) on the Series 63. ERCC were then contracted to port SUN's Network File System over both ISO and Arpa protocols. Apart from the direct benefits to the infrastructure this also gave ERCC, RAL and the users an early awareness of the strengths and weakness of the OSI standards.

### 4.3.4 Lessons Learned

These activities have taught us many things which should be incorporated into the joint collaborative programme.

- It makes more sense for management and administrative support to be fully integrated with the Directorate rather than carried out by another organisation; any other arrangement simply adds to the communications problem.
- Infrastructure needs to be more carefully defined in terms of its objectives and target populations. The word covers a wide spectrum of issues ranging from office automation for the Directorate, through electronic mail for the whole community to common-base-like facilities for academics. It is better to define separate projects than to have a single catch-all heading.
- Infrastructure of various kinds needs to be planned and implemented before the commencement of the actual programme, as recommended by the Alvey Committee. It must also provide full facilities from the start, not rely on incomplete systems with the promise of developments to come. It is essential to a programme of this kind, not an optional extra to be added if funds can be spared.
- Having technical developments carried out within the infrastructure means that, while requests may be received from specific projects or parts of the community, the developments can be carried out so as ultimately to benefit a far wider community.
- Infrastructure must select those items which should survive the end of the programme and arrange for that to happen through mailshots, clubs and other awareness activities.
- Major infrastructure items, such as electronic mail for the combined academic and industrial communities, should be tackled more thoroughly and a mechanism put in place which is national and independent of individual research programmes.
- A mechanism is needed to provide a computing infra-structure for the industrial community similar to the one for the Alvey academics.
- Infrastructure needs its own budget, Director and status equal to the research areas for large items. Small items like Poplog support should not be classified as infrastructure but funded as pull through from research. The functions of pull-through and infrastructure are different.
- A complex computing infrastructure such as SERC's Common Base can be used as an aid to pull through.
- The different cultures and expectations, level of involvement, rules and so on, between DTI and SERC communities were problems. The joint collaborative programme will make it even more important that these are understood and taken into account. For example, SERC' s Engineering Application Support Environment must work effectively alongside an IED infrastructure.

### 4.3.5 Successes

The lessons learned tend to be negative - things which could be done better next time. However the infrastructure as a whole made many contributions to the programme and to the concepts which

are now accepted as part of the normal culture. Some of these are:-

- Mailshots;
- Clubs, Advisory Groups, SIGS;
- SERC's Unix policy;
- the monitoring package;
- EMR contracts mechanism;
- a high quality typesetting service;
- workshop organisation, including introducing many to the pleasures of The Cosener's House.

### 4.4 Infrastructure Section

#### 4.4.1 Introduction

At the start of this period, the section membership was:

- R E Thomas
- H K F Yeung
- D G Hicks
- B W Henderson
- M L Joseph
- M H Roberts
- C D Rust
- R A Day
- A B Lowe
- P J Isserlis
- I J Johnson
- N B M Calton
- I J Gunn
- M I Woods
- D F Smith
- P J Hemmings
- P A Jeffery

Arrivals

- APM (transfer) September
- BWH (transfer) October
- KMT (transfer) January

Promotions

- PAJ - SO
- NBMC - SSO

Departures

- ABL October
- IJG November
- DKG (Trainee) December
- MLJ December
- MIW February
- CDR June
- PAJ July

At the end of this period, the section membership was:

- R E Thomas
- H K F Yeung
- D G Hicks

- B W Henderson
- M H Roberts
- R A Day
- A P McDermott
- P J Isserlis
- I J Johnson
- N B M Calton
- D F Smith
- P J Hemmings
- P A Jeffery
- K M Tarling

The overall objectives of the section are:

a. Provide Systems support for the machines associated with the Alvey SE/IKBS Infrastructure and the Interactive Computing Facility. This covers:
   - Pyramid
   - VAXes, including the Infrastructure sites, the ID machines, and the Strathclyde ICF machine.
   - UTS, including applications (till February).
   - Communications: X25 and ethernet over the VAXes, SUNs, Pyramid, and UTS (the latter till February).
   - Investigate connections to Cray.
   - 3B2.

b. Develop and enhance LAN protocols.
c. Manage the EUCS GEC 63 Support Contract (till June).
d. Manage UNIX licensing.
e. Manage the RAL part of the Alvey Infrastructure Project
f. Provide a Finance System for the Division
g. Provide consultancy for the ECSTASY Project
h. Support the Informatics Division Unix Service (IDUS)
i. Provide software to control jobs for a Linotronics 100 printer
j. Interface Transputers to an IBM 6150
k. Provide systems benchmarks, management and consultancy for EASE

The following shows the responsibilities of individuals within the Section:

**Francis Yeung**
Systems support. Covers VAXes, Pyramid, UTS, 3B2 development, IBM 6150.
**Mark Roberts**
UNIX systems support. C++, IBM 6150.
**Brian Henderson**
UNIX systems support. IBM 6150.
**Chris Rust**
UNIX systems support. DWB, Linotron.
**David Hicks**
UNIX systems support. UTS, Ultrix, Linotron.
**Mei Joseph**
UNIX systems support. UTS.
**Bob Day**
Communications, covering X25, ethernet and asynch.
**Tony Lowe**
Divisional communications facilities support, especially concerned with management of the ID Ethernet Local Area Network.
**Andrew McDermott**

Divisional communications facilities support, especially concerned with management of the ID LAN.

**Jeremy Isserlis**
Communications. Protocol support, sendmail, Divisional mail service.

**Ian Johnson**
X.25 support on Pyramid and VAX. Investigate and develop OSI protocols and applications on Pyramid and SUNs.

**Neil Calton**
Communications. Distributed Services including NFS, NC.

**Ian Gunn**
Development and support of Newcastle Connection and NFS. Support of News.

**Mike Woods**
Research Associate. Worm servers.

**Danny Smith**
Research Associate. X.400 and X.500.

**Peter Hemmings**
Alvey Management Support. Manager of Finance Project. ECSTASY.

**Paul Jeffery**
Alvey Management Support. Finance Project. ECSTASY.

**Kevin Tarling**
ECSTASY. Mounting X.500 code.

### 4.4.2 Systems

This year saw a considerable change in the role of the Systems team. Classical Systems activities grew less and less. Work on the Primes came to a stop, and very little effort was required on VAXes and Pyramid (apart from Communications work, see later). UTS was run down and closed. The Alvey Infrastructure requirements were few. Instead, effort went into the IBM 6l50/Transputer link and the connection of the Linotronics 100 to the Departmental system. Effort was also expended in defining the EASE Questionnaire and putting together the benchmark suite. At one stage, it looked as if some of the ECSTASY work would also be undertaken, but unfortunately MLJ left and the work had to be moved elsewhere.

#### 4.4.2.1 Prime Systems

During the autumn of 1987, a pilot Primix service was set up by MHR on Prime-a to allow members of the user community to determine how useful Primix would be in their work. Following this, the Prime General Meeting agreed not to accept Primix for a full user service, and all work on Primix was wound up.

RET continued to chair SDM until the decision was taken to run down most of the machines in 1988. This effectively put a stop to any more development work. Since UMIST provide Systems support for the Primes, there was no further involvement required.

#### 4.4.2.2 UTS

UTS had never had a large user population, and it was proving expensive to continue running it. A plan put forward by HKFY on UTS closure was accepted by both CCD and ID, and the service was terminated (with extreme prejudice) at the end of February 1988. The two main proposals in the closure plan were that (a) the computing requirements of the Cambridge users would be met by a SUN workstation, and (b) the 4250 service would be replaced by the Linotron service.

#### 4.4.2.3 Text Processing

DGH and CDR were involved in a project to connect the Linotronics 100 phototypesetter, purchased by Reprographics, to the Departmental Service, thus providing on-line access. The work included the RISCS Interface (used by Repro to control the altered spooling system); alterations to the spool system on a SUN; connecting the Macintosh to a SUN, transferring files between the two; and investigating ways of creating PostScript files on a Mac that could print on laserwriters. A set of

user commands based largely on the existing lpr, lpq and lprm commands, has been provided. The one major purpose of this implementation has been to prevent files from being automatically printed. A system has been devised where the control files can be manipulated so that the operator may move files between directories, change expiry and due-to-be-printed dates, and selectively print pages from files. In addition, a service was to be provided for IBM-hosted users; this has been delayed until IBM provide their own suitable software. CCD have postponed their development of this and are waiting for the IBM code. Otherwise, the project is now complete (though it seems little used).

#### 4.4.2.4 IBM 6150

HKFY, MHR and BWH have been heavily involved with the IBM 6150 system. The machine already at RAL underwent a number of changes of Operating system, together with a series of upgrades. It is now running AIX 2.1.2 (and will shortly go to AIX 2.2), and was changed from a model 25 (2.1 mips) to a model 125 (4.5 mips) with hardware floating point and an extra disc. It also has a 3278 emulation board (allowing it to be used as a PROFS terminal) and TCP/IP ethernet. This last item has caused some problems to the Service, and to date these have not been fully resolved. The current version of AIX includes BSD sockets, required for IBM's implementation of X-Windows.

In November, outline agreement was reached with IBM on a proposed Joint Study, which would involve connecting Transputers to the 6150 and reporting on the effect of using this system in an Engineering environment. RET organised the paperwork, and tried to chase this through the various systems. This has taken a very long time, including the involvement of senior people in Swindon. The agreement was finally signed by SERC in June. IBM's part of the deal is to provide three machines, with a variety of peripherals. These have now begun to arrive.

In anticipation of this work, investigations into Transputers on the 6150 started much earlier. The Inmos TDS system was ported, and integrated into the Unix environment. A single transputer board was successfully connected, and a version of the Mandelbrot program run (not very impressive visually on a black and white screen though!).

Modifications to the algorithm and using 5 transputers, it was possible to obtain a five-fold increase in speed. The Gaussian elimination algorithm from BIM2D was converted to run over a network of transputers, and BIM2D itself was run using this algorithm. There was a long delay before Inmos' FORTRAN compiler was available, which allowed engineering applications to be developed in a high level language (rather than Occam). In addition, the Occam toolkit had to be mounted, and the MSDOS interfaces replaced. A version of BIM2D was successfully run, and one trial involving a 32-transputer board has produced a system seventy times faster than that obtained on a single T4.

#### 4.4.2.5 EASE Assessment

Following the definition of EASE, work was started in planning the first of the assessments which would be required by the new policy. Systems had a full share of this, providing benchmark programs for Languages (Fortran, C and Pascal) and Unix Systems (AIM2, Byte, Spiral and sysv_interface). In addition, HKFY was responsible for producing the first draft of the questionnaire, which would be used to elicit relevant information from suppliers in as painless a manner as possible. RET spent some time interacting with EC Group to refine this questionnaire as the EASE requirements changed.

Once the initial set of test routines had been provided (and other members of the Department bullied into producing applications benchmarks), the set was documented and handed over to EC Group for running. Further tests were provided by them to cover X-Windows, and by NBMC to evaluate NFS. This last was considered very necessary, following experiences with different manufacturers.

The actual Questionnaire was sent out in June, and most of the replies have been received. Benchmark machines have also been obtained, and much testing undertaken. It is intended to provide a paper for CFTAG in September, giving a general view of the ability of the contenders to perform in an Engineering environment.

### 4.4.3 Communications

The Communications Section suffered the loss of three members during the year. Ian Gunn left to take up a programming job with Reuters, and Tony Lowe transferred to A&G Division to join a project studying the behaviour of ocean waves by radar. Mike Woods left in February to become an IBM PC expert. In addition, IJJ has had considerably mixed fortunes, having had a severe bout of flu during the winter, and then being involved in a serious car accident. All this has made it very difficult to carry out the work required. On the credit side Andrew McDermott transferred from Graphics Section; he has taken over the management of the LAN from Tony. DFS has proved to be a great asset also.

#### 4.4.3.1 Department LAN

Since ABL's departure, most of this work has been undertaken by RAD and APM. Much of the requirement has come from the office moves. The main work has been the installation of thin ethernet in R1, and the R25 connections. The interface to the RAL Site LAN required a complete rewiring of the ID Comms rack. In order to help keep track of all this, APM has set up a database giving details of the connections of machines to the ether.

RAD and APM have investigated a LAN modelling package called PLEXUS from Insight International. This allows a model to be built up of a LAN and the hosts attached to it, and gives details of LAN traffic and host loads. The advantage of using such a package is that it might be possible to plan for file server upgrades rationally, rather than by the ' finger in the air' approach used at present. For the evaluation a model was set up of nfs5 and all its discless clients. The results were encouraging enough to suggest a continuation of the work. The HP Monitor has proved very powerful in taking measurements.

#### 4.4.3.2 RAL Site LAN

RAD and APM have been involved in the setting up of the Site LAN. The installation moved on fairly slowly; meanwhile everyone tried to work out how to manage it once it was commissioned. RAD's contribution was to investigate the running of IP protocols over the LAN (of increasing interest as other Departments get SUN workstations). He produced some traffic analyses, and suggestions as to how things might be managed. These Management Guidelines based on our own experiences of running the ID LAN found favour with the Management Committee (a slight case of grasping anything that fills the vacuum!), and are now being tidied up to become the first stab at solving at least the human side of managing a potentially unmanageable system.

RAD negotiated for Informatics to provide advice and help to other Departments when installing IP equipment and software, in return for manpower from CCD. Help has also been given to those working on PC/NFS for the TECHELEC and Neutron Division Villages.

APM is now collecting statistics for the number of packets sent over the Bridge IB/2 onto the Backbone. Other Villages use DEC LAN Bridge 100s which are not capable of all the functions required by the ID Village but can be accessed centrally by CCD. It is therefore easy for CCD to gather statistics from other villages but not from ID, so we have to send them to CCD manually.

#### 4.4.3.3 Bridge Evaluation

The JNT announced that they were looking for an organisation to evaluate MAC bridges with a view to providing advice to the UK academic community on which bridges to purchase. As this is an area in which Communications Section has an interest as well as some expertise (gained when we undertook the evaluation of bridges for the RAL Site LAN last year), RAD prepared a bid to do this work, which was accepted. This means that for the next two years the Section will perform a continuous assessment of Ethernet bridges, with a view to providing the list of approved bridges that JNT will recommend for UGC purchases. York officially starts on this on the 1st August; once again APM will be involved, along with RAD.

During April and May APM helped RAD with the evaluation of the BICC ISOLAN Primary Bridge which was subsequently bought from FOSS and is now in place as the bridge between Red and

Green Ethernets.

#### 4.4.3.4 X25

Both IJJ and PJI were involved in trying to get SUNlink X.25 version 5 and the Coloured Books package working. Eventually, the Yellow Book Transport Service software was acknowledged by SUN to be bad and replaced. The Coloured Books Service provides users of SUNs with PAD and File Transfer facilities over JANET. The implementation is such that the access to these facilities is transparent to the user : previously, users had to login in to a machine such as Pyramid-a to use these facilities. IJJ achieved this by using the REX protocol which SUN and Pyramid supply. This RPC protocol allows the remote execution of commands on a server, and ensures that the remote command inherits the same context as the client process.

IJJ commissioned X.25 on the Pyramid WorkCenter nfs4 after it was upgraded to run OSx 4.1. This was not straightforward, as the X.25 distribution tape from Pyramid contained new versions of some programs, now with added bugs! IJJ had to back-off the new programs, and re-install earlier versions from Pyramid-a.

IJJ attended a meeting of the Joint Network Team LAN Advisory Group on January 7. The aim of this group is to provide input to section B of the JNT on technical and strategic matters concerning LANs in the UK Academic Community. The work that members of the LAG undertake includes evaluating products, providing input to standards committees etc. In representing RAL ID, IJJ can try to make sure that LAG decisions are relevant to the networking environment in Informatics. This is important because most of the LAG members come from the large mainframe, connection-oriented mould.

#### 4.4.3.5 Mail

PJI has continued his work on the departmental mail system to handle electronic mail to the unix based workstations and, eventually, the unix system multi-user minis. So far this is based around the notorious sendmail package and SUN's Networked File System, NFS. Diversions along the way were concerned mainly with acting as an unofficial alpha test site for SUN's chargeable (and paid for) networking products, by now based on SUNlink X.25 version 5 and the York Coloured Book software as resold by SUN. The system now handles mail for all the IDUS machines, dealing with an average of 700+ messages per day.

Further developments included: improving the mail headers, providing client user commands to inspect the progress of X.25 mail leaving the mail server and providing mail access (with authorisation) to sites through the PSS gateway from sendmail via standard user mail interface programs. Some faults in mail address handling were corrected and the Departmental Mail System now knows about the common ISO international domain names.

#### 4.4.3.6 Distributed Filesystems

NBMC has continued with the distribution of NFS to the Alvey sites, and NFS was installed at Edinburgh (the final site) in December. Bug reports have continued to come in and these have been fixed where possible. MIW also assisted NBC in some of the VAX work.

Some time was spent by NBMC aligning uids and gids on Vax-f for Yellow Pages, and helping MLJ with NFS on the ULTRIX machine (Vax-m). In addition NBC has produced a comprehensive guide to NFS and Yellow Pages (CTN/P19). A precis of this was issued as an IDUS paper. NBMC has prepared and given a talk on NFS at a number of New Users Courses.

NBMC went to Sussex to help them reinstall NFS on their VAX. NBMC also prepared for and installed NFS on Vax-c at RAL. He has recompiled and installed a number of utilities on the ID VAXs which had been affected by some missing bug fixes in the libc library. These remade utilities were sent out to the Alvey sites with VAXs. In addition, NBC prepared and distributed the binary files for NFS so that sites could attempt to build their own kernel.

NBMC prepared for running the NFS evaluation test suite on the Apollo, helped run the tests, and investigated some of the problems that arose. A paper on the results and remaining problems with Apollo's NFS was produced.

APM and NBMC have begun work on implementing Yellow Pages on the Pyramid. A client only service has been established on nfs4 and login altered to permit YP access. The YP utilities have been tested with the new release of OSX4.1. Problems with the passwd program were fixed. With help from APM the system utilities have been recompiled to work with YP.

RAD and NBMC evaluated a new 3rd party controller for SUN fileservers. Called the Rimfire, it was claimed that the controller would outperform the standard SUN offering by a factor of two. This might be true for test cases; unfortunately when it was tried with the NFS benchmarks it was found that its performance at high loads was actually worse than the SUN controller.

#### 4.4.3.7 X.400 and X.500

DFS has continued his work with the OSI standards. This has involved reading and summarising the protocol specifications, attending meetings, and delivering seminars. The first half of the X.400 recommendation summaries have now been completed. He has joined the IGOSIS IG5 and IG8 groups (Message Handling and Directory Services respectively), and is attending meetings of both groups. He has attended conferences and seminars on X.400, and attended courses on ASN.1 and X.500.

During December, negotiations commenced with UCL to get ourselves involved with a project on directory services. The project is called THORN (THe Obviously Required Name-server). As a prerequisite, the ISODE (ISO Development Environment) from Northrop needed to be installed.

In February, DFS took delivery of the THORN code from UCL, and proceeded to install it. He was requested to document any problems that were encountered, and report back. DFS modified the installation documents and returned these to UCL for perusal. Next, he was asked to help with making comparisons on the time delays between using X.2S and TCP/IP over Ethernet for accessing the directory. It is now possible for us to bulk load data across the network into the UCL directory.

RAD has been involved in organising a small project with KMT and DFS to attempt to use X.500 in a real application - as a way of allowing IDUS users to control their choice of mailbox within the IDUS Mail Service. This involves a fairly loose interface of the UCL THORN code to sendmail; KMT carried out the actual work on this project.

Various new versions have appeared at irregular intervals, and DFS has been the guinea-pig used to see if each version can be installed by an Australian-standard idiot (thus certifying the installation procedure as proof against the British-standard version), and checking that the stuff actually works once installed. He has been able to feed back a lot of "helpful" comments to UCL in both respects.

DFS has been progressing with the task of integrating the X.500 directory with the ELM mailer. This is a test bed to see how a directory should (or shouldn't) be used within a mail interface. This is getting to be quite interesting, the essentially boring bits of just getting the two to interwork having now been overcome.

#### 4.4.3.8 News

NBMC spent quite a lot of time becoming familiar with the Usenet News system and uucp, following IJG's departure. As a result of this several changes were made to the newsclean procedure on Vax-d to make expiration of news more efficient and reliable. An investigation was made to see whether expire could be made to run on nfs3 but this proved to be not feasible. However, the exercise did provide further useful knowledge about the News system. As a result of this, changes have been made to the News-posting program inews, and the News-reading program rn so that articles reflect the correct mail address (for rl.inf, the new mail server) in the headers. Work is now proceeding to migrate News to Pyramid-a, in preparation for the withdrawal of Vax-d from service next year.

#### 4.4.3.9 Networkshop

Along with RAD and DFS, IJJ attended Networkshop 16 in rain-swept Reading from March 22-24. The whole attitude of this meeting was different from last year, as the number of SUNs and other UNIX systems in the community has greatly increased. For IJJ, the most noteworthy point was Roger Evans, head of the Supercomputer Unit at RAL, getting very enthusiastic about running RPC-based applications between UNIX workstations and the Cray. For RAD, the highlight was to hear the JNT finally accept that distributed file systems are important, and that they will have to make recommendations concerning them without recourse to OSI protocols.

DFS was immediately involved with setting up a demonstration of the THORN project at Networkshop, following his brief visit to Oz. This involved building a system, installing the code, and setting up the completed product at the site. The demonstration was a great success.

#### 4.4.3.10 European Networkshop

RAD (with DFS) attended European Networkshop for the first time. These are organised by RARE, and this year's took place in Les Diablerets, a small village in the Swiss Alps. The main topic of the workshop was the proposed specification for COSINE (the intended European OSI network), along with plenty of opinions on how to implement it (or, more accurately, on how it *shouldn't* be implemented!). There were some interesting semi-technical papers too. The visit was complicated by the fact that (a) the JNT lost the applications; (b) DFS was being paid for by the University of Queensland, not RAL; (c) the University of Queensland basically believes travel should be free (hitch-hiking?), necessitating frequent referral to the ox-cart timetables etc. RAD & DFS took the opportunity whilst "almost there" to visit IBM's European Networking Centre in Heidelberg & find out about IBM's forthcoming products in X.400 mail.

#### 4.4.3.11 Compute Server

MIW worked on the Worm server project, which attempted to provide a system which would make use of spare compute cycles in machines around the network. Much progress was made including the development of a reliable remote procedure call mechanism. Nearly all the fundamental services are now provided (that is, those outlined in CTN 9) but MIW left before he was able to complete his work on the higher level issues. This is now in a demonstrable, albeit frail, state. Hopefully it will be possible to resurrect the work one day, and to find someone with enough time and effort available to prototype some "real" applications over it.

#### 4.4.3.12 Esprit Project - ARGOSI

RAD became involved in an ESPRIT II project proposal with DAD, JRG and DCS. RAL was originally invited to join a project with the unlikely aim of transferring Computer Graphics Metafiles across X.400 networks, mainly because the latter were there. RAD attended a meeting in Berlin where the real aim of the project was properly identified. This is to study how one uses OSI networks to achieve distribution of graphics applications, a subject not at all well understood at present. This proposal is now going ahead, and RAD is participating with the aim of eventually bringing to the section the task of handling the networking issues involved in the project, called ARGOSI (ARGOSI stands for Applications Related Graphics and Open Systems Integration; every ESPRIT proposal must have a suitably meaningless acronym!). Preparing the proposal meant a considerable number of meetings scattered around Europe Paris (January), Rome (February), Abingdon (March) and finally Paris again at the end of March. RAD also organised the Abingdon meeting, held over a weekend in the Abingdon Lodge Hotel. The ARGOSI proposal was finally kicked into shape by the end of March, allowing it to be submitted to the Commission 5 days before the April 12th deadline - something of a record. The current state of play is that the Commission probably will fund it (albeit with only 50% of the budget requested). RAD and DAD spent some eventful days in a variety of European locations rewriting the budget and persuading everyone to agree to it.

#### 4.4.3.13 Access to Cray Facilities

RAD spent a small amount of time setting up a SUN system to access the Atlas Cray for the purpose of job submission/retrieval. The rationale for this was twofold: a desire by CFTAG to assess the feasibility of providing "fast batch" access to the Cray, and a desire by CCD to gain experience of Unix access to the Cray, in anticipation of UNICOS developments in particular. The work involved connecting a SUN to the Hyperchannel that currently connects the Cray and Vax/VMS workstation and installing the appropriate drivers and Craystation software. This proved successful and the system has had some limited but regular use. It is planned to expand the usability of the system in the light of a grant award to the Dept of Mechanical Engineering at Sheffield University, who wish to access the Cray in this way.

### 4.4.4 Management

This year saw the beginning of the end of the Alvey Infrastructure. In December, the Alvey Board decided to close the GECs, and to cut the funding by half in the next financial year. Hints of this had already been received earlier, so the October Site Managers Meeting was very low key. Ironically, the January meeting (in Brighton) was quite lively.

Disposal of the GECs proved easier than anticipated, as Daresbury had a use for them, and transfer to them was within the rules. Only Essex have decided to continue to run the machines. A greater problem was the EUCS Support contract. It proved necessary to invoke the termination clause, which is not something one wants to do at the best of times. Again, it was ironic that EVCS just managed to complete the NFS work before the machines were closed. If only everything had been two year's earlier.

The year also recorded two firsts: we managed to complete all the reconciliations and get all the bills in before the end of the financial year, and PAJ managed to produce a paper containing details of the statistics from all the machines. PJH and PAJ organised the Site meetings, and PJH and RET carried out the reconciliation visits. Agreement on next year's budget was also reached, although it was only possible to save £40K. In one case, the amount agreed for 1988/89 was more than previous years (since those without machines did not have to pay the 10% usage fee).

In April, RET and PJH were forced into a considerable amount of digging, caused by a request for data by the Public Accounts Committee, which was investigating the National Audit Office report. The greatest problem was ensuring that all the figures presented from the various different areas (both subject and geographical) were consistent. Eventually, since nothing further was heard, it was assumed that the figures were accepted.

### 4.4.5 Central Servers

RAD was involved with JRG in the ECF's Operational Requirement and subsequent Tender for Central Servers. These are defined to be machines capable of supplying NFS and paging services for single-user workstations, along with providing good communications to JANET and to University campus networks. CFC wants to place Central Servers in University Departments where a significant number of workstations are either already present or will appear as the result of new grants. Using a Central Server means that economies can be made by avoiding expensive purchases of discs for individual workstations, as well as giving the workstation users access to a better range of services.

As a result of this work SUN and Pyramid were selected as potential suppliers, and a Pyramid WorkCenter purchased for further evaluation. CFC has now made funds available for the first batch of Servers, and bids nave been invited for their placement. RAD is assisting in the evaluation of these bids.

### 4.4.6 ID UNIX Service

The running of a recognised Departmental service must be considered one of the success stories of the year. A small management team chaired by KFH, with RET as secretary, handled the project. MEC reported on the service aspects, and RAD was in charge of the Technical projects. Further

management input came from USM (service), ULM (strategy) and IDUUF (user forum). It proved possible to agree budgets and future work plans.

RAD has run the text processing project (which saw the establishment of its basic DWB service), and the mail service project (very much a Comms. Section show, with most of the work done by PJI and described elsewhere). RAD also purchased a new fileserver for IDUS and produced a plan for the rationalisation of the VAX systems in the Department in the light of the rundown of Alvey finance. It was decided that we should scrap everything except Vax-d. Plans are also in hand for the removal of the last SUN2s from the Gold service.

A security breach was noted, and this has caused work to start on a proper Security Policy document.

Negotiations have begun with CCD to see whether we can use their services for performing dumps. The main problem is the lack of high-speed connections to the IBM systems. At the last meeting, CCD were investigating mounting TCP/IP on the 3090. Various printers have been taken on trial to see which machines should be purchased in future. Work is still in progress.

### 4.4.7 Ecstasy

ECSTASY is the Control Engineering environment being written at UMIST to interface various existing packages to make interworking easier. It is based on PASET tools, and Pro-MATLAB, and interfaces to the simulation package ACSL. The intention was to bring this into use during the year, both for academic and commercial engineers. RET acted as consultant to this effort (mainly helping them produce an understandable project description). This was sent round to a great many interested parties in the autumn of 1987, and the replies were sufficiently encouraging to allow work to continue. However, there have been many delays, and beta testing will now not take place till the autumn of 1988. The intention is to hand the system to RAL to organise support and maintenance (possibly with a Commercial organisation such as Cambridge Control).

In order to provide the necessary help, it was agreed to start training RAL staff. Initially, this involved HKFY and MLJ, but, having just got started, MLJ resigned. Given the shortage of staff in Systems, it was decided to move the project to a new home, and PJH and PAJ began to be involved. They were joined by KMT in February. Together, it proved possible to mount a version of the software at RAL (although there were frequent changes to the code at UMIST) and to interface a new simulation package, TSIM.

In addition, it was decided to test the portability of the software by trying to mount it on a VAX running VMS. The work is being done at Oxford, with the contract managed by RET. So far, progress has been slow but steady. The main problem has been simulating the Unix pipe mechanism.

### 4.4.8 Alvey Mail

During November, PJH became responsible for the Alvey Mail project. He carried out an analysis of the replies to the Alvey Mail questionnaire concerning the quality and usefulness of the service. Little seems to have been done with the information, however. It was decided (by the Alvey Directorate) to close the service at the end of September 1988, but then a late request was received to extend the service to the end of the year. Current thinking within DTI suggests that any future service will be based on Commercial systems, and that no further RAL involvement will be required.

### 4.4.9 Finance Project

PJH developed the Divisional Finance Project, aimed at automating the production of regular financial statements for the Department by the DAO. This had begun by studying the methods used by the previous DAO. A feasibility study was carried out to see what information could be extracted from FDS, the on-line system available on the central IBM. The study showed that while there was a lot of relevant information accessible, it was geared to casual use from terminals only. There were also some limitations on textual output. PJH had consultations with Central Computing Division

which resulted in a variation of the FDS program suitable for this project, and wrote a set of programs to produce the tables required by IGLM finance papers. PJH produced the papers himself initially, and then organised a suitable interface so that the job could be performed by the DAO.

Some changes have been required since the original system was installed. One set was necessary to reflect changes that were made in FDS at the change of the financial year. Others were added to handle departmental data, including project definitions and allocations, pertaining to different financial years, and a method of including the DAO's descriptions of requisitions.

#### 4.4.10 TIGER

TIGER is a UIMS (User Interface Management System). A UIMS is used by application programmers to write their own customized interfaces. A visit to Team Engineering in Santa Cruz, California, was carried out in February. DGH helped Brian Colyer to use TIGER to re-program some of the user interface components of the apple finite element application. Although only a small subset of the apple code was actually interfaced, enough was done to convince Brian of the suitability of TIGER. Since then, DGH has been evaluating the TIGER package. Essentially, this has so far meant taking two Fortran-77 applications, removing the "ww specifics, and replacing them with TIGER function calls. The aim is to fully replicate the functionality of the original interactive graphics. In parallel with this task, UMIST are evaluating PASet, using the same two Fortran-77 programs. A comparison of the two UIMS will then be possible.

TIGER employs high-level graphics drawing routines and so certain functions that are performed with the ww routines can not be performed with TIGER. At the moment it looks as if PASet might be able to provide more functionality than TIGER as far as graphics primitives are concerned but TIGER appears easier to program.

#### 4.4.11 Trainees

Once again, ID played host to 7 trainee scientists, to give them some short exposure to Unix. CDR supervised them, and RET provided the customer feedback. The extra time, and the previous training in Unix and C, meant that the results were better than in previous years. However, it was the last time that UTS could be used, so new plans will be required when the next batch arrive.

#### 4.4.12 Business Cards

PAJ automated the production of Departmental Business cards (originally designed by NBMC) so that the DAO can produce them on request with the minimum of input. Individual cards have been provided to group leaders and other selected people. General cards are available from the DAO for anyone.

#### 4.4.13 Departmental Handouts

PJH produced a revised set of Informatics handouts from material supplied by group leaders. These have to be generated in a variety of ways and PJH designed and implemented an interface for generating them automatically.

#### 4.4.14 Conferences, etc

- DGH represents Systems Section at the Monthly UNIX Service Meeting. APM represents Comms Section.
- PJH attend the GECOPS meeting with EUCS and GEC.
- PJH, RET, NBMC attend the Alvey Infrastructure Project Progress meeting.
- RET attended RAL-UMIST SDM.
- RET attends DEC Progress Meetings.
- RET, HKFY, RAD, attend ULM.
- RET, PJH attend EUCS Management Meetings.
- RAD, ABL and APM attend the meeting on Site LANs organised by CCD.
- RET, RAD attend NDM.
- RET attends FSC.

- RET attends RCCC.
- RET attends ECSTASY Management meetings.
- RET, RAD attend IMM.
- NBMC and PJI attended a Network design and protocols course at ICS in London, and the UKUUG Net Workshop at City University in London.
- NBMC Papers: Everything you always wanted to know about NFS. CTN/P19/97. An overview of the Network File System and Yellow Pages. IDUS Note 12.
- IJJ has joined the Joint Network Team's LAN Advisory Group to represent the needs and interests of ID. The background work for this involved trying to make sense of the minutes of previous JNT-LAG meetings!
- IJJ attended Compec '87 on November 20. This did not have much of interest in the Communications/Systems fields. Displays that IJJ did find interesting included Benchmark Technologies with their high-end graphics machine and the Transputer Forum. Participants in the Forum included Niche Technologies, who sell a VMEbus Transputer card for SUNs.
- Since joining the section Andrew has replaced both Tony Lowe and Ian Gunn on the Unix Service Meeting at which he represents the Communications Subsection.
- MIW and RAD attended the International Conference on Distributed Computer Systems in Berlin which proved invaluable in shaping the design of the Worm Server project.
- MIW continued to attend Brunel University one day each week, for an MSc computer studies course.
- RET, KFH attended the Alvey Evaluation day, Kingsgate, October 1.
- KFH, RET, NBMC, PJH, PAJ attended Alvey Site Managers Meeting, Coseners, October 13.
- RET, HKFY, MHR, BWH attended the 6150 presentation, Warwick, November 18.
- RET attended the ODA seminar, London, November 23, 24.
- RET attended the DB Workshop, Coseners, December 3.
- PAJ attended the November Occam Course at RAL given by INMOS.
- KFH, RET, NBMC, PJH, PAJ attended Alvey Site Managers Meeting, Brighton, January 28.
- KFH, KMT attended the X-windows workshop which was held at the lab.
- NBMC attended a one day Networking UNIX course at Instruction Set in London.
- NBMC Papers: NFS Evaluation Suite. CTN/P2l/88. Instructions for running the NFS Evaluation Suite.
- During January APM went on a series of courses in London to learn about networking protocols.
- PAJ attended the advanced 'C' programming course at Instruction Set in January.
- RET attended the Esprit meeting at QMC, January 7.
- RET attended a meeting on "Choosing an IPSE" given by NCC, January 12.
- RET attended the Alvey Comms Club meeting at Kingsgate House, January 28.
- IJJ attended the JNT LAN Advisory Group, January 7.
- IJJ attended the Pyramid User Group meeting, January 28.
- RET attended CDTCE meeting, UMIST, March 10.
- NBMC attended the Omnicom courses on the OSI model and Upper Layer Application Protocols (3 days). He also attended the Networks 88 Exhibition and the European UNIX show in London.
- Paper: NFS Evaluation on the Apollo. CTN/P29/88.
- DGH has attended a two day course in Manchester to learn about PASet and offer advice on the two Fortran-77 programs.
- PJI: Courses: MRS, given by Omnicom. Meetings: Pyramid User Group.
- IJJ attended the 5th meeting of the JNT LAN Advisory Group (LAG) held on 27th April. This meeting discussed the evaluation mechanisms for evaluating new items of comms kit, and the setting up of a Ethernet Bridge Evaluation Centre, which ID will run.
- IJJ attended the meeting of the UK Pyramid User Group held on 5 May, along with PJI. The view of those users still having servicing and software reliability problems was that Pyramid had greatly improved their response.
- IJJ attended the 8th IEEE DCS meeting held in San Jose CA on 13th to 17th June. This covered much new work in the area of distributed computing, and also some applications of

established work. One particularly interesting item was a reliable NFS service using replicated servers that are (transparently) accessed via fault-tolerant intermediate agents.
- IJJ, along with MHR, attended the Summer 1988 USENIX Conference held in San Francisco. This was of a much higher quality than previous USENIX conferences because authors had to present their papers in full to the Conference committee, rather than just an abstract as before. Some of the presentations described software tools and systems which are expected to enter the public domain and could be useful at RAL.
- IJJ Papers etc.
  - CTN15 Distributing WAN Services to Machines on a LAN.
  - CTN25 Report on Pyramid UK User Group meeting held on 25 January 1988.
  - CTN26 Running The Coloured Books Service.
  - IDUS18 The Departmental Coloured Books Service.
- MHR attended the San Francisco Usenix conference in June, and made visits to SUN, Pyramid and the NASA Ames laboratory in California.
- RET attended the EASE workshop on Integrated Systems, Leeds, April.
- RET attended the NCC workshop on System Development Methods, London, May 19.
- RET attended the Systematica Demonstration of their SUN Development tools at Heathrow, May 20.
- RAD attended Omnicom's courses on MHS, X.500 Directory Services, and ASN.1.

### 4.5 Human Computer Interaction

#### 4.5.1 Introduction

The section's interests lie in the general area of user interface design on advanced workstations, undertaken both by doing R & D work in the area and by supporting relevant research work elsewhere. The major funding areas are:

1. Technical support, by work in the user interface/window management area mainly for the Alvey LDP/HI Directorate.
2. Programme support, primarily for the Alvey HI community, but also for the wider ex-Alvey MMI community.
3. Investigation of more advanced techniques of possible use to the SERC Engineering Board community, particularly with funding from the EB's Computing Facilities Committee.
4. Direct research grants from SERC committees, particularly the Computing Science Sub Committee.

Staff currently in post are:

- Ken Robinson (KR)
- Tony Williams (ASW)
- Tony Conway (TC)
- Mark Martin (MMM)
- Keith Dancey (KDG)
- Chris Crampton (CMC)
- Crispin Goswell (CAAG)
- Graham Freeman (TGF) (Visitor)

CMC and CAAG both got through the promotion system this year. Both Helen Jenkins (HVJ) and Jacqui Smith (now Perkins) have provided effective secretarial support during the year.

#### 4.5.2 Window Management

The Alvey MMI Directorate approved work to proceed at RAL on a Client Server Interface. The project's objectives are two-fold: (a) define a low-level software interface (known as the Client-Server Interface or CSI) to window management functions implementable on a range of workstations, and (b) implement the CSI on selected workstations as an existence proof. With

vendor support for the CSI, application toolkits such as WW, which at present require extensive work to port to new environments would become much more widely available, easing greatly the work of applications programmers. Phase (a) was completed last year. The implementation on the PERQ (with limited functionality) is complete. Further work has been stopped due to (a) the disappearance of any significant UK vendor and (b) the wide availability and vendor support for X.

Some interesting prototyping work was done on a layout manager (user interface) based on the CSI (CAAG). Some experience has been gained with X version 11 including performance improvements which make the SUN version usable (CMC, CAAG) as well as the application of the MIT bug fixes. Some assessment of associated X software has also been made.

### 4.5.3 Edinburgh CCS User Interface

Robin Milner's group at Edinburgh have a reputation for good formal methods work, and have realised that a good user interface is necessary for effective take-up of their work by ordinary software engineers. Following some discussions the Alvey Software Engineering Directorate agreed to fund work at RAL to provide a user interface for the CCS concurrent programming workbench. MMM has done most of the work in providing a prototype user interface based on the object-oriented toolkit (see below), with help/comments/criticism from the rest of the section.

### 4.5.4 WW and Utilities

MMM has continued to work on this graphical toolkit, aimed at applications programmers needing tools to write highly interactive applications. This year's improvements include: extensions to the conv utility to enable pictures in troff or PostScript documents; pulldown menus; greying; bezier curves; flood fill; arbitrarily large cursors; more font metrics; and extensively reworked input. Some work was also done to isolate more effectively machine dependencies. WW is now available on SUN X11 and X11 release 2, and on the Whitechapel HiTech. The usual support activities have continued.

Experience with the Spy screen editor has led to MMM writing TEN, which gives more screen real-estate back to the user, as well as better functionality based on WW improvements such as filestore browsing, menus, cursors, small text areas and cut and paste with the window manager. A trial version of slow scrolling, and many changes to the user interface, were undertaken. The rewritten man page now has an annotated picture.

### 4.5.5 RALpage

RALpage is the new name for the PostScript previewer. During November 1987 the software was posted to the Usenet news network and is in use at many hundreds of sites world-wide. The software has since been improved to read screen fonts in preference to the previous algorithmically generated ones. Some productising has been done to make it part of the ID Unix Service. (Mostly CAAG, with some ASW.)

There has been considerable commercial interest, and RAL Admin have (eventually) drawn up a contract, although this took some considerable time.

### 4.5.6 Alvey Demonstration

The Alvey Demo material has been tidied up and is now in one place (MMM).

### 4.5.7 Extensibility Project

This CSSC-funded project is investigating the ways in which extensibility can operate in a graphically-driven environment. It is now well into the first phase with various experimental tools built by CAAG - a graphical spreadsheet with a spy-like user interface, and a graphical unix terminal emulation which has programmable menus. Discussion papers have also been produced (CAAG, ASW).

### 4.5.8 Object-Oriented Toolkit

A prototype basic level OO Toolkit has been developed, mainly by CMC, but with much advice (you can't be serious!) from ASW, CAAG, and MMM. This is written in C++. A set of primitive classes, useful for building more complex widgets, has been provided and will be distributed shortly. The GNU C++ compilation system has been obtained with a view to comparing it with the AT&T system.

### 4.5.9 Programme Support

CAAG continues to act as Mailshot Coordinator, with KR trying to sort out minor problems as necessary. CMC looks after the videotape library.

#### 4.5.9.1 Who's Who

This project aims to provide access to information on MMI research interests and services in the UK. KGD took over the project from Arthur Seaton and has done most of the direct database and form design work using various versions of INGRES.

After many problems with the public domain INGRES, the SUN INGRES version was purchased. This took three months to arrive as Harwell Contracts were determined to sort out the whole software licence situation properly. After many calls of increasing intensity they relaxed their stance and shortly after Xmas it arrived (KGD, KR). The work of structuring the database and correcting the data was also undertaken. The front-end (user interface) for the database has been defined but so far has resulted in bug reports rather than software. A paper version has been produced for DTI.

#### 4.5.9.2 Committee Support

TC looks after the Alvey Human Interface Club Steering Committee, under Vic Maller's chairmanship. As well as the usual secretarial duties, this has also required organising a HI Club meeting in November (with KGD) , and some support work for the HI Special Interest Groups. The HI Professional Bodies Liaison Group is also supported.

#### 4.5.9.3 PUMs

PUMs are Programmable User Models - these are things that the interface designer might have to program in future to see how good or bad his interface design is. (Think about an architecture which has memory which forgets if you give it too much to remember.) Richard Young at the MRC Applied Psychology Unit at Cambridge is undertaking this work with Alvey HI funding. KR is the Monitoring Officer for the project.

### 4.5.10 COMMETT

COMETT is another Euro-initiative, this time for courseware for CBT. DAD, KR, ASW and TC have prepared an outline project for a course to be given on HCI in December at Darmstadt.

### 4.5.11 Research Projects

The Chemical Engineering Plant Design proposal finally did not get funded, with comments betraying the fact that it was not really understood. The Twinning proposal with the Technische Hochschule, Darmstadt was also not funded.

Now the good news. ASW, TC & KR spent many months preparing ESPRIT II proposals and it is now very likely that three of these will be funded EWS (a high power technical workstation), ELO (The ELusive Office - mobile teleworking), and MMI2 (multi-modal interface to knowledge based systems, mainly written by Mike Wilson). A number of IED proposals are also under preparation; and a number of discussions have been held with DEC - a large award under their European External Research Programme is likely.

### 4.5.12 Miscellaneous

The usual collection of things that do not fit neatly above are reported on here.

Exploitation of RAL Software. There has been much discussion and some actual progress with BTG on the exploitation of WW and associated software, with BTG finally relinquishing their rights.

KR has probably suffered the most. ASW had managed to persuade ICL to allow spy to be distributed to commercial companies (for internal use only), and later in the year KR finally got ICL to let us sell up to 500 copies per year!

UIMS Survey. ASW cooperated with MJP on the gathering of information for the ECF Programme, generating assessment criteria and a detailed assessment of the products. TGF, a visitor from Australia's CSIRO, has been working on the assessment of Apollo's Open Dialogue.

ECSTASY. This is a project at UMIST on which ASW provides consultancy on user interface issues.

#### 4.5.13 Future Developments

The following projects are envisaged for the coming year, given funding:

1. Extending the object-oriented library for graphical user interface development.
2. Continuation of work on the Extensible Graphical Programming project.
3. Commencing work on the ESPRIT II projects.
4. Preparing the COMETT courseware.
5. Building up the Human Factors work.

#### 4.5.14 Conferences and Courses

- ECF Workshop on UIMS, Glasgow, 19-21 September 1987 (ASW)
- Visual Programming Workshop, EuroPARC, March 1988 (ASW, CAAG)
- OOPS Symposium on User Interface Technologies, London Zoo, May 1988 (CAAG, talk on Object-Oriented Toolkits (ASW))
- Management Course I Part 2 (CAAG)
- Technical Writing Course (CAAG)
- X Conference, Boston, January 1988 (CAAG)
- X Tutorials, 1, 2 (CAAG, CMC, ASW)
- Visual Programming Symposium, London (CAAG)
- Alvey HI Club Town Meeting, London, October 1987 (TC, KR)
- Next Steps in Cognitive Science Meeting, Oxford, November 1987 (TC)
- BPsS Mathematical Statistics Meeting, London, November 1987 (TC)
- Human Factors Laboratories Meeting, Loughborough, December 1987 (TC)
- User Modelling SIG Meeting, London, March 1988 (TC)
- Alvey HI Club Meeting, London, April 1988 (TC, KGD)
- ESPRIT Conference, Brussels, September/October 1987 (KR)
- IPR and the Law Course, Southampton, January 1988 (KR)
- ESPRIT II Proposers' Day, Brussels, February 1988 (KR)

### 4.6 Image Processing

#### 4.6.1 Vision

The staff involved are:

- Ms K M Crennell (KMC)
- Mrs D C Parsons (DCP) - part-time

##### 4.6.1.1 Vision Club

KMC has continued to organise the Alvey Vision Club, particularly its very successful three day conferences. She coped with approximately 180 delegates and all the organisation at Cambridge in September 1987. This year she is being assisted by local organisers in Manchester in arranging for 170 delegates to attend AVC88 at the end of August.

Plans are also well advanced for a 2-day workshop to be held at Cosener's House in November. The title - Exploitation of Vision - was so well chosen that it is reported that Timothy Walker, head of IED, wishes to attend.

#### 4.6.1.2 Micro-Vax Computing Service

KMC with the help of DCP has continued to provide systems programming and management for the VMS MicroVax II system which provides image capture, manipulation and display facilities. These are used by IPAL and 2D Object Identification projects. Progress on these two projects, which were within Infrastructure Group throughout the report period, is reported under Computational Modelling, in sections 2.5 and 2.6 respectively.

This system is also used by J Burren's Group in CCD.

#### 4.6.1.3 Publications

- Image Processing & Pattern Recognition Paper 1988
- The Analysis & Applications of Electronic Speckle Pattern Interferometric Images, K M Crennell, presented at AVC88, the Annual Meeting of the Applied Vision Association, 11-13 April 1988, Oxford.
- Third Alvey Vision Conference, K M Crennell, Alvey News, April 1988.
- Proceedings of the Fourth Alvey Vision Conference, K M Crennell - one of Alvey Vision Club Committee joint editors, 302 pages, held at Manchester, September 1988.
- The Design & Implementation of a Portable Image Processing Algorithms Library, K M Crennell, to be presented at ' Image Processing 1988', and published in the proceedings by Online Conferences in November 1988.

#### 4.6.1.4 Meetings, Conferences, etc

KMC attended:

- AVC87 in Cambridge.
- Workshop on Parallel Processing at Leeds, January 1988.
- Tutor at one-day conference on The Challenge of Management at Somerville College, Oxford, arranged for final year undergraduates by the Industrial Society.
- Tutor at EITB training course Insight into Computing for sixth formers, at Reading University.
- Tutor on Microcomputers in Schools at Cambridge in June 1988.
- Numerous careers conventions selling the idea of careers in computing to local schools.
- As a member of the interview panel for the Group C Review, she has been a member of many recruitment boards.

### 4.6.2 Image Processing Algorithms Library (IPAL)

IPAL is a library of portable image processing algorithms being developed by an Alvey MMI grant. The method is to obtain contributions and provide a coordinated library, which will be taken over by NAG.

#### 4.6.2.1 Co-ordination (R Maybury)

This is largely a matter of regular contacts with NAG. In addition to this RM has been convening regular meetings of all the members of the project. He acts as both secretary and chairman to these meetings. The usual attendees have been:

- A Bartlett: NAG
- M Carter: RAL
- K Crennell: RAL
- E Golton: RAL (S and A Department)
- S Hammarling: NAG
- R Maybury: RAL

All these meetings are written up as PROFS documents with key-words IPA, technical, meeting.

As part of this function RM attends the main project management meetings at NAG in Oxford. These are held quarterly and are chaired by B Ford. The monitoring officer, D Rutovitz, attends and

three people from outside are also invited.

- A Clark: BAe now Essex
- P Gregory: RSRE (has not made it to a meeting yet!)
- P Otto: UCL

The final part of this role is the yearly advisor's meeting. This is held at RAL and RM was heavily involved with the organisation of this years meeting on 23 June. He prepared a paper on the specification of the C Library and presented it to this meeting. The total attendance was thirty with five of these from RAL and three from NAG.

#### 4.6.2.2 Fortran Library (R Maybury)

The emphasis in 1987 was on the creation and documentation of the core routines on the library. RM placed a lot of importance on getting agreement on common standards and conventions for these routines. The prevention of the erosion of the conventions has required frequent intervention on his part. The responsibility for final documentation lies with NAG and this has been a serious cause of delay in the project. Part of the purpose of getting together a set of documented routines was to act as a catalyst to the contributions on which this project is, in theory, based. So far the Fortran Library is based on core routines written by RAL members of the project and routines from Starlink modified by E Golton and M Carter. RM added a set of mathematical morphology routines for simple operations based on grey-levels. These and core routines which RM has written and documented are the main direct contribution to the Fortran Library.

As well as contributing routines for IPAL, KMC has maintained a public version of the entire source and documentation for the Fortran library. Two example programs have also been written. One is a simple fixed demonstration (DEMOIPAL). The other (IPALIMS) provides menu-based access to all the IP AL routines. However, its use as a test vehicle for establishing the interworking of routines is more important than its role as a demonstration. Both were shown to members of the Technical Advisory Meeting.

During the Summer a student (TCP) from Warwick University demonstrated the portability of the code by implementing it on two different transputer systems using the Parallel Fortran compiler. Both demonstration programs can now be run on T400 and T800 based systems. The latter, using a single transputer, performs as quickly as on the MicroVax II.

#### 4.6.2.3 The C Library (R Maybury)

RM started work on the C Library from a position of total ignorance! This covered his knowledge of both C and UNIX so a first step was a visit to MRC at Edinburgh. The group visited is headed by the monitoring officer for the project and he has several years experience of producing software in C. One result of this visit was to obtain a tape of their image analysis software. After NAG colleagues had tried and failed to read this tape RM took over and UNIX support read it in. Since March RM has been experimenting with this software and has run it on the PYRAMID, SUNs and the image processing section MicroVax which runs VMS.

RM produced a paper on his experience running this software and, since the MRC software is likely to be the biggest single contribution to the C Library, he also produced a draft specification of the C Library based on this software.

RM has started work on implementing some basic routines in C as a first step towards standardising the behaviour of the MRC software. The error handling is one area which RM has identified as needing work in order to bring the software up to the standard required in a library.

KMC has successfully called C routines from a Fortran main program on the MicroVax. This enables users of the IP AL Fortran library to call the C library routines without having to re-code them in Fortran.

#### 4.6.2.4 Algorithms (M Carter)

Since completing his High Energy Physics thesis at Durham, MC has been working on image processing activities initially as part of the 2D object identification, but more recently has been concerned with implementing algorithms for the IP AL Library. This has consisted of some chasing up of people in the Alvey vision community for Fortran code for the library; collaboration with Ted Golton on his filter and transform routines and writing Fortran code for various algorithms recommended for inclusion in the library by the project image processing algorithms survey. The latter has involved research using the original paper describing the algorithm; generating the code and checking that it conforms to the original algorithm; extensive testing of the code performance and its handling of error conditions and the production of documentation for the subroutine.

In November last year MC attended a one week course run by the Transputer Initiative on Occam and the transputer. He has written software for image display and manipulation on the transputer graphics system bought for the Image Processing Group and implemented various algorithms on the transputer based digital signal processing system bought for evaluation of its applicability to image processing problems. Some interest has been generated in using a transputer system in space applications and this has led to a small grant to assess the use of transputers in image compression of satellite imagery for the CDS experiment on the SOHO mission. This involves choice of the appropriate compression technique and design of a transputer based system for its implementation. This has also brought out the possibility of using transputers in the photon counting detector system for space/ground applications where it will allow the hardware for event recognition and location to be replaced by a more sophisticated and versatile software approach. This has involved collaborative meetings with RGO and UCL and research into centroiding algorithms and system design over the last month or so.

#### 4.6.2.5 Publications and Conferences

Papers by R Maybury:

- IPAL/9.1/87: Report on Visit to MRC.
- IPAL/11.1/88: Experience with MRC Software
- IPAL/12.1/88: Priorities
- IPAL/12.2/88: C Language Version

### 4.6.3 Object Recognition

The Alvey research project Identification of Object from 2D Images of Natural Scenes was started at RAL by Josef Kittler. With his move to Surrey, RAL has contributed to the project with effort at the rate of 2MY per year. Josef Kittler continues to manage the activities. The main people at RAL are:

- E R Hancock
- M Petrou

Regular progress meetings with Surrey ensure that the co-operation is successful.

#### 4.6.3.1 Object Labelling (ERR)

Research into the uses of contextual information in object labelling has continued by ERR. In collaboration with Josef Kittler, he has written a paper summarising work on evidence combining strategies for use in probabilistic relaxation. This paper was submitted to the International Journal of Pattern Recognition and Artificial Intelligence and was accepted for publication without alteration.

As an application of some of the theoretical ideas described in this paper ERR has developed a highly robust edge-labelling algorithm. This represents the first really successful application of relaxation labelling to edge-labelling. The success has results from the consistent formulation of the labelling problem adopted in the theoretical work. A paper on the edge-labelling strategy has been submitted to IEEE Transactions on Pattern Analysis and Machine Intelligence. The code for the algorithm has been contributed to IPAL.

At present ERR is concluding some work concerned with extending a technique known as discrete relaxation. The results look fairly promising and he Is preparing them for publication in the journal Pattern Recognition.

As far as future research is concerned, the plan is to extend the work on context to include studies of Markov fields and the modelling of label processes using Gibbs samplers. The work will probably be concluded with a comparative study of different contextual decision strategies.

#### 4.6.3.2 Optimum Filter (MP)

Most of the year MP has spent working on optimum filters for edge detection.

#### 4.6.3.3 ESPRIT II (ERR, MP)

In February and March, MP and ERR were involved in attempts to obtain ESPRIT funding. This activity involved a great deal of effort in preparing the consortium proposal document on Modular Imaging Understanding System and attendance at technical meetings with partners from France, Germany, Spain and Portugal. The proposal was in the event unsuccessful. However, the experience gained and the contacts made were both valuable. Hopefully, both will be useful in bidding against round two of ESPRIT-II.

#### 4.6.3.4 Speech Support (ERR)

During the year ERR continued to provide support for the Alvey Speech Club. The Club held workshops in Cambridge during September and in Oxford during March. In both cases ERR was responsible for local arrangements, finance and the preparation of a report describing the workshop proceedings. The Speech Club Committee held three meetings at which ERR acted as Secretary. Throughout the year he edited the speech component of the MMI mailshot.

The Club is at present making plans to extend its life beyond the end of Alvey Programme with a view to providing a similar role in fostering the needs of speech technologists in the IT92 and ESPRIT programmes.

#### 4.6.3.5 Papers and Conferences

Being an Atlas Research Fellow, Maria Petrou spent some time teaching Mathematics at St Hilda's College in Oxford to students of Engineering.

Papers

**M Petrou:**

- An Expert System for the Agricultural Industry and the Environment Control, Procs of EURINFO 88.
- On the Optimum Edge Detector, Procs of the Alvey Vision Conference 1988.
- Image Segmentation and Uncertainty, by Wilson and Spann. A book review, in the Newsletter of the International Pattern Recognition Association, February 1988.
- A Report on the Conference EURINFO 88, Internal report.

**E R Hancock:**

- Edge-Labelling using Dictionary-Based Probabilistic Relaxation, E R Hancock and J Kittler. Submitted for publication in IEEE Trans PAMI.
- Combining Evidence in Probabilistic Relaxation', E R Hancock and J Kittler. Accepted for publication by the Intern J of Pattern Recognition and Artificial Intelligence.
- Alvey Speech Projects - A Progress Report, 1987 Alvey Conference Proceedings.
- Production and Decay of the $\omega\pi^0$ State at 1250 Mev/$c^2$ Produced by 20 GeV Polarized Photons on Hydrogen, J Brau et al, SLAC-PUB, 4431, 1987; RAL Report, 87-078, 1987. Phys Rev D37, 2379, 1988.

- Forward Charge Asymmetry in 20 GeV γp Reactions, V R 0'Dell et al, Phys Rev D36, 1, 1987.

Internal Reports

- MIUS ESPRIT proposal document, April 1988.
- Proceedings Alvey Speech Club Workshop on Speaker Characteristics, September 1987.
- Proceedings Alvey Speech Club Workshop on Pattern Matching and Parsing, March 1988.
- Alvey Speech Club Committee Minutes, 9 November, 21 January, 15 June.
- MMI Speech Newsletters, November, February, May.

Conferences

**M Petrou:**

- British Pattern Recognition Association Conference in Cambridge, April 1988.
- First European Conference on Information Technology, EURINFO 88. in Athens, Greece, May 1988.

**E R Hancock:**

- September 15-17, Alvey Vision Conference, Cambridge.
- September 16-18, Alvey Speech Club Workshop on Speaker Characteristics, Trinity Hall, Cambridge.
- October 28-29, Alvey 2D Consortium Workshop, Bristol.
- November 19-20, DAP Course, QMC London.
- March 6-8, Alvey Speech Club Workshop on Parsing and Pattern Matching, Keble College, Oxford.
- March 28-30, British Pattern Recognition Association Conference, Cambridge.
- June 6-8, Computer Vision and Pattern Recognition Conference, Ann Arbor, Michigan, USA.

## 4.7 IKBS

### 4.7.1. Introduction

#### 4.7.1.1 Staff

The main changes over the year have been losses.

- Martin Dunn (MBD) - left 7/88
- Tony Lucas (AJL) - left 6/88
- John Smith (JWTS)
- Kevin Tarling (KMT) - left 3/88
- Mrs Sheila Davidson (SGD) - part-time

#### 4.7.1.2 Section Objectives

To promote and support SERC's research programme in IKBS and systems architecture . This is, at present, principally funded through the Alvey programme and most of the section's work is concerned with technical support and management of the Alvey IKBS and Architecture programmes. There is also a small amount of work for the Engineering Board's Environment Committee and research and development work.

#### 4.7.1.3 Progress Summary

The year has been one of some uncertainty. With the Alvey programme reaching maturity, the main question has been what would follow it and what the Laboratory's role in such a programme would be. Many of the doubts remain and the section has been obliged to work within the general constraint that RAL's infrastructure support of the Alvey programme would be reduced by half in financial year 1988/89 and fall away completely in the following year. Thus the pattern has been one of continuing staff redeployment throughout the year. Nonetheless much useful work has been

done in supporting the active IKBS and architecture communities built up during the Alvey programme.

### 4.7.2 IKBS/Architecture Programme Support

#### 4.7.2.1 Research Clubs

A two day meeting of the KBS Club (Secretary JWTS) was organised in January at St Anne's College Oxford. The format consisted mainly of (excellent) tutorials. There was lively and appreciative participation by the Club members. A second, one day, meeting of the Club was held in June when the main items were presentations on completed projects and discussion of the future needs of IKBS research and the possible role of the Club in this.

The Architecture Club (Secretary MBD) has held three meetings during the period. The first (in October 1987) was a presentation by the ANSA project, which helped explain why this seemingly elusive project was of considerable importance to a wide range of projects. In November 1987 a meeting was held to discuss future funding options for the UK architecture community (mainly Esprit and the then unannounced UK programme). John Elmore from the EEC provided valuable comments and there was a lively discussion. Finally, in March, Alan Bagshaw's swansong as Alvey Architecture Director was a presentation on the new UK programme as he perceives it; the Club also received reports from the three SIGs it had established (Knowledge Manipulation Engines, Parallel Declarative Systems and Systems Architecture on Silicon).

The Logic Programming Club has held one major meeting over the period. JWTS is now the Secretary and is working closely with Steve Torrance, Coordinator for the Logic Programming Club. The meeting focussed mainly on projects in progress but, like all other Clubs, was understandably anxious to consider its own future in the light of funding opportunities After Alvey.

SGD has provided invaluable support in ensuring the smooth operation of all three Clubs.

For all three Clubs, the future is hazy. It is not yet clear whether they will still have a role in the new UK programme or, perhaps, more widely in Esprit. In the meantime they are serving a valuable function in keeping their Alvey communities together.

#### 4.7.2.2 Workshops and Special Interest Groups (SIGs)

The workshops and SIGs supported by Alvey in IKBS and Architecture have been a highly successful part of the whole programme, bringing together academics and industrialists to discuss specific topics in some detail. Sadly the workshops budget has been halved in 1988/89. This has meant more work for MBD/SGD in ensuring cost-consciousness in the assessment and support of workshop proposals from the community. Despite the constraints, a reasonable programme has been maintained.

#### 4.7.2.3 Alvey Project Monitoring

MBD has been responsible for appointing and overseeing the work of Monitoring Officers (and uncles) to the projects, with support from SGD. Apart from the purely administrative task of ensuring Monitoring Officers are in place and paid for their services, the main emphasis has been on ensuring that reports of value to the Directorate are obtained from the Monitoring Officers.

AJL has personally monitored projects in the Vision, Logic Programming and Infrastructure areas.

#### 4.7.2.4 Abstracts/Deliverables

SGD has been obtaining and publishing in Alvey News, abstracts of work flowing from Architecture and IKBS projects . The response has been good and the publication has provided a valuable shop window for many of the projects.

#### 4.7.2.5 Software Support: SIGAI

The Special Interest Group in AI is a long-standing Committee which has continued to play a valuable role in advising SERC and the Alvey Directorate on the software needs of AI researchers.

AJL has been its Secretary. Topics of particular concern to the Committee have been the report of the UK AI Toolkit Committee (see below) and the Information Engineering Directorate's strategy document for systems engineering (produced as part of the planning process for the new UK programme).

#### 4.7.2.6 Software Support: NIP

AJL and KMT have continued distributing new releases of the New Implementation of Edinburgh Prolog (NIP) to SERC and Alvey supported groups. The continuing development of NIP is supported by a contract administered by the section with advice from SIGAI.

#### 4.7.2.7 Software Support: Poplog

AJL and KMT have also continued to oversee contracts to Sussex University for development of Poplog and to Systems Designers for maintenance of the system. Poplog is an increasingly popular environment for AI research, which includes Prolog, Common Lisp, POP 11, Standard ML, object oriented programming and other valuable features.

#### 4.7.2.8 Software Support: New Toolkits

Following the interim recommendations of the UK Toolkit Committee, contracts were placed to incorporate part of KEATS (the Knowledge Engineers Assistant - the product of an Alvey project) into Poplog and to develop the STRATA toolkit (initially using Poplog Common Lisp). AJL has overseen these developments and RAL has been chosen as a beta test site for STRATA.

#### 4.7.2.9 Software Support: Benchmarking Prolog

AJL and KMT have continued their work of benchmarking different implementations of Prolog and writing up the results.

#### 4.7.2.10 Software Support: KRSTL

SIGAI placed a contract to initiate a Knowledge Representation Systems Trials Laboratory at Edinburgh AI Applications Institute; a related (DTI) contract has established a Parallel Architectures Laboratory at Edinburgh. These, and other contracts to Edinburgh for Lisp and Prolog standards work have been monitored by KFH and AJL.

#### 4.7.2.11 Information Services

The IKBS Mailshot (run by JWTS and SGD) has continued to thrive over the year. A survey conducted during the year has shown that recipients value the service highly and, interestingly, distribute their own copies widely within their organisations. Sadly this is a service which will soon have to cease unless other arrangements are made to continue it.

The IKBS (electronic) bulletin board (JWTS) has also continued to be a valued service to the community. Occasionally technical problems have limited the extent of its distribution over one network but it is still being produced at the rate of approximately one per week. Again this is a service that will have to end soon unless other arrangements are made.

#### 4.7.2.12 UK AI Toolkit Committee

The UK AI Toolkit Committee (Secretary JWTS) finally produced a report during the year recommending a substantial investment in UK/European toolkits; the report has been considered by SIGAI and some of the results of its early work (STRATA and KEATS on Poplog) are now becoming available.

### 4.7.3. Other Activities

#### 4.7.3.1 ARTIFACE

AJL and JWTS have continued to support the SERC Environment Committee's Artificial Intelligence Facility for Engineers. This consists of two IBM PCs and a SUN 3/160, with appropriate AI software, which are loaned to engineers in universities for short periods for evaluation.

#### 4.7.3.2 Prolog Database

KMT has written a database in Prolog to maintain records of university users of NIP and Poplog.

#### 4.7.3.3 Evaluation of Expert Systems Shells

MBD has undertaken a fairly extensive evaluation of a number of expert systems shells available on PCs. These include Crystal (including version 3), Xi Plus, Savoir and KES. As part of the evaluation a number of expert systems have been developed, including one to play noughts and crosses! Full reports of the evaluations have been published.

#### 4.7.3.4 Neural Networks/Genetic Algorithms

MBD has been developing interests in weak machine learning techniques which might come close to imitating the behaviour of the human brain. These include some understanding of neural networks and developing learning techniques based on the classifier/genetic algorithm systems of Holland et al.

#### 4.7.3.5 AISB Quarterly

JWTS is Reviews Editor of the AISB Quarterly.

### 4.7.4 Publications

- M B Dunn, Expert Systems Shells: A Comparison of Savoir, Xi Plus and Crystal, RAL Report, RAL-87-067.
- M B Dunn, Expert Systems Shells II: KES and Crystal 3, RAL Report, RAL-88-0l9.
- J W T Smith (Secretary), What the UK Needs to do about AI Toolkits, a report by the UK AI Toolkit Committee.
- J W T Smith, Report on KBS Club Technical Session - Alvey Conference 1987 in Alvey Conference Report, September 1987.
- KBS, Logic Programming and Systems Architecture Clubs; papers and reports of meetings in 1987/88 (J W T Smith and M B Dunn).
- M B Dunn, reviews of Intelligent Knowledge Based Systems and the Artificial Intelligence Review in AISB Quarterly.
- M B Dunn, Report on the European Seminar on Neural Computing.

## 4.8 SE

### 4.8.1 Introduction

SE Section is much more intimately involved in the management of the Alvey SE Programme than IKBS and MMI support. Together with the specific topics discussed below the section is involved in financial planning of the programme and assisting in providing the IED/public interface.

#### 4.8.1.1 Staff

The staff involved in the work are:

- Mike Russell (FMR)
- Mrs Jill Cheney (JMC)
- Terry Mawby (until 1 August) (TPM)

### 4.8.2 Monitoring

Involvement in the IED (nee Alvey) programme has continued throughout the year, by assisting in co-ordination of the existing Alvey Programme and planning for the new IT92 Programme. The success of the monitoring officer programme, developed by the Alvey SE Division and later extended to other Divisions, led to the adoption of a standardised monitoring programme for the whole IED Programme. The management and operation of the monitoring officer programmes has been a major part of the support function provided by RAL for the IED.

### 4.8.3 Deliverables

Awareness is an important fact of the IED Programme and is supported in part by the monitoring programme. This is achieved by the publication of Abstracts of project Deliverables. Analysis of the public response and interest in the Deliverables has shown that the Abstracts play an important part in the dissemination of technical information about the Alvey IT projects.

# Informatics Annual Report 1988-9



## 1. INTRODUCTION

The Annual Report covers the year ending September 1989. Its main purpose is for internal use in the Department, indicating what has been achieved and by whom. Hopefully it also gives new members of the Department some idea of the work programme in total and its objectives.

The Divisional Structure throughout the year was

1. Design: M R Jane
2. Computational Modelling: F R A Hopgood (Acting)
3. Systems Engineering: R W Witty
4. Distributed Computing Service: K F Hartley

It is interesting to note that this is the first year since the Department was formed that there has been the same structure and Division Heads throughout the year. This will not be the case in the year 1989/90 as the post of Head of Computational Modelling has now been filled by D R S Boyd and R W Witty will be leaving to take up a post with the European Commission at ISPRA in Italy.

The year has seen the completion of the Alvey Programme with the Department putting in a small amount of effort to wind the programme down gracefully and pay the remaining bills. As a result, the major funding source this year has been the Computing Facilities Committee of the Engineering Board and the major function has been the development of the Engineering Applications Support

Environment (EASE) with its emphasis on providing Awareness to the engineering community. The Transputer Initiative continues to flourish with a well attended first Annual Conference.

The Department had hoped to play a significant role in providing the infrastructure for the post-Alvey joint SERC-DTI collaborative research programme. However, it was decided that a much leaner infrastructure would be provided to support the new programme. Consequently, the level of support is constrained to providing some effort to monitor the programme and assist DTI with managing the programme. The Department bid for research funding from the new initiative and had hoped that this would be both substantial and available in April 1989. At the end of September 1989, there was still no definitive view of what projects would be funded and when they would start. This has caused a great deal of uncertainty during the year and, as a result, it has been difficult to provide a coherent plan of activities, particularly in the second half of the year.

In Europe, the ESPRIT I Projects that the Department has been involved with are drawing to a close. To replace these, the Department was successful in being awarded four ESPRIT II contracts. These have now all started and are beginning to shape the future work programme.

This will be the last year when the annual report covers the period September to September. The advent of the Forward Job Plan for staff requires a mid-year review of staff activities at the end of June. Consequently, it has been decided that completing the report year at the end of June also will synchronise the two activities. The next Annual Report will, therefore, cover the period from September 1989 to the end of June 1990.

Last year's Annual Report gave the Department organograms at September 1987, September 1988 and December 1988.

Appendix A reproduces the December 1988 organogram, while Appendix B gives the Organogram at September 1989.

## 2. DESIGN DIVISION

### 2.1 Design Division - Introduction

Design Division consists of three groups - Applications Integration, Systems Interface and User Interface - together with the Transputer Coordination Unit and the London and South-West Regional Support Centre Unit.

The objective of Design Division is two-fold:

1. to provide effective support for programmes such as EASE and the Transputer Initiative which are targeted at the Engineering Community, and
2. to carry out an associated series of R&D activities supported from a variety of funding sources (SERC, DTI, CEC as well as from industrial sources).

Highlights of the past year, which are detailed in the sections below, are:

a. EASE educational and support activities
b. Data Exchange Standards: the CAD*I project, STEP (STandard for Exchange of Product data) and associated work in electromagnetics
c. Work on Window Management systems and toolkits for User Interface Design
d. Support for the ECSTASY (Control Engineering) project
e. Extensible Graphical Programming
f. Intelligent Front-End and Energy Kernel System
g. (with UMIST) UIMS Evaluation Exercise
h. Support of the Transputer Initiative
i. Start-up of ESPRIT II projects Euro-Workstation (EWS) and ELusive Office (ELO).

The Division expects that its main objectives in the coming year will be:

i. Support for the Engineering Community, primarily through the EASE Programme. This will include the provision of tools, assessment reports, and involvement in education awareness and training.
ii. Continuing support for the SERC/DTI Engineering Initiative in the Applications of Transputers.
iii. Continuation of R&D activities that provide a synergy with EASE Programme activities. This is likely to be provided primarily through ESPRIT funding, although there may be a follow-on to the COMETT cooperation coordinated by ZGDV, Darmstadt.

In addition to these broad targets, each Group and the Transputer Units have identified their own specific objectives for 1989-90. These are detailed, together with a review of 1988-89 activities in the sections that follow.

### 2.2 Applications Integration Group

#### 2.2.1 Staffing

Staff in post.

- Bryan Colyer (BC) Group Leader
- Jan Van Maanen (JVM) Section Leader
- Deborah Thomas (DT) Section Leader
- Kevin Duffey (KPD)
- Mike Mead (MM)
- Alan Middleton (AJM)
- John Chandler (JEC) Joined the Section on 17 July 1989 for 6 months
- Paul Clayson (PFC) 2 - 3 days per week from April 1989 to October 1989.

The Group is divided into two Sections, one (led by JVM) is mainly concerned with data exchange, and the other (led by DT) with databases; however, DT has also been involved in data exchange.

#### 2.2.2 Objectives for 1988/89

The objectives for the Data Exchange Section over the year were to contribute to the CAD*I project, to contribute to the development of standards in engineering data exchange, and to increase the awareness of these standards in the academic community.

The main objective of the database section was to look into how databases may be used to integrate engineering applications. The initial work has used relational databases, the SQL query language and the Express data modelling language.

Specific objectives for the year were:

- participation in EASE educational activities
- writing and editing of the final report on product analysis data exchange for CAD*I
- participation in national and international standards activities on data exchange
- conversion of CAD*I software for use with STEP
- development of a compiler for the data modelling language Express
- development of a mapping from Express to SQL
- to begin development of a subroutine interface to provide access to a data scheme based on Express whether stored in a database or a neutral file
- development of a data model in Express for electromagnetic fields

#### 2.2.3 EASE Educational Activities

We were heavily involved in the CFTAG Data Exchange Workshop held in April 1989. Following initial approaches made there, it was decided to submit a bid for a Data Exchange Community Club to CFC. JVM has been responsible for discussing this proposal with interested persons in universities and elsewhere, and has written the proposal for submission to CFTAG.

A number of articles describing our work and achievements have been written, and will be published in forthcoming issues of Engineering Computing Newsletter.

### 2.2.4 CAD*I Project

At the beginning of the reporting period, the Group's activities were directed mainly to the CAD*I project. This involved the definition of a neutral file interface for finite element data for structural analysis purposes. The neutral file definitions were tested by several pilot implementations of a data transfer by means of a neutral file. Geometry data was transferred into a finite element mesh generator, and then on to a finite element analysis package. We were involved in a successful demonstration of the CAD*I project at Copenhagen in October 1988. The final report on product analysis data exchange was written during the year; this will be published by Springer- Verlag as a book in a series describing the whole project. JVM, MM and DT acted as editors, collating contributions from other European partners, in addition to making major contributions of their own.

### 2.2.5 STEP Participation

As part of the CAD*I project we were required to participate in STEP , which is being developed under the auspices of the International Standards Organisation. After the end of our involvement in CAD*I (October 1988) we were encouraged to continue this work by CFC (following So workshop on data exchange). JVM and DT have attended meetings of relevant STEP committees. A large task has been our involvement in the critical review of the first ISO Draft Proposal for STEP. DT and JVM attended meetings of the BSI panel which is monitoring STEP, and organised a BSI panel to review the FEM (Finite Element Modelling) portions of the Draft Proposal. JVM was involved in a panel to review the STEP Physical File proposals.

### 2.2.6 STEP Software Development

A program for reading CAD*I files has been converted to enable it to read the STEP physical file. Work has begun on two pilot STEP implementations: from the STEP physical file to MSC/Nastran, and from physical file to the post processing program FAMresult.

STEP relies on the data modelling language Express. A compiler for this language is being developed, and it produced its first useful results during the year. A pretty print program for Express is under development.

### 2.2.7 Mapping from Express to SQL

Some work had previously been done in this area by McDonnell Douglas in the USA. MM and DT studied this work and found it deficient in many ways. They proposed an alternative solution and published an internal report which was then used as a basis for the project described below. Feedback from the project has resulted in changes in the original proposal and a revised report will be issued.

The mapping described in the report is based on an ideal world and does not consider actual DBMS limitations. In particular, it does not take into account the fact that most systems have a limit on the number of characters used for table and column names. KPD has designed a name generation algorithm which generates unique table and column names of restricted length from the original Express entity and attribute names. This work will be published soon as a RAL report.

### 2.2.8 Standard Access Subroutines

It should be possible to design a set of subroutines that allow an application package to access data according to a standard data schema with the actual data storage mechanism (eg database or neutral file) being transparent to the program. We already had a set of subroutines to access data from a neutral file so PFC designed a similar set to access a relational database based on the mapping described above. He will publish an internal report describing his findings and the coding of the routines.

### 2.2.9 Data Model for Electromagnetics

A simple neutral file for electromagnetics has been designed previously and is in use for simple data transfer between several research codes. It was decided to take this neutral file and formalise it into the data modelling language Express to enable wider use to be made of the technical

content. This was then used to derive a database schema for more tightly integrating the codes together. KPD successfully completed this project and published the results in a RAL report.

### 2.2.10 Miscellaneous

BC has attended Project Board and Review meetings for CAD*I. He participated in the development and writing of a Brite/Euram proposal named AIDA (an environment integrating artificial intelligence, design and analysis for advanced magnetic devices). The proposal was submitted; its fate is not yet known. He has also worked on an individual merit interest - fully automatic meshing - which has made considerable progress this year. He has further developed a graphical interface package originally written by him to enable the porting of large electromagnetics finite element programs to the SUN (these were originally developed at RAL, and are now marketed by Vector Fields Limited, Oxford).

### 2.2.11 Conferences and Meetings Attended

**31 August-2 September 1988**
Cambridge Factory 2000, JVM, MM.
**5 September 1988**
CAD*I Working Group 6, Aachen, DT, AJM
**12-13 September 1988**
CAD*I Project Board and Review Meeting, Brussels, BC
**13 September 1988**
BSI AMT/4, London, DT
**September 1988**
CODATA, 11th International Conference, Karlsruhe, DT
**17-21 October 1988**
West Palm Beach ISO TC184/SC4WG1, JVM, DT
**20-21 October 1988**
Copenhagen CAD*I Workshop, BC, MM, AJM
**8 November 1988**
BSI AMT/4, London, DT
**2 February 1989**
BSI AMT/4, London, DT
**20-21 February 1989**
CAD*I Project Board, Leuven, BC
**3-6 April 1989**
Boston ASPLOS III, MM
**9-10 May 1989**
CAD*I Project Board, Vitrolles, BC
**23-25 May 1989**
Stratford-upon-Avon, NAFEMS Conference, JVM. MM
**10-14 April 1989**
San Antonio ISO TC184/SC4/WG1, DT, MM
**11-12 April 1989**
Leeds Data Exchange Workshop, BC, JVM, AJM

### 2.2.12 Papers

External Publications

- J Van Maanen, D Thomas, M Mead, CAD*I: A Standard for the Exchange of Product Definition, Analysis and Experimental Data. Paper presented at the Conference Factory 2000, Cambridge, 31 August - 2 September 1988.
- M Mead, J Van Maanen, D Thomas, The CAD*I Standard for Finite Element Data Exchange, paper presented at the Second International Conference on Quality Assurance and Standards in Finite Element Analysis, Stratford-upon-Avon, 23-25 May 1989.

- D Thomas, J Van Maanen, M Mead (editors). Research Reports ESPRIT. Specification on a CAD*I neutral file for product analysis data exchange. Springer-Verlag (to be published).
- J Van Maanen, J Leuridan, Methods for Transfer and Integration of Product Analysis Data. Submitted to International Journal of Computer Integrated Manufacturing.

RAL Reports

- A Mapping from RALBIC to CAD*I Data Formats, RAL-88-107 KPD.

### 2.2.13 Objectives for 1989/90

A main objective for the next year is to make all aspects of the expertise of the group available to the academic community. We intend to disseminate our results and information as widely as possible, in the fields of data exchange and engineering databases.

Effort will be devoted to participation in STEP and similar activities relating to data exchange with the aim of keeping abreast of new developments in this area, so that we can continue to inform the academic community.

A significant amount of effort will be devoted to support of the Automotive Design Project headed by Birmingham University, which involves other academic institutions and automotive industry partners.

We shall continue work on coding subroutines to read and write to databases. Using these, an actual electromagnetics package which currently uses a neutral file will be modified for use with a database. The results from this work will be fed back to STEP in order to influence the programming interface.

## 2.3 Systems Interface Group (SYSIG)

### 2.3.1 Staffing

Staff in post during the year were:

- K Robinson (KR) Group Leader
- V A Burrill (VAB) Novel Interfaces Section Leader (joined 17 July 1989)
- C A A Goswell (CAAG)
- I Wilkinson (IW)
- C M Crampton (CMC) Window Management Section Leader (left 4 April)
- T A Watson (TAW)
- A V Shrimpton (AVS)
- D Mac Randal (DMR) Software Environments Section Leader
- K G Dancey (KGD) (from 17 October)
- K M Tarling (KMT) (left 9 September).

### 2.3.2 Group Objectives

The group's major interests are in providing tools, techniques and environments for the engineering community. The tools and techniques are directed at support for highly interactive user interface design; the environments provided are aimed at providing productive, integrated software for engineering applications development and execution. To this end, the Group undertakes a range of activities, from research (with a practical flavour), through advanced and conventional development, to support. Each activity is intended to act as a source of ideas and inputs for the others.

### 2.3.3 Window Management

The X Window system is now a de facto standard for window management in the IT industry. Sun Microsystems will provide, eventually, a version (merged with NeWS, their own WMS) as a product. This project is now well overdue - at least 18 months late. As a consequence, given the number of SUN systems in the SERC community, it was decided to provide a version of the vanilla MIT X

software tuned for the SUN. CMC and TAW, with input from CAAG, investigated the performance bottlenecks and applied a number of speed-ups to the MIT XI1R2 distribution, making this available on the Janet Access Machine (JAM). TAW then took the vanilla XIIR3 release and applied both the RAL and Purdue fixes; this has also been made available on JAM, and the speedup information fed back to both MIT, and to the community at large via Usenet.

**Chris Crampton shows off RAL's Window Management activities to the Engineering Board Computing Committee, Ken Robinson behind**

**Large View**

For the first part of the year TAW worked on providing a driver for the RAL GKS to work under X. Initially this work was done in cooperation with colleagues at the University of Manchester, but subsequently effort demands at Manchester led to TAW completing the work herself.

### 2.3.4 UID Toolkits

MMM's ww toolkit has been available, and under development, for some time. A limited amount of development has been undertaken this year by MMM mainly on behalf of internal users, and that mainly on behalf of CAAG. AVS since her arrival in July, has been familiarising herself with ww.

One of the CFC workshops suggested that an investigation be undertaken of the toolkits available on X. Work on this has just begun, with TAW and KR mainly thinking so far about things like

assessment criteria. The work itself will be undertaken in cooperation with DCSD staff.

The RAL object-oriented toolkit development, mainly by CMC, was brought to a basic working state and then frozen, as the effort available to work on it was far less than that required to give a satisfactory product.

### 2.3.5 EuroWorkStation (EWS)

This ESPRIT II project aims to develop state of the art hardware and software for a European contender in the Stardent/Silicon Graphics market. The project is in several parts, and that with RAL involvement is to develop a board and associated software to enable quality 3D graphics interface to be developed. This part of the project is know as GRACE (GRaphics ACcelerator Engine), and RAL's role is to provide an Interaction Framework which will act as a vehicle for high-quality user interface design. There is also a work item for assessment of novel input devices.

The first part of the year was spent in revising the project to meet the reduced funding (some 38% of that requested) provided by the Commission. This effectively meant that the first half of the project was undertaken, with some concomitant impacts on the project deliverables and timescales. The situation was compounded by the Commission requiring a further 9% cut to accommodate contributions from a Spanish partner they required us to take on board!

The project began on I January, although contract signature was much later. Initial recruitment was not successful, and the effort on the project had to be found from existing staff, with MMM doing most of the work until he left, but with CMC, CAAG, TC and KR also pitching in. VAB joined the project on her arrival in July, and IW a few weeks later. Towards the end of August it was agreed that Chris Wadsworth, David Johnston, and Brian Henderson would be sub-contracted to work on the project also.

So far work has fallen into three main areas:

1. the requirements for the Interaction Framework (IF) itself (MMM, CMC, CAAG, VAB, KR, TC);
2. the relationship between the IF and the graphics hardware, the basic software/hardware on the GRACE board, and UIMS (MMM, CMC, CAAG, KR, TC); and
3. an initial assessment of available input devices and the methods to be used for assessment (TC, MJP, KR).

A specification document has been prepared as a first deliverable and provided to the Commission.

### 2.3.6 ECSTASY

This project, funded by the Control and Instrumentation Sub-Committee via the CDTCE Management Committee, is aimed at providing a common environment for control engineers, for both standard package access and control system algorithm development. This has not been the smoothest of projects, for a variety of reasons, most of which are outside RAL's direct control. The basic environment is developed at UMIST'S Control Systems Centre under an SERC development contract, with other developments taking place in other HEIs. RAL's role is to provide management and technical support. This has meant making arrangements for beta testing, developing an interface between ECSTASY and the TSIM simulation package, and providing advice on general software and project management issues as needed. DMR and KGD have done most of the technical and detailed support work, while KR has handled most of the project management end, as well as attending the CDTCE Management Committee meetings and numerous other meetings.


**ECSTASY being demonstrated to the Engineering Board Computing Committee**

**Large View**

During the first part of the year support was given for the first phase of beta testing, with sites at Warwick and Sussex principally involved. The results were fed back to a RAL-organised user community on 17 April. The comments made at that meeting caused somewhat of a rethink and the phase 2 beta testing was postponed to September as a consequence. On 18 April an ECSTASY course was run at RAL which was fairly successful, at least from the viewpoint of the course attendants the RAL people had a rather frantic time caused by various hardware and software installation problems, exacerbated by only limited access to the course room.

The TSIM software has been interfaced to ECSTASY, but further developments have been badly delayed, mainly due to problems caused by the unreliability of Fortran 77 under OS4, which should be resolved by the end of August.

In parallel with all this activity, Oxford University's Engineering Science's Department has been attempting to port the ECSTASY environment to VMS. This has been a long-drawn out saga, primarily because the small amount of effort available (6 man weeks) has been spread out over some 12 months, and recently compounded by the resignation of the programmer.

### 2.3.7 Extensible Graphical Programming

This is a SERC-funded project to investigate ways with which extensibility can be built-in to a graphical programming environment. Most of the detailed work is being done by CAAG, with occasional contributions from KR & TC. During the year, work has been built on the experience gained with a graphical spread-sheet and terminal emulator. A program has been written which allows the user to construct user interfaces on the fly. It is possible to layout a user interface as the interface is running, and attach actions and menus to the buttons and text areas. A simple language has been designed and implemented within this program for describing the dynamics of user interfaces, though this work is not yet complete.

The User Interface editing tool has been merged with the terminal emulator to facilitate rapid generation of front ends to existing text-based tools. Some work has been done to evaluate other user interface toolkits form the mutability and extensibility points of view.

Another experimental tool written during this year has been a data presenter, which is able to implement (currently only most of) the functionality of several existing tools, such as the MON process monitor and the FS Kent tool for file system browsing.

A seminar has been give on the subject of extensibility, which will form the basis of a future paper. Much planning has been made for future directions, including implementation of a graphical programming module to the User Interface module.

Absence of the planned object-oriented toolkit (due to lack of staff) has hindered progress this year.

### 2.3.8 Intelligent Front End (IFE)

This SERC-funded Intelligent Front End (IFE) project is DMR's project, and is collaborative with the University of Strathclyde. It finished in July. It addressed the difficulties that end users experience when attempting to use existing engineering appraisal packages. There were two main issues, firstly the poor quality of current user interfaces for existing engineering appraisal packages, and secondly the high level of skill/knowledge required to drive an appraisal package.

The IFE consists of a central blackboard, accessed by several knowledge bases - for dialogue handling, user modelling, and building the user conceptualization. The dialogue knowledge base uses a dynamic form-fill package, together with the other supporting packages such as a geometric modelling system, a map utility, etc, to obtain raw user input. The use of a knowledge-driven forms package enables a happy medium to be steered between application-driven question/answer input and unstructured command language input, and permits the intelligent use of inferred (ie context sensitive) defaults.

The raw user input is interpreted, checked and expanded by the other knowledge bases to produce a problem/building specification as conceptualized by the user. A further knowledge base then maps the building specification into the format/structures required by the application package and generates the commands necessary to drive the application package to produce the information required by the user.

A demonstrator system, based around Strathclyde's ESP program, is now available and the final report for SERC is in production. The complete infrastructure is in place, though due to the limited scale of the project, the knowledge bases supplied with the system are fairly rudimentary. The demonstrator is currently being distributed to more than 10 sites worldwide that have expressed an interest in seeing it. Several of these groups are interested in using the empty infrastructure as UIMS for developing specific front ends for their own packages.

### 2.3.9 Energy Kernel System (EKS)

The Energy Kernel System is an object-oriented programming (OOP) environment, funded by the Building Sub-Committee and CFC, for building thermodynamic analysis software. Its main objective is to enable research teams currently investigating various aspects of building simulation, especially thermodynamic performance to use software easily and safely from other groups for those parts of the overall appraisal system that are not directly concerned with their research. A second objective was to enable a collection of validated components/sub-systems to be built up, so that the

robustness and integrity of appraisal software could be improved. This leads naturally to OOP and object-oriented databases (OODB). However, as the OOP approach to thermodynamic simulation is still unproven, it is important to show that the use of the EKS and its OOP approach will bring substantial benefits even in the construction of conventional simulation packages.

In July 88, CFTAG commissioned a report on extant OODBs from Leeds University. DMR was involved in this, partly as a representative of CFTAG and partly because of the interest in OODBs as a major piece of EKS infrastructure. In December, the report to CFTAG was submitted, and the following month saw the start of the EKS project. The RAL end is run by DMR. Two other groups are funded by the SERC Building Subcommittee, Strathclyde University - looking at the objects required - and Newcastle University - looking at the simulation process as a whole. RAL is funded by CFC, as part of the EASE programme, to provide the infrastructure necessary for the above groups.

After a slow start, an OODB, OB2, has been obtained and installed. A survey of existing simulation models has been completed and a suitable class hierarchy is currently being designed.

### 2.3.10 Other

As usual there are some items which do not fit cleanly into any of the above categories. Here they are, in no particular order.

#### 2.3.10.1 IED Support and Funding

This includes the support given to the Alvey MMI Directorate, mainly by CAAG (the last MMI Mailshot before handing over to John Smith), and KGD, who took over from A Conway as the secretary to the Human Interface Club Committee. This work was essentially complete by the end of January.

KR has continued to act as the monitoring officer for the Programmable User Models Alvey grant. He has also participated in discussions on RAL'S possible role in IED-funded activities. The proposals prepared for possible funding under the joint SERC/DTI IEATP initiative attracted interest, but no funding.

#### 2.3.10.2 Exploitation of RAL Software

So far this last year has seen the situation improve with Contracts at RAL actually generating (in May) a draft form of agreement enabling RAL to sell software it develops. The final form has not yet been seen, however and so far as KR is aware ww, ten etc have still to be sold despite numerous requests for copies.

The first copy of the licence for the RALpage PostScript interpreter has at last been sold, and many companies and individuals continue to express interest in the software.

#### 2.3.10.3 DEC European External Research Programme (EERP)

DEC offered (originally 100%, then 75%) discount on DEC equipment as part of their EERP. As a result, two of the 12 MIPS DECStation 3100s (not to be confused with the inferior VaxStation 3100s) were delivered and are being used on the Extensibility project (qv).

#### 2.3.10.4 ELO

KR and CAAG particularly have made some contributions to this ESPRIT II project, more detail on which can be found in User Interface Group's report.

#### 2.3.10.5 ECFE

KR attends ECFE. He also acts as the project officer for the UKC EMR on Software Tools.

#### 2.3.10.6 Unix Liaison Meeting

CAAG is secretary to this. KR also attends.

### 2.3.11 Conferences Attended

- USENIX c++ Conference - 17-25 October (CMC)
- BCS HCI SIG UID - 31 October (KR; CMC - talk)
- BCS Future of Graphical Software - 26 January (CMC - talk)
- Copenhagen Workshop on WMS and Graphics (CMC - talk)
- BCS Seminar on State of the Art Electronic Publishing (KGD)
- BCS Seminar on Object-Oriented Databases, London - 17-25 October (KGD)
- Landmarks in Electronic Publishing - 13-14 April 1989, Durham (CAAG)
- Raster Imaging and Digital Typography (CAAG on review committee)
- BCS Displays Group seminar on Interactive Documents, RAL 26 October 1988 (KR; KGD; CAAG - talk)
- Intl conf 'Building Simulation 89', Vancouver - 23-24 June 1989 (DMR - talk)
- IEEE seminar 'PCTE', London - 19-20 September 1988 (DMR)
- UNICOM seminar 'Object Oriented Programming', London 17 November 1988 (DMR - talk)
- Several BCS OOP & HCI meetings (DMR)
- SERC ITA Workshop, London - 14 March 1989 (DMR - rapporteur)
- SERC Workshop 'Future Control Systems Needs', Cambridge 14-15 December 1989 (KR; DMR - talk)
- UNISYS Open Computing Conference, London - 24/25 November (KR - talk)

### 2.3.12 Courses Attended

- CCS Course, CHORUS Systeme, April (MMM)
- Objective-C (TAW)
- C++ Cirencester (TAW)
- C++ Programmer's Workshop - 21/25 August, London (VAB, IW)
- Control Systems Theory Vacation School, UMIST - 16-21 April (KGD)
- C Programming - 21-25 August, RAL (KGD)
- IXI X Window System Course, RAL - 22 March 1989 (KR, CAAG)
- Silicon Graphics Course, Abingdon - 3 November 1988 (CAAG, MMM, CMC, KR)
- Introduction to Control and Simulation, Warwick University 14-18 July (DMR, KR)

### 2.3.13 Papers

External

- Mac Randal D F Object-Oriented Database Systems The OOPS Report 2 1 p3 (1989)
- Mac Randal D F Object Oriented Databases Proc. Seminar on OOP, London, 1988
- Mac Randal D F User Interface Design Tools Proc. Seminar on Future Needs 1988 in control Systems Design, Cambridge,
- Clarke J A & Mac Randal D F Building Energy Simulation: Delivering Power to the People Proc Building Simulation 89, Vancouver - 23-24 June 1989
- Clarke J A & Mac Randal D F An Intelligent Front-End for Computer-Aided Building Design accepted for European Simulation Congress, Edinburgh - September 1989
- EWS Specification - Report to European Commission, M M Martin June 1989

### 2.3.14 Objectives for 1989/90

**EWS**

- design prototype Interaction Framework (IF)
- Prepare paper on IF
- Prepare paper on input device assessment.

**EKS**

- Produce a specification of the prototype environment
- Have at least 50% of the infrastructure in place.

**Extensibility**

- Complete work on 'programming language' and tools

- Prepare paper (? for CH190)
- Develop assessment work
- Prepare follow-up proposal - maybe

**ECSTASY**

- Get UMIST to get it robust and with good performance
- Establish smooth-running support mechanism
- Get involved with R&D towards ECSTASY 2.

**EASE X toolkits**

- Complete assessment and make recommendations
- Prepare paper on toolkits.

**R&D proposals - ESPRIT, IED**

- Possible topics
- EWS follow-up
- remote group working
- hypersomething? - perhaps in context
- input device developments and assessment?

### 2.4 User Interface Group (UIG)

#### 2.4.1 Staffing

Staffing during the Year September 1988 - August 1989.

- Anthony Conway (TC) (Group Leader)
- Human Factors (HF)
  - Peter Kent (PK) (PHIGS)
  - Zsusan Mills (ZM) (Sandwich Student 28.3.89 to 25.8.89)
  - Martin Prime (MJP) (HF/UIMS)
- User Interface Managements Systems (UIMS)
  - Simon Greenaway (SG) Vacation Student 6 weeks to 30.9.89)
  - Lakshmi Sastry (LS) (UIMS) (from 10.7.89)
  - Mark Martin (MMM) (Resigned 4.8.89, to CETIA, France)
  - Dale Sutcliffe (DCS) (In Australia until January 1990)

Although the Group has two sections (Human Factors and User Interface Management Systems), staffing considerations have forced a degree of flexibility into peoples' work: for example MJP has spent much of the year working on UIMS and MMM spent much of 1989 on the ESPRIT-II EuroWorkStation (EWS) Project. Cooperation with other Informatics Groups and with CCD is needed in the Graphics area.

#### 2.4.2 Objectives

The Group has responsibility for work under the EASE Programme on UIMS Evaluation (with UMIST) , PHIGS, Human Factors relating to User Interface Design. With Systems Interface Group (SysIG) we are also involved in two ESPRIT-II Projects: EWS and the ELusive Office (ELO). It is likely that work on Standards for the new programme will be carried out in conjunction with DTI/NPL. It is possible that the group will provide some input into the ARGOSI Project.

(Extensibility Dr A S Williams + TC grant application, but work is being carried out in SysIG).

#### 2.4.3 UIMS Evaluation

This has involved MJP and TC (together with David Hicks from Applications Integration Group before his departure, and with UMIST). The evaluation of three DIMS systems - PASet, BLOX and Tiger - has been completed and the Report submitted to CFC via ECFE and CFTAG. Overall it

seems that UIMS are at an early stage of development as products: it is too early to recommend one particular system to the community or to populate the EASE environment. MJ1P's UIMS survey paper has been updated and issued as a RAL report. This has been used as a basis for discussions with UIMS suppliers (commercial and research) at CHI'90 and MJP has been invited to a UIMS Panel Session at Eurographics '89 in Hamburg. A version is also being prepared for journal publication. A seminar has been organised at UMIST to be held in September 1989 to report back to the EASE Community on the results of the UIMS exercise. Further work on DIMS (and alternatives such as toolkits) available under X and making use of graphics standards (GKS and PHIGS) will be evaluated in conjunction with UMIST in the course of the next year.

**Martin Prime demonstrating UIMS to the Engineering Board Computing Committee, Chairman seated, Malcolm Atkinson standing centre with Bob Hopgood left and Brian Colyer right looking on**

**Large View**

Attention also needs to be paid to rapid prototyping techniques. It is hoped to hold a Technical Workshop in 1990 with supplier input, and to make a UIMS available for extended trial in a suitable HEI Engineering Department. LS has recently joined the Group and will, after a period of training and familiarization, be taking over work in this area.

### 2.4.4 PHIGS

PK has been working on the development of an evaluation procedure and test suite for PHIGS. The outline of this activity has been approved by ECFE and is described in Software Development Notes 57 and 60. It is hoped to actively involve engineers in the conversation of existing routines to run using PHIGS. PK has also been actively involved in the Joint CCD/Informatics Graphics activities. One expansion of activity in the standards area may come in the course of the next year with PK being involved with IED/NPL Standards activity for the new programme. There is some potential involvement with ARGOS I in relation to work on PHIGS.

### 2.4.5 Human Factors

Experimental Work:

This was on hold for the first part of the reporting year owing to lack of effort. In the latter part of the year this activity has involved MJP and ZM with some input from TC.

The Digitry system has been set up to allow psychometric studies to be carried out (chiefly where timing down to millisecond accuracy is required: which is not possible under UNIX on the SUNs). This runs on a PC system which now has an associated CD-ROM set up and running. ZM and MJP have carried out a study on the effects of different menu styles on selection performance. Currently this has been written up as an internal note, but should form the basis of a publishable conference paper.

Work using Swinvel-3D for DataGlove assessment and development of interactive techniques using DataG10ve have been started. (Some of this work is under the ESPRIT-II EWS Project.)

HF Awareness:

Some preliminary planning work in this area has taken place. This has included an approach to Aston University over the DTI Instructional Video Scheme and investigating other ways (such as Hypertext and PC-based tools) for presenting HF information in a usable way for engineers.

In relation to this the Course Human Factors Aspects of User Interface Design developed in part under the COMETT initiative has relevance. This has involved most of the members of SysIG and UIG together with others such as David Johnston (interactive colour editor _ Red): major effort has been from MMM, Crispin Goswell, MJP, Ken Robinson and TC. Additionally it is likely that a number of HEI engineering sites may be able to make use of HF guidelines and/or active help from UIG: especially if the extended UIMS evaluation scheme goes ahead.

### 2.4.6 ESPRIT II Projects

These both started in January 1989 and are jointly run by SysIG and UIG. The primary role of RAL in both projects is user interface design and associated software provision together with some evaluation work.

#### EuroWorkStation (EWS)

EWS is concerned with the production of a high-end 3D graphics workstation. We are involved with the design of the GRACE graphics board and software which also is responsible for user interaction with the system. TC and MJP have provided input to the Technical Papers for this project and work is currently in hand on assessment of and techniques for the use of the VPL DataGlove.

#### Elusive Office (ELO)

ELO is concerned with the provision of the next generation of portable workstations. As well as providing good communications with central sites via conventional telecomms and Cellnet the system will provide an integration between the applications and an associated help and training system. RAL's major role is on the (software) Integration Framework. TC and KR have provided most of the input to the Technical papers and some initial specification and selection work. The effort on the project plan is minimal during the current year ramping up in the last quarter of 1989.

### 2.4.7 COMETT

This was a result of a successful bid for funding under the CEC COMETT (COMmunity action programme for Education and Technical Training) Programme. The consortium was headed by ZGDV, Darmstadt. Only partial funding was made available for the first phase of this project. RAL's contribution was a Course on Human Factors Aspects of User Interface with innovative software for cooperative working and demonstration. Contributions to the project were made by TC, KR, CAAG, DJJ, MJP and MMM. The Course is intended to have a large hands-on component. This was an activity jointly undertaken by SysIG and UIG.


**Ken Robinson explaining RAL's cooperative working research to the Engineering Board Computing Committee**

**Large View**

### 2.4.8 Other Activities

EASE start-up including assistance with questionnaire and visit design (TC). Grant bids prepared for IED and Joint Research Council Initiative (TC). Some involvement with external bodies including the DECUS AISIG and the (Alvey) Human Interface Club (TC).

### 2.4.9 Conferences

(Excluding one-day meetings: covered by internal reports.)

- CFTAG Meeting on Graphics Standards (Manchester) DCS, TC
- Computer-Supported Cooperative Work Conference - MJP.
- HCI'88 - PK
- CHI' 89 - MJP
- Seminar on Apricot Sigmex - PK.

### 2.4.10 Courses Attended

(Excluding local Safety Courses etc.)

- Instruction Set C Course - ZM
- Internal C Course - LS, PK
- Occasional Speakers Course - MJP, TC.

### 2.4.11 Papers

(Excluding ELO and EWS documents.)

Internal:

- Software Development Notes:
  - SDN 44-46: COMETT Course Contents and associated material
  - SDN 47: CCS Editor
  - SDN 51: Broadcasting the SUN Screen
  - SDN 52,53,55: COMETT Course Software
  - SDN 54: COMETT Techniques Report
  - SDN 57: PHIGS Assessment
  - SDN 60: PHIGS Workprogramme & Barcharts
- Management Notes:
  - MN 45: UIG Initial Work Programme
  - MN 46: IED/SERC Collaborative Programme Update
  - MN 47: HIC Effort in EASE 1989-90 (with SysIG)
  - MN 49: HCI Notes Series (with SysIG)
  - MN 52: Projects, Staff and Effort Allocation in SysIG and UIG for 1989-90 (with SysIG)
- Internal Notes:
  - INT 55 System Simulation Ltd Meeting
  - INT 56 Instruction Set Ltd Meeting
  - INT 57 Visit to LFCS, Edinburgh
  - INT 58 HIC'88
  - INT 60 X-Windows Third Technical Conference
  - INT 61 Visit to Darmstadt (ref COMETT)
  - INT 64 Apricot Sigmex Graphics Seminar
- UIMS Notes:
  - UIMS 1-5,7 UIMS Progress Meetings (UMIST & RAL)
  - UIMS 6 Report on UIMS Evaluation Exercise
- HF Notes:
  - HF 7 HF Equipment List
  - HF 8 AID Project Meeting
  - HF 9 BCS Expert Systems Group Meeting
  - HF 10 Conference on Computer-Supported Cooperative Work
  - HF 11 Visit to BAe Bristol (Sowerby Research Centre)
  - HF 12 Visit to System Simulation Ltd
  - HF 13 Apollo Visit to RAL
  - HF 14 IEE Lecture - Philip Johnson-Laird
  - HF 15 HUFIT Project

- HF 16 BCS HCI SG Meeting - ITS and Authoring Systems
- HF 17 Using the Digitry System
- HF 18 Acoustic Environments
- HF 19 Soft PC
- HF 20 Red Documentation
- HF 21 CHI'89 Conference

- RAL Reports:
  - UIMS Which Report (MJP)

#### 2.4.12 Objectives for 1989/90

- EASE UIMS:
  - Revisit UIMS Evaluation and Toolkits as per CFC recommendations).
  - Seminar at UMIST in September 1989. MJP and TC to give papers.
  - Workshop in 1990.
  - Try to arrange for selected HEI sites to use a UIMS during 1990.
  - Work on Rapid prototyping
- EASE PHIGS:
  - Evaluation work as per SDNs 57 and 60.
  - Graphics Meetings Informatics/CCD.
- Human Factors work: Experimental -
  - Extend menu study and publish/present as conference paper.
  - Develop work on DataGlove use: where not covered by ipr under EWS.
  - Develop/explore ways of providing HF information to engineers in a usable form ('packaged' - video, hypertext, courses). May involve specific design help with UIMS usage.
- OTHER:
  - IED Standards Activity - it is likely that PK will be involved with this in the coming year. The precise duties and level of involvement have still to be determined.
  - ARGOSI - PK may also be involved in some input to ARGOSI.
  - External Grants - continue to pursue external funding (especially ESPRIT II, Joint Research Council and SERC Committees). Under existing DTI Link rules for the new programme it does not seem likely that out potential commercial collaborators will be able to afford to participate.
  - To identify any gaps in the Group's technical and other expertise and, funding permitting, attempt to fill these.
  - To try to ensure that all members of the Group attend at least one major international conference in the coming year.
  - Encourage external publications and conference papers.

### 2.5 Transputer Coordination Unit

#### 2.5.1 Staffing

Staff in post at end of August 1989.

- Mike Jane (MRJ) Coordinator
- Cyril Balderson (CB) Deputy Coordinator, Unit Leader and Suppliers Liaison
- Raymond Fawcett (RJF) Loan Pool Coordination and Support Centres Liaison
- Terry Mawby (TPM) Publicity and Promotion
- Linda Reed P/T (LJR) Loan Pool Manager

TPM joined the Unit in August 1988, followed by RJF in December. LJR joined in March replacing Fran Childs who returned to Space!

### 2.5.2 Objectives for 1988/89

To carry out the Initiative programme in accordance with the Report of the CFC Working Party on Engineering Applications of Transputers, October 1986. In 1989-90, to carry the programme forward as may be modified in light of a Market Survey currently under way, and to target Continental Europe for the Awareness Programme.

### 2.5.3 Coordination Function

The Coordination function in respect of this Initiative has a number of identifiable components reflected in the job responsiblities above. These can be regarded as customer or client oriented. There are in addition various activities which are Programme oriented including servicing of Committees and Meetings, and organising Conferences, Workshops and Seminars. A recent innovation has been in setting up and servicing a small number of Transputer Applications Community Clubs.

### 2.5.4 Programme Support

CB started the period as Secretary to the Transputer Applications Management Group (TAMG) , and of the Directors Meeting, and was also Chairman of the Managers Meeting. CB also liaised between the DTI and the Support Centres in drawing up a Project Monitoring scheme in line with requirements for DTI partial funding of the project. CB also arranged purchase of equipment for the Loan Pool and the Transputer Support Centres from budgeted and windfall funds.

### 2.5.5 Suppliers Liaison

Since February this year, CB has been primarily responsible for liaison with Suppliers of Transputer hardware and software, encouraging them to assist and benefit from the facilities offered by the Initiative. Typical activities are in negotiating sponsorship or special deals to have new equipment available in Centres at the lowest possible cost; support of the Initiative Training Courses through companies sales promotion etc and encouraging companies to submit technical material to the Mailshot for publication. The present level of sponsorship is in excess of £700K.

CB is Secretary to the Transputer Applications Management Group (TAMG) and is a member of the Directors and Managers Meetings.

### 2.5.6 Centres Liaison

RJF joined the Unit in December 1988 and has taken over Liaison with the Support Centres, and more recently coordination of the Loan Pool. The first of these activities is aimed at encouraging the sharing of ideas and resources between Centres, monitoring the performance of the Centres under the terms of the Contract, and obtaining data for the DTI project monitoring system. RJF is now Chairman of the Managers Meeting and Secretary to the Directors Meeting.

### 2.5.7 Loan Pool

The Loan Pool coordination activity (RJF) is primarily the pre- and post-loan phase wherein loan applications are collected and assessed against guidelines, and submitted to TAMG for approval or rejection, and also in the obtaining of deliverables in the form of reports for publication, and software for provision to the Software Exchange Library.

The major job greeting LJR on joining the Unit was in the cataloguing and distribution to Support Centres of equipment purchased late in the Financial Year with a special DTI funding. Since then, the Loan Pool records have been updated and developed so that more and better information is available for assessing loan requirements. This activity involves checking and testing of kit before dispatch and return, and having procedures to cope with user problems in hardware or software supplied on loan.

### 2.5.8 Publicity and Promotion

TPM has been responsible for putting the Initiative in the Industrial and Academic Shop-Window. The Initiative Display Stand is to be seen at Exhibitions and Conferences around the UK and elsewhere. There have been two major events demanding much effort and support from the Laboratory and the Support Centres, (a) the PC User Show in June and (b) the Initiative Conference and Exhibition at Liverpool in August. Heavy demands are made on the Laboratory Stores and Transport services in dispatching the Stand to all parts, and to everyone's credit, it remains by and large unscathed. TPM carries the onerous task of Editor of the Initiative Mailshot. This is established as a regular reliable reference to activities and products within the Transputer community and is eagerly sought after.

TPM is planning new ventures called Transputer Fairs aimed at taking awareness of Transputers into the more outlying areas of the Regional Centres.

### 2.6 London and South East Regional Transputer Support Centre

The Centre is the Industrial contact point for London and South East England for the SERC/DTI Initiative in Engineering Applications of Transputers.

#### 2.6.1 Staff in post at end of August 1989

- Mike Jane (MRJ) Head of Centre
- Richard Parkes (RP) Manager
- Paul Shortall (PTPS)

In addition, a number of members of the Department act as advisers and provide support for Centre activities. Chris Wadsworth (CPW) , David Johnson (DJJ) and Cyril Balderson (CB) give lectures supporting Awareness; and technical seminars. CPY and DJJ together with Francis Yeung (HKFY) and Brian Henderson (BWH) offer technical support for Centre activities. Linda Reed (LJR) provides backup for hardware problems on Centre equipment.

PTPS joined the Centre on 31 July as an understudy for RP who has since left the Laboratory.

#### 2.6.2 Objectives

The principal function of the Centre is to assist with the Industrial Awareness programme run by the Initiative by offering appropriate education, pump-priming and evaluation facilities to companies in the Region. The Centre also has a mandate to offer consultancy in the design and support of Transputer-based applications.

#### 2.6.3 Centre Support

A monthly meeting of all Departmental staff involved in the operation and use of the Centre is held under the Chairmanship of MRJ. This meeting advises the manager on matters of interest and agrees the programme of the Centre with attendant commitments.

#### 2.6.4 General

A total well in excess of 135 (the number of names in the Visitors Book!) have been through the Centre since it was opened in April 1988. Many of these have been associated with training and awareness seminars, and others as single visitors, either as users of facilities or during visits for consultancy etc.

#### 2.6.5 Awareness Courses

The course programme was established early in 1989 and to date the number of courses and total participants is as follows:

- Management Awareness (4 courses, 45 total attendees)
- Other Awareness Courses - specially targeted (3,60)
- Exploiting the Transputer (2,21)

#### 2.6.6 Consultancy

Detailed discussions about specific projects have been held with over 15 companies and six of these have generated specific follow-up activity.

More details of this work are to be found in the Parallel Processing . Group submission for this document.

### 2.6.7 Hardware and Software fami1iarisation (hands-on)

The Centre has a range of hardware and software to use and demonstrate the effectiveness of Transputers. The main activity is based on 6 IBM PC-AT style machines, with various Transputer boards added. The Centre also has Meiko equipment and access to IBM 6150 and Sun Workstations able to host Transputer systems. To date, although in use fairly regularly by members of the Department and the Laboratory, take up by Industry has in fact been disappointing. It is expected that this will be successfully addressed in the near future.

### 2.6.8 Future Plans and Objectives

The Centre would expect to benefit from new activities arising out of recommendations from a market Survey which has just been completed. The survey was on behalf of the Initiative and was seeking to identify the perceived needs of Industry from the Initiatives centres.

On the Courses front, the Centre is about to start offering courses for Fortran users of Transputer systems, and the course programme in general is now being considered.

## 3. COMPUTATIONAL MODDELLING DIVISION

### 3.1 INTRODUCTION

### 3.1.1 Staffing

The major problem has been the lack of a Division Head. Consequently, F R A Hopgood has attempted to act as Associate Director of Engineering, Department Head of Informatics and Computational Modelling Division Head. This, inevitably, has resulted in more of the Division's management being devolved to the Group Leaders. A Division Head, Dr D R S Boyd, has been appointed from 2 October, 1989, which should ensure a better organisationa1 structure in the next year.

### 3.1. 2 Highlights

The Division has continued to have difficulty matching staff with projects. The Mathematical Software Group has had particular problems attempting to complete two Alvey projects, provide the infrastructure for the EVEREST ESPRIT I project and keep the CFC applications software programme running despite the loss of staff during the period.

The Engineering Applications Group has provided the main thrust in putting genuine engineering software on the new workstation architectures. Many problems have been encountered and we have provided detailed critical information back to the suppliers. Even so, the potential of the new systems has been amply demonstrated.

The Parallel Processing Group continues to focus its activities on the transputer but with an eye to seeing how general particular approaches can be. In particular, Chris Wadsworth is trying to define a generic architecture for parallel processing akin to virtual memory in single processor systems.

The progress in the Computational Fluid Dynamics area has been disappointing. After a highly successful workshop in Abingdon, Swindon Office has been very slow in appointing a CFD Co-ordinator. This has slowed down the related activities.

The Visualisation Group continues to focus on both image processing and the output of multi-dimensional data. A major achievement has been the production of the IPAL image processing library for NAG. Research into object recognition continues in association with Surrey University.

Hopefully next year will see the production of a set of tools for the rendering of complex multi-dimensional data.

## 3.2 MATHEMATICAL SOFTWARE

### 3.2.1 Staffing

- Chris Greenough (CG) Acting Group Leader
- John V Ashby (JVA)
- Eitan M Azoff (EMA) (resigned - 21/7/89)
- Raymond J Fawcett (RJF) (transferred to Transputer Unit 1/1/89)
- Ron F Fowler (RFF)
- C John Collie (CJC)
- G Goodsell (GG) (joined 4/9/89)
- Andy D Irving (ADI) (transferred to Technology Department 17/4/89)
- Dayal Gunasekera (DG) (Visitor from University College Swansea working on the ESPRIT EVEREST Project)

### 3.2.2 Objectives for 1988/89

The main purpose of the group is to provide a focus of computational techniques and software from which the research community can request advice and assistance in solving computational problems in mathematical physics.

The major objectives of the group for this year have been:

- Completion of Alvey Process and Device Modelling Projects
- Continuation of the ESPRIT EVEREST Project
- Release 3.0 of the Finite Element Library
- Continuation of the ESPRIT ACCORD Project
- Contributions of the specification of EASE

Coupled with these specific objectives has been the continuing process of securing new funding for research and development programming from SERC, DTI and EC.

### 3.2.3 Engineering Applications Support Environment (EASE) (CG, JVA)

During this year the group has been active in the planning and monitoring of the EASE Programme. CG is a member of the ECFE (Engineering Computing Facilities Executive) and has contributed to the discussion on the EASE Environment.

Over the past year some consideration has been given to the Engineering Applications Support Environment. TAPDANCE has been seen as a possible type of environment required by engineering users and a number of Divisional presentations have been given. (CG, JVA)

### 3.2.4 Finite Element Library (FELIB) (CG, CJC)

Over the past year the Library has only progressed slowly. Although Release 3 of the Library was completed and sent to NAG Ltd for assessment in October, detailed amendments requested by NAG have delayed the general release. The amount of effort available for the project has been very small (a small part of CG), in the new year CJC started to work on the project.

During the last 6 months CJC has familiarised himself with the Library by firstly proof-reading the current User Documentation and making suggestions for improvement, and secondly by implementing the Library on the SUN UNIX System. This has involved the production of a SUN specific Machine Constants Library and suitable Make files. As part of this exercise a number of timing trials have been comparing the SUN and Prime versions of the Library.

Attention has now turned to Release 4 of the Library and versions for the Stellar and Ardent. A number of bugs have been encountered in the Stellar Fortran compiler and now that these have been overcome work has started on using the vectorising and parallelising features of the system.

### 3.2.5 ESPRIT Device Modelling Project - EVEREST (CG, DG, JVA, RFF)

The major objectives of the project this year have been to develop and implement algorithms for the three-dimensional transient analysis of semiconductor device structures. A secondary objective has been to plan the development of the fully adaptive version of the EVEREST Suite.

During this period the EVEREST Project has entered its fourth and final year. Difficulties in recruiting suitable staff have hindered the progress of this project but CG and DG have been able to ensure that the major milestones have been met, although RAL have not been able to contribute fully to the programme of the project. As a result RAL have sub-contracted some of the programming tasks associated with the data management to staff at UMIST. CG continues to direct the software programme within the project coordinating the effort of five partners and the effort at UMIST.

**Chris Greenough explaining EVEREST to the Engineering Board Computing Committee**

**Large View**

DG has continued the implementation of the Solver Module of the suite and the three-dimensional transient code has been completed. With the completion of the basic on-state program, a comprehensive testing programme has been undertaken by DG and CG to ensure that the suite is

both robust and produces the correct results. Some twenty benchmark problems have been defined for this purpose.

In the second half of the period JVA and RFF started to work on the project. As a result RAL is now able to contribute to the full programme of the project. JVA is now contributing to the activity on mesh adaption using the Alvey TAPDANCE Suite as a test bed, and also to the project software suite in the area of geometric modelling. RFF has concerned himself with implementing the whole suite (four large programs with three associated libraries) on the Stellar. A secondary activity for RFF has been the development of the physical models library used by the Solver Module and the Post-Processor.

### 3.2.6 ESPRIT Parallel Processing Project - ACCORD (CG)

The ACCORD Parallel Processing Engineering Applications Library (APPEAL) has continued development, with CG providing the project with detailed assessments of the library on design, portability and functionality.

The library has been implemented on the Prime, Vax and Stellar and a number of test programs have been prepared to perform timing comparisons.

CG has transferred the role of software co-ordinator of the serial library to another partner, so that co-ordination of the software and documentation of Release 2 of the library can be preformed by the same site.

### 3.2.7 Alvey Device Modelling Project - DEVMOD (EMA, RFF)

The Alvey funded project on device simulation ended on 31 March 1989 and although a follow-on project was proposed, RAL was eventually not included. The role of RAL in the project has been to develop a two-dimensional device simulator based on the results of the EVEREST Project.

Throughout the year EMA and RJF have been developing and testing the two-dimensional device simulator DEVMOD which is one of the kernels populating the TAPDANCE Environment.

Early in the year, the off-state version of the program was made available to the partners and work then continued to complete the fully coupled on-state solver. There-has been a significant development of the physical models used within DEVMOD and the program has been tested using a sub-set of the EVEREST Benchmark set. DEVMOD is now able to solve all the problems in this set and a number of reports have been written on the results.

As part of the project the User Documentation and the Technical Manual have been produced as reports.

Although DEVMOD is not currently being developed as part of a major project, it is being successfully used as a test-bed for physical models and adaption methods within the EVEREST Project.

### 3.2.8 Alvey Process Modelling Project - TAPDANCE (CG, JVA, RJF)

As with the Alvey Device Modelling Project the Process Modelling Project came to an end in March. RAL's role in the project has been to develop an integrating environment for the four other software modules being developed within the project.

This has resulted in CG, JVA and RJF producing TAPDANCE.

Over this year JVA has had the repsonsibi1ity for the day-to-day running of the software integration and has also helped the other partners integrate their kernels within TAPDANCE.

RJF has been responsible for the development of the ion implantation kernel SIMPLANT, and for developments of the geometric modeller to include simple lithography processes.

### 3.2.9 Building Performance and Assessment (ADI, CJC)

In the first half of the period ADI was a member of the group and his work associated with building performance and model assessment has continued. ADI has continued work on non-linear performance analysis and developed the methods in collaboration with Bristol University. He has also continued work with CJC on the time series analysis techniques with building model assessment.

In April ADI was transferred into the Energy Research Unit of Technology Department which was thought a more suitable environment for this type of work.

### 3.2.10 Conferences Attended

1. International Conference on the Simulation of Semiconductor Devices and Processes, Bologna, Italy, September 88. (CG, JVA)
2. Numerical Analysis of Semiconductor Device and Integrated Circuits, Trinity College, Dublin, July 1989. (CG, JVA, RFF)
3. Alvey Layer Processing Club, University College, Swansea, September 1988. (JVA, RFF)

### 3.2.11 Courses Attended

1. Multigrid, University of Oxford, April 1989. (CG, JVA, RFF)
2. Management Development, Joint Training, April/May 1989. (JVA)
3. Management for Senior Grades, Joint Training, February/March 1989. (CG)
4. NASECODE Short Course on Software for Device and Process Simulation, Trinity College, Dublin, July 1989. (CG, JVA, RFF)
5. SERC Induction Course, RAL, November 1988. (RFF)

### 3.2.12 Papers and Reports

1. C. Greenough, D. Gunasekera, C.J. Fitzsimons, P.A. Mawby and M.S. Towers, Modelling Semiconductor Devices in Three Dimensions, Short Course on Software for Process, Device and Circuit Modelling, NASECODE VI, Trinity College, Dublin, 1989.
2. J.V. Ashby, E.M. Azoff, R.F. Fowler, R.J. Fawcett and C. Greenough, Coupled Process and Device Modelling with TAPDANCE, Software Forum in NASECODE VI Conference, Trinity College, Dublin, 1989.
3. R.F. Fowler and E.M. Azoff, The Alvey 034 Device Modelling Program - DEVMOD, Alvey Layer Processing Club Meeting, Swansea, September 1989.
4. R.F. Fowler and E.M. Azoff, Benchmarks for the Alvey 034 Device Modelling Kernel, RAL Report, RAL-89-071.
5. E.M. Azoff and R.F. Fowler, The TAPDANCE kernel DEVMOD - Technical Report, RAL Report, RAL-89-043.
6. E.M. Azoff and R.F. Fowler, The TAPDANCE kernel DEVMOD - User Manual, RAL Report, RAL-89-044.

### 3.2.13 Objectives for 1989/90

In the next year the group will continue its development of mathematical algorithms and software and provide a general advice service in these areas.

Specific objectives for the year will be:

- Completion and release of Release 3.0 and 4.0 of the Finite Element Library.
- Completion of the three-dimensional device simulator within the ESPRIT Project EVEREST and its distribution to the UK community.
- Evaluation and distribution of the ACCORD APPEAL Library on vector architectures such as the Stellar and Cray.
- Contributions to the specification and design of the EASE Environment and to its population.
- The securing of new funding for semiconductor device modelling and algorithm development for vector and concurrent architectures.

## 3.3 ENGINEERING APPLICATIONS

### 3.3.1 Staff

- N J Diserens (Group Leader)
- C S Harrold
- M Chow
- Manjit K Bopari has worked with the group for part of the year.

### 3.3.2 Objectives

- Adaptation of the TOSCA suite of Electromagnetics programs to the STELLAR GS1000, STELLAR GS2000 and ARDENT TITAN1 Computers as part of the EASE assessment of these supermini workstations.


**PE2D, TOSCA and CARMEN being demonstrated to the Engineering Board Computing Committee**

**Large View**

- Assessment of the AMT DAP using the BIM2D package (a boundary integral magnetostatics package for 2D) as an example. The work centred on adapting the dense matrix solver to the DAP architecture. The DAP graphics system DAPIX, written by Intercept Ltd., is being assessed.

- To write a computer program to represent the acceleration of a charged particle beam in an RF Quadrupole accelerator, representing the space charge in a finite element system, and to commission the writing of a pre and post processor.
- To participate in the TEAM workshops (Testing Electromagnetic Analysis Methods), which is an international collaboration to provide benchmarks and to compare analysis codes.

### 3.3.3 Achievements

1. The TOSCA solver package has been ported to both the STELLAR and ARDENT machines (NJD). Some work has been done on the pre and post processors SCARPIA and TOSCA, but problems with the PHIGS graphics system on the STELLAR computers has prevented full implementation so far (NJD) Further tuning work is being done on the solver, which on the GS2000 is about 7 times slower than the CRAY X-MP and about 16 times as fast as the SUN 3/140 (MCC). The CARMEN eddy current package has been mounted on the STELLAR but no tuning has yet been done (NJD).
2. The BIM2D package has been ported to the SUN system where it is used, with only the parts of the program which can be adapted for parallel operation being sent to the DAP (MC and CSH). Work on the AMT DAP has concentrated on developing an efficient method for solving the matrix equation. Solutions are obtained by partial inversion of a submatrix and, if necessary, reducing the rounding errors by iteration. The procedure relies on the diagonal dominance of the coefficient matrix and solutions can be obtained in about half the time required by the Gauss-Jordan method (CSH).
3. The work on the RFQ accelerator project is nearing a conclusion. Shortage of staff has prevented some of the original objectives from being attained, but a working program should be delivered to Los Alamos in September 1989. The pre and post processor has been written by Vector Fields Ltd, and the complete system is now under test (NJD).
4. The TEAM workshop Problem 12, which is a coupled problem in which a copper cantilever is subjected to transient magnetic field, is being worked on in collaboration with Vector Fields Ltd. VF are preparing a transient version of the CARMEN eddy current package and we are writing a program to calculate the deflections. It is hoped that the two analysis programs may be made to run in parallel on the STELLAR GSIOOO. (NJD)

### 3.3.4 Courses and Conferences

1. STELLAR Optimization and Tuning Course, Boston, Ma USA, January 1989 (NJD)
2. TEAM workshop Bievres (Paris) March 1989 (NJD)
3. TEAM workshop Okayama (Japan) September 1989 (NJD)
4. Vector Fields European Users' meeting CERN May 1989 (NJD)
5. COMPUMAG Tokyo September 1989 (NJD)
6. IUSC Working Party on CAD/CAM (NJD)
7. Conference on Magneto Optical Storage, London, March 1989 (CSH, MC)
8. DAP Group Meeting Bracknell, April 1989 (CSH, MC)
9. Exploiting the Transputer, RAL, July 1989 (CSH, MC)
10. CERN Summer School in Computing, Bad Herrenalb, West Germany, August 1989 (MC)
11. 9th OCCAM User Group Meeting, Netherlands (MC)
12. Course in Written English (MC)

Various meetings were attended at IEE London by Group staff.

### 3.3.5 Presentations and Reports

1. Presentation to VF European Users' meeting. TOSCA modelling of the Input Gap to the Chalk River RFQ1. (NJD)
2. Paper to COMPUMAG. Experience in the Use of Vector Processors for 3D Static Analysis. (NJD)
3. RAL report (In preparation). Fast Matrix-Matrix Multiplication via Recursion on the AMT DAP. (CSH)

4. RAL report (In preparation). Solution of Dense Matrices Applied to a Boundary Integral Program for Magnetostatic Field Calculation on the AMT DAP. (CSH)

### 3.4 PARALLEL PROCESSING

The Parallel Processing Group (PPG) undertakes projects and development work on the systems aspects and programming techniques of parallel processing, as well as monitoring and assessing developments in the field generally. Advice and assistance is also given on porting applications to parallel systems. PPG also supports the programme of the SERC/DTI Initiative on the Engineering Applications of Transputers and of its London and South East Regional Support Centre located at RAL, both of which are coordinated in separate Units in ID.

#### 3.4.1 Staffing

- C P Wadsworth (CPW)
- H K F Yeung (HKFY)
- D J Johnston (DJJ)
- M H Roberts (MHR) left February 1989
- B W Henderson (BWH)

D J Johnston and B W Henderson were successful in obtaining promotion in June 1989 to SSO and HSO, respectively.

#### 3.4.2 Objectives

Current interest is focussed mainly on scalably parallel architectures such as ones with distributed memory, eg the transputer and hypercube machines. A medium-term goal (12 to 24 months) is the integration of the transputer and/or other parallel systems into the EASE programme. The ease with which this can be achieved may well depend on the rate at which the community develops the ability to exploit parallel processing without the need for explicitly parallel programming. The long-term goal is to provide an effective environment for developing applications on and for parallel systems.

Much of the Group's work concerns the porting of applications to parallel systems, both by ourselves directly and through advice and assistance to others. The benefits gained serve both to widen knowledge of effective parallelisation techniques and to consolidate an understanding of user needs for an effective applications environment for parallel systems.

Porting an application is typically undertaken jointly with an applications team, eg internally or via Transputer Centre contacts, in one of two ways:

- Type A: PPG does the bulk of the work with the other party providing applications expertise (80% PPG, 20% other).
- Type B: The other party does the bulk of the work with assistance on parallelisation techniques from PPG (20% PPG, 80% other).

The aim in Type B projects particularly is to make PPG's expertise accessible to others (and to increase our own knowledge and expertise further!). Proposals for more Type B projects are particularly sought.

Specific objectives for 1988/89 have been as follows (in no particular order):

- Formally start 6150 Joint Study with IBM and complete the two major tasks scheduled (software for 6150 to serve as front-end to a transputer system, and port of a first real application);
- Enable 6l50/transputer combination to be used as an internal service by CMD;
- Support the RAL Transputer Centre and Transputer Initiative Co-ordinator with technical expertise as required;
- Develop two courses for RAL Transputer Centre;

- Consolidate and extend the range of tools available for transputer systems, in particular monitoring, worms, and standard harnesses;
- Assess and make available software that enhances the transputer systems in the community;
- Establish funding for at least one externally funded project.

### 3.4.3 Transputer Technical Support

Logically this may be divided into support for the Transputer Centre and support/advice to the Transputer Initiative Co-ordination Team, though in practice it is sometimes difficult to distinguish the two roles (eg hot-line service to a loan-pool beneficiary who may not, strictly speaking, lie within the region served by the RAL Centre.)

#### 3.4.3.1 Transputer Centre

The year has seen a strong build-up in most parts of the Centre's programme (booked usage by Industry of the Centre facilities is still proving a disappointment) and hence in the technical support provided by PPG.

3.4.3.1.1 Courses

PPG regularly contributes to two courses offered by the Centre: a half-day seminar Transputer Awareness for Managers (CPW - 90 mins) and a one-day course Exploiting the Transputer (all PPG staff). These courses now run regularly at monthly and two-monthly intervals respectively. Each is normally concluded with a visit to the RAL Centre and demonstrations by PPG staff (except when held off-site). Number of times held during the year were:

| | |
|---|---|
| Monthly Awareness | 6 |
| Special Awareness | 2 |
| Exploiting Transputer | 3 |

In addition, a special two-day course was designed for a joint audience from Cambridge Instruments and the EBL group at RAL.

3.4.3.1.2 Discussions/Consultancy

CPW and/or DJJ have frequently participated in discussions with prospective industrial customers of the Centre. HKFY and BWH have also been involved in several of these meetings. Usually a member of the Co-ordination Team, or the Centre Manager, is also involved, with the technical lead corning from PPG (and the customer!). Among the companies with whom discussions have taken place are:

- *Vector Fields
- *Halcrow
- *Cambridge Instruments
- *Wootton Jeffreys
- *Marconi
- *Mullard Space Science Lab
- Harwell
- EEV
- Hydraulics Research Lab
- EPL Training
- Smith Industries
- Colin Coleman & Co
- Sienna Systems
- Transport Studies Group
- Flowmetrics
- MOD

(The MOD pair did not say (were not allowed to ?) which office/establishment they were from! The asterisks above indicate those companies with whom there has been specific follow-up to date, either in the form of consultancy/ sponsorship, work done for or with the company, or development of a special or on-site course.

3.4.3.1.3 User Support

DJJ has provided nearly all the day-to-day support to users of the Centre: getting users started; hand-holding; tutorial assistance; hot-line service for telephone/email/postal queries from users.

This area of support has seen a sizeable increase in activity recently, particularly since the exhibit at the PC User Show in May 1989. With changing priorities for PPG (from pressure on CFC booking), it may become necessary to cut back in this area, eg users outside the South East Region may be referred to their own Centre.

**3.4.3.2 Transputer Initiative Co-ordination**

CPW is frequently asked by the Co-ordinator for advice on technical matters pertaining to the Initiative, in particular: advice to loan and grant applicants; appraisal of loan applications; comments on miscellaneous papers or proposals received; technical negotiation of EMR developments contracts. CPW also provided technical liaison to the QUB/Brunel/Liverpool EMR survey of language and compiler facilities for parallelism (this has close connections to a collaborative project PPG hopes to be involved in - see 4.7 below). CPW is a member of the Transputer Applications Management Group (TAMG) which oversees the operation of the SERC/DTI Initiative.

DJJ has been involved with the evaluation of all new hardware and software products being considered by the Initiative, both new products (eg 3L Parallel Fortran, Motherboards, TRAM Modules) and new releases (eg product releases of TDS and TDT) , and of initial versions of software generated by EMRs (eg port of GRAIL to a PC).

PPG staff have provided effort to man the Transputer Initiative stand and show demonstrations at the BAAS Exhibition, Oxford, September 1988 (CPW, DJJ, and Rajka Popovic) and at the PC User Show, May 1989 (DJJ).

**3.4.3.3 Applications Workshop**

CPW chaired the Applications Workshop held by the Transputer Initiative at Cosener's House, Abingdon, on 14-15 February 1989. As with the previous Workshop, this took the form of invited presentations followed by parallel sessions (twice) interleaved with reports back to a general session. The three parallel sub-groups were: Control; Modelling; and Inputs, Data and Output.

DJJ wrote most of the Workshop Report with inputs from CPW, MHR, MRJ, Terry Mawby, and Raymond Fawcett who acted as notetakers in the parallel sessions. The major recommendation (now implemented) was the establishment of three Transputer Applications Community Clubs (TACCs) in Image Processing and Pattern Recognition, Molecular Modelling, and Real Time Control and Simulation.

**3.4.3.4 Demonstrations**

With the popular appeal and attention focussed on the transputer, demonstrations have become a seemingly ever-growing part of PPG activities for a variety of arranged and casual visitors. At times it has seemed that hardly a day has gone by without one!

Among those to whom presentations have been given, in addition to the courses and companies mentioned above, are:

- CFC
- EM Committee
- HEP Committee
- IUCC
- SERC Brussels Office

- DTI Chief Scientist
- IBM Academic Programmes Section
- BBC Science Now
- Prof Watase (Japan)
- Prof Vismanathan (India)
- Prof Brown (Rochester, US)
- Prof Hodgson (N Carolina)
- Dr O'Callaghan (CSIRO)
- Prof Newman (Hong Kong/Oxford)
- Yeong Shoon Lau (Singapore)
- + miscellaneous UK academics

The range of demonstrations available has been steadily expanded and consolidated during the year. The standard set that has been regularly shown now consists of:

1. Ray Tracing
2. 2D Wave Equation
3. N-Body Problem (two window demo)
4. BIM2D Electromagnetics
5. Interactive Mandelbrot Set

All of these run on the Meiko Computing Surface, except for BIM2D which is hosted by a 6150 (developed under IBM Joint Study - see 4.6 below) .

Demo (2) was written by DJJ in response to an observation (by CPW) that the standard Meiko demo was unimpressively slow - DJJ's version, now optimised, achieves 12 frames/sec against Meiko's 3 frames/sec! Programming effort was about 2 man-weeks; this illustrates a common experience with developing software for transputers that a relatively small effort can produce considerable performance benefits once relevant optimisation principles are understood. In programming the demo, DJJ also developed a geometric harness, a communication structure for a transputer network reflecting the geometry of a generic type of problem exemplified by wave propagation. This and the other demos on the Meiko system also illustrate the benefits of electronic reconfiguration of the transputer network in the Meiko system (the demos all run on a different topology).

Other demos available are:

i. Field Potentials (two window demo)
ii. Monitoring Processor Utilisation
iii. Finite Element Stress Analysis
iv. Rotating Hypercubes
v. Mapping Images on Rotating Sphere
vi. Rotating Globe (special case of (e)

Demos (a) and (b) were developed by BWH; (a) shows a visual comparison of the performance of a 6150 alone (with FPA) versus that of a 6150 plus 4 transputers (see 4.6). Demo (c) simulates an explosion in a pressure vessel, eg a nuclear rector, and was developed during a Transputer Initiative loan to Swansea. Demos (d), (e) and (f) were developed by DJJ; a special feature of (f) is that the world rotates backwards!

### 3.4.4 Transputer Developments

#### 3.4.4.1 Unix Server for 386 Machine

As part of the ESPRIT Accord project Vector Fields approached PPG to undertake a port of the host server for 3L Parallel Fortran from a PC to a Research Machines 386i running Unix. An extension to the Department's Accord sub-contract from Vector Fields was agreed in June and the work is now nearing completion. The work is based on the similar port for the 6150 host and has been done by BWH.

#### 3.4.4.2 Monitoring Tool

BWH developed a simple monitor for a transputer network which provides statistics on the run-time performance of each transputer in the network. This is interfaced to a graphics display program to plot the data and enhance the debugging and optimisation capabilities of the monitor. The present version of the graphics plotter allows plots of up to 32 transputers to be viewed concurrently.

#### 3.4.4.3 Parallel Worm

DJJ wrote a worm program that explores a transputer network to discover the number of processors present and how their links are connected. In contrast to most such software, including the standard worm in Inmos' software distributions, this worm explores many branches of the network in parallel. This enhancement becomes particularly significant when the network is large, for which there are analogous considerations in the boot software for loading a multi-transputer application onto a large network.

#### 3.4.4.4 Assembler Programming

Despite Inmos' best efforts to convince the world that Occam was the assembler language of the transputer, there is a more traditional assembler and much performance advantage can be gained by programming critical routines selectively in assembler. DJJ has investigated the relative efficiency of programming the transputer in assembler, compared both to Occam and to traditional sequential languages (Fortran, C). The results have been documented in PPG Note 12 for an example set of graphics primitives. An abridged version is to appear in the Transputer Initiative Mailshot.

#### 3.4.4.5 Porting Fortran

Following discussion with Wootton Jeffreys, DJJ has ported one of their traffic modelling applications called ASPECT first on to a single transputer and then on to a multi-transputer network. ASPECT is a near ideal candidate for parallelisation, involving independent calculation of shortest paths for all possible pairs of starting and finishing sites in a traffic network (a bit of cleverness/thought may of course reveal a much "better" parallel algorithm!). DJJ investigated the possible choices for porting the original Fortran code to multiple transputers in order to determine the tradeoffs involved.

This work, along with that on the worm and on assembler, have been written up as PPG Notes. All three contain work worthy of outside publication and routes for this are being pursued.

#### 3.4.4.6 Spy on ATW

DJJ has ported the spy editor developed at RAL to the Atari Transputer Workstation (ATW).

#### 3.4.4.7 DTI Parallel Software Evaluation

DTI have recently launched a scheme to place six (initially) different transputer software products for use at about twenty sites each. DTI chose to call it Parallel Software Evaluation. The scheme is operated by the University of Southampton.

PPG bid for and have now received Helios (PC-version) and the 3L Parallel Languages (Fortran, C, Pascal) for evaluation. The evaluation will require a report to be produced by the end of the first year (Summer 1990). Others wishing to try out the products and contribute to the evaluation which PPG will be doing are welcome.

#### 3.4.4.8 Programming Environment

There is by now a considerable variety of approaches, and substantial differences of detail within approaches, to programming transputer systems. The variety becomes even greater when one looks at other parallel systems, eg hypercubes or various shared memory multiprocessors.

There is a growing realisation, at least within one half of the parallel processing community, that this state of affairs cannot continue if general parallel processing is to deliver its promised benefits. (For

a suitable consideration CPW might be persuaded to disclose which half of the community is starting to think right!).

CPW has spent much time cogitating these matters, with several lengthy and helpful discussions with Stuart Robinson particularly. Initial conclusions were presented in an invited paper at the Unicorn Seminar on Software for Parallel Computers.

### 3.4.5 Solar A Project

In mid-April CPW was contacted by Space Science Department with an appeal for urgent help with programming in C on one of their projects. IDHM was immediately keen for ID to be seen to be helping others in RAL. After a rapid but thorough survey by IDHM of who could do the job, involving it seems all in PPG as well as others, BWH was selected as the lucky one to bail out Space Science (sorry: to make Informatics expertise available to other Departments!).

BWH was on loan to Space Science for two months (May and June), with occasional days since. Stuart Robinson has been the Informatics link for the loan and a source of expert help about C.

The work consisted of developing a system to allow testing of a space-borne instrument to be carried out in an automatic way. A 386 PC was used to control the test bed and the instrument. A test language was developed to allow long and laborious tests to be carried out with results logged and errors flagged.

A side-benefit of the loan was to provide a further link with the transputer activities in Space Science and at the Mullard Space Science Laboratory (MSSL) with whom RAL collaborates on the Solar A Project. As a result a Special Awareness Seminar (half-day) was given at MSSL (Dorking).

### 3.4.6 IBM Joint Study

#### 3.4.6.1 Background

This Joint Study with IBM involves the IBM 6150 workstation and the transputer. IBM have provided RAL with three 6150s on loan for the duration of the project (two years). The Joint Study started officially on 1 November 1988 with the completion of delivery of the loan machines. The general aim is to explore the potential for enhancing the capabilities of an advanced graphics workstation (6150) with a reconfigurable parallel computer server (transputers).

#### 3.4.6.2 Initial phase (HKFY, MHR, BWH)

With a jump start on the official start date, initial work has been completed well ahead of the target dates. The software to enable the 6150 to serve as a front-end to a transputer system has been in a stable state since the end of 1988. This consists of an AIX device driver and the afserver program which serves the transputer network with file-handling and screen and keyboard access via the 6150. The port of afserver to the 6150 has also been extended to provide IPC facilities between the server process and other processes running on the 6150. Later, BWH has revised the server program to use the AIX device driver for accessing the (first) transputer board.

Porting a first application, an electromagnetics package BIM2D, was successfully completed by MHR in collaboration with Vector Fields. BIM2D is a 40000-line Fortran program and the port was achieved with only 700 lines needing to be ported (and parallelised) to the attached transputer system. The results of this work are being presented at the Compumag Conference in Japan in September 1989. A demonstration of an interim version was given by MHR and Vector Fields as part of the latter's contribution to a presentation by the ESPRIT Accord project. Later, BWH has ported a PHIGS implementation of the GINO simulator from Vector Fields onto the 6150, and extended the BIM2D program to allow it to use the new simulator.

#### 3.4.6.3 Further Applications (HKFY)

With the loss of Mark Roberts at the end of February 1989 and the loan of BWH to the Space Department and Vector Fields, the project has been for a time moving in a single track rather than spearheading in parallel. Though ideally one would like to advance both the system and application

aspects of the project in tandem, progress has been made on both fronts throughout the year, albeit one at a time.

On the system side, one of the major developments is the implementation of the LAN based transputer server. This allows transputer systems to be accessed remotely and would be useful to some of the workstations here which are not expandable. The transputer server is effectively a compute server in the conventional sense which happens to be using the transputers for its operations. In practice, the server runs as a daemon process on the host machine which communicates with the clients using the TCP/IP protocol. However, by using the socket utilities, the implementation is not much exposed to the underlying protocol. The software is further protected from the various schemes, data is stored on different machines by adopting the XDR format in exchanging data between the server and the clients.

On the application side, a number of packages have been investigated which includes TOSCA, SPICE (a circuit simulator package), SCNAPT (an electronic circuit analysis package), APPLE (a finite element package), and ONDA (a river modelling package). With the effort presently available, it is unlikely that more than one application from the list would be embarked upon, and this makes the decision even harder to arrive at. In general one would prefer a real application to a toy program and ONDA scores handsomely on this count as it is currently used by both the National River and Thames Water Authorities. If realism is the main criteria, ONDA will probably be chosen in due course and the project will be carried out in collaboration with Sir William Halcrow & Partners. ONDA has already been ported successfully to the 6150 above.

#### 3.4.6.4 6150/Transputer Development (BWH)

BWH installed the new operating system for the 6150. The new release, AIX 2.2.1, included NFS and X-Windows (Version 11) which had been holding up the work on the project.

BWH developed a demo for the IBM 6150 that illustrates the speed difference between a 6l50+FPA and a 6150+4 Transputers. The demo consists of calculating the field around a set of electrical potentials in an area of 200×200 points. The demo uses X-windows to allow two windows, one from the IBM 6l50+FPA and the other from the IBM+4 Transputers, to be watched at the same time.

BWH tried to port the circuit design package SPICE onto the 6150. It was envisaged that this program could be altered to use Transputers to speed up its processing time. The available source code of this program was a few releases old. Unfortunately the program would have required a massive amount of re-writing to enable it to run. The program was thus abandoned for the time being.

BWH spent time porting an X11 version of the WW windowing library onto the 6150. This was successful. An attempt to port the graphical editor program ten (which runs on WW) to the 6150, was then made. It was found that this was 90% effective. A problem in the byte-ordering of the directory structure on the IBM has prevented this task from being completed.

### 3.4.7 Research Proposals

PPG joined three consortia in collaborative IED/IEATP proposals whose progress has spanned the full year of this annual report. One of these, as expected, failed to get past the outline proposal stage. A second one, on graphical monitoring tools for transputer systems, was invited to submit a full proposal but the lead partner (GEC Marconi) took a dislike to the LINK funding rules which were introduced at that stage. An attempt to resurrect the project in a proposal to DARPA in the US, with much more generous funding rules, was made but came to nothing.

The third proposal entitled Fortran for Scalably Parallel Systems with Intercept Systems, Meiko, and Brunel University was technically approved in February 1989 (ranked third out of 12 approved from a total of 108 outline proposals originally in Parallel and Novel Architectures). The project will aim to develop the techniques needed to detect and extract parallelism from Fortran programs for multi-transputer target systems. As yet, however, the expected formal

offer/announcement to the project consortium has not been issued from IED. Estimates of when this might happen are deferred to next year's report!

Discussions have also been held with IBM UK Scientific Centre, Winchester, on common interests and possible joint activities, but are currently dormant following the transfer of the IBM leader, Tom Heywood, from Winchester to Hursley.

### 3.4.8 Miscellaneous

#### 3.4.8.1 Graphical colour editor

DJJ designed and implemented a graphical colour editor called red on SUN workstations for the Human Factors Group in Design Division.

#### 3.4.8.2 Handbook of Logic in Computer Science

CPW has participated in two weekend meetings at Cosener's House as part of a project that has been running for several years to produce a three-volume Handbook of Logic in Computer Science, edited by Profs Gabbey, Abramsky & Maibaum of Imperial College. Each volume will have 10 to 12 chapters of about 50-80 pages. Volume 1 is nearing completion and is now expected to be published in 1990. CPW is principally involved with two chapters, on Denotational Semantics and Domains, in Volume 2 in the curiously named role of Second Reader (first reader might be more accurate). The main connection in this activity with parallel processing is that it is being done in parallel with everything else! (Other chapters in the Handbook will cover work on concurrency a la Milner, Hoare, Winskel, Plotkin, etc.)

### 3.4.9 Conferences Attended

1. CONPAR 88, UMIST, 12-16 Sept 1988 (CPW)
2. ITEX, Barbican, November 1988 (CPW)
3. Alvey SIG on Parallel Declarative Systems, London, November 1988 (CPW)
4. Computational Science Initiative Workshop on Parallel Computing, Daresbury, November 1988 (CPW: invited talk)
5. RSRE Symposium on Parallel Processing, Malvern, November 1988 (CPW)
6. ULCC/RCI Symposium on High Performance Computing, London 14-15 December 1988 (CPW)
7. SERC/DTI Transputer Initiative Applications Workshop, Coseners House, 14-15 February 1989 (CPW: Workshop Chairman)
8. OUG Workshop on Transputers, UNIX and Future Systems Engineering, University of Kent, February 1989 (CPW)
9. BCS Display Group Seminar on Parallel Processing for Display, London, April 1989 (CPW)
10. SERC Town Meeting on Parallel Computing, London, May 1989 (CPW)
11. Unicorn Seminar on Software for Parallel Computers, London, 13-15 June 1989 (CPW: invited paper)
12. 28th Annual International Conference on Parallel Processing, Chicago, 8-12 August, 1989 (CPW)
13. SERC/DTI International Conference on Applications of Transputers, Univ of Liverpool, Sept 1988 (HKFY)
14. Occam User Group (OUG) Technical Meeting 9, Univ of Southampton, Sept 1988 (HKFY)
15. Edinburgh Concurrent Supercomputer (ECS) First Annual Seminar, Edinburgh, Sept 1988 (HKFY)
16. Dore Seminar (Ardent Ltd), London, November 1988 (DJJ)
17. SERC/DTI Transputer Initiative Applications Workshop, Coseners House, 14-15 Feb 1989 (DJJ) (Report Editor)
18. PC User Show, London, May 1989 (DJJ)
19. Workshop on Parallel Computing, Daresbury. June 1989 (DJJ)
20. SERC/DTI Transputer Initiative Applications Workshop, Coseners House, 14-15 Feb 1989 (MHR)

21. OUG Technical Meeting 9, Univ of Southampton, September 1988 (BWH)
22. OUG Technical Meeting 10, Enschede Netherlands, April 1988 (BWH)

### 3.4.10 Courses Attended

1. Management Skills for Technical Professionals (Career-Trak Seminar), London, March 1989 (CPW)

### 3.4.11 Papers

#### 3.4.11.1 External

1. Who Should Think Parallel?, Unicorn Seminar on Software for Parallel Computers, Novotel, London, June 1989 PPG Note 11). (CPW)
2. Joint editor of [5] (CPW).
3. Implementing a Boundary Integral Method on a Transputer System, to be presented at Compumag 89, Japan, Sept 1989. (With C W Trowbridge and C H Bryant of Vector Fields). (MHR)
4. Joint editor of [5]. (MHR)
5. Report on Applications Workshop, Cosener's House, Abingdon, SERC/DTI Transputer Initiative, February 1989. (DJJ)

#### 3.4.11.2 RAL Reports

None during this period.

#### 3.4.11.3 Internal

1. Porting Fortran to Transputers : Report of a Visit by Wootton Jeffreys, Transputer Initiative Note 18, July 1988. (CPW)
2. PPG Contributions to EASE, several iterations, October 1988 to May 1989, CMGLM/P17/89, May 1989. (CPW)
3. Report on 9th OUG Technical Meeting at Southampton, September 1988 (with BWH). (HKFY)
4. Report on ECS 1st Annual Seminar, University of Edinburgh, September 1988. (HKFY)
5. IBM 6150/Transputer Project Specification. PPG Note 1, November 1988. (HKFY)
6. AIX Device Driver for the Transputer Board PPG Note 6, February 1989 (HKFY)
7. TDS and TDT Servers (for 6150), PPG Note 7, March 1989. (HKFY)
8. IBM 6150 Progress Report, CMGLM/P10/89, April 1989. (HKFY)
9. RAL/Halcrow Onda Project Specification, PPG Note 13, August 1989. (HKFY)
10. Porting Fortran Applications to a Transputer Network, Transputer Initiative Note 24, March 1989. (DJJ)
11. Graphics on a Transputer Network, PPG Note 9, April 1989. (DJJ)
12. Red: an Interactive Graphical Colour Editor, PPG Note 10 and Human Factors Note 20, June 1989. (DJJ with M J Prime)
13. Experiences of Transputer Assembler Programming", PPG Note 12, August 1989. (DJJ)
14. Transputer Development Toolset and Fortran on the IBM 6150, PPG Note 2, November 1988. (MHR)
15. Structure of Transputer BIM2D, PPG Note 4, February 1989. (MHR)
16. Development History for Transputer BIM2D, PPG Note 5, February 1989. (MHR)
17. Joint author of [8]. (BWH)
18. Ginosim : GINO graphics simulator for GSL, PPG Note 8, March 1989. (BWH)
19. Report on 10th OUG Technical Meeting at Enschede, The Netherlands, PPG Note and Transputer Initiative Note 33, July 1989. (BWH)
20. Report on Loan to Space Department, CMGLM/P27/89, July 1989. (BWH)
21. 386 Device Driver and Afserver for Vector Fields, PPG Note 15, August 1989. (BWH)

### 3.4.12 Objectives for 1989/90

The general thrust of the Group's work on parallel processing as outlined in 4.2 will continue with an increasing emphasis on addressing the problems associated with providing machine independent parallel software. This is seen as a key step towards the integration of parallel systems into EASE (at least for a range of parallel architectures wider than one machine).

Specific objectives for 1989/90 are as follows:

1. Pursue the IED/IEATP proposal Fortran for Scalably Parallel Systems through to a formal offer to the consortium and at last get this project started;
2. Decide on and develop further applications for the 6l50/transputers as specified in the Joint Study agreement with IBM;
3. Continue the technical support provided to the Transputer Centre and the Transputer Initiative Co-ordinator;
4. Develop at least one further course involving hands on practicals for the Transputer Centre (probably 3L Parallel Fortran).

Previous plans for future work in parallel processing have been thrown into some confusion by the current difficulties in booking to CFC/EASE. As a result, three of the Group (DJJ, BWH and CPW in varying proportions) are now providing additional effort for the ESPRIT European Workstation project run by Ken Robinson in Design Division.

Further objectives in parallel processing are therefore tempered by the fact that at the time of writing there is no effort spare to address these laudable aims, which include:

a. Extend PPG expertise to at least one other parallel architecture besides transputers (probably Intel iPSC/2 hypercube);
b. Assess the difficulties to be faced in developing and implementing a common programming model based on a virtual architecture for a range of parallel systems;
c. Undertake technical developments on transputers that widen their availability to the end user;
d. Establish one further externally-funded project.

Some of (a) to (d) may become feasible should the IED proposal (1) eventually fall through.

## 3.5 COMPUTATIONAL FLUID DYNAMICS

### 3.5.1 Staffing

The group consists of Alan Bryden (ADB) and Manjit Boparai (MKB). MKB joined the Laboratory on 16 January 1989.

### 3.5.2 Objectives

The main objective is to provide the computing infrastructure for the Engineering Board CFD community. This breaks down into two sub-objectives in the current year:

- Set up a Community Club in CFD, and
- Use CFD as a demonstrator within EASE, eg to populate the software environment and demonstrate its use in real engineering applications.

### 3.5.3 Achievements

The CFD Programme has its basis in an Advisory Group report to the Electromechanical Engineering Committee in May 1988. Following discussions between Swindon Office and RAL, ADB organised a Workshop in Abingdon in January 1989 attended by leading practitioners in CFD from industry and academia. The recommendations of the Workshop were presented first to EMEC, which agreed to fund a Co-ordinator in CFD, and then to CFC which agreed to allocate 3MY of the effort within EASE to CFD.

Since then ADB has been following through some of the recommendations of the Workshop. He is currently involved in discussions with CFD users prior to setting up a Community Club later this

year, and in determining the problems it will address. He is also discussing with Swindon Office details of the proposed Link Programme in CFD.

MKB is undergoing a period of training in use of numerical software at RAL. She transferred the FE Library to the Stellar computer and is currently extending one of the Library modules from 2D to 3D and using it to solve a benchmark problem from the Team Workshops, viz a coupled problem to find the vibrational modes of a bar oscillating in a time-dependent electromagnetic field.

### 3.5.4 Conferences and Courses attended:

1. Superperformance Computing: an International Perspective, Cliveden Hotel 3 Nov 1988 (ADB)
2. Computational Aeronautical Dynamics, Antibes, France, 17-19 May 1989 (ADB)
3. UNIX Course, 3-7 Oct 1988 (ADB)
4. UNIX Course, Feb 1989 (MKB)
5. Introduction to CFD, Cranfield, 31 May-2 June 1989 (MKB)
6. SERC Computing School, Coseners House, 10-21 July 89 (MKB)

ADB also spent a week in the USA from 6-10 November, for discussions at NASA Ames Research Center, Moffat Field, California. He also visited Stellar Computers, the Concurrent Computational Group at Caltech, Pasadena, and San Diego Computer Center.

### 3.5.5 Publications

1. Proceedings of a Workshop on CFD, Abingdon Lodge Hotel 4/5 Jan 1989 (ADB)

### 3.5.6 Future Programme

The timetable for the future programme will be influenced by the date of appointment of a CFD co-ordinator by EMEC, the setting up of a LINK programme, and the appointment of a new member of staff experienced in CFD.

The Community Club will determine an initial set of test problems across a range of applications in CFD. This is already being done by ERCOFTAC (the European Research Community on Flow Turbulence and Combustion) in some areas, mainly in problems associated with aeronautics. Within the next year a version of the NASA Ames data on Turbulent flow will be mounted on SERC computers and a few guinea pig users will start to use the system. An initial design of a CFD software system will be carried out in collaboration with the Mathematical Software Group. A start will be made in integrating this activity into the overall software environment and in applying it to the solution of test problems.

Throughout emphasis will be directed towards use of graphics supercomputers like Stellar and Ardent Titan and parallel processing systems.

## 3.6 VISUALISATION GROUP

The need for visualisation arises from the increasing complexity of data and models which computers manipulate, to an extent that printouts or traditional plots are unable to convey the information. Often the data is in the form of images and these too need to be manipulated and displayed in order to be understood. In the opposite direction, the higher-level information needs to be extracted from images usually derived from an external source. The work of the group is responsible for research/ assessment/ development/ integration/ enhancement/ publicity in this area.

### 3.6.1 Staff

During the year, the staff in the group have been

- Julian Gallop (JRG) Group Leader
- Bob Maybury (RM) IPAL
- Martin Carter (MKC) IPAL
- Edwin Hancock (ERH) Image Interpretation

- Janet Haswell (JH) Image Generation
- Rajka Popovic (RP) Image Generation

During the year, Martin Carter and Rajka Popovic gained promotion to a HSO. The Group also had the services of trainee, Sue Davidson, from October 1988 to April 1989.

### 3.6.2 Objectives 1988/89

The group was formed with a number of projects that were due to come to an end during the period of this report. Furthermore, it was also formed with a brief that was not previously explicit in the department - to be responsible for the visualisation of complex data and models. The main objectives therefore were to determine

- gain a better understanding of the visualisation subject area, so that future work in support of the EASE programme and other funding sources could be defined
- make specific facilities available:
  - software - UNIRAS, PHIGS+, Dore
  - Stellar and Ardent superworkstations
- begin to carry out assessments (superworkstations, visualisation software, and solid modelling)
- consolidate the work on IPAL and define future work
- consolidate the work on object identification and define future work

### 3.6.3 Image Processing - IPAL (RM)

#### Alvey Project MMI27

RM has continued his role of coordinating the RAL effort with NAG. However this effort has dropped during the year and is now simply RM plus a small fraction of MKC. Technical meetings have continued and are written up as PROFS documents with key-words IPAL MEETING. At the current level of effort the meetings have become less formal.

#### Integration into EASE

Part of the work that the group will do for EASE is to integrate the IPAL library into the environment. Planning has started and some commercial examples of image processing environments are being studied.

#### GKS Interface

Sue Davidson wrote interfaces to GKS for both the Fortran and C libraries. This work was done as a six month trainee project under the supervision of RM. For the purpose of demonstrating the code, RAL-GKS was used for the Fortran library and SunGKS for the C library.

The library was demonstrated at ITEX at the Barbican in November 1988. The demonstration was written and set-up by RM but run by NAG.

#### Trial release of the Fortran library

A limited trial release of the Fortran library started in January 1989. Prior to this the library was subjected to testing at NAG by Mike Hooper. This trial release code has been mounted and tested at RAL by RM but is of limited interest since there are major gaps. NAG have issued the software to a very selected set of trial sites and will issue it to a further set soon.

#### Additional Chapters for Fortran library

Work to fill the gaps in the library has continued. Specifically E Golton, from Space Science Department, has supplied a comprehensive set of transform routines and Robin Oldfield (NAG) has added routines for texture. This additional material is not in the trial release.

#### The C Library

RM has concentrated his efforts onto the C library. Agreed changes to the structure definitions have been implemented. The major effort has been to extend the library to handle float data-types for

pixels.

Effort is going into the production of initial documentation for this library.

### 3.6.4 Use of transputers for space applications (MKC)

Over the last eighteen months we have been involved in a collaboration between RGO and the space science department at RAL developing an image photon counting system (IPCS) for both ground based and space applications. Our main contribution to the project has been in the design and development of a system to perform the real-time processing of data from the image intensifier. This has involved specifying the computation required, coding algorithms and testing their performance on a transputer based system and producing analysis software to study the behaviour of the intensifier. The electronic hardware for the first prototype of the system has been built and we are about to begin testing of the individual components. As part of the study for the next stage of the system we have looked at the real-time implementation of connected component analysis using a transputer based system and the theoretical implications of the sampling theorem for separation of overlapping events.

### 3.6.5 Other Projects for Space Applications (MKC)

Other projects worked upon include a study of image compression for use in space applications and the use of a Vax based transputer system running parallel Fortran.

### 3.6.6 Identification of Objects from 2-D Images (ERH)

Research on an Alvey funded project concerned with the identification of objects from 2-D scenes continued this year. This project is a collaborative venture involving British Aerospace, Bristol University, Marconi, Reading University, RSRE, STL and Surrey University.

Work at RAL has centred on various aspects of the use of contextual information in pattern recognition and in particular the study of relaxation processes. The collaboration is now preparing its final report.

This year research has concentrated on a new methodology for discrete relaxation. The aim has been to develop better methods for the consistent labelling of arrangements of image entities. The result has been a labelling procedure that can be realised by the iterative updating of symbolic assignments. This method has several attractive conceptual and computational features. In particular, it demonstrates how consistent labelling problems can draw on Waltz's dictionary representation of constraints through a congruency concept. This is a novel approach which enhances and extends the usefulness of the dictionary idea. It means that discrete relaxation algorithms can be applied to highly structured labelling situations without degrading their representational capacity.

A full account of the method has been prepared and submitted for publication in the Pattern Recognition Journal. Several shorter papers on the conceptual basis of the method, its applications and its control have been accepted for publication in refereed conferences.

In order to draw together some of the work on the application of relaxation processes, a comparative study of different edge postprocessing studies has been undertaken. The conclusion of this work is that the objective quantification of contextual information using the relaxation framework has some important performance advantages over more heuristic approaches. In particular relaxation is superior to the popular edge postprocessing methods of Canny and Spacek. A paper describing this work is to be published.

A high point of the year has been the acceptance of a paper by the highly selective journal IEEE Transactions on Pattern Analysis and Machine Intelligence.

### 3.6.7 Vision by Associative Reasoning (ERH)

An IED proposal to extend the work on relaxation within the context of artificial neural nets has now been 90 percent approved. The partners in the project are RAL, RSRE, Surrey University, and York

University, with BAe and another as yet undetermined partner acting as exploitive uncles.

The project is concerned with developing methodology for subsymbolic processing of uncertain image data. Research at RAL will concentrate on extending relaxation methods beyond horizontal information processing through the use of hierarchical constraints and vertical evidence combining procedures.

### 3.6.8 Superworkstation assessment (JH)

Some work towards the assessment of superworkstations has been undertaken. Some applications are being mounted by others in the division. The group is responsible for coordinating the assessment and for the overall report.

As part of this, JH is responsible for system management and temporarily acts as system administrator for the Stellar, initially model GSIOOO and now the GS2000, and Ardent's Titan superworkstation. This involves setting up the systems to fit transparently into the Informatics network, installing and checking out new software, setting up accounts and assisting users. JH has also administered a colour thermal printer attached to the Stellar plus a few other Informatics colour machines. JH will shortly pass day to day administration of these systems over to the operations section along with details of maintenance though she will continue to offer technical support.

### 3.6.9 Image Generation Software (RP, JH)

The group is installing and gaining expertise in a number of image generation systems - UNIRAS, AVS, Dore (including portable Dore pronounced Doray), Renderman (not obtained at present) and PHIGS+. Technical support can be offered to users within the department and (probably after some package selections) to external users.

UNIRAS has been installed on the colour Sun 4/260 in Lab 11 (JH). Since the set of manuals is very large, a simple users' guide will be needed, either written here (JH) or elsewhere if suitable (Central Computing Department or other UNIRAS users).

Dore is installed on the Titan 1. RP is providing technical expertise for Dore, having been on Ardent's Dore course (with JH). Portable Dore has been installed on the colour Sun 4/260 (JH) and a Portable Dore launch was hosted at RAL on behalf of Ardent on 20 July (JRG, RH, JH and several members of Distributed Computing Systems Division (RT, ACD, IV).

RP is responsible for technical support of PHIGS+. Version 1.5 of PHIGS+ graphics library arrived with the Stellar GS1000. After RP had done the first test, numerous errors were found and reported back to Stellar. The new 1.6 version was installed at the beginning of 1989.

Since then, RP has provided continuous technical expertise for Stellar users, and has written an internal report Introduction to Stellar PHIGS+ Library.

Some work on comparing these systems has been done. JH is comparing AVS (Application Visualization System) from Stellar and Dore (Dynamic Object Rendering Environment) from Ardent. AVS provides both an interactive system and a toolkit for programmers to handle graphics input and output, whereas Dore is a graphics toolkit to handle graphics output using simple rendering methods such as wire frame up to ray traced images. A report comparing PHIGS+ and Dore libraries is due to be issued (RP).

### 3.6.10 Solid modelling assessment (RP)

As a part of this project criteria for selecting the package were established. RP attended the CAD/CAM exhibition at NEC Birmingham in March 1989.

### 3.6.11 Catalogue of graphics software on transputers (RP)

Although the transputers are not the brand-new hardware, there is no proper and complete catalogue of available graphics software. RP had the task of collecting and systemising data for such a catalogue. The aim is to produce the first version and make it available through the National

Transputer Centre, and via the computer network. The catalogue will be regularly updated. At this point, collecting is in progress and the initial data is put together and will be sent to companies for approval.


**Opening of National Transputer Centre, Sheffield. Clive Betts, Doug Lewin, Iain Barron**

**Large View**

### 3.6.12 Ray-tracing of CSG trees using SCRIP (RP)

The first phase of the project is completed (ie a simple tree can be loaded, processed and rendered on the screen). The paper is written and will be presented at the Parallel Computing 89 conference at Leiden in Holland, September 1989.

### 3.6.13 Graphics standardisation

JRG has participated in 3 ISO meetings on PHIGS PLUS. The work is derived from the de facto document PHIGS+ which was produced by a number of USA suppliers. The ISO group itself includes USA suppliers, Sun, HP/Apollo. Some major concerns are to ensure that PHIGS PLUS is an adequate basis for interactive display of complex data and of product data.

JRG is also the document editor for the ISO Fortran binding of GKS-3D. The DIS (Draft International Standard) was produced in late 1988 and the meeting to resolve the votes and comments was held in June 1989. The final task is to produce the international standard based on the decisions of that meeting.

### 3.6.14 ARGOSI (ESPRIT II)

The group participates in ARGOSI, which contractually started on 7 March, but technically on 1 April this year. JRG participated in most of the meetings which established the project and now leads the Classification Workpackage. Since the project started, RM has also taken part. (RAD from

DCSD and DAD from SED are also heavily involved, with RAD being the RAL representative on the management board.)

### 3.6.15 Support for Alvey Speech and Natural Language Club (ERR)

ERR continued to act as secretary until April 1989. The Club held its final meeting at Worcester College, Oxford in December. This meeting had a twofold purpose. Firstly, it provided a forum for a retrospective review of the Alvey speech and natural language programme. Its second function was prospective, providing the UK speech and language research communities the chance to express their views concerning the new SERC-DTI joint framework to its administrators and to discuss the possibility of a new Club within this framework.

A new Club (the UK SALT Club) has been established. ERR acted as interim secretary and was involved in the initial organisation of the Club's inaugural meeting at Keele University in April. The organisational responsibilities have now been handed over to the DTI.

### 3.6.16 Joint Appointment (ERR)

ERR has joined the academic staff in the Electrical Engineering Department at Surrey University as an Associate Lecturer. This involves teaching various aspects of electrical engineering to first and second year undergraduates.

### 3.6.17 Apple Mac Support (JH)

JH has continued to advise and assist people within the Laboratory in the use of the Mac+ and Mac II and purchase of new software.

### 3.6.18 Middlesex Polytechnic MSc in Computer Graphics (JH)

JH completed the examinable section of a part-time M.Sc. course in December having passed all the exams gives her the temporary title of Post Graduate Diploma. A dissertation remains to be submitted, of which the original topic was to be a visualisation toolkit using PHIGS+ and X11. However this will be altered and delayed since Stellar have themselves implemented a system, in the form of AVS.

### 3.6.19 Conferences Attended

1. International Conference on Pattern Recognition, Rome, November 1988 (ERH)
2. IEEE International Conference on Image Processing, Singapore September 1989 (ERH)
3. Fifth International Conference Positano, on Image Analysis and Processing Italy September 1989 (ERH)
4. Fifth Alvey Vision Conference Reading September 1989 (ERH)
5. Science in Business and Industry, BA l50th meeting Oxford September 1988 (RP)
6. The 3rd IMA Conference on Mathematics of Surfaces, Oxford, September 1989 (RP)
7. New Tools for Shape Modelling, London, May 1989 (RP)
8. SERC/DTI Seminar on Graphics on Transputers, RAL July 1989 (RP)
9. Eurographics, Nice, Sept 1988 (JRG, JH)
10. Image processing and its applications (IEE), Warwick, July 1989 (RM)

### 3.6.20 Courses attended

1. Induction Course, RGO, October 1988 (RP)
2. UNIX Fundamentals I (Instruction Set), London, November 1988 (RP)
3. C Programming Workshop (Instruction Set), London, November 1989 (RP)
4. PHIGS+ (Stellar), Newton, Mass, USA, January 1989 (RP, JH, JRG)
5. Porting and Optimisation for the Ardent TITAN; Fortran and C (Ardent), Milton Keynes, June 1989 (RP,JH)
6. Dore Programming Course (Ardent), Milton Keynes, June 1989 (RP, JH)
7. Year 3 of Part-time MSc Course in Computer Graphics, Sept 88 to Sept 89 (JH)
8. System Administration Course for Stellar Superworkstation (Stellar Computers), Boston, USA, 18-20 January 1989 (JH)

9. The Future of Graphics Software (one day BCS seminar), London, 26 January 1989 (JH)
10. SERC Computing Summer School, October 1988 (MKC)

### 3.6.21 Publications

**External Publications:**

1. Hancock, E.R. and J. Kittler, A Label Error Process for Discrete Relaxation, submitted for publication, 1989.
2. Hancock, E.R. and J. Kittler, Edge Postprocessing - A Comparative Study, Fifth Alvey Vision Conference, Reading 1989.
3. Hancock, E.R. and J. Kittler, A Comparison of Dictionary-based Relaxation Processes, Fifth International Conference on Image Analysis and Processing, Positano, Italy 1989.
4. Hancock, E.R. and J. Kittler, Edge Labelling by Discrete Relaxation, IEEE International Conference on Image Processing, Singapore 1989.
5. Hancock, E.R. and J. Kittler, Discrete Relaxation, Submitted for publication in 'Pattern Recognition', 1988.
6. Hancock E.R. and J. Kittler, Edge-labelling using Dictionary-based Probabilistic Relaxation, Accepted for publication in IEEE Transactions on Pattern Analysis and Machine Intelligence, 1989.
7. Kittler, J. and E. R. Hancock, Combining Evidence in Probabilistic Relaxation, International Journal of Pattern Recognition and Artificial Intelligence, 3, pp.29--52, 1989.
8. Hancock, E R, Impressions of 9th ICPR Rome, IAPR Newsletter December 1988.
9. Ray Tracing on the SCRIP Machine, "Parallel Computing 89", Conference proceedings, R Popovic.
10. The design and implementation of a portable image processing algorithms library in Fortran and C. M K Carter, R Maybury, et al. Presented at the poster sessions of the Warwick conference and published in the proceedings.
11. ISO Information processing systems - Computer Graphics - GKS-3D language bindings - Part 1 Fortran binding - ISO DIS 8806/1 (JRG was document editor).

**Internal Reports:**

1. IED Proposal 'Vision by Associative Reasoning' , November 1988. (ERH)
2. Progress in Relaxation Labelling, MMI007 Final Report, February 1989. (ERH)
3. Introduction to Stellar PHIGS+ Library, Visualisation Technical Note 1. (RP)
4. Introduction to the Stellar GS1000 and GS2000; Visualization Technical Note 3. (JH)
5. Notes on the X window manager uwrn at Release 1.6 and 2.0 of Stellar O.S.; Visualization Technical Note 4. (JH)
6. Notes on PHIGS+ at release 1.6 and 2.0 of Stellar O.S.; Visualization Technical Note 5. (JH)
7. Notes on XFDI at release 1.6 and 2.0 of Stellar O.S.; Visualization Technical Note 6. (JH)
8. Use of centroiding algorithms in an image photon counting system (Nov. 88). (MKC)
9. Description of the implementation of a connected component analysis algorithm (May 89). (MKC)
10. Implications of the sampling theorem for separation of overlapping events. (Aug. 89). (MKC)
11. Use of the Vax based transputer system (Aug. 89). (MKC)

**External Seminars:**

- November 1988, University of Surrey. (ERH)
- Lectures on Computer Graphics at LNETI, Lisbon, May 1989 (Graphics Standards, User Interfaces, Visualisation, Informatics at RAL) - part funded by British Council. (JRG)

### 3.6.22 Objectives for 1989/90

For EASE, a number of objectives are being defined:

- produce assessment on superworkstations, based on departmental and external experience
- define and begin to populate a visualisation toolkit, handling multi-dimensional data, geometry and images
- produce survey of available solid modelling software

- integrate IPAL into EASE.

To provide the experience and basis for this work and as a service in itself, further collaborative projects within CMD will be defined.

The group will also be able to provide expertise in graphics and image processing on transputers.

We hope that the SERC/DTI JFIT project Vision by Associative Reasoning will finally secure its funding and be able to start. The ESPRIT project ARGOSI will complete the Classification Work Package, but the group will be participating in other work packages.

Other funding and clients will be sought to complement the work being done for the EASE programme.

## 4. SYSTEMS ENGINEERING DIVISION

### 4.1 INTRODUCTION

Systems Engineering Division consists of two groups, Knowledge Engineering and Software Engineering. Both groups are small in RAL terms. Each has a dual role of direct participation in the Department's support of the Engineering Board and a research programme which generates knowledge, skill and technology to be fed, indirectly, into EB support. Whilst the two groups' foci are distinct, they are united by the common threads of representation and reasoning.

This year has seen both groups working hard to obtain funding for their research programmes from external sponsors such as ESPRIT and IEATP. Both groups have also enjoyed stable staffing and successful recruitment exercises. With the appointment, this year, of a new group leader for SE, the Division has achieved a stable management structure.

KE group has continued its expansion through successful recruitment exercises and research project bids. Much hard work this year will be rewarded next year when two excellent new staff members will join the group's projects sponsored by ESPRIT, IEATP and direct industrial sponsorship.

This year has seen the termination of one of KE's most successful projects, Paralfex. This Alvey funded work had two main themes, graphical explanation and knowledge based architectures for the financial domain. Paralfex's Source of Finance Adviser was ported to the Compaq 386 and interfaced to Lotus 1-2-3 by a one year Sandwich Student.

After much hard work KE Group was awarded, with 6 partners, the MMI2 project by ESPRIT in January 1989. MMI2, Multi-Modal Interface for Man-Machine Interaction with knowledge based systems, aims to build a human-machine interface which will incorporate multiple modes of interaction; adapt to different classes of users; and provide intelligent, cooperative dialogue facilities. MMI2 will use the design of computer communications networks as its problem domain.

Links to other parts of RAL were boosted by the Lyman Space Mission project. A feasibility study was undertaken on the role of a knowledge-based system acting as an Operator's Adviser, which would capture some of the knowledge of the resident astronomer.

KE Group has achieved direct industrial sponsorship of its work from the Water Authorities and British Telecom. These projects will begin in the next reporting period. So, too, will projects sponsored by JFIT's IEATP programme. Considerable effort has been expended by KE Group this year in research proposal preparation and negotiation.

The KE Group has contributed directly to the support of the SERC's Engineering Board. In particular, KE Group organised the AI for Engineers EASE workshop, has helped with the AIAI contract, monitored an Alvey project, and acted as secretary of SIGAI.

The Group's research proposal and recruitment successes should make the next few years work rewarding and exciting.

The staffing and management of SE Group has been considerably strengthened this year. Dr S K Robinson was recruited to lead the Group. This has allowed Dr D A Duce to resume his 1M duties full time. The recruitment of Dr J M Spivey of Oxford University as SE Group's second Atlas Fellow, together with the part time appointment of Dr C M P Reade of Brunel, has greatly increased the group's academic links and intellectual horsepower.

SE Group staff are to be congratulated on achieving a PhD, MSc and an MBCS between them this year. Education, training and membership of professional bodies are strongly encouraged in this Division.

SE Group continues to collaborate closely with Manchester University on the IPSE 2.5 project, one of the largest Alvey projects. SE Group's role is concerned with the mechanised support of formal methods of software development and in particular with aiding formal reasoning itself. In the first half of the year the first prototype, FRIPSE, was constructed: Manchester implemented a generic proof assistant whilst RAL constructed a prototype structure editor for BSI VDM. FRIPSE has since undergone a major redesign and changed its name to Mural. SE Group's effort has improved the user interface and developed a mechanism for translating specifications and designs into theories in the generic proof assistant. SE Group has continued to work on the BSI standard for VDM.

SE Group has completed a project to produce a yacc-like parser generator system, written in Standard ML, which produces output code in Standard ML. This work was undertaken as part of the Alvey FORSITE project.

Formal specification and verification are the cornerstones of SE Group's research programme. Both Atlas Fellows and the part time academic visitor are extremely active in these areas, publishing profusely. With the Atlas Fellows linked to Oxford's Programming Research Group, their work has a Z, Occam and CSP flavour. This fits well with SE Group's work on the formal specification of computer graphics and in particular, ISO Standards for GKS and the development of a Reference Model for Computer Graphics.

SE Group, with DCS Division, is a partner in a new ESPRIT project called ARGOSI (Applications Related Graphics and OSI Standards Integration) which seeks advances in our capability to transfer graphical information across wide area networks. This year saw a major effort to bid, negotiate and start up this project.

SE Group completed work on the ERIL project, funded by SERC's Computing Science Committee. ERIL is a theorem prover for experimenting with specifications and for prototyping abstract data types, and is used by several research groups in the UK and abroad. ERIL is based on the use of rewrite rules for computing and for reasoning with equations. As well as developing ERIL, the group has organised its distribution and support and run tutorials and special interest group meetings which have helped to form an active UK research community in the equational area. The ERIL work has led to the award of an IEATP research grant on the Verification Tools for LOTOS Specifications.

SE Group has been working directly for the EASE programme. This has primarily been on the definition of the overall EASE strategy, the planning of the EASE IPSE-type environment, and the assessment of current IPSE technology such as PCTE, ISTAR and Maestro. The Division has also supported the Environment Committee's IT Advisory Group.

In spite of the considerable effort which the Division has had to expend on the pursuit of external research funds, it is pleasant to see how much excellent technical progress has been made. With over 30 external publications this year the Division has made a major contribution to IT research in the UK; has formed lasting collaborations throughout Europe and the USA; and has helped shape the future of the EASE programme.

### 4.2 KNOWLEDGE ENGINEERING GROUP

#### 4.2.1 Staff in post at end of August 1989

- Gordon Ringland (GAR) (Group Leader)
- Helen Chappel (HRC) (from October 1988)
- John Galletly (JRG) (visitor from University of Buckingham)
- Charlie Kwong (CKYL)
- Simon Lambert (SCL)
- Michael Wilson (MDW)
- Lana Woodhead (LNW) (sandwich student from July 1988 to July 1989)

### 4.2.2 Objectives 1988/9

1. Establishing and maintaining a funded R&D programme in AI, where possible in collaboration with SE and HCI. This is required as an element in maintaining the effectiveness of the Department.
2. Promotion and support of the SERC's research programmes in KE/IKBS. This has been mainly funded by the Alvey Directorate and the work is concerned with technical support of the Alvey IKBS programme. There has also been work for the Engineering Board's Environment Committee and the Computing Facilities Committee.

### 4.2.3 Paralfex (CKYL, SCL, GAR, LNW)

The Alvey-funded Paralfex project came to an end in March 1989. The two main themes of the project, graphical explanation and knowledge base architectures for the financial domain, had both been brought to a successful conclusion.

The Source of Finance Adviser, the project's testbed system, had its graphical interface considerably enhanced. One aim was to enable a mode of consultation whereby the user directed progress. This was done by the user volunteering the information which would lead to determining whether a source of finance was feasible or not. The second aim was to allow the user to hypothesize about different situations. It is now possible for the user to change earlier inputs and see in a consistent way the effects on the viability of the sources.

In addition, the explanation mechanism was made more flexible by allowing the user to look at the explanation for any entity in the currently visible network and allowing the network to be expanded at any time with mouse clicks on the finance options. However, a bug still exists which causes the answer/input text in the command window to be printed over the questions being asked. This required a lot of effort to track down and report to Ferranti, who have not supplied a fix.

A general knowledge base architecture has been developed using the Source of Finance Adviser as a reference to stimulate and test ideas. The architecture has two elements: an inheritance network of entities in the domain, and what we have called problem solving contexts. The inheritance network achieves both abstraction and explicitness of knowledge, which have been shown to be vital for high-quality explanation of reasoning and conclusions. Entities in the knowledge base stand for domain concepts, general and particular, and represent their stereotypical form. Specialised types and instances of concepts inherit their properties by default (e.g. control knowledge of how to obtain a value for the entity). Any differences from the default must be explicitly specified. This makes for a better understanding of what reasoning is being done and why. In addition, the representation of control knowledge is a simple and uniform one which enforces explicitness about the ordering of the investigation, something which in rule-based expert systems is too often encoded implicitly in the rule order.

Problem solving contexts are a means of representing situations where, as a result of making an assumption or reaching a conclusion, a whole mass of new information becomes available to the problem solver. An example is the knowledge of expected financial ratios which becomes available when a company's market sector is known. Such knowledge should be represented declaratively; it is integrated with the inheritance network by having a context declaration associated with an entity in the knowledge base specifying what new values are acquired when that entity is being or has been evaluated.

The architecture has implications not only for explanation but also for reuse of knowledge. There are a number of ways in which this desirable goal is made possible. Firstly, the inheritance network obviously lends itself to reuse by its very nature: domain-independent entities such as Derived Number and domain- specific ones such as Financial Ratio will be needed in many different applications. Secondly, there is the idea of 'packages of knowledge' standing for such groupings of domain entities as the company's balance sheet. This is integrated by permitting the context declarations to refer to such packages bodily when appropriate. Finally, the idea of 'perspectives on knowledge', in which different user roles have different views of a situation but still have much in common (like lender and borrower), are handled as a special case of the problem solving context in which the nature of relationships between entities are being redefined in the new context.

The Knowledge Engineering Group's sandwich student from Teesside Polytechnic (LNW) spent some time on the Paralfex project. The Source of Finance Adviser was successfully ported onto Goldworks, an AI toolkit running on a Compaq 386 machine, and some experimentation was performed with forms of explanation made possible by Goldworks' facilities. An interface to Lotus 1-2-3 was implemented which allowed values to be read from a spreadsheet without querying the user. Not only did this work give us another comparative version of the Adviser, it was also valuable input to the evaluation of toolkits.

### 4.2.4 Multi-Modal Interface for Man-Machine Interaction with knowledge-based systems: MMI2 (HRC, GAR, MDW)

MMI2 is a five year research project drawing on 60 man years of effort that started in January 1989 with funding from the CEC under the Esprit initiative. The consortium undertaking the project consists of two software companies, two universities and three research laboratories: that is BIM (Belgium) as prime contractor, with Intelligent Software Solutions (Spain), University of Leeds (UK), Ecole des Mines de Saint-Etienne (France), SERC/RAL (UK), ADR/CRISS (France), INRIA (France).

The objective of the project is to develop a highly interactive multi-modal interface for human-machine interaction with knowledge based systems. More specifically, the project aims to build a human-machine interface which will:

- incorporate multiple modes of interaction;
- adapt to different classes of users;
- provide intelligent, co-operative dialogue facilities.

The interface will provide simultaneous interactive use of modes suitable to support the developed skills of professional users, and natural communication modes well suited for naive users. These modes include: Natural Language typed at the keyboard (English, French and Spanish), Graphics with Direct Manipulation, Mouse Gesture, and Command Language.

The interface will initially be developed to accommodate a Prolog based knowledge based system for local and wide area computer network design, which provides the requirement for intelligent dialogue, different classes of users, and the integration of multiple modes of representation and communication. The interface will be designed to be portable across a range of potential applications of knowledge based systems. Tools for the rapid adaptation of the interface will be developed in the later stages of the project.

In the first phase of the project, the general architecture of the overall system has been described, the common meaning representation (CMR) which will be used to communicate between the modules in the interface has been outlined, and work has begun to specify individual modules of the interface and demonstrator application.

The Knowledge Engineering group at RAL have been involved in the specification of the general architecture and the common meaning representation, and have a specific involvement in the modules which address user modelling and the graphical interface mode.

The overall architecture of the project can be viewed as a three layer structure with the different interface modes represented by modules (or experts) in the upper layer, the central layer contains 6 experts to manage dialogue, and the lower layer represents the application program. The six experts in the dialogue management layer may be imagined as being placed on the points of a pentagram with one in the centre. The central expert acts as a switching facility to direct information packets between the other 5 dialogue management experts; the second communicates with the application; the third stores information about the state of the screen and user interface; the fourth constructs and manages a model of the user; the fifth manages the dialogue context; and the sixth manages the semantic information required to communicate between the user and the interface.

#### 4.2.4.1 User Modelling

User modelling in MMI2 is performed by one of the experts in the dialogue management layer of the architecture. This component records information about the level of ability of the user, what type of user it is, the preferences of the user, the knowledge that the user possesses and what the user is trying to do. Using this information, the system can be more cooperative in its response because it can adapt its behaviour according to who is using the system.

Work on the user modelling component has been carried out by RAL during the first six months of the project and has included collaboration with partners in the project consortium who are involved in the knowledge acquisition for the project. During this time, an extensive literature review on user modelling was carried out for the deliverable dl part 1, and the architecture of the user modelling expert and its role were defined in the deliverable dl part 2.

Work at RAL on the user model is continuing in the second six months of the project. During this time, the basic framework of the user modelling process will be programmed in BIM_prolog. Collaboration will continue with partners involved in knowledge acquisition to discover the way in which real experts in the domain create a model of their clients during interaction with them. This will become the content of the user model. Meanwhile theoretical work will continue at RAL to investigate ways of exploiting the full potential of natural language for user modelling.

#### 4.2.4.2 Common Meaning Representation (CMR)

The CMR is the language which will be used to communicate between the various experts in the interface. This requires the CMR to represent not only information derived from English, French or Spanish natural languages, but also from graphic, gestural and command language input from the user and the output from the application program.

The details of the representation have not been completed yet, although several features of it have been agreed. A major review of representations used for similar systems has been undertaken by RAL and delivered to the CEC. Since it is essential that all interface experts can use the CMR, one of the major problems with establishing it is to manage the agreement of all the partners in the project on the requirements it must meet and its structure. The initial specification of the CMR is planned to be developed by the end of 1989.

The CMR will use a reified typed first order logic with annotations to describe speech acts. Temporal information about the dialogue event, language specific details to enable the resolution of deictic and inter-sentential anaphora and other non-common information will also have to be added to the CMR packet sent between experts, although they will not be incorporated in the CMR itself.

#### 4.2.4.3 Graphics Mode

The graphics mode in MMI2 is required to support user input to the demonstrator application KBS in the form of diagrams of computer networks which the user is designing. It will also have to output graphic forms of networks, but also data about the network performance as graphs and tables. These in turn should be modifiable by the user by direct manipulation, but also through natural language or a combination of natural language and direct manipulation. These requirements have given rise to several interesting research questions. For example, what in the domain representation is being referred to if the user asks for the longest bar in a histogram to be

extended. The representation of both the graphical description itself and the domain information being represented by the graphic at a level which will support the reasoning required to perform this request is currently absorbing much research attention.

A review of graphic interfaces has been performed and presented to the CEC. The specification of the graphical mode will continue into 1990, with the first program due for delivery in December 1990, although the more complex components required to solve problems such as that outlined above are not expected until mid 1992.

### 4.2.5 Lyman Space Mission (GAR, SCL, LNW)

A feasibility study was undertaken on the role of a knowledge-based system in assisting in the Lyman Space Mission (the Far Ultraviolet Spectroscopic Explorer). The role examined was that of an Operator's Adviser, which would capture some of the knowledge of the resident astronomer. The benefits would be savings in cost and time, consistency of performance and archiving of knowledge. The study resulted in a contribution to the proposal for UK participation in the Lyman mission. It is hoped that funding for the proposed work will follow.

### 4.2.6 Water Project (GAR, SCL, HRC)

The Knowledge Engineering Group has just begun work on a project for a consortium of Water Authorities and Water Companies under the coordination of the Water Research Centre, Swindon. The aim is to develop a pilot knowledge-based system for assisting in the operations of water network management and control. The project plan calls for a definition phase to put some limits on what can be achieved and to outline some essential requirements, followed by a phase of prototyping and the building of a pilot system for one particular site. The pilot will be such that it will then be possible to create a platform - a site-independent but domain-specific knowledge base on which further site-specific applications may be built.

Not only will the results of the work be useful to the consortium members, but they will involve some challenging research issues such as time-constrained reasoning, representation of network knowledge and truth maintenance.

The project is, at the time of writing, in the definition phase. The first knowledge acquisition meeting was held at the offices of Wessex Water in Poole in August.

### 4.2.7 Future Research Plans

Work is about to begin on a joint KBS application project with British Telecom (project ADAM) which they will fund on the planning of strategic management decisions (CKYL, SCL, GAR). Further application project research is planned with British Telecom which it is hoped will be started within the next year.

A proposal for a CASE studentship at the University of Buckingham for work on Knowledge-Based Systems in Strategic Planning was prepared by JRG and GAR. The proposal was successful and work related to the group's activities is expected to start in January 1989.

Following the feasibility study on the project for the Lyman Space Mission, a proposal for the full joint UK/US/Canadian research project, including the proposal for a Knowledge Based application to be undertaken by this group (HRC, SCL, GAR, LNW), has passed the Phase A review by the British National Space Centre and it is hoped that it will be funded in approximately two years.

Following proposals submitted to JFIT under the IEATP programme in August 1988 two research projects on KBS development methodologies are currently under contract negotiation and are expected to begin funded work in the near future. Logica will act as prime contractor on Project Gateway (CKYL, GAR, MDW) which will investigate metrics for large knowledge based system. British Aerospace will act as prime contractor on Project Rocket (CKYL, SCL, GAR, MDW) which will investigate and develop methods and tools for the development of closely coupled knowledge based systems and conventional software systems.

Members of the group (CKYL, GAR, MDW) are currently drafting proposals in response to the second call for the CEC Esprit IT initiative for further research on KBS development methodologies which will be submitted in 1990.

An initial outline research proposal has been submitted to the second call for proposals under the IEATP programme to investigate measures for assessing the impact of IT on user organisations, with STC as prime contractor (CKYL, GAR).

Several outline proposals have been submitted to the Joint Research Council Initiative on Cognitive Science and Human Computer Interaction by MDW and members of other groups in Informatics for interdisciplinary research.

### 4.2.8 EASE

In December 1988 members of the group (GAR, MDW) helped organise a workshop at RAL on behalf of the SERC CFC to review the current support offered to engineers for work involving Artificial Intelligence (AI) and to determine the engineering community's requirements for continued support.

Following this workshop, the CFC accepted proposals for the EASE programme which includes general support for AI use by engineers, and specifically it will be incorporated within the EASE software environment. Members of the group have been working with members of the software engineering group on proposals for the AI component of the EASE software environment.

Another aspect of EASE where members of the group have contributed is in developing the structure of a comprehensive survey of the current use of computers by engineers and their perceived future needs. This survey is expected to be conducted in the near future.

### 4.2.9 Other Activities

#### 4.2.9.1 Alvey Project Monitoring

During the year MDW has monitored Alvey project IKBS 098, A Knowledge Acquisition Methodology for Research Associations, in which role he has attended project management and technical meetings, assessing both aspects of the project's progress.

#### 4.2.9.2 SIGAI

Until March 1989 MDW undertook the secretaryship of the committee SIGAI. SIGAI has been an advisory committee on Artificial Intelligence to SERC and Alvey in the past. SIGAI is currently in abeyance while the SERC/DTI JFIT is being organised.

#### 4.2.9.3 Prolog Standards (CKYL)

The working group for BSI Prolog Standardisation is IST/5/I7. This group now meets only to discuss and promote the UK view on contentious issues rather than defining the BSI Standard.

The effort of defining the standard has been taken into international levels where ISO working group SC22 WG17 is working to produce an ISO standard for Prolog. The BSI Standard will be the same as the ISO Standard. UK delegates to the ISO meetings are elected from the BSI group.

The ISO meetings are held in the spring and autumn every year. The next is scheduled to take place in Ottawa, Canada on October 11-13 1989 followed by Vienna, Austria (Spring 1990), Marseilles, France (Autumn 1990) and Budapest, Hungary (Spring 1991).

The ISO Standard Prolog currently exists as Draft 2.0 which will be discussed in Ottawa.

#### 4.2.9.4 Toolkit Evaluation (CKYL, LNW)

The Joint project with the Water Research Centre requires a toolkit on which to build the KBS. The evaluation of two contending systems Goldworks II and NEXPERT was started by LNW before she left and is now to be concluded by CKYL.

#### 4.2.9.5 Reviewing and Refereeing

During the year, members of the group (HRC, SCL, CKYL, MDW) have contributed several book reviews to the AISB Quarterly, and acted as referees for other academic journals. MDW has continued as a member of the editorial board of the journal Interacting with Computers.

#### 4.2.9.6 Systems Engineering Division Colloquia (SCL)

A series of Divisional colloquia has been organised by SCL with the objective of maintaining awareness and stimulating interchange between members of the Division. The colloquia are given by members of the Division on aspects of their work, on a particularly significant paper (the journal club idea) or on some general topic of interest, and take place every few weeks.

### 4.2.10 Conferences Attended

**GAR**

- ESPRIT Technical Week, Brussels, Nov 88.
- Workshop on AI and Software Engineering, University of Exeter, April 1989.
- International Joint Conference on Artificial Intelligence, Detroit, August 1989.

**HRC**

- Expert Systems'88 , Brighton, December 1988.
- First European Summer School on Natural Language Processing, Knowledge Representation and Logic, Groningen University, Netherlands, June 1989.

**CKYL**

- Expert Systems '88, Brighton, December 1988.
- GoldWorks User Group Meetings AI Ltd, Watford, 16 Jan., 20 April 1989.

**SCL**

- 4th Alvey Explanation Workshop, University of Manchester, September 1988.
- Conference on Knowledge-Based Systems in Government, Bristol, November 1988.
- First International Conference on Principles of Knowledge Representation and Reasoning, Toronto, Canada, May 1989.

**MDW**

- BCS HCI Group Meeting, User Models and Muddles, London, U.K. Nov 1988.
- IEE colloquium on software engineering practices for KBS. London, U.K. March 1989.
- AISB '89, The Seventh Conference of the Society for the Study for the Study of Artificial Intelligence and the Simulation of Behaviour. Brighton, U.K. April 1989.
- Aries in the City colloquium on software engineering and KBS. City University, London, U.K. July 1989.

**LNW**

- GoldWorks User Group Meeting, AI Ltd, Watford, 20 April 1989.

### 4.2.11 Courses Attended

**GAR**
Advanced Project Management, London, January 1989.

**HRC**
Tutorial on Knowledge Acquisition at Expert Systems '88, Brighton, December 1988.
Advanced Prolog Course, AI Ltd., Watford, UK, April 1989.

**CKYL**
Management Training Course, 13-17 March (part 1) 24-29 April (Part 2).

**SCL**
Summer School on Model-Based Reasoning, Artificial Intelligence Applications Institute, Edinburgh, August 1989.

### 4.2.12 Papers

#### 4.2.12.1 External


- Barnard, P.J., Wilson, M.D. and MacLean, A. (1988), Approximate modelling of cognitive activity with an expert system: a theory based strategy for developing an interactive design tool, The Computer Journal, October 1988. (Re-printed in L. Damodaran (Ed.), Human Computer Interaction, Cambridge University Press: Cambridge, U.K., 1988).
- Cahour, B., Chappel, H.R., Falzon, P., Ringland, G.A. and Wilson, M.D. (1989), Literature Review on User Modelling, MMI2 project report RAL/4, March 1989. Also in J. L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Chappel, H.R. and Wilson, M.D. (1989), Summary of Multi-Modal Interface Projects, MMI2 project report RAL/1, January 1989. Also in J.L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Chappel, H.R. and Wilson, M.D. (1989), Example Interactions with Multi-Modal Interfaces, MMI2 project report RAL/2, January 1989.
- Chappel, H.R. and Wilson, M.D. (1989), Checklist of Aspects of Dialogue and User Models, MMI2 project report RAL/3 January 1989.
- Chappel, H.R., Ringland, G.A. and Wilson, M.D. (1989), User Modelling Expert, MMI2 project report RAL/7, June 1989. Also, in J. L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Kwong, C.Y.L., Lambert, S.C. and Ringland, G.A., The Use of Graphics and Text in Explanation for Knowledge-Based Systems, submitted to IT 1990 Conference.
- Lambert, S. C. (1988), An Architecture for Knowledge-Based Systems in Finance: A Description of Work in Progress, Proc. 4th Alvey Explanation Workshop, publ. IEE., 1988.
- Lambert, S.C. and Ringland, G.A. (1989), Representing Knowledge in Financial Expert Systems, International Conference on AI in Industry and Government, Hyderabad, India (to appear).
- Lambert, S.C. and Ringland, G.A., Representing Knowledge in Financial Expert Systems: Directions in Reuse, submitted to IT 1990 Conference.
- Ringland, G.A., Chappel, H.R., Lambert, S.C. and Wilson, M.D. (1989), Literature Review of the Representation of Knowledge and Semantics throughout Systems, In J.L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Ringland, G.A. and Wilson, M.D. (1989), General Architecture and Common Meaning Representation, MMI2 project report RAL/5, June 1989.
- Ringland, G.A. and Wilson, M.D. (1989), Graphics and Common Meaning Representation, MMI2 project report RAL/6, May 1989.
- Wilson, M.D. (1989), Architecture of the Graphical Mode, In J .L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Wilson, M. D. (1989), Literature Review of Graphical Interfaces, In J. L. Binot (Ed.) "Literature Review and General Architecture", Esprit P2474 Deliverable dl, Everberg, Belgium: BIM.
- Wilson, M.D. (1989), Why don't Knowledge Based System developers use Software Engineering techniques already? In the Proceedings of the IEE colloquium on software engineering practices for KBS, London, March 1989. London: IEE.
- Wilson, M.D. (1989), Knowledge Acquisition: the current position, In "Knowledge Acquisition for Expert Systems", London: IBC Technical Services.


#### 4.2.12.2 RAL Reports

None

#### 4.2.12.3 Internal

None

#### 4.2.12.4 Talks Presented

- Chappel, H., Why Are User Models Useful to Expert Systems?, RAL Systems Engineering Division Colloquium, April 1989.
- Chappel, H., User Models in the MMI2 interface, Commission of the European Communities MMI2 Esprit Project Review, Brussels, Belgium, July 1989.
- Lambert, S.C., Model-Based Reasoning, RAL Systems Engineering Division Colloquium, August 1989.
- Ringland, G.A., Explanation in a Financial Knowledge Based System, Basque Colloquium on Artificial Intelligence in Financial Applications: Bank and Insurance, Bilboa, Spain, March 1989.
- Ringland, G. A., New Directions in Knowledge Representation, University of Surrey, Guildford, U.K., April 1989.
- Wilson, M. D., What User Models aren't to Designers, BCS HCI Group Meeting, User Models and Muddles, London, U.K. Nov. 1988.
- Wilson, M.D., Why don't Knowledge Based System developers use Software Engineering techniques already?, IEE colloquium on software engineering practices for KBS, London, March 1989.
- Wilson, M.D. Why don't Knowledge Based System developers use Software Engineering techniques already?, RAL Systems Engineering Division Colloquium, April 1989.
- Wilson, M. D., Ergonomics in Expert System Design and Development, Ergonomics Unit, University of London, Lecture for the MSc in Ergonomics, May 1989.
- Wilson, M. D., Knowledge Based Systems and Software Engineering, Aries in the City colloquium on software engineering and KBS, City University, London, July 1989.
- Woodhead, L. N., The Source of Finance Adviser, Goldworks User Group Meeting, AI Ltd., Watford, April 1989.

### 4.2.13 Objectives for 1989/90

1. To maintain and extend a fully funded R&D programme in pure and applied AI. Where possible this will be done in collaboration with Industry.
2. To advance the field to benefit both general software development, and in particular knowledge based systems.
3. To promote and support the SERC's research and awareness programmes, for instance EASE.

## 4.3 SOFTWARE ENGINEERING GROUP (SEG)

### 4.3.1 Staffing

This year the Software Engineering Group has remained at about the same overall numbers, although the members of the group have changed. In November, Dr Jeremy Dick (AJJD) left to work at Racal Research Ltd, Reading. In October, Dr Mike Spivey (JMS) , an Atlas research Fellow, joined the group and in April, Dr Stuart Robinson (SKR) , who had been a part-time visitor from Brunel University, joined the group as Group Leader. Dr Chris Reade (CMPR), a lecturer from Brunel University, also joined in April, filling the part-time visitor role vacated by SKR. CMPR's interests in formal methods compliment the activities in the group in this area and go part way to fill the gap left by Jeremy. In July, Brian Matthews (BMM) obtained a permanent HSO post in the group and, finally, Dr Francese Cormellas (FC), our visitor from Universitat Politecnica de Catalunya, returned home to Spain in August having completed his visiting year.

BR received a PhD from the University of Edinburgh with his thesis entitled The Design and Implementation of an Interactive proof editor and became a MBCS in May 1989. BMM successfully completed a MSc in the Foundations of Advanced Information Technology at Imperial College London in October. This culminated in an original research project, which BMM undertook

on the use of the ERIL equational reasoning system, and completed in October. JCB registered for a Ph.D (Algebraic Approaches to Model-Oriented Specification) at Manchester University in October 1988.

JMS is taking a leave of absence at the Computer Research Laboratory, Tektronix Inc., Beaverton, Oregon and at the Department of Computer Science, Cornell University starting in October 1989.

The current staffing of SEG is summarised below:

- SKR: Dr Stuart Robinson (Part Time Visitor, Became Group Leader in April 1989)
- DAD: Dr David Duce (Grade 7)
- Formal Methods section
  - AJJD: Dr Jeremy Dick (Research Associate, Left November 1988)
  - JCB: Juan Bicarregui (Research Associate)
  - FC: Dr Francese Cormellas (Visitor, left August 1989)
  - BMM: Brian M Matthews (Research Associate, Obtained permanent HSO July 1989)
  - BR: Dr Brian Ritchie (Fixed Term SSO)
  - JMS: Dr J M Spivey [Mike] (Atlas Fellow)
  - JCPW: Dr Jim C P Woodcock (Atlas Fellow)
  - CMPR: Dr Chris M. P. Reade (Part Time Visitor, Started April 1989)
- Environment section
  - JRK: John R Kalmus (Permanent HSO)

### 4.3.2 Objectives 1988/1989

#### 4.3.2.1 Introduction

EASE

The current Engineering Board supported research community tends to be split along Committee lines. This does not take into account computing solutions that often straddle several communities' application areas. Therefore, CFC is taking an active role in facilitating cross-fertilisation between Committees, disciplines and industry in the computing area and, as part of this activity, the Engineering Applications Support Environment (EASE) programme has been initiated with the mission statement:

To stimulate and encourage engineers to use appropriate, state-of-the-art software and hardware to enhance their research

Specifically, CFC wishes to encourage engineers to migrate to state-of-the-art integrated project support environments (IPSEs). These will be available in the 1990s as the result of Alvey and Esprit funded research activities.

Integrated Project Support Environments

Until very recently, most software has been developed and maintained predominantly on large, centralised computer systems using ill-matched tools and methods. It is now recognised that better control and productivity gains can be achieved through increasing the amount of Computer Aided Software Engineering (CASE) support available.

A number of such tools have been brought to the market but have, in general, suffered from the lack of a unified approach. Users incur unnecessary costs and risk loss of control in manually converting results produced by one tool into a form suitable for another. Coherent, complete tool sets covering the whole range of tasks of system development and maintenance have not been available on a common basis. It is against this background that the concept of an Integrated Project Support Environment (IPSE) has emerged. An IPSE is a software development environment

- within which the user can hold, in computer processable form, all of the managerial, administrative and technical information describing and, defining the current state of a system and its past history,

- into which tools can be integrated this information throughout all the maintenance of the system, and to support the processing of phases of the development and
- within which the developed software is integrated in terms of its data input/output, (uniform) user interface and processing model.

Engineering Software

The software systems developed and supported by the engineering community are, in general, large and complex. Such activity, in the academic community, frequently involves an integration of commercial and academic software to produce ENVIRONMENTS suitable for interactive design. The need for tools to assist this integrative activity have already been identified by the CFC Workshop on Tools for Integration, and are actively being explored within the Software Engineering R&D community.

The software design process itself is one of exploration of alternatives and, consequently, most Engineering Board Committees see the need for the expert and intelligent retrieval of data and its interpretation. Such intelligent access and use of data is actively being researched within the Knowledge Engineering R&D community.

The major activities in software engineering (SE) and knowledge engineering (KE) supported by JFIT (Joint Framework for IT) can therefore be expected to deliver systems that are relevant to the engineering community as a whole. To assess this expectation, JFIT is anxious to have joint programmes with the other Engineering Board Committees to try out SE and KE research results in real environments.

#### 4.3.2.2 SEG Objectives

In the context outlined above, the Systems Engineering Division needs to act as an interface between the (eg JFIT sponsored) IT research community, in particular the Software and Knowledge Engineering communities, and the traditional engineering communities which are supported by the EASE programme. To meet this requirement the Division needs to have a (well informed) foot in both camps, acting as a bridge (in the form of education and technology transfer activities) between the two.

Therefore, the major thrusts of the Software Engineering Group are:

1. Software Engineering Environments all the Engineering Boards' Committees have an interest in modern information processing system production techniques, and SEG have responsibility for computer aided software engineering ENVIRONMENTS and tools for software integration applicable to a wide range of engineering activities.
2. Software Engineering Research awareness, development and critical assessment of (new) methods and tools, based on formal mathematical principles, for the expression of specifications and designs.

This is all undertaken within the unifying research theme The Quality Certification of Software Products.

#### 4.3.2.3 Quality Certification

Introduction

A software product is a set of components such as

a. Requirements document
b. Formal Specification document
c. Design document
d. Source Code
e. Executable Code
f. User Manual
g. ISO standard

A software process is that which is done rather than that which is produced.

For example:-

| process | product |
|---|---|
| programming | source code |
| compilation | executable code |

Any SE programme has two major goals

1. improved QUALITY of the software product
2. improved PRODUCTIVITY in the software process, for example, that achieved by reuse

SEG does not tackle productivity issues, except where SEG's own productivity in achieving quality objectives is impeded. The concentration is on quality issues.

Software quality is a property of the software product. Software quality has nothing to say about the process, ie high quality of a software product is not necessarily guaranteed by a high quality software process.

The properties which make up software quality include performance, reliability, security, correctness, usability and cost. Certain quality properties may be directly measurable, for example CPU time, memory occupancy, lines of source code, etc.

However, other properties have a certain subjectivity that makes it difficult, if not impossible, to measure, for example usability, maintainability etc.

Certain quality properties are certifiable. Certification is taken to mean the independent (of the software producer) and repeatable demonstration that a software product possesses a specified property or set of properties. A simple example of certification would be the independent verification that a software product's executable code is less than 64 Kbytes; once verified a certificate would be issued indicating that the product has been examined and the truth of the claim established.

The SEG Research Theme

The idea of having a long term theme, which ties together various semi-independent activities within a group, has advantages eg: Reliability at Newcastle, Ada at York, Formal Methods at Edinburgh.

The SEG research theme is the search for techniques to demonstrate
The Quality Certification of Software Products
that is, techniques which will enable SEG to independently and repeatably demonstrate that certain software products possess certain well specified properties as outlined above.

#### 4.3.2.4 SEG Research Objectives

Within the group, quality certification is approached from the formal methods angle. Two strands of interests are describable as:

1. a general understanding of software quality The first strand is concerned with understanding what properties of a software product (remembering that this includes design and documentation, as well as source and object code) can/cannot be formally described, proven or measured. This understanding should be communicable to others, at least in the form of examples, and possibly (preferably) in the form of some general theory of software quality.
2. the means to certify quality The technology to certify quality, from the formal methods standpoint, is the capability to prove that products possess some formally specified properties. Also included under this category' are tools to aid in this process. SEG aims to make a contribution both through the development of new proof techniques, and through the

development of tools which make the theoretical techniques of others accessible to a wider audience. In this context the ERIL project (and the LOTOS project, starting in October 1989) and the IPSE 2.5 project are seen as key. The tool construction task is not seen as a lower task; it is the crucial technology transfer or industrialisation step at which the UK is so poor and on which economic prosperity is crucially dependent.

#### 4.3.2.5 The Relationship between SEG Research and EASE

**EASE : A Need for Quality Tools and methods**

Throughout the EASE programme, tools and methods will need to be critically assessed and monitored. The Informatics Department's evaluation work requires judgements about the 'quality' of software to be made so that the standard of the software releases to engineers can be assured. There is, therefore, a need to understand the issues involved in software quality and active research in this area assists this process.

**EASE : committed to education and awareness**

SEG research activities enable the group to undertake technology transfer on emerging methods and tools and to advise ECFE in these areas.

**EASE : as a nationwide IPSE for engineers**

Formal methods, safety critical issues and CASE/IPSE tools are all involved in the ultimate vision of EASE as a nationwide IPSE for engineers.

**EASE: Standards**

The issues concerning whether software processes conform to standards leads to the work on certification identified in SEG's research plan. For example, David Duce's work on GKS.

### 4.3.3 IPSE 2.5

IPSE 2.5 is a major Alvey project to research and develop an Integrated Project Support Environment based on advanced distributed systems and man-machine interfaces, and incorporating support for both the practice and organisation of design tasks. A major objective is the development of an integrated framework for supporting the use of formal methods in software development, including formal specification and theorem-proving techniques.

The project began in October 1985 with three initial collaborators (ICL, STC and Manchester University) and had a successful first review with the Alvey Software Engineering Directorate in July 1986. RAL joined the project in April 1986. Three additional industrial partners have also recently joined the collaboration.

At RAL, Juan Bicarregui (JCB) and Brian Ritchie (BR) are engaged in the project. DAD is the RAL representative on the project Review Board. The work at RAL is carried out in very close collaboration with the University of Manchester. JCB and BR spend a fair proportion of their time at Manchester.

The Manchester/RAL part of the IPSE 2.5 project (Theme C) is concerned with the support of formal methods of software development and in particular with aiding formal reasoning itself. The intention is to build tools which enable a user to construct proofs at the workstation; modern workstations such as the SUN3 should make it possible to design proof assistants which are much more usable than earlier tools developed around glass teletype interfaces.

Manchester has concentrated upon the specification and implementation of a generic proof assistant (known variously as FRIPSE, Magus and (currently) the Mural Proof Assistant); RAL has concentrated upon implementation of a "Mural VDM Support Tool" for both specifications and designs using BSI VDM. The intention is that specifications (and the refinement of one specification to another) in the latter should be "translated" into theories in the generic proof assistant, including those proof obligations which must be discharged in order to verify a specification or design step.

Originally, the VDM support tool was intended to be minimal, the main aim being to provide an existence proof that the generic proof assistant could be instantiated to support particular

formal methods. However, in consideration of the present status of the IPSE 2.5 theme responsible for a full support system, RAL have been encouraged to make the design less minimal.

Over the period August December, the first prototype, FRIPSE (Formal Reasoning in an IPSE) was constructed: Manchester implemented a prototype generic proof assistant from a formal specification, whilst RAL constructed a prototype structure editor for BSI VDM. The latter included the ability to generate proof obligations from specifications and translate them to expressions in the generic logic of the proof assistant. This early version was demonstrated at a review of the IPSE 2.5 project on January 17th.

JCB and BR submitted and subsequently presented a paper on the VDM support work to the 1st International Conference on Systems Development Environments & Factories (Berlin, May 9 -11). They also gave demonstrations of the same prototype system at the conference.

Since this time, FRIPSE has undergone a major redesign (and been renamed as Mural). The largest changes are to the user interface, taking into account the experiences with the initial interface. The initial link between the VDM support tool and the proof assistant consisted solely of a means for translation VDM expressions (such as proof obligations) into proof assistant expressions. It was decided that a fuller translation mechanism was necessary (and feasible within the lifetime of the project). Thus BR and JCB's time on IPSE 2.5 since February has been divided between improving the interface to the VDM support tool and specifying a mechanism for translating both specifications and designs into theories in the generic proof assistant. Some initial ideas on such translation are documented in a project document. Both tasks are ongoing at present.

There are also plans to produce a Book of Mural, documenting the system and the designers' experiences in implementing in Smalltalk from formal specifications. BR and JCB have produced a first draft of their chapters.

BR and JCB are currently searching for funding for further work with Mural beyond the lifetime of the IPSE 2.5 project. Future proposals include collaborative work with Tim Clement at Manchester University relating specifications and program transformation.

### 4.3.4 BSI-VDM

BR and JCB have continued to sit on the VDM Specification Language standardisation panel (IST/5/50) with the intention of making the Mural VDM support tool follow the standardised language as closely as possible. During the year the major components of the language, abstract syntax, ASCII and 'mathematical' versions of the concrete syntax, context conditions and semantics have gradually stabilised and been brought together into the first version of the proto-standard which was released in May. There are also moves afoot to set up an ISO working group for VDM SL.

### 4.3.5 SML-YACC

The aim of this project was to produce a yacc-like parser generator system written in SML which produces output code in SML. This project was undertaken as part of the Alvey FORSITE project. The SML-Yacc Parser-Generator System was completed by BMM at the end of November 1988.

There were two major problems to be overcome in the final testing of the system. One was associated with a problem in the Edinburgh ML system which meant that large parsers would not be loaded into the system. BMM tackled this problem by breaking the output down into smaller components, which are then rebuilt when loaded into ML. The other more major problem was a problem of an underspecified case where no action is associated with a empty production in the grammar. In this case a value is needed but none is known to the system. BMM resolved this problem by requiring the user to declare a dummy value in such cases.

As a case study in the use of the parser-generator, an implementation of a lexical-analyser-generator was produced by SKR and BMM. This tool was designed to be compatible with SML-Yacc. Although a full implementation was not achieved in the time available, this work demonstrated the ease of use and general applicability of the Parser-Generator system.

To complete the work on the parser-generator, a prototype parser for the Z-specification language was produced by BMM. This used the grammar for Z as used in the for the FORSITE project and supplied by RAGAL Research Ltd. This parser is the subject of a group report.

The parser-generator has been distributed to Oxford University, RACAL Research Ltd, and Brunel University. Imperial Software Technology has also expressed an interest.

The User Manual for SML-Yacc has been produced by BMM as a Laboratory Report. Further publications on this project are in preparation.

### 4.3.6 Formal Specification and Verification

For some years now JGPW has been an investigator on the CICS project being carried out jointly by IBM UK laboratories at Hursley, and the Programming Research Group (PRG) at Oxford. The research objectives are to demonstrate the applicability of mathematics to the development of large industrial software products. These objectives are being met, since the Z notation, which is based firmly on elementary set theory, has been used by IBM to develop the latest release of the CICS transaction processing system. Furthermore, IBM have stated their intention to continue this research.

Working with his D. Phil student, Jim Davies, JGPW completed a specification and implementation of the Ethernet protocol in Timed CSP. This is the first major use of the theory, and it has thrown up many research topics. At present, work is proceeding on a set of proof rules to make proofs easier. It will not be possible to complete the proof that the implementation satisfies the specification without a probabilistic model for CSP.

JMS has been working on a rigorous description and standardization of the Z notation which has resulted in the publication of his book The Z notation: a reference manual.

JMS has undertaken an investigation of tool support for Z specifications and has studied two case studies in formal specification:

i. a real-time kernel;
ii. the UNIX tool 'make'.

JMS has been working on consistency theorems for free type definitions in Z.

Funded by the Austrian Ministry of Science and the British Council, JCPW spent two weeks as Gastprofessur at the University of Klagebfurt in Austria. He taught a course on formal specification in Z.

Working in collaboration with Hewlett-Packard research Laboratories at Bristol, JCPW has discovered some strategies for substantially reducing the burden of proof in the implementation of occam programs from their specifications. The main idea is to prove that there is a normal-form specification which corresponds exactly to a normal-form process. The specifications that are being worked on are then transformed into their normal forms; these then corresponded to normal-form processes, which are then transformed into the final implementation. None of the usual inductive proofs that recursive programs satisfy certain predicates are necessary, the task of implementation being reduced to one of transformations by rewrite-rules.

JCPW has recently started work with IBM UK Laboratories at Hursley on large-scale proofs of parts of the CICS transaction processing system. JCPW has developed proof techniques for Z specifications and refinements, and shown how these can lead to routine calculations using Abrial's B proof assistant. In order to prove large specifications correct, it is necessary to structure the proofs in a careful way, deliberately minimising the amount of effort required. It turns out that a well-structured specification or design in Z also has a well-structured proof. That is, the proofs of theorems about individual pieces may be composed, just as the pieces themselves are composed. Thus, instead of large proofs, one need carry out only small proofs, thereby keeping the process manageable.

CMPR is beginning a survey of existing theorem proving systems in UK in October.

JMS has been studying the application of the Boyer-Moore theorem-prover to reasoning about specifications in the Z style.

Further, JMS has been developing a theory of exceptions in higher-order lazy functional programming with applications to term-rewriting and implementing a theorem-prover for higher-order equational logic.

JMS has developed and presented courses in the area of Dijkstra's calculus of weakest pre-conditions.

DAD has continued to work on the formal specification of graphics standards. This project started in 1985 and ended in April 1989. The relationship between GKS and PHIGS has received considerable attention. This work culminated in a paper at the Eurographics '89 conference. Essentially PHIGS can be described as a database on top of GKS or GKS-3D. Traversal of this database generates graphical output, which can be described in terms of GKS functions. This simple model does not completely define the relationship between GKS and PHIGS; there are complications arising from differences between coordinate systems and clipping in the two systems. The control of operator attributes, visibility, highlighting and detectability, is also different in the two standards, which limits the analogy.

The relationship between GKS-3D and PHIGS is one aspect of a broader issue, namely, a Reference Model for Computer Graphics. Insights from the specification work formed the basis of an outline reference model. This work is discussed in the section on standards activities below.

A review of GKS is now starting within ISO, and the work of the completed formal specification project discussed above is being fed into this process. Papers have been written for the March 1989 meeting which describe a simpler structure for GKS and propose the removal of extraneous functionality. Central to this proposal is the explicit idea of a picture in NDC space which the application is constructing, and the notion of a workstation viewing this picture through a filter mechanism based on the PHIGS name set mechanism. Some of the ideas in this originated in the original specification project. The description of GKS produced by this project has also been simplified extensively by using more abstract data-types and functionality. A formal specification of the simplified model has been given which has a particularly simple structure.

DAD spent a week working with Drs P J W ten Hagen and R van Liere at CWI, Amsterdam, on formal specification of the GKS input model and extensions thereof, at their invitation. A description of the GKS input model using Hoare's CSP notation, was produced as a result of this collaboration. This paper has been accepted for the Eurographics '89 conference. The description shows clearly the differences between the different operating modes for GKS logical input devices and gave the authors some new insights into the input model.

It has long been felt that it should be possible to allow user-configurable input devices and allow hierarchically structured devices. During a visit to CWI in February 1989, it was found that the CSP input description could be extended easily to describe hierarchically structured devices. Some examples were worked out and the first draft of a paper was produced.

DAD spent a week at INRIA, Paris, teaching part of a course on distributed graphics.

DAD is Vice Chairman of Eurographics and Programme Co-Chairman for the Eurographics '90 conference.

### 4.3.7 Graphics Standards

DAD has participated in the BSI Computer Graphics Committee IST/3I and in the international work on reference models and revision of GKS. DAD and FRAH are currently joint editors of these two documents.

Both activities have built on insights arising from the GKS formal specification project. The Reference Model work has deviated significantly from the component/framework model mentioned in the last Annual Report. The work has reverted to a layered structure similar to that proposed in

February 1988, but now recognizing four layers: application, virtual, logical and physical. This approach was developed at a meeting in January 1989 and refined at a meeting in May 1989. Since that time effort has been expended on improving symmetry between input and output in the model.

An outline proposal for a revised GKS was developed by FRAH and DAD in conjunction with Dr K W Brodlie at the University of Leeds. The direction of the work has been to develop a cleaner structure than that in GKS ISO 7942:1985. The initial proposals were subject to international review in March 1989 and a fuller document has been completed which takes into account the comments made. This document will be subject to international review in October 1989.

DAD also participated in a meeting in February 1989 which aimed to produce an improved input model for graphics standards. Again, work from the formal specification project provided input to this meeting. A report has been produced which will be considered by ISO SC24 Working Group 1 in October 1989. The results of this work have also been partially incorporated in the revised GKS draft.

DAD has just completed a book with Dr D B Arnold at the University of East Anglia on the first generation of standards for computer graphics.

### 4.3.8 ARGOSI

DAD is involved in the Esprit II ARGOSI Project which began in April and finishes in March 1992. Project ARGOSI (Applications Related Graphics and OSI Standards Integration) is a multi-national European project funded under the Esprit II Programme which aims to advance the state of the art in the transfer of graphical information across wide area networks. Two of the specific objectives of the project are:

1. To improve both the quality and applicability of Standards in the area of graphics and of the application of OSI standards to the transfer of graphical information.
2. The development of a detailed understanding of how to construct systems which use graphics and OSI networking. This understanding will be applicable across a wide range of application domains.

The first stage of the project is looking at the classification of applications in terms of their graphics requirements and the networking services required for those graphics. It is important to emphasize that the project is not about graphics in isolation, nor networking in isolation, but about the particular problems and requirements arising from the combination of graphics and networking.

Participation in standardization activities is another major theme within the project, and the consortium members are already well-known for their contributions to either graphics or networking standards in ISO/IEC and CCITT. This reference model, or classification scheme, will also be used to guide their input to the standards-making process to achieve the objectives of improving the quality and applicability of standards. Obviously, the reference model has to take into account a broad range of application areas and existing practical experience with graphics and networking. The consortium members wish therefore to gather information and requirements for the combination of graphics and networking services from as broad a range of organizations as possible, together with experience of using combinations of existing graphics and OSI standards.

RAL are leading the Classification Workpackage and the participants here are currently interviewing a large number of user organizations.

### 4.3.9 Graphics in Esprit

DAD and FRAH worked with the Esprit Directorate and Eurographics, to formulate a proposal for a Special Interest Group on computer graphics within the Esprit Programme. Three information exchange sessions on graphics in Esprit have been organized in conjunction with Professor Encarnacao and Dr Schonhut in Darmstadt, as part of the Eurographics '89 Conference Programme.

**Ruth Kidd demonstrating to Jurgen Schonhut at the BCS Displays Group Meeting**

**Large View**

### 4.3.10 Equational Reasoning Research

This work was funded by SERC's Computing Science Sub-Committee. The ability to reason with equations (for example, to deduce conclusions from a set of equations), is important in a number of areas, for example specification of abstract data types and their validation, program transformation, synthesis of programs, program optimisation and solving equations. Jeremy Dick (AJJD) has over a number of years developed a rich theoretical framework for equational reasoning and has developed a practical tool, ERIL (Equational Reasoning an Interactive Laboratory), based on this framework. ERIL is a useful tool for experimenting with specification and prototyping of abstract data types, and is used by several research groups in the UK and abroad. ERIL is based on the use of rewrite rules for computing and reasoning with equations.

Unfortunately, AJJD left the ERIL project in November 1988. This was a major set back to the progress on this project. However, before leaving, AJJD did complete the implementation of the Recursive Path Ordering and also the Unfailing Completion method within ERIL.

AJJD also commenced a new clean implementation of the ERIL system in the PROLOG language, which was to incorporate new features which seemed desirable in the light of the experience

gained in using the ERIL system. Due to changing requirements (see below), this work was curtailed after the departure of AJJD.

During the first half of the year (Sep 88 - Feb 89) John Kalmus (JRK) was involved in the ERIL project. The ERIL Users' Manual was issued by JRK and Jeremy Dick (AJJD) as a Laboratory Report in September 1988.

A paper written jointly by AJJD, JRK and Dr. Ursula Martin of Royal Holloway and Bedford New College, University of London was submitted to Acta Informatica in January 1989. Entitled Automating the Knuth Bendix Ordering, it describes a new approach to dynamically orienting rewrite rules during Knuth Bendix completion which has been successfully implemented in ERIL.

JRK also helped run several meetings over this period. For example, he was the principal organiser for the BCS-FACS Term Rewriting Tutorial and Workshop, the organiser for the "ERIL collaboration meeting" and the co-organiser for the Term Rewriting Group meeting.

During this time, JRK was responsible for the distribution of the ERIL system and User's Manual, and for maintaining a mailing database of postal and e-mail addresses used for publicising meetings of the Term Rewriting Group. BMM took over these functions in April 89 when JRK moved to the EASE environment project.

Early in the year, BMM, in support of the ERIL project, undertook an investigation into the use of the ERIL system as a tool for theorem proving. He found that the tool proved flexible, and could be used for a variety of differing equational techniques, although the size of problem which could be undertaken within the current ERIL implementation was not great. This work became the subject of BMM's MSc dissertation. BMM is now following up this work by investigating the flexibility of the ERIL system for differing configurations of the Knuth-Bendix algorithm and the Unfailing Completion algorithm.

In order to continue activity on the ERIL project, BMM undertook (in February) to review the work undertaken under the CSSC grant on the ERIL project. From discussions at this time and later, within the department and -with informal collaborators at Royal Holloway and Bedford New College, it was decided that a sensible approach to further activity was to 'freeze' ERIL in its current implementation, and to concentrate on extracting essential features with the view to producing a 'toolkit' of useful functions for equational reasoning within a functional language such as Standard ML. BMM has been carrying out some preliminary studies into this, and is producing a formal algebraic specification of the toolkit. Contact has been made with the group at CRIN, Nancy, France, who use a toolkit produced in the functional language CAML. It is hoped that this work will continue under the IED LOTOS verification project which commences in October.

CMPR, DAD, and BMM will be involved in SERC IED project with RAL/RHBNC/Glasgow Verification tools for LOTOS Specifications starting in October 1989.

### 4.3.11 EASE Environment

CFC wishes to encourage engineers to migrate to state-of-the-art integrated project support environments (IPSEs). These environments will be available in the 1990s as the result of Alvey and Esprit funded research activities. However, due to the wide technology gap between existing practises and IPSEs, CFC believes that an environment developed and offered now using this new technology would run the risk of being rejected by the community as requiring too much retraining.

CFC therefore recommended the approach taken in developing the prototype environment be as follows:

- Build an initial environment using commonly available current tools (FORTRAN etc) for delivery to the community in the near future.
- Assess IPSEs as the source of a second generation of this environment. For example, PCTE, ISTAR and Maestro need to be evaluated to see if they could form the platform for engineering-specific tools.

A major decision at the last CFC meeting was that Informatics should produce the initial software environment and undertake the assessment of IPSE technology. To encourage use of the initial environment by the community, it should be populated by a set of tools or modules with wide applicability. SEG have been given the task of planning this activity and assessing IPSE technology as it emerges.

In the second half of the year (Mar 89 - Aug 89) JRK began working in the area of Software Engineering Environments, under the direction of SKR.

As an initial assessment activity, a course on PCTE and Eclipse, run at University College Aberystwyth, was attended by SKR and JRK. in April 1989. It became clear during the course that the software provided by the Sapphire Project, which was the only SUN version of PCTE (In-Kernel) available at that time, was in a rather volatile state and would continue to be so for some time. Other candidate environment bases, such as Maestro and ISTAR, are being explored.

A major task for JRK during this period has been to gain a working knowledge of available IPSE (Integrated Project Support Environment) technologies, with the view of producing a survey document (as an internal report) by the end of the year. As part of this process, an Emeraude implementation of the Portable Common Tools Environment (PCTE) has been installed on a SUN 3 Workstation, and will be used as part of an assessment of PCTE as a Tool Support Interface (TSI).

### 4.3.12 Concurrency

In collaboration with He Jifeng, a colleague at the Oxford PRG, JCPW has been working on a combination of Z and CSP. They have developed several special refinement techniques that have proved to be useful. This has resulted in several case studies which show how concurrent systems may be developed in a state-based framework.

As an alternative to the approach using a combination of Z and CSP, JCPW has investigated Cliff Jones' work on the specification and development of concurrent systems using rely and guarantee conditions. The original work concentrated on operation decomposition in particular on parallel decomposition - and issues of data refinement were less well treated. JCPW has discovered hitherto unknown problems in the technique, and shown that they militate against hierarchical design. As a development proceeds, important sorts of refinements cannot be proved correct without knowledge of how the rest of the system is being developed. If such refinements are permitted, then the technique cannot be described as hierarchical; if, on the other hand, they are forbidden, then the technique has poor expressive power. JCPW has started on some collaborative work with Cliff Jones that promises to attack these problems.

### 4.3.13 Functional Programming

CMPR has written a book Elements of Functional Programming" which has been published by Addison Wesley.

JMS has been exploring the applications of category theory to functional programming and program transformation, and has prepared and presented courses in this area.

JMS has been studying the implementation techniques for lazy functional programming languages.

### 4.3.14 Support Activity

**ERIL**

The distribution of the ERIL equational reasoning system continues, being carried out by BMM after the departure of AJJD. New sites include Twente University, the Netherlands, and RSRE, Great Malvern.

AJJD also set up a mailing list for the Term Rewriting Group, which BMM has now taken over.

**LCF**

BMM continues to distribute the Rutherford Standard ML/Cambridge LCF system, although requests for this system are declining.

**EASE**

Benchmarks for software engineering tools were requested in support of the EASE programme. However, due to the highly interactive nature of most such tools, this did not prove trivial. BMM attempted to produce a version of SML-Yacc suitable for automated benchmarking. This was not a success as Edinburgh Standard ML proved not portable enough for the purpose. BMM then produced a simplified version of the ERIL system suitable for this purpose.

**Poly-ML**

Poly-ML from Imperial Software Technology was received and mounted by BMM.

### 4.3.15 Conferences Attended

**RWW**

- VDM Europe, CEC Dublin, Sept 88.
- PCTE v CAIS, NCC London, Oct 88.
- SE Quality Ass, CSR Bristol, Oct 88.
- ESPRIT Tech Week, CEC Brussels, Nov 88.
- IPSE 2.5, NCC Manchester, Jan 89.
- Safety Rel Sys, CSR Oxford, Feb 89.
- 1992, KPMG London, May 89.
- Def Stan 0055, MOD Malvern, June 89.

**SKR**

- Exploiting Formal Methods, BCS-FACS workshop, Imperial College London, 25th May 1989.
- Software Quality Workshop, Napier College, Edinburgh, 27-28/6/89.

**DAD**

- Eurographics '88
- Esprit Technical Week.
- Eurographics UK Chapter Conference
- NCGA.

**JRK**

- BCS - FACS Term Rewriting Tutorial and Workshop, Wills Hall Bristol September 88.
- ERIL collaboration meeting (Cosener's House, Abingdon, October 88)
- Term Rewriting Group meeting (Hatfield Polytechnic, December 88)
- 4th Conference on Software Engineering Environments, University of Durham, April 1989).

**BMM**

- Term Rewriting Workshop, TRG/BCS-FACS, Bristol University, Sept 1989.
- Term Rewriting Group Meeting, Hatfield Polytechnic, Dec 1989.
- Z User's Meeting, Oxford, Dec 1988.
- Logic Programming Workshop, Imperial College London, February 1989.
- CASE Tools Theory and Practise, Workshop at the IEE London, February 1989.
- Rewriting Techniques and Applications Conference Chapel Hill, North Carolina, USA, April 1989. Preceded by a visit to SUNY Albany, New York State, USA.
- Term Rewriting Group Meeting, RHBNC, May 1989.
- Exploiting Formal Methods, BCS-FACS workshop, Imperial College London, May 1989.
- UNIF'89, 3rd International Unification Workshop, Lambrecht, West Germany, June 1989. Followed by a visit to Centre de Researche en Informatique de Nancy, Nancy, France.

**CMPR**

- BCTS 5, Royal Holloway and Bedford New College, April 1989.
- Exploiting Formal Methods, BCS-FACS workshop, Imperial College London, May 1989.

- RuG "Mathematics of Program Construction", Twente University, June 1989.

**JCB**

- 2nd VDM-Europe conference, Dublin Sept 1988.
- 1st International Conference on Systems Development environments and Factories, Berlin May 1989.
- IEE Seminar: Application of CASE Tools, London Feb 1989.
- BCS-FACS Seminar: Exploiting Formal Methods, I.C. May 1989.
- Term Rewriting Workshop, RHBNC May 1989.
- Generic Logic Workshops, Manchester Univ, September 1988 and May 1989.

**BR**

- 2nd VDM-Europe conference"Dublin September 1988.
- 1st International Conference on Systems Development environments and Factories, Berlin May 1989. 1st Int. Conf. SDE&F, Berlin May 1989.
- IEE Seminar: Application of CASE Tools, London February 1989.
- BCS OOPS-23 Meeting, London, April 1989.
- BCS-FACS Seminar: Exploiting Formal Methods, I.C. May 1989.
- Software Quality Workshop, Napier College, Edinburgh, June 1989.

**JCPW**

- The Workshop On Refinement, Open University January 1989.
- 5th Int. Workshop of System Specification and Design, Pittsburgh, July 1989.
- Workshop on Formal Methods, Halifax, Nova Scotia, July 1989.

### 4.3.16 Courses Attended

**RWW**

- Brain Skills, TMI, Sep 1988.
- Change Management, TMI, Nov 1988.
- New ACR, RAL, Dec 88.
- Senior ACR, RAL, Mar 89.
- Proj Man Tools, NCC, Mar 89.
- Ten15, CITI, June 88.
- 'Z' Spec Lang, Praxis, Feb 89.
- ML, EGCS, June 89.

**SKR**

- Praxis Z Course London, March 1989.
- Workshop on PCTE / ECLIPSE, UCW Aberystwyth, May 1989.
- Harold Wroe's Time Management course, April 1989.
- Interactive Video Course July 1989.

**JMS**

- Z Users' Meeting, Oxford, December 1988.
- Mathematics of Program Construction, Enschede, The Netherlands, June 1989.

**BMM**

- Common Lisp Course, AIAI, Edinburgh, 30th January - 3rd February 1989
- Harold Wroe's Time Management course, April 1989.
- Interactive Video Course July 1989.

**JRK**

- SERC Induction Course, Royal Greenwich Observatory, Herstmonceux, September 1988.
- Course on Lambda Calculus and Combinators, CTCS, University of Leeds, December 1988.
- Workshop on PCTE / ECLIPSE, UCW Aberystwyth, May 1989.
- Course on Programming in Standard ML, University of Edinburgh, June 1989.

- Harold Wroe's Time Management course, April 1989.
- Interactive Video Course July 1989.

**JCB**

- ML course, LFCS May 1989.
- Lectures on category theory, Mike Spivey at PRG, May/June
- Harold Wroe's Time Management course, April 1989
- Interactive Video Course July 1989

**BR**

- Introduction to Neural Nets, Harwell Training Centre September 1988.
- "The CASE for Apollo" sales pitch, Milton Keynes October 1988.
- Joint Training Section: Interactive Skills Course, Clevedon, December 1888.
- Introduction to X Windows, RAL, March 1989.
- Harold Wroe's Time Management course, April 1989.
- Interactive Video Course July 1989.

### 4.3.17 Publications

#### 4.3.17.1 External


- Reade, C M P, Elements of Functional Programming, Addison Wesley, International Computer Science Series, 1989.
- Matthews, B M, Strategies for Theorem Proving in an Equational Reasoning System - MSc Dissertation, Dept of Computer Science, Imperial College London, October 1988.
- Duce, D A, GKS, Structures and Formal Specification, Eurographics '89 Conference Proceedings.
- Duce, D A ten Hagen, P J W, and van Liere, R, Components, Frameworks and GKS Input, Eurographics '89 Conference Proceedings
- Duce, D A and Hopgood, F R A, Graphics Standards and Networking, Notes for a course on distributed graphics, INRIA, May 1989.
- Duce, D A and Hopgood, F R A, Computer Graphics Systems, chapter for a reference book on computing, Butterworths (to appear).
- Duce, D A and Hopgood, F R A, Graphics Systems: Integration and Standards. Computer Graphics '88 Conference, October 1988 (to appear).
- Duce, D A and Hopgood, F R A, Integration through Standards, Computer Graphics '88 Conference, October 1988 (to appear).
- Kalmus, J R, Dick, A J J, and U Martin, Automating the Knuth Bendix Ordering. Submitted to Acta Informatica
- Bicarregui, J C and Ritchie, B, Providing support for the formal Development of Software, in Proceedings of the 1st International Conference on System Development Environments & Factories, Berlin, May 1989 (to appear in 89-90).
- Bicarregui, J C and Ritchie, B, Mural Proof Obligation Generation Specification, IPSE 2.5 document 060/00149/2.1, June 1989.
- Ritchie, B and Taylor, P The Interactive Proof Editor: An Experiment in Interactive Theorem Proving in: G. Birtwistle and P .A. Subrahmanyam (eds.), 'Current Trends in Hardware Verification and Automated Theorem Proving', Springer-Verlag, 1989.
- Woodcock, J C P, Some Problems with Jones Rely and Guarantee Conditions' in Refinement: Theory and Practise (ed. P. Scharbach), Blackwells, 1989.
- Woodcock, J C P, Simple Transaction processing and CSP in: Formal Methods: Theory and Practise (Ed. P. Scharbach), Blackwells, 1989.
- Woodcock, J C P, Parallel Refinement in Z Proceedings of the Workshop on Refinement, The Open University, January 1989 (to be published by Butterworths).
- Woodcock, J C P, Transaction refinement in Z, Proceedings of the Workshop on Refinement, The Open University, January 1989 (to be published by Butterworths).

- Woodcock, J C P, Calculating Properties of Z Specifications Procs 5th International Workshop of Software Specification and Design Pittsburgh 1989.
- Woodcock, J C P, Mathematics as a Management Tool: Proof Rules for Promotion Procs 6th Annual CSR Conference on Large Software Systems Bristol 1989 Proceedings of the Workshop on Formal Methods (Joint Editor) Halifax, Nova Scotia 1989 .
- Spivey, J M, The Z notation: a reference manual. Prentice-Hall International, 1989.
- Spivey, J M, Free type definitions. Proceedings of the Z Users' Meeting. Programming Research Group, Oxford, December 1988.
- Spivey, J M An introduction to Z and formal specifications. Software Engineering Journal 4, 1 (January 1989).
- Spivey, J M, A categorical approach to the theory of lists. In 'Mathematics of Program Construction' (Ed. Jan L.A. van de 375, Springer-Verlag, 1989. Snepscheut). LNCS 375, Springer-Verlag 1989
- Spivey, J M, A Functional Theory of Exceptions. Submitted to Science of Computer Programming.


#### 4.3.17.2 Internal


- Reade, C M P, Balanced Trees with Removals: An Exercise in Rewriting and Proof Brunel Technical Report. July 1989.
- Matthews, B M, SEDN 25 - Trip Report: Z User's Meeting, Oxford, Dec 1988.
- Matthews, B M, SEDN 28 - Using a Parser for Z-Specifications Produced by SML-Yacc.
- Matthews, B M, SEDN 41 - Workshop on Software Tools for Workstations, RAL, June 1989.
- Matthews, B M, SEDN 47 Trip Report: Rewriting Techniques and Applications Conference Chapel Hill, North Carolina, USA, April, 1989.
- Matthews, B M, SEDN 54 Trip Report: UNIF' 89, 3rd International Unification Workshop, Lambrecht, West Germany, June, 1989.
- Kalmus, J R and Dick, A J J, ERIL (Equational Reasoning: an Interactive Laboratory) User's Manual, Version R1.6a, Lab Report No. RAL-88-055, September 1988
- Bicarregui, J C and Ritchie, B, SEDN 11, Trip Report - VDM 88, Dublin, September 1988.
- Bicarregui, J C and Ritchie, B, SEDN 461, Oct 88 Trip Report - 1st International Conference on System Development Environments & Factories, May 1989, W. Berlin.
- Ritchie, B, SEDN 12, Report on "The CASE for Apollo", Milton Keynes October 1988.
- Ritchie, B, SEDN 36 Trip Report - 00PS-23 Meeting, London Zoo, April 1989.


### 4.3.18 Objectives for 1989/90

#### 4.3.18.1 EASE

The overall objective of the EASE environment project is to develop a national IPSE for EASE by the year 1995. The environment is to be based on de facto standards. The environment is to stimulate and encourage engineers to use appropriate, state-of-the-art software and hardware to enhance their research. Its use is to be encouraged by being designed so that it can be populated by a set of tools or modules with wide applicability.

As a sub-goal, the initial environment needs to be designed and built. This process is to be led by SEG. Existing 'conventional' environments (such as ECTASY and EKS) need to be examined and the results of this uti1ised in the design process. A suitable environment basis needs to be identified and the appropriate tools then integrated onto that basis.

Further, emerging IPSE technology needs to be monitored as part of the design process for the follow-up, IPSE based environment. This assessment activity is seen as an on-going commitment to SEG.

#### 4.3.18.2 Research

SEG research projects should lead towards increasing SEG's strength in

1. theoretical computer science

2. formal specification
3. proof techniques
4. tools
5. metrics

SEG needs to build up the right intellectual environment (the skills, enthusiasm and energy of the members of SEG) and the right physical environment (offices which are conducive to concentration but allow group interaction, computing facilities, laser printers, etc).

On the intellectual side SEG needs to build up its

1. theoretical ability generally, by formal training and individual/group initiatives
2. formal specification capability, by tackling, for example, case studies such as the 'formal techniques for ISO graphics standard specification' problem.
3. proof capability by
    a. An involvement in formal proof systems and tools, for example LOTOS, IPSE2.5
    b. consideration of proof obligations thrown up by the case studies
    c. asking the question what can be proven about a product?
4. work on the general understanding and theory of quality;

Specifically, our research plan is

a. to finish Mural (March 1990) and then to exploit it in a subsequent project (yet to be approved).
b. to start the LOTOS project. This involves the project group all becoming familiar with LOTOS, equational reasoning and concurrency (through courses run within the group) and then undertaking a series of case studies.
c. to become involved in IPSE research activities
d. to become collaborators in the ESPRIT funded, formal methods research programmes.

## 5. DISTRIBUTED COMPUTING SYSTEMS DIVISION

### 5.1 INTRODUCTION

DCS is primarily a service Division. It serves the communities supported by the bodies which fund the Department. It also serves the other three applications Divisions within Informatics. Finally it makes its expertise available to the rest of RAL. Its main functions are:

- Support - both technical and managerial - of projects, programmes and user communities, including the hundred or so members of Informatics Department;
- Awareness assessing products and making the information available to potential consumers within our user community;
- Development - taking new products and ideas, adapting them and integrating them into our working environment;
- Research - at least potentially in the areas of distributed systems, communications and graphics.

For K F Hartley this was the year of the paper mountains. Firstly a start was made on archiving documents relating to the Department's involvement with the Alvey Programme. Having been responsible for helping set up a Departmental archive, KFH then set about trying to fill it and follow the guidelines. There are five filing cabinets full of papers and several cardboard boxes which were returned by Adrian Wheldon, having been given to him in March when the Alvey Unit evaporated.

Secondly, it was decided by ECFE that RAL should join the Open Software Foundation, which is the organisation of companies IBM, DEC, HP-Apollo, Apollo-HP, Siemens, Bull and 150 others - trying to create a portable rival to the Sun/AT&T flavour of Unix. KFH and Neil Calton attended a Members Meeting in Monte Carlo, added our names to various SIGs and have since been deluged in paper. Massive draft descriptions of the Operating Systems Component, copies of every response to Requests for Technology, project plans, discussion papers and so on. Much of this is

sent out by special courier. It is certainly possible to see what we get for our subscription. If only we had the manpower to become actively involved in a couple of SIGs or even to take a serious look at all the papers.

The third mountain of paper arrives regularly from the library at Swindon. The Department Head decided that we ought to see copies of the Official Journal of the EEC. This turns out to be comparable to Hansard, reports from the High Court and more. Much more. One can only be impressed by the effort involved in typesetting so much material at high speed with so few errors. FRAH persevered for a week, then asked KFH to select relevant pieces. We are now trying to stop the flow altogether.

Fourthly, Helen Jenkins has succeeded in merging KFH's files with his Group Leader's files into one coherent system. She is also able to retrieve files on request, at impressive speed.

Finally, Geoff Lambert manages to obtain, organise and distribute a hill of paper which describes the Everest project in more detail than most of us care to know about.

Following the Departmental reorganisation for July 1988, this year has also seen many changes. The computer room has been drastically modified and improved. Lab 11 has been completely refurbished and again greatly improved. New offices in R1 have been allocated, occupied and fitted with appropriate communications, sometimes in that order. A major upgrade of Sun's operating systems, involving a hundred or so machines, was carried out with minimal disruption. At the end of the year we are about to embark on an experiment in doing without maintenance of our diskless Suns, as just one of the changes brought about by the Summer financial crisis.

Alvey has gone, Esprit I is evolving into Esprit II, and IEATP may arrive soon. Some things, however, remain constant. We are still short of text and graphics effort, could do with more in systems and communications, and have nobody to work on Argosi. In spite of that, progress has been made with GKS, local and remote access to Supercomputers and in Directory Services. Major visible contributions have been made to EASE through the work of the assessment team, improving the quality, quantity and distribution of the Engineering Computing Newsletter, and organising a succession of too successful (that is, over subscribed) education events.

This year the decision was taken to recognise at Divisional Meetings achievements over and above the call of duty. The following Achievers have been embarrassed in this way since the scheme started:

- Geoff Lambert: for the original suggestion;
- Rodney Tillotson: for sorting out the Sun maintenance bill;
- Sheila Davidson: for her work on the Newsletter whilst still learning Framemaker
- Predrag Popovic: for his work with the trainee scientists (and tackling RET's programming task before they did)
- Helen Jenkins: for obtaining two distinctions in her first year BTEC exams.

### 5.1.1 Courses

- BTEC Business and Finance Course (first year) Abingdon HVJ
- Executive Secretary Course London February HVJ
- One Minute Manager Oxford July KFH
- BCS PDS Supervisors Course CSSC July KFH

### 5.1.2 Conferences

- NCC Conference Blackpool March KFH
- OSF Monte Carlo May KFH

### 5.1.3 Divisional Objectives for 1989/90

- Ensure continuation of EASE+ funding.
- Finally complete all involvement in the Alvey Programme. with the remains given a decent burial in the Archive.
- At least one other substantial body of non-DCSD files in the Archive.

- Obtain enough funding for the tasks which need to be done, and the staff to carry out those tasks.
- Informatics to participate fully, stylishly and effectively in the RAL Open Days.
- Update the technology of HVJ's office.

## 5.2 TECHNICAL SERVICES GROUP

### 5.2.1 Staff

At the start of this period (September 1988), the group membership was:

- R E Thomas (RET)
- R A Day (RAD)
    - N B M Calton (NBC)
    - P J Isserlis (PJI)
    - A P McDermott (APM)
    - I J Johnson (IJJ)
    - N J Watkins (NJW)
    - M E Claringbold (MEC)
    - P D Athawes (PDA)
    - S K Chanda (SKC)
    - A J Lucas (AJL)
    - D S Barlow (DSB)
    - W J Hewitt (WJH)
- R Tillotson (RT)
    - K M Lewis (KML)
    - M D Phillips (MDP)
    - A M Jackson (AMJ)
    - L J Reed (LJR)
    - I Vollmer (IV)
    - A S Jaroslawska (ASJ)
    - A C Davis (ACD)
- R M Kidd (RMK)
    - P L Popovic (PLP)

Jeremy Isserlis left in November. Andy Jackson transferred to A & G Division in December. Mark Phillips returned to work in November, following his accident in the summer.

The July 1988 reorganisation placed Tony Lucas, Subodh Chanda and David Barlow in the Assessment team on a temporary basis. From September, Tony and Subodh decided to remain there; David moved to Support.

Linda Reed transferred to the Transputer Coordination Unit in February 1989, Karen Holloway joined Distributed Systems in January 1989, and Pat Athawes transferred to Systems Administration (taking over Linda's work on Security). Kevin Lewis was involved in a rugby accident which put him out of action from January to March 1989.

Mark Phillips left in June 1989. Karen changed her name half way through (just to confuse the mailing lists).

Ines Vollmer and Ian Johnson were promoted to HSO.

At the beginning of August, the group membership was:

- R E Thomas
- R A Day
    - N B M Calton

- A P McDermott
- I J Johnson
- K Goswell (nee Holloway) (KG in this report)
- N J Watkins
- M E Claringbold
- S K Chanda
- A J Lucas
- W J Hewitt

- R Tillotson
  - K M Lewis
  - D S Barlow
  - I Vollmer
  - A S Jaroslawska
  - A C Davis
  - P D Athawes
- R M Kidd
  - P L Popovic

In the middle of August, the Communications and Systems parts of the Distributed Systems section became a separate group. Since this took place at the end of the reporting period, it is not presented separately here.

### 5.2.2 Objectives 1988/9

The Group has three sections: Distributed Systems, Systems Admin and Text/Graphics. Distributed Systems has two main activities: systems/communications support and assessment. Systems Admin covers operations and support activities.

The main objectives are as follows:

a. Distributed Systems. Support for Systems and Communications both within the EASE community and IDUS. Development of ISO Mail facilities. Development of high-speed access to Cray. ARGOSI Esprit 2 project involvement. Assessment of workstations for CFTAG.
b. Systems Administration. Support for SUNs in HEIs and the Department. Operation of Department Service. Department Security. Assistance with Grant Model development.
c. Text/Graphics. Support of Text and Graphics systems within the Department and EASE community. Maintenance and development of RAL GKS.

### 5.2.3 Bridge Evaluation (RAD, APM)

RAD and APM have been involved with the Ethernet bridge evaluation work contracted to the Division by the JNT. Stage One of the work involved RAD in the construction of a questionnaire to around 20 suppliers, to find out what products were available, along with brief details. From the replies to the questionnaire, a shortlist was drawn up of products which should be subject to detailed testing in future.

Several remote bridges (ie bridges that can connect Ethernets that are not at the same site) were evaluated in detail. This proved to be a moderate hassle, particularly in getting evaluation machines on the dates promised, and with physical interfaces that we had suitable cabling for. However, a report was submitted to the JNT, and there are now a set of recommendations for this area.

During the summer, the cisco combined bridge and router was evaluated. This had a dual interest: the JNT were interested in its bridging capabilities, and the routing capabilities were of interest to EASE (with a view to use of high-speed links to the Cray etc).

Part of the work involves publishing summaries of what is available to the community. This turns out to be a logistic headache, as the JNT decided that they wanted extra reports in a form suitable for publication to the wider community, but omitted to say this in the original negotiations, specifying

reporting to themselves alone. However, a compromise has now been found whereby suitable extra reports can be generated without too much extra work.

A significant change also occurred in the JNT's attitude to evaluations during this period. Whereas before they favoured producing a single recommendation for a product, and using this as a bargaining tool with suppliers, they have now adopted a policy of approving an arbitrary number of products, and letting individual sites do the haggling. This shift is very similar to that made by CFC with workstation evaluation. Although this means potentially more bridges being evaluated in detail than was first envisaged, it makes running the rolling evaluation a lot easier than would otherwise have been the case.

### 5.2.4 Yellow Pages (NBC, APM)

NBC has worked on implementing a Yellow Pages service on the Pyramid. A client-only service was established on the Pyramid Workcenter (nfs4) and utilities altered to permit YP access. APM has been helping with the Yellow Pages on the Pyramids by compiling and testing utilities that need the YP libraries.

Problems with a number of programs were fixed by NBC. A disk crash then resulted in a loss of much of the YP software and a lot of the work had to be repeated by both NBC and APM. The new system has been tested and has been installed on the Pyramid (pyr-a). Completion of the implementation awaits the delivery of some missing source by Pyramid UK Ltd. A list of required software has been compiled and sent to Pyramid. In return we have provided a Pyramid client in the US with details of our YP implementation. However, we have not yet obtained the required sources.

### 5.2.5 Usenet News (NBC)

NBC has installed the Usenet News software on the Pyramid Workcenter (nfs4). This includes the latest version (2.11) of the News reading software. As part of this work he also installed and implemented UKUUCP on nfs4. With the official closure of the VAX at the end of March, NBC moved the spool directories from vax-d to nfs4. All the software and maintenance scripts have been tested and the system is running well. Versions of rn and inews have been installed on Suns and the Pyramid. NBC (with IV) reconfigured the kernel on nfs4 as the machine was becoming very slow (due to lack of memory) now that it had to run News.

The uucp link to Warwick has successfully been established on nfs4, but there are problems with outgoing calls. NBC has investigated this and it requires software from Pyramid to fix. However, since ukuucp is not a Pyramid product help has been limited to informal channels.

NBC has pursued the possibility of RAL getting the News directly from Kent. At one stage this looked a distinct possibility. However, Kent have decided that they do not need any more feed sites at the moment so were not prepared to send us News directly. Fortunately, the service from Warwick has now improved since they get news from Kent via ftp. NBC has been talking to the people concerned at Warwick about RAL also obtaining News over ftp, which would be much quicker. It will also be needed if RAL is to supply News to other sites.

### 5.2.6 Remote Access to Supercomputer Project (RASP) (RAD, IJJ, NBC)

RAD was involved with NBC and IJJ in the setting up of a project with researchers in the Mechanical Engineering Department of the University of Sheffield to provide fast access to the Cray. "Fast" in this case is a relative term - the CFC has agreed to the funding of a 64 Kbit/sec leased line from RAL to Sheffield for the project. This is still considerably slower than ideal, but should be much better than JANET access, particularly as the use of a leased line means that there is freedom to use protocols (such as NFS) which would not be permitted over JANET. The CFC have funded this work as a trial of the fast batch mode of working.

It is desired to run the TCP/IP protocols and possibly NFS between the Sun in Sheffield and the Sun in Atlas. One way of doing this is to use X.25 to carry the IP using a standard encapsulation. To test running IP over X.25, IJJ established IP routing between the Suns jam and juniper. Although

there is only a slow-speed X.25 link between the two machines, it gave some idea of what can be achieved.

To simulate the KiloStream link from Sheffield to RAL before the line is installed, IJJ arranged the loan of a Sun from SE Group (willow) and moved it to Atlas to be in close proximity to sam. IJJ installed a MCP board (Sun's high-speed comms controller) in willow and tested it. This board is necessary to drive the Kilostream line at 64 K bps.

In April, the KiloStream line from Sheffield to RAL came into operation. The researcher at Sheffield (2 P Wang) is making some use of the line, and this will increase as his knowledge of UNIX improves. To assist in this, NBC and IJJ invited Mr Wang for some training when he was visiting RAL in May. This comprised general UNIX usage, UNIX administration and debugging (NBC), and usage of the Cray Station software and NFS (IJJ).

### 5.2.7 SunOS 4.0 (RT, NBC, IJJ, NJW, IV, LJR)

RT has managed the preparations for upgrading to release 4.0 of the Sun OS. NBC assisted with the introduction and assessment of Sun OS4.0 by gathering and comparing performance measurements of ND and diskless NFS.

IJJ mounted SunOS 4.0 on two machines (louis and redwood), making them available for trial use by interested software developers at RAL before the public trial of SunOS 4.0 started. In addition, IJJ took a member of the operations staff (IV) through the procedure of installing SunOS 4.0 on redwood, so that operations had a taste of what to expect.

NJW was responsible for testing some of the IDUS software on a trial system running Sun OS 4.0. This included installing and testing Fortran, the NAG Fortran Library and Adobe Transcript 2.1, and testing Unipress Emacs. Part of the testing of Transcript was delayed due to the absence of DWB Text Processing software on the trial system.

IJJ looked at a new feature of SunOS 4.0, the Automounter. This allows dynamic mounting of filesystems upon demand, multiple sources (servers) for filesystems, un-mounting of filesystems upon an inactivity timeout, and the use of YP maps to hold configuration information. IJJ took the Automounter configuration that M Martin had been using and ran it on redwood. The result of this led to IJJ making recommendations on the suitability of the Automounter for use on the Suns in IDUS.

Eventually, SunOS 4.0 was installed in the Department on all except a few stand-alone machines, where software needing the earlier version was being run.

### 5.2.8 TCP/IP on IBM 3090 (IJJ)

CCD have purchased a box to enable TCP/IP connections to be made to the 3090. This enables a direct connection to the Department's Suns, and has allowed experiments with 3270 emulation software and NFS. The former was provided by Simware, and a beta test version appeared to provide the necessary functionality (3270 screen in a SUN window). It is expensive, so a decision to purchase it has been postponed. In the meantime a SUN hardware product will also be tested (when SUN can deliver).

IJJ assisted CCD in the evaluation of VM/NFS on the IBM 3090. This consisted of running a subset of the EASE benchmarks from a Sun, redwood, to the 3090. IJJ was only able to run some of the tests because VM/NFS does not support directories. The VM/NFS server was in an unreliable state at this time, so IJJ was only able to run the test for one pass. Nevertheless, IJJ obtained performance figures for the most important NFS operations and the level of VM/NFS's adherence to the NFS protocol.

### 5.2.9 IP Addressing (RAD, NBC, APM, IV, ASJ, ACD)

NBC, APM and RAD have been involved with changes to the IP addresses of machines on the ID ethernet.

APM helped IV, ASJ and ACD in bringing up the ID village with the new address scheme (he provided the new Hosts table). Tests were carried out with a few machines before the whole network was switched over.

It had been hoped to move to the new IP broadcast convention (all ones) at the same time but unforeseen problems with booting some machines means that this move has had to be delayed. NBC and RAD carried out some tests on a private ethernet and found some problems with rwho and with Suns broadcasting on zeroes at boot time. It is hoped that this problem will soon be overcome.

### 5.2.10 Transcript (NJW)

NJW has installed Adobe Transcript 2.1 on a Sun 3/50 running SUNOS 3.4 and has tested it in order to allow a decision to be made in favour of Adobe Transcript or that supplied by Sun.

She has also ported Transcript 2.1 to a SUN4 under SUNOS 4.0. This was so that we would be able to provide Transcript to grant holders who have bought SUN4s, only to find that SUN-supplied Transcript is not yet available for this architecture. It has subsequently become apparent that there are licensing problems involved with this; it is not clear whether these will be resolved before SUN themselves get around to providing a SUN4 version. In order to fix a known fault in the Adobe Transcript, NJK incorporated another program into the Transcript suite, to allow Sun raster files to be printed.

### 5.2.11 PC-NFS (APM)

APM has ordered, installed and tested PC-NFS from Sun. The testing proved satisfactory and the Transputer Centre have ordered 6 more copies. APM has written a report on PC-NFS which because of its wider applicability has been circulated beyond the normal audience for Comms technical notes.

### 5.2.12 THORN, ISODE (RAD, NJW, KG)

Before departing, Danny Smith (DFS - our Aussie) installed the THORN X.500 code that he had been working with on nfs3, along with elmdir, a version of the mail interface program that can interrogate the X.500 Directory. He also wrote up his year's work. This was semi-completed in the usual hurry before he left; he and RAD then spent some time (courtesy of IPSS) sending versions of the report backwards and forwards between RAL and Brisbane in order to get it in a suitable shape for release to the outside world. (This proved to be a very effective mode of working, due to the 10-hour time difference a version worked upon at RAL and sent by RAD before leaving for the night would be received by DFS early in the Australian morning, giving him a day to work on his next contribution and mail it back for RAD to pick up on his return in the morning.) The finished report was submitted by DFS to his University as the first year of a Master's degree; a somewhat expanded version is being published as a RAL Report.

For two weeks, NJW assisted in rebuilding work lost on nfs4, after a disk crash. This included the THORN, ISODE and ELM software which needed to be configured and rebuilt from sources. She has provided some support for this software. In February NJW did some timing tests of the THORN software. During these, the software stopped working. The fault was found to be with the THORN database. NJW rebuilt the database and then retested the software. NJW then handed over the responsibility of the THORN software to KG. The new distribution has improved support for images in the directory, for display under X and SunView. This has been tested on the samples provided and possible formats for local examples investigated. KG has also set up basic monitoring of outside access to our data.

KG has been exploring the existing ISODE sources and documentation. The newest was obtained as soon as available, and ISODE-5.0 was built, tested and installed on nfs2. All five volumes of the User's Manual were coaxed from the LaTeX source. Study commenced, in conjunction with other system documents. Further copies of the User's Manual were made and dispatched to the JNT for distribution.

### 5.2.13 Directory Services (KG)

ISODE-5.0 provides QUIPU, an alternative (and genuine X.500) directory service to THORN. KG built our first QUIPU Directory Service Agent (DSA) and rebuilt THORN to be self-contained on nfs2 and to run over the new version of ISODE. Old versions of THORN and ISODE were archived. KG brought the Informatics Department data in both QUIPU and THORN directories up to date, by means of scripts written to process an ascii text version of the departmental Directory Card. (One day it will be the other way around!).

KG installed a transport-level bridge (part of the ISODE distribution) on nfs2. This bridges ISO TPO packets between ethernet and X.25, so allows a QUIPU interface running on any workstation on the network to make "direct" calls to a remote DSA anywhere on JANET. This is not an essential feature for QUIPU functionality, since our local DSA can make the calls instead, but is desirable. THORN theoretically could make far greater use of the bridge: this was explored, but when initial attempts were unsuccessful (with no documentation and little help from support people at UCL), efforts were shelved pending the arrival of the next release of THORN.

A further supplied interface for the QUIPU directory, widget, was built and tested. As an interface, this is horrible, but will be useful as a model for future developments, demonstrating how to use the directory access library directly.

### 5.2.14 X.500 Pilot Project (RAD, NBC, KG)

NBC, KG and RAD have been involved in an X.500 pilot project to provide a site-wide directory service. A joint bid with CCD was submitted to the JNT and has been accepted. Sun equipment is being supplied for the project.

### 5.2.15 Network Management (APM, LJR)

In his role as Network Manager APM has continued to allocate Internet Addresses to new machines and keep the Hosts database up to date. APM has applied for and obtained a Class B network number from the DDN Network Information Center (in the US) to use for the RAL IP network and is currently engaged in working out a new addressing scheme.

An HP Ethernet Monitor was loaned to Oxford University for half a week during January. APM took the monitor up and set it up and retrieved it when they had finished with it.

During February APM was involved in some detective work trying to figure out who was involved in logging onto the Stellar as root. Although the problem was not completely resolved, the major cause for concern (apparent logins early in the morning) was traced to a faulty time-stamp operation in the log mechanism. LJR actively assisted with this.

### 5.2.16 Office Wiring (APM)

APM was asked to help with the planning of computer communications wiring in the first floor offices acquired from HEP. His suggestions included rewiring the Thin Ethernet already on that floor, three RS232 connections for all offices on one side and some on the other side and two connections for the remaining offices as well as one Profs coax for each office. He also asked for extra mains sockets in the plastic trunking as experience has shown that the number put in earlier offices was never enough. He was also involved in setting up comms for people as they were forced into offices before the comms wiring was finished.

### 5.2.17 X.25 (NJW)

In January, NJW installed and tested X.25 and the yellow book on nfs1. This was needed for spooling to the Linotron.

Sunlink X.25 was a major part of NJW's work during April-June.

X.25 version 5.2 was eventually received from Sun. NJW installed this on kiwi, a 3/50 with an X.25 line and tested it successfully. She then installed the current release of the Coloured Book software

and tested it with X.25 5.2. When it proved to be running correctly, she installed X.25 version 5.2 on nfs2, the mailserver. This version of X.25 was required for future trials of MHS(X.400).

NJW received an advanced copy of X.25 version 6.0 (the version required for use with SunOS 4.0). She installed this on redwood, a disced sun, and, after moving the X.25 line from G5I to G50, she tested it. Then she recompiled the current version of the Coloured Book software (1.1) for SunOS 4.0 in order to test it with version 6.0 of X.25. It was found that, while all the Coloured Book source files could be recompiled, the yellow book listening daemon (for incoming call requests), which was supplied as a binary, would not run on SunOS 4.0. NJW is now waiting for the new version of Coloured Books (version 2.0).

### 5.2.18 Linotron (KG, NBC)

Some time ago, the Department provided a spooling system for the Reprographics Linotron phototypesetter. Unfortunately, both authors left and, with little demand for the service, the facility fell into disuse. Recently, it was found that the system had never provided a reliable service.

NBC and KG have been involved with trying to sort out recurrent problems. Their efforts have been hampered by there occasionally being genuine hardware faults which are not always easy to distinguish from software problems with the RAL spooling system.

Tests by Telecomms. On the line were inconclusive, and NBC is studying the documentation with a view to rebuilding the system on another Sun.

It has been discovered that Kodak sell a turnkey system, including a SUN, to handle Linotron spooling. A preliminary meeting showed that it does indeed meet most of the requirements. We are waiting to see whether Kodak are prepared to make the necessary mods to allow the identification of networked jobs (and also whether RAL has any money to buy it anyway).

### 5.2.19 Modems (RAD)

Without having to do anything much, RAD was able to offer members of the Department a major technological breakthrough. For many years people who have tried to use dial-up terminals from home have been frustrated by the appalling quality of BT's lines, and the uselessness of the modems supplied by CCD Telecomms in coping with line noise. Telecomms finally admitted defeat with these modems and started a trial of decent error-correcting modems. RAD organised the acquisition of some of these for certain key members of the Department; they were a revelation, and make computing from home a positive pleasure. The success of these has stimulated a lot of interest, and demand is steadily increasing from other members of the Department for modems. All we need now is to be able to run X-windows over a modem link and we needn't bother to come into work at all any more!

### 5.2.20 Workstation Evaluation

MEC, AJL, WJH and SKC have formed the backbone of the section throughout the period. PDA and DSB were original members, who have since been transferred to other work. RAD, NBC and RET have played an active role and the first assessment also involved NJW, APM, Julian Gallop, Peter Kent and Dale Sutcliffe.

The first evaluation was to identify possible successors for the SUN3 as a middle of the range workhorse. This eliminated the Intel 80386 machines at the lower end of the market and the specialist graphics engines at the other end. The plan of campaign was to produce a shortlist of suppliers, to ask for a questionnaire to be completed, and to benchmark the most suitable machine in the supplier's range. The majority of these would use the Motorola 68020 processor.

By using the knowledge of the interested parties in the Department, by scouring the advertising press, and by visiting a Trade exhibition, a shortlist of 9 suppliers was produced. These were asked to complete the very comprehensive questionnaire, based on questions asked when the SUN3 was selected.

The benchmark tests were designed to assess three areas: the compilers and application packages, X-windows, and NFS. NBC provided technical assistance with running the NFS evaluation test suite on the Stellar machine (since this gave access to a non-SUN implementation), and investigated some of the problems that arose. NJW provided programming support for the IBM benchmark for EASE. DSB assisted in the running of the benchmarks on these machines, and later ran the analysis programs on the data obtained, to produce the figures for the final report. APM provided assistance in installing equipment and attaching machines to the Departmental ethernet. The suppliers were asked either to loan RAL a machine for the Section to benchmark or to run the RAL benchmarking software at their own sites. Only one chose the latter. In several cases, others loaned machines on more than one occasion as they improved software.

With one supplier providing neither questionnaire nor benchmarking machine and another deciding for itself that it was not suitable, the shortlist was reduced to 7. A detailed paper of information and benchmarking results was presented to CFTAG of 5 September, revised and updated for CFTAG of 16 November. These meetings concluded that -

- SUN3 should continue to be the recommended workstation;
- SUN4 and DEC VAXstation should go onto the Approved list;
- Apollo and IBM should go onto the Approved list when, and if, NFS was working satisfactorily (subsequently, IBM was approved, but to date Apollo's NFS continues to have serious drawbacks);
- X-windows was still fairly new technology and could not be considered compulsory yet;
- The exercise should be repeated when the major suppliers had a Motorola 68030, or equivalent, machine on the market (see below) .

### 5.2.21 80386 Evaluation

The 80386 machines had been excluded from the first assessment. The plan was to ask the suppliers to complete a questionnaire (modified in the light of experience), to discuss this and their machine(s) with RAL, and to benchmark a loaned machine at RAL.

With an initial list of about 40 suppliers, it was clear that there were many more in this field than in the "mid-range" of the previous exercise. It being impractical to assess such a large number, only those running some form of Unix provided by the supplier were considered. This procedure reduced the number to 19, of which 8 agreed to take part. Subsequently, 9 of the rejected suppliers requested questionnaires. The revised questionnaire was sent out at the end of January with the request that it be completed and returned by the end of February. Within this period, only 5 questionnaires were returned, and, even more discouragingly, only 1 machine made available for benchmarking. The period was therefore extended to the end of April, allowing another three questionnaires to be returned and another two machines tested.

Although a large number of 80386 suppliers run a version of Unix, it is apparent that most of them target users wishing to use desktop publishing and database software rather than compilers and engineering packages. MS-DOS is still considered to be the prime operating system in most cases. The suppliers, in general, are vendors of hardware and basic software only, and refer the purchaser to software houses for anything else.

With this background, the technique of using a questionnaire proved less effective than before, since the suppliers were able to provide much less information about their machines, particularly in any depth of detail. There was, especially, little information on what packages were available on their hardware. This contrasts with the suppliers of the larger workstations, who provide catalogues.

The overall conclusion is that there is insufficient reason, at present, to add 80386-based machines to the Approved list.

### 5.2.22 68030/RISC Evaluation

CFTAG requested that the SUN3 replacement exercise be repeated, since there had been a considerable change in the marketplace in 12 months. Work started at the beginning of May, expecting the 68020 workstations to be replaced by machines using the 68030 or RISC processor.

All those participants invited in the first exercise were again invited, together with a number of others. Various improvements had been made to the benchmarks, particularly the NFS ones (to overcome caching). It was also considered necessary to change the baseline SUN3/60 machine from 4Mb to 8Mb. IBM and Apollo declined to provide machines on loan, so the ones already at RAL were used (and in some cases old data was re-analysed, as little had changed). 15 Machines were handled this time, and a report was produced for CFTAG's September meeting. The DECstation and SPARCstation performed well, and have been recommended for Approval. The SUN 3/80 had most tests run with software Floating Point, and the error was discovered after the loaned machine had been returned. Steps are being taken to redo the tests. Several other machines showed impressive raw speed, but lack relevant software. In general, the expected workstation power has increased by a factor of 5 since last summer.

### 5.2.23 New Benchmarks (SKC)

SKC has been attempting to improve the applications benchmark set, concentrated in the applications area, notably in the FE field, and, in particular, with the BIM2D, DFT and Nastran packages. In the AI/SE field, the idea of using ML was abandoned after consultation with members of SED. Instead ERIL is being considered. Other additions include tests for the Ada compiler and for GKS. However, suppliers could not provide Ada or GKS for benchmarking during the evaluation, and the other benchmarks are not yet in a form that can be used.

NBC has been making additions and improvements to the NFS evaluation test suite. Some extra functionality tests have been written and all the basic tests have been changed to allow easy parameterisation and to increase the default values, so that the programs are a more rigorous test of the newer, more powerful machines. The read test has been altered so that random reads can be specified in an attempt to defeat the NFS caching mechanisms. Also, two Yellow Pages tests have been written. New scripts for running the tests, and a set of awk scripts for analysing the results have been written.

NBC has also produced some test results for running the new suite of tests between various combinations of Sun clients and servers. Some of these showed peculiar performance drop-offs which need further investigation.

### 5.2.24 Day to Day Operations (RT, AMJ, IV, LJR, ASJ, ACD, PDA)

The team is responsible for the operation of the Departmental Service, including dumping, filestore management, fault finding and liaising with engineers. New machines have been installed. Departmental mailing lists are maintained, and the Mail/News system supported.

Records are kept of the location and configuration of the machines. The Summer Financial crisis demonstrated that more effort is required to keep these records up-to-date. General support includes the JANET Access Machine, which provides the basis of software supply to the community.

### 5.2.25 Computer Room

During the period, it was decided to divide the Computer Room in two, with half going to EBL. This involved much liaison with EBW, and the reorganisation of the machines. Eventually everything came back to normal. The work included the provision of a security lock for the door, and the installation of a fire-proof safe for the dump tapes.

### 5.2.26 SunOS Upgrade

The upgrade from version 3.4 to 4.0 was planned and undertaken. It included setting up trial systems so that users could ensure that their software still worked under the new version. Then all the servers and the individual disced Suns were converted. Several have had to remain at the previous revision, because of particular software problems. One of the difficulties of the whole exercise concerned the lack of a suitable X.25 from Sun. The technical problems involved are discussed earlier under Distributed Systems (see 2.3.1.5).

### 5.2.27 Lab 11 (IV, RET)

The role of Lab 11 was reviewed, and a new layout planned, which included the removal of old kit. New furniture has been purchased, and installed.

### 5.2.28 Day to Day Support Activities (KML, DSB, NJW)

The team support both the users in-house and grant holders in the Universities. Queries are answered, and equipment moved. They are responsible for the transportation and setting up of the EASE Training set of Suns, a frequent occurrence which takes at least a day to perform. Advice on costings is supplied for Grant Applications. Liaison with Sun over orders and maintenance is undertaken. Documentation is also covered here, but this has had to take second place to all the other activities. The Introductory User Guide is in the process of being updated.

### 5.2.29 Machine Disposal (KML)

The changing nature of the Department's work has seen the need to dispose of a lot of kit. This includes VAXes, PERQs, SUN2s and the Orion. Most of the effort involves liaising with stores.

### 5.2.30 Text (RMK)

Since Jan Malone left in August 88, work on text processing has effectively been suspended until a replacement is found. However, RMK has kept track of reported problems, and has helped users whenever possible. She also incorporated user comments into Jan's WYSIWYG criteria list. Recently, RMK checked the code left by Jan Malone for positioning troff output on "new"-style LaserWriters, to try to solve the page position problem.

### 5.2.31 GKS (RMK, PLP)

In August 88, RMK released RAL GKS 1.20 on the Primes. this included some new facilities to ease the conversion of existing programs from GINO-F to RAL GKS. This will be the last GKS release on the Primes. The corresponding release of the RAL GKS 1.20 Master source was done by RMK in September.

PLP has completed a GKS driver that generates PostScript output. The original driver was written by a Starlink VAX/VMS user. This was converted by Martin Prime to run on Unix. PLP first adapted this driver to run on the Prime and then went on to enhance the UNIX driver. New features like support for Landscape/Portrait page orientations, Encapsulated PostScript File Format and device-independent handling of hardware text were added. Existing code was in many cases expanded and sometimes completely rewritten in order to make fullest possible use of the graphic capabilities of the PostScript language. As a result, the driver now generates structured, efficient and compact PostScript code that can be either sent to a hardcopy device such as LaserWriter or (if it is in EPSF format) imported into another document.

RMK managed a collaboration between Trudy Watson and Tony Arnold (University of Manchester Computer Graphics Unit). The aim of this is to produce a RAL GKS driver for X on the SUN. A side-effect of this collaboration is that Tony Arnold has done much of the work of getting a working RAL GKS system under SunOS4.0. The driver works reasonably well on monochrome Suns, but is slow on colour workstations (because X is slow on colour machines). It will be included in a future release of RAL GKS.

RMK started planning the work needed for RAL GKS to be validated by the GKS Testing Service run by NCC. A number of enhancements and bug fixes are needed before the implementation will pass the tests.

PLP has put the RAL GKS Master Source under sccs (Unix's Source Code Control System). This was done in two stages. First, only a part of the Master Source was put under sccs. Experience of using sccs on such a large system was gained and remedies for sccs drawbacks were found before full implementation went ahead. Scripts for using sccs were written and a trial generation of RAL GKS release 1.15 for OS4.0 performed. Following this, PLP installed the updates for release 1.20 of the Master Source, and started work on 1.30 (adding in the PostScript and X drivers).

RMK has been working with CCD on updating the RAL GKS Guide. This has involved fairly major changes to the text of the manual, plus a lot of consistency checking.

### 5.2.32 NAG Graphics (RMK)

RMK has produced NAG Graphics libraries for use on the SUN and the Pyramid. She has also written the necessary RAL-dependent user documentation to accompany the NAG Graphics Manual. Some changes had to be made to the GKS interface which was supplied by NAG: the interface used the Draft Standard of GKS, whereas RAL GKS is now an implementation of the International Standard; and some tailoring of defaults was needed so as to fit in well with RAL GKS. Details of these changes and suggestions for improvements have been passed back to NAG.

### 5.2.33 Primes (PDA)

PDA is the Manager for the two Primes in the Department and also Resource Manager for the other four at RAL. The master machine, RL.PA, is scheduled to be closed by March 1990 and all the others must close before or at the same time since the software is controlled by RL.PA. The operating system has been frozen at Rev20.2 for some time and so, too, has the system software wherever possible. User support and system support, if necessary, are performed under contract by UMIST.

A regular meeting has been set up to highlight problem areas and report on the progress of closure procedures. PDA is heavily involved in the planning of the timesca1es to ensure that reasonable allowance is made for the tasks to be efficiently carried out. Tape decks have given cause for concern. After much pressure from PDA to Prime Area/District Managers on the subject, and many hours of our site engineer plus the field engineer working on the decks, both decks are now working efficiently.

The biggest problem of the closure seems to be the need to retrieve a lot of archive data in order to transfer it to other systems. There is no means of extracting this data other than perform a Retrieve, which is very labour intensive (files will be distributed over a number of tapes). Since there is a limited amount of disc space for the retrieved files to occupy, the potential problem is obvious. Discussions have been held with individuals to try to keep this activity down to a minimum.

### 5.2.34 Trainee Programmers (PLP, RET)

PLP supervised a group of Trainee Programmers on their three-week C-project. This was a C fuzzy clock" program (presenting the time in the form almost noon). Preparing for this, PLP completed the project himself and also put together a brief introduction to Sun workstations. He also helped in setting-up the EASE training machines, which were at Trainees disposal (mercy?) for the entire project. PLP and RET conducted the acceptance tests of the Trainee code, which showed a number of problems. The exercise went very well, and enabled the trainees to gain experience with workstations (previously this training was carried out using UTS on the IBM).

### 5.2.35 Demonstrations (RMK, PLP, IV)

During September and October 88, RMK and PLP worked on software for two demonstrations: a graphics demo to members of CFC and a text processing demo for the BCS Displays Group Meeting on Interactive Documents. RMK gave these demonstrations. IV was involved in the setting up of the SUN network and due to people being out at the last moment, was roped in to deal with the final panic stage of the installation.

**Ruth Kidd demonstrating at the BCS Displays Group Meeting, Professor Heather Brown facing the camera**

**Large View**

### 5.2.36 Alvey Infrastructure (RET)

Alvey funding for Infrastructure ended officially on March 31 1989, but the final clearup continued into the next financial year. The main effort has therefore been in bringing the contracts to a close. The GEC machines were closed in April 1988, and most found their way to Daresbury. A final Site Managers meeting was held in October. Agreement was reached with Contracts on the rules for disposal of equipment, and the VAXes have been offered to sites. So far, only EdAI have refused the offer!

RET and Peter Hemmings have been involved in the reconciliation of the contracts. Thanks to Peter's efforts, all the bills for the first 9 months of the year were received on time. The final quarter cannot be paid until after April 1 1989, and there are still three bills outstanding.

The Project Meeting has been formally terminated.

### 5.2.37 IDUS Management (RET, RAD, RT, RMK)

The Departmental Unix Service is managed by a small committee. This receives reports from the Service Meeting and from the various technical projects associated with the service. This year has

seen the phasing out of the SUN2s, considerations of security and the refurbishment of Lab 11 and the Computer Room. Attempts were made to identify the money and effort used by the service, but the Laboratory finance system was not up to the need to redistribute this back to funded projects. A more labour intensive scheme had therefore had to be adopted. It is reported that MSA will solve this, and many other problems.

The major concerns of users have been the continued unreliability of pyr-a and the state of the laser printers. The major upgrade to SunOS was successfully completed. Improvements to the file servers continue, and a loan pool of shoebox discs made available for solving short-term problems.

### 5.2.38 Security (RET, LJR, PDA)

Following the scare caused by the USA Unix virus, Division Heads decided that the Department should take a much more serious view of Security. RET was appointed Security Officer, and is charged with preparing and implementing a Policy. LJR helped initially, and PDA took over when LJR transferred.

RET prepared a paper for Division Heads, looking at the implications of the strategy set out in Ken Hartley's original paper. Part of the requirement centred on the production of a Code of Practice for the Department, which every member would be expected to abide by. LJR prepared the first few drafts of this, and the job is being completed by PDA. Meanwhile, Division Heads asked RET to carry out a proper Risk Analysis. This led to a considerable amount of work, including literature searches. The resulting paper attempted to quantify the threats and countermeasures for a whole range of activities, from fire to hacking. This led to a complete policy document which will affect all the Department. To date, this document is still being discussed.

Initial steps are being taken to improve the security of the Department. LJR has checked the root to root access on machines. Unknown users that have been added to local passwd files have also been checked. Sysdiag was passworded on each machine and then later removed on most machines. No entries are to be without passwords. The combination lock on the Machine Room is now operational. A fire-proof safe has been purchased to hold dump tapes. Offices will normally be kept locked outside prime shift. Lists of who knows what passwords will be maintained.

PDA has been on the first of the Civil Service courses on Security. The next course will cover the CRAMM Risk Analysis software, which has been ordered but has not yet arrived.

### 5.2.39 Grant Modelling (PDA)

A project on Prime A, concerning a forecasting model for SERC grants has been extended. PDA works with Jim Hailstone, who is currently consulting for Swindon. She has been heavily involved in planning and preparing programs for use when the data is available. A lot of , learning' has taken place, in preparation for moving the prototype from Prime A to another machine. PDA also prepared to receive grant data for the Modelling project. Shortly, Swindon should be able to contribute data on a regular basis, and the model should begin to give relevant results.

### 5.2.40 UMIST Contract (RET, RT, KML)

With the closing down of the Prime service, UMIST's support contract has been changed to provide support for ECFE-related activities. GAL chairs the management meeting, with RET in attendance. As part of this work, UMIST have been preparing a number of documents on Introduction to SUN, Systems Administration, and Primos to SUNOS conversion. RT and KML have assisted in reviewing these.

### 5.2.41 Esprit Project (RAD)

RAD is involved with the ARGOSI Esprit project. The Commission decided to accept the proposal, but contingent upon a budget cut of about 60%. This was fairly standard for all proposals, and was caused by a gross underestimate on the part of the Commission as to how many projects would require funding from a fixed-size pot of money.

However, the Commission also required ARGOSI to absorb a project in a vaguely similar area, and restructure to accommodate the partners of the other project. RAD and DAD spent an entertaining, if somewhat gruelling, few days in Brussels and in Paris persuading the other partners that proposals for doing this worked out by RAD/DAD/JRG on the back of several envelopes would do the trick. The revised proposals seemed to satisfy the Commission.

A number of promises of a contract were made by the European Commission, but during January and February nothing materialised. Then, at the beginning of March, we were summoned to Brussels to re-re-re-discuss the proposal. Having negotiated this hurdle, we got a provisional go-ahead and were able to hold a project kick-off meeting at Cosener's House. As by that stage we hadn't got a written contract, nobody was too keen to really get started; since then the Contract has come through.

This led naturally to the next problem - finding someone to do the work. We went out to recruitment for an RA (in a joint effort with Ken Robinson who needs a small army to work on his projects). Although Ken was quite successful (at least in the sense of finding people he'd like to offer a job to), for ARGOSI we had no luck. RAD was on the Board for the interviewing, and it appeared that the problem is that the RA advertisement was (as always) geared to junior, relatively inexperienced people. What ARGOSI needs is people who have some experience plus an interest in ISO Standards (which in itself requires the sort of philosophical outlook that comes with experience!). We are now attempting to raise our sights a bit, which of course involves the usual battle with Personnel.

Technical work finally started on this project on April 1. Two strands of activity are underway at present. The first is to start classifying existing graphical applications in terms of their graphics and networking requirements. This involves going out and visiting providers and users of software, and asking them detailed questions. (This is a similar idea to the proposed HEI visits, except that ARGOSI got there first!). To date RAD has been involved in these visits along with David Duce, Julian Gallop and Bob Maybury.

The project held a one-day progress meeting in Milan in May to discuss progress so far. This was very useful, with some genuine work being done. Since then the RAL team managed to make 3 visits (organising them is not easy, a lesson to be taken on board for the HEI visits.) The most interesting was one to the Met Office in Bracknell, where they actually use GKS for some applications.

The second task is to set up basic X.25 connectivity between partner sites, with a view to its use for a demonstrator of ISO graphics + networking across Europe. RAD is task leader for this. Although PDNs will probably be used for the connectivity, there is interest in using the facilities promised by the COSINE project. RAD attended the first COSINE Users' Group meeting in Brussels to get an introduction to this.

The inability to recruit RA staff to the project makes progress very difficult, with RAD, JRG, RM and DAD having to reschedule some of their other work to devote time to ARGOSI.

### 5.2.42 Glasgow EDRC Procurement (RAD)

RAD (with J R Gallop) spent a considerable amount of time advising Central Office on the computer procurement aspects of the proposed IRC at Glasgow. Christened the Engineering Design Research Centre (EDRC) , this facility was proposing a $500,000 purchase of workstations, servers and fast networking to hold it all together. Apart from the relatively straightforward technical issues, the whole saga proved to be somewhat political in nature. The role of RAD and JRG was to satisfy themselves (and hence Central Office) that the equipment proposed was suitable for the job (although it was not clear at the time exactly what the job would be), and that the procurement process was "fair". All this proved to be a complex story; suffice it to say that after a number of visits, reports etc a mutually acceptable outcome seems to have been achieved.

### 5.2.43 Meetings

The Group is involved in a considerable number of meetings, both departmental, laboratory-wide and external. The following indicates who goes to which.

- Unix Service Meeting - RT (Chairman), LJR (Secretary), DSB (Secretary).
- RAL LAN Management Meeting - APM, RAD.
- Alvey Infrastructure Project Meeting - RET (Chairman), PJH (Secretary), KFH, NBC.
- Unix Liaison Meeting - KFH, RET, RAD, RT et al.
- Engineering Computing Facilities Executive - KFH, RET, GAL, RMK (Secretary), PDA (Secretary).
- SUN Progress Meeting - RET, RT, KML (Secretary).
- Inter University Software Committee - KFH.
- IUSC Working Party on Workstations - RET.
- Inter University Network Committee - RAD.
- RAL Office Systems Panel (ROFSP) - RET.
- RAL Training Advisory Panel - RET.
- Finance Sub-Committee (FSC) - RET.
- IDUS Management Meeting - KFH (Chairman), NBC (Secretary), RET, RT, RMK, RAD (earlier).
- NAG User Group - NJW.
- CCD/ID Graphics Meeting - RMK.
- RAL GKS Technical Meeting (with CCD) - RMK, PLP.
- EASE/SUS/Assessment Meeting - MEC (Secretary).
- IDUUF - WJH (Secretary), APM (Secretary).
- RAL/Swindon/SUN Maintenance Meeting - KML.
- Advisory Group on Computer Graphics (AGOCG) - RMK (Secretary), FRAH (Chairman)
- Government Unix User Group - RET.
- GUUG Comms SIG - RET.
- Informatics Division Heads Meeting - KFH, CB (Secretary)
- DCS Group Leaders Meeting - KFH (Chairman), HVJ (Secretary), RET, GAL, RAD, FMR.

### 5.2.44 Conferences Attended

**1988:**

- GINO-F User Group, Birmingham University, September, RMK, PLP
- Pyramid User Group, September, IJJ
- CFTAG Workshop on Graphics Standards, Manchester, October, RMK
- Seminar on Benchmarking, Apollo, October, AJL
- Silicon Graphics Seminar, Abingdon, November, WJH
- FEGS User Meeting, Cambridge, November, MEC, SKC
- Trinitec Unix System Seminar, London, December, SKC
- Open Network Computing Seminar, SUN Microsystems, December, RAD
- JNT LAN Advisory Group Meeting, December, APM, IJJ
- ISODE Seminar, RAL, NJW
- EUUG Autumn Conference, London, NBC
- UKUUG Conference, Kent, NBC
- Unix Networkshop, RAD, NBC, IJJ

**1989:**

- ECUG Meeting, RAL, January, RMK, MEC, AJL
  RAL
- EASE User Group RAL (Presentations by RET and RAD), RAL, January, RET, RAD (et al)
- SUN UK User Group Meeting, Cambridge, January, NBC
- 2nd UK Academic Community Directory Group Meeting, January, KC
- Winter 1989 USENIX Technical Conference, San Diego, January/February, IJJ
- Network Services Seminar (Presentation by RAD), RAL, February, RET, RAD, NBC, NJW (et al)
- Pyramid User Group Meeting, IJJ, IV

- Ada Exhibition, London, February, MEC
- Which Computer Exhibition, Birmingham, February, MEC
- UKUUG Security Workshop, February, RT, IJJ
- Government UNIX Group, March, PDA
- Grant Forecasting Model Demonstration, Swindon, March, PDA
- Acorn Workstation Demo, March, MEC
- CAD/CAM Exhibition, Birmingham, March, SKC
- X11 Workshop, RAL, March, MEC, SKC, AJL, WJH
- OSF Members Meeting, Monte Carlo, March, NBC
- UNIX User Show, London, RET, NBC
- SUN UK User Group RAL (Presentations by RT, RET and RAD), RAL, RT, NBC, RET, RAD
- UK Academic Community Directory Group Meeting, London, KG
- IGOSIS London, April, KG
- Landmarks in Electronic Publishing Meeting, April, PLP
- European Unix User Group, Brussels, April, WJH
- Modern Practice in Stress and Vibration Analysis, April, WJH
- SUN Scientific Workstations Presentation, Harwell, April, MEC
- SUN SPARC Presentation, Harwell, April, MEC
- SUN SPARC Presentation, Reading, April, RET
- X Terminals Presentation, IXI, April, RET
- Paralysis by Analysis, RAL, May, PLP
- Government Unix Group Security Working Party Meeting, London, May, PDA
- Grant Modelling Project, RAL, May, PDA
- Coloured Book Software Seminar, June, NJW/KG
- CUE Seminar, June, RET
- DEC New Products Presentation, June, RET, MEC, WJH, AJL
- UKUUG Summer Technical Meeting, Strathclyde, June, KG
- Stellar Demonstration, July, MEC
- Networkshop 17, Warwick University, RAD, IJJ, APM

### 5.2.45 Training Courses

- GKS-3D, RAL, RMK
- SERC Induction Course, RGO, PLP, WJH
- C Programming Language, PLP, RMK, SKC, DSB
- Message Handling Systems, NBC
- ASN.1, NBC, IJJ, KG
- OSI Reference Models, NJW
- ISO Upper Layers, IJJ
- OSI Conformance Testing, RAD
- Practical Networking: X.25, Exeter, NJW
- Pyramid Tuning, IV
- Unix Fundamentals, ACD, PDA
- Pyramid Operating System, ACD
- Systems Administration, LJR
- Management Seminar, PLP
- X Seminar, PLP, RMK
- SERC Appraisal Interview, RT
- End Users Course, DSB
- Occasional Speakers, NBC
- Advanced Unix Tools, KG, APM
- 3-Com Users Update Forum, APM
- Advanced C, IJJ
- MHS/X.400, NJW, KG
- C Programming Workshop, NJW, WJH
- Directory (X.500), KG

- Speaking Technically, PLP
- Fundamentals of Computer Security, CSSC, PDA
- USENIX Tutorials on Kereberos Authentication System and Apollo's NCS, San Diego, IJJ

### 5.2.46 Papers

#### 5.2.46.1 Internal

- Evaluation of NFS on the Stellar GS1000 (with RAD): NBC
- The Usenet News System at RAL (CTN/P34/88): NBC
- The use of the EtherPADs: APM
- The Hosts Database (re-write of CTN/P22): APM
- Report on USENIX Summer Conference, San Francisco, June 20-25 1988 (CTN/P3l): IJJ
- Report on Pyramid UK User Group Meeting, (CTN/P32) May 5 1988: IJJ
- Report on 8th International DCS conference, San Jose, June 13-17 1988 (CTN/P33): IJJ
- Report on Pyramid UK User Group meeting, September 21 1988 (TR/P1): IJJ
- The Sun UK User Group Conference (DCSD/TR6/89): NBC, RET
- Report on the UNIX Networkshop Meeting (DCSD/TR5/89):NBC, RAD, IJJ
- Report on the Software Developers' Conference on UNIX System V Release 4.0 (DCSD/TR7/89): NBC
- Summary paper on UNIX System V Release 4.0 (for inclusion in the ECN): NBC
- Adobe Transcript 2.1 (CTN/P35): NJW
- Report on the Advanced Unix Tools Course (DCSD/TR7/89): KG
- The Idus Mail System - re-issue 1 (IDUS17): NJW
- Report on the EUUG Autumn 1988 Conference (DCSD/TR9/89): NBC
- Report on the UKUUG Conference (DCSD/TR11/89): NBC
- Report on the European UNIX User Show (DCSD/TR14/89): NBC, RET
- Report on the OSF Meeting, Monte Carlo (DCSD/TR13/89): NBC, KFH, K Farvis
- The Winter '89 USENIX Technical Conference (TR/P15): IJJ
- How to operate the KiloStream line from RAL to Sheffield (CTN/P39): IJJ
- Strathclyde UKUUG meeting (DCSD/TR17/89): KG

#### 5.2.46.2 RAL Reports

EASE Workstation Assessment RAL-89-017: RET + 9

### 5.2.47 Objectives for 1989/90

As the Division has a new structure these objectives are collected together for the two new Groups which had been TSG during the report period.

#### 5.2.47.1 Objectives for Technical Services Group

- Complete assessments of central servers (with SSG), X-terminals, data archive systems, super graphics workstations (with CMD) and compute servers.
- Live use of Ada and GKS benchmarks.
- Improved robustness of IDUS, as measured by decreased user complaints.
- Passage through the period of reduced Sun maintenance avoiding total chaos and a successful resumption of normal service when circumstances permit.
- Validation of RAL GKS with at most one health warning.
- A programme of work being carried out for AGOCG.
- Informatics Primes closed down and users successfully relocated (with MSG).
- Departmental Security Policy agreed and implemented without alienating users.

#### 5.2.47.2 Objectives for Systems Support Group

- Yellow Pages source obtained from Pyramid.
- 3270 emulation running on Suns (when funds allow) and removal of all 3270 terminals.
- A working dumping service to the IBM 3090 (with TSG).
- New IP addresses operational.
- Transcript distribution problems resolved (with TSG).

- Replacement of Informatics Directory yellow card by an on-line ISO Directory Service with a usable user interface.
- Successful completion of the X.500 Pilot project.
- Version 2.0 of Sun Coloured Books software operational.
- A reliable service between Informatics and the Linotron (and back) established.
- Performance drop-offs in NFS benchmarks understood.
- An RA (or equivalent) appointed and working on ARGOSI.

### 5.3 MANAGEMENT SERVICES GROUP

#### 5.3.1 Staff

- Geoff A Lambert(GAL) Group Leader
- Peter J Hemmings (PJH)
- Janet R Smith (JRS)
- Susan Chilton (SCH) (arrived 3 July 1989)
- Sheila G Davidson (SGD) (arrived 1 April 1989)
- John W T Smith (JWTS) (arrived 1 April 1989)
- Carol Barnes (CB)

Fran M Childs (FMC) departed 31 March 1989

#### 5.3.2 Objectives for 1988/9

The objectives of this Group are to provide those services for Informatics Department which it is sensible to centralise. Some are provided on behalf of the whole Department, eg EASE services, Departmental Administration Officer, others for specific projects, ESPRIT project support.

#### 5.3.3 Alvey Infrastructure (PJH)

The project formally ended in March 1989. The last six months of this project were fairly quiet. The Site Managers attended a final meeting as Cosener's House on 20 October 1988. There were no technical issues outstanding and it only remained to dispose of the equipment, with the sites being allowed the option of retention either as gifts or loans according to the age and value of the equipment.

All of the sites except Newcastle were visited and satisfactory reconcilliations were provisionally agreed pending the submission of final bills. All but two sites (Oxford and Imperial) have submitted final bills.

#### 5.3.4 Alvey Mail (PJH)

The Alvey Mail service closed on 31 December 1988 with much lamentation from a number of users. Central Computing Division kept the machine running on an informal basis for several weeks after the formal closure, forwarding incoming mail and sending notes about the closure back to the senders of such mail. PJH spent a lot of time chasing the DTI to give the machine to SERC and a letter was eventually received from them in August.

#### 5.3.5 Informatics Finance Project (PJH)

PJH has maintained the programs used by the DAO to produce the departmental finance paper. A certain amount of maintenance work is required, mainly when the financial year changes.

There had been a problem drawing the boxes around tables, which had persisted from the early days of the project. This was believed to be due to an obscure bug in the Unix utility tbl used in conjunction with troff. The output routines were changed to use a series of user defined Postscript macros. Some other improvements to the layout were made at the same time.

Generally this project requires hardly any changes to be made as a result of changes in the operating system CMS. However, when CMS 5.5 was introduced at the end of April it contained a

bug, believed still present, which prevented the monthly updates from completing correctly. It was therefore necessary to circumvent this problem.

### 5.3.6 SERC Computing Summer Schools (PJH)

PJH acted as one of the course tutors at a Summer School held at the end of September 1988 in Cosener's House, being responsible for one of six tutor groups. PJH repeated this role at another Summer School in July 1989.

### 5.3.7 Mailing List Project (PJH, JRS)

PJH has been developing a project to meet a wide range of Departmental requirements using mailing list data. The aim of this project is to maintain information about Departmental contacts. Subject interests, committee memberships and newsletter distribution requirements are recorded. The Department already has two large mailing lists which have been used to establish the initial data. Facilities provided by this project already include the ability to display lists of users and view details of any selected user, then define subsets within the list. It is possible to produce individually addressed copies of a standard letter to members of the subset and to produce typed address labels.

### 5.3.8 File Server Project (PJH)

PJH was asked to investigate the usage of the SUN Fileservers installed by the ECFE at six universities (Lancaster, Leicester, Oxford, Swansea, UMIST and Warwick). Each site was visited; it was found that some sites already had extensive experience of UNIX and using SUNs and that there had been no major problems. Some sites, however, did not have such expertise locally and these visits helped to clarify the amount of support needed from SERC when such installations take place.

Essex, Leeds and Strathclyde are due to receive servers in a subsequent round and PJH and GAL have carried out preliminary visits to discuss aspects of the installation.

### 5.3.9 Informatics use of Central Computing (PJH)

PJH has become the Informatics representative for the use of these facilities. Work has begun on tidying up the user accounts to correspond with current projects.

### 5.3.10 Publicity Services (SGD, FMC, SCH)

Sheila Davidson (SGD) assumed responsibility for the production of the Engineering Computing Newsletter, taking over from Fran Childs (FMC), upon her arrival at the beginning of April. The decision was taken to give priority to increasing the frequency of production from quarterly to monthly and to achieve a significant increase in the circulation.

To reach these objectives, a stable version of Framemaker had to be obtained, mounted and SGD trained in it's use. Production schedules had to be agreed with Reprographics, material had to be obtained from the community and a distribution network set up with the HEI community to supplement the standard mail list. Overall, these objectives have been met, the circulation nearly double what it was twelve months ago, and with the Newsletter attracting favourable comment from many diverse sources. These are viewed as initial objectives and it is intended to improve both the presentation and content of the Newsletter in the future.

Susan Hilton (SCH) joined the Group at the beginning of July and has assumed responsibility for the production of other publicity material about EASE. Initially the majority of her time has been taken up trying to understand the background to the formulation of the policy, prior to producing a glossy for general circulation. She is also attempting to ensure that the various Secretariats making up the Central Office at Swindon are kept fully aware of the various aspects of the EASE Programme and that such material as we have is readily available to the user community.

SCH has commenced revising the EASE definition document and the associated schedules. Work has also started on updating the Departmental handouts.

### 5.3.11 Education and Awareness (JWTS)

Education and Awareness has been defined as one of the high priority areas of the EASE Programme. Unfortunately staffing this activity has proved to be a major problem. Professor H Rosenbrock was appointed as Education Co-ordinator at the beginning of the year but resigned at the end of June 1989 on a matter of principle and interpretation of policy, a serious loss, especially as a replacement has not been identified.

John Smith (JWTS) joined the Section at the beginning of April and, with the assistance of David Lomas at UMIST, provides the main effort.

The following events have been organised during the year by GAL, with assistance from JWTS, SGD, HVJ and David Lomas (UMIST):

| | | | | |
|---|---|---|---|---|
| Workshop | Graphics Standards | 18-19 October, 1988 | Manchester University | 55 |
| Course | PostScript | 2 November 1988 | RAL | 16 |
| Seminar | AIAI Tools | 13 December 1988 | RAL | 60 |
| Seminar | Network Services | 23 February 1989 | RAL | 58 |
| Seminar | X-Windows | 22 March 1989 | RAL | 100 |
| Display | Computer Graphics Metafile | 29 March 1989 | Manchester University | 30 |
| Workshop | Data Exchange | 11-12 April 1989 | Leeds University | 60 |
| Seminar | Kent Tools | 1 June 1989 | RAL | 50 |
| Course | Server-System Administration | 17 August 1989 | RAL | 6 |

The other major activity of the Education and Awareness team has been to initiate a programme of visits to the Engineering Departments of all HEIs in the UK. One objective of this activity is to attempt to identify the base level from which to measure the impact and effectiveness of the EASE policy. A number of pilot visits have been undertaken, to Strathclyde, Warwick, Bristol Polytechnic, UMIST, and from these a questionnaire has been developed. This will be used as the basis of the information gathering process.

### 5.3.12 Departmental Administration Officer (CB)

Carol Barnes has continued to provide a day-to-day administrative service for all staff in the Department. In addition, she has been involved in major office accommodation re-planning, refurbishment and fitting of new offices, and the organisation of many office moves.

Another important task has been to provide Division Heads with regular expenditure and effort usage summaries to enable close monitoring and matching to allocations. This has been particularly important over the last year with the closing down of the Alvey Programme and the monitoring of expenditure at the end of the financial year and in the current financial climate.

The past year has seen a growth in the responsibilities of the DAO and it is now essential that a part-time AO be recruited to provide assistance.

CB is also Secretary of the Informatics Division Heads Meeting, and of the SERC Suggestions Scheme Local Awards Committee.

### 5.3.13 CFTAG and ECFE (GAL)

GAL has acted as Secretary to the Computing Facilities Technical Advisory Group (CFTAG), and as a consequence has been a member of the Engineering Computing Facilities Executive (ECFE) along with KFH and RET. This has resulted in a significant number of follow-up actions after the meetings.

### 5.3.14 ESPRIT 962-EVEREST (GAL)

GAL continued to provide management support to the project. This has involved the organisation of two full reviews, in December 1988 and June 1989, plus all the routine administration, report production, and contract renewal. In addition, preparations have commenced for the Esprit conference and exhibition at Brussels in November and for a follow-on project funded by EVEREST II.

### 5.3.15 SERC Professional Development Scheme (PDS) (GAL, KFH)

DCSD is to be involved in the pilot project and GAL was invited to act as Secretary to the organising committee. KFH is the co-ordinator of the Informatics participants, with the Department Head as co-ordinator-in-chief of the SERC Pilot Scheme.

### 5.3.16 Conferences

World Computer Congress, San Francisco, August/September '89, GAL

### 5.3.17 Courses

- Power Communication Skills, Oxford, GAL
- PostScript, RAL, PJH
- SERC Summer School, Cosener's House, PJH
- All EASE Workshops and Seminars, RAL and External, GAL
- Data Exchange, Leeds University, April, JWTS
- Kent Tools, RAL, June, JWTS
- Server System Administration, RAL, August, PJH

### 5.3.18 Papers - External

- ESPRIT-962 Consolidated Interim Report, No.5 (GAL)
- ESPRIT-962 Consolidated Interim Report, No.6 (GAL)
- ESPRIT-962 Technical Annex, Version No.5 (GAL)

### 5.3.19 Objectives for 1989/90

- Increase circulation and improve technical and visual impact of the Newsletter.
- Complete initial HEI visits by Christmas.
- Report on HEI visits by March 1990.
- Organise Education Programme with at least 50% of events remote from RAL.
- Produce EASE glossy and Departmental handouts to new format.
- Update EASE Definition and Schedules.

## 5.4 IED UNIT

### 5.4.1 Staff

At the start of the report period the Alvey Unit contained the following staff:

- M B Dunn (MBD)
- F M Russell (FMR)
- J Cheney (JC)
- T P Mawby (TPM)
- S G Davidson (SGD)
- J W T Smith (JWTS)
- K G Dancey (KGD)

When it was created one of the objectives of the Alvey Unit was to disappear by March 1989. This it duly did. Martin Dunn transferred to Central Computing Department to work on Administrative computing. Jill Cheney also moved to Central Computing Department. Terry Mawby transferred to the Transputer Co-ordination Unit. Keith Dancey transferred into Design Division to work on the Ecstasy project. At the end of March, Sheila Davidson and John Smith joined Management Services Group of DCSD.

The sole survivor, Mike Russell, became the founder member of the IED Unit. In August he was joined by Tony Lubbock (AJKL), who continued to work for Adrian Wheldon, himself now nominally at Swindon. Both work for the Systems Engineering Director in DTI's Information Engineering Directorate.

Thus at the end of the report period the IED Unit consists of:

- F M Russell (FMR)
- A J K Lubbock (AJKL)

### 5.4.2 Objectives 1988/89

The objectives of the Alvey Unit were clear, if impossible. They were to maintain all the invaluable services which Informatics Department provided to the Alvey IKBS, Software Engineering and HCI Directors, and their successors in IED. In the meantime the budget was cut in half and the staff had to be reduced to zero by 31 March 1989. The hope was that by then SERC and DTI would have agreed how these or similar activities should be continued for what became IEATP. In the event the decision was taken that none of these activities should continue.

On the other hand, it was agreed that Mike Russell should put his experience to use in organising the monitoring of the Systems Engineering projects in IEATP. The objective of the IED Unit is therefore to provide a home for Informatics Department staff who spend much of their time at DTI's Kingsgate House, and whose duties do not fit naturally into the structure of Informatics Department.

### 5.4.3 Alvey

It is easy to imagine the problems of trying to maintain services for as long as possible whilst the expertise and experience necessary was evaporating at an increasing rate. It is greatly to the credit of all the staff involved that they turned their hands to many new tasks knowing that they would probably only be doing them for a short time.

During this period all three mailshots continued to appear at regular intervals. Monitoring officer reports were chased and consultants paid. The IKBS Bulletin Board was maintained. Deliverables were chased and published regularly. Workshops were organised, the bills paid and reports obtained.

Increasingly effort was put into persuading IED to take over some of these activities or even show much interest in the Alvey Programme. In fact, all attention was focused on defining what the new Programme should be like in spite of the fact that a significant proportion of the Alvey projects were still running. This seems like a very sad end to what had started off with such high hopes and had, in fact, made substantial progress towards vital strategic objectives.

The withdrawal of staff to continue the monitoring of the Alvey programme contributed to the termination of publication of the abstracts of Alvey project deliverables. These abstracts constituted the prime method for dissemination of information about the results and products of the programme into the public domain. Hence, one of the prime objectives of the Alvey programme - the dissemination of the research results - was prevented by default.

The abstracts also enabled quantitative assessment of the performance of the projects to be made for programme evaluation purposes. The requests for further information about the research results prompted by these abstracts provided additional data for evaluation purposes.

### 5.4.4 IED

The main objective for Mike Russell was to set up and operate a Monitoring Officer (MO) programme for the new SERC/DTI IT programme. By the end of this reporting period monitoring officers have been selected for >90% of the approved projects in the IEATP programme in Systems Engineering.

These MO reports will be used to judge progress of the 60-odd new projects and the several remaining Alvey projects. To assist the Director of Systems Engineering, Mike Russell is required to analyse the MO reports and prepare a summary indicating problems and achievements. On the basis that the projects have been selected for technical excellence and that adequate support has been provided, then the main uncertainties relate to the previously unspecified project staff. The MO reports will pay special attention to the nature of project staff interactions in addition to the quality of the project deliverables.

The MO reports will form a coherent record of project performance using the deliverables as a quantifiable parameter of achievement. In the event of a project failing to perform satisfactorily the MO reports will be used to justify any actions taken by the Directorate. Good communications between team members is very important and MOs should attempt to identify where in-house staff training would benefit the project.

### 5.4.5 Mica

Individual research has been conducted by Mike Russell into previously unexplained defects in natural mica crystals. Strong circumstantial evidence has been found for a new solid-state recording process of exceptional sensitivity. It is possible that this new recording process might have practical implications in the area of data storage and the feasibility of duplicating the process in the laboratory is being examined by a RAL/Shanghai (China) collaboration. Recent detailed study of the (supposed) positron tracks in mica has shown that the new recording process responds to both elastic and inelastic lattice perturbations. Recording processes based on inelastic scattering, such as caused by ionization, are well known. However, the observation that the recording process in mica can respond to elastic events is a significant discovery with wide ranging implications.

If this interpretation is correct then it is predicted that very directional, high energy, soliton-like entities may be created in nuclear interactions within a crystal. A RAL/Frankfurt/Brighton collaboration has been formed, to seek experimental evidence for Supra-Ballistic Phonons, to investigate this exciting possibility.

### 5.4.6 Publications

#### 5.4.6.1 External

F M Russell, Nuc Tracks Radiat. Meas., Vol 15, 1-4, 41-44 (1988). Identification and selection criteria for charged lepton tracks in mica.

#### 5.4.6.2 Internal

- F M Russell, RAL-89-031, Permanent recording of transient lattice perturbations.
- F M Russell, RAL-89-0l9, First observation of single phonon tracks in mica.
- F M Russell, RAL-89-037, Supra-Ballistic Phonons.

### 5.4.7 Objectives

- To direct the operation of the Monitoring Officer programme.
- To complete the selection of Monitoring Officers for all the Systems Engineering projects.
- To organise a one-day seminar on monitoring procedures for the MOs.
- To analyse the MO reports for potential weaknesses and problems.
- To advise the Director, Systems Engineering, of potential and real problems in project performance.
- To initiate the RAL/Shanghai experimental collaboration.
- To direct and coordinate the RAL/Frankfurt/Brighton experiment to detect Supra-Ballistic Phonons.

# Informatics Annual Report 1989-90



## 1. INTRODUCTION

The Annual Report this year does not cover a complete year going from September 1989 to June 1990. The aim was to bring the Annual Report into line with the first half of the Reporting Year for scientific staff and to avoid the inevitable delay caused by summer holidays. In the event, some contributions were very slow appearing. In consequence, the holiday season arrived before the completion.

The main purpose of the report continues to be for internal use in the Department indicating what has been achieved and by whom. It also gives new members of the Department some idea of the work programme in total and its objectives. The set of Informatics Handouts together with the latest Annual Report provides a good overview of the last year's activities.

The Divisional structure has not changed throughout the period but the Division Heads have:

1. Systems Engineering Division: R W Witty (until November 1989) D A Duce (Acting from November 1989)
2. Design Division: M R Jane
3. Computational Modelling Division: F R A Hopgood (Acting until October 1989) D R S Boyd (from October 1989)
4. Distributed Computing Service: K F Hartley

The recruitment of K G Jeffery to fill the Systems Engineering post means that 1990-91 may be a year when all four Grade 6 posts are filled for the first time - let us hope that no-one falls under a

bus or gets lured away!

The major funding in the Department still comes from the Computing Facilities Committee of the Engineering Board. The major function for CFC has been the development of the Engineering Applications Support Environment (EASE) with its emphasis on Awareness. This year the events organised have grown considerably with the annual EASE Conference at Manchester being a great success. The Newsletter has increased its circulation significantly. Through the year, a large number of visits to HEIs was made and this has given us a much greater insight into what the users required and raised the level of awareness of EASE. The big challenge for the coming year will be in the production of the first version of the EASE environment.

The joint SERC-DTI collaborative research programme eventually decided to provide EASE-like support for the researchers in that programme. While part of the effort in 1989-90 was finalising the Alvey programme, work did start on activities relevant to the new programme. Hopefully, the merit of this work will be recognised and the funding will continue for the period of the programme.

This year has seen the level of activity in the research area increasing significantly, particularly from the European programmes. A substantial level of funding in the Department now comes from external sources. The quality of the Departments research strength in IT is being recognised. One significant event was the invitation by ERCIM, a consortium of European research laboratories, for RAL to join as the prominent UK IT research laboratory. This will strengthen our ability to do joint research in Europe.

This year saw the retirement of two long-standing members of Informatics and RAL's engineering design staff Bryan Colyer and Jim Diserens (actually August 1990). Both played a prominent role in pioneering the use of interactive computing in engineering design with a number of major achievements. Some compensation for this loss was the recognition of David Duce's work in formal specification by the award of an Individual Merit Grade 6 promotion.

Appendix A gives the September 1989 Organogram for the Department, while Appendix B gives the Organogram at the end of June 1990.

## 2. SYSTEMS ENGINEERING

### 2.1 INTRODUCTION

Systems Engineering Division consists of two groups, Knowledge Engineering and Software Engineering. Both groups are small in RAL terms. Each has a dual role of direct participation in the Department's support of the Engineering Board's programmes and a research programme which generates knowledge, skill and technology, to be fed, indirectly, into Engineering Board support and other programmes in which RAL is involved.

For the Knowledge Engineering Group, the year has seen considerable technical progress on the ESPRIT projects and industrially sponsored projects which were agreed in the previous year.

The Group devoted considerable energy to the preparation of proposals in response to the Call from the SERC/DTI IEATP Programme. Whilst technical approval was given to several projects, only one, Gateway, has come to fruition as an IEATP funded project. A second proposal, whilst not funded as an IEATP project, has resulted in a direct collaboration between STC, the University of Buckingham (through a CASE Student-ship award) and RAL, in the area of Strategic Investment Decisions in IT. Effort has also been devoted to seeking further ESPRIT funding. The effort of fund-raising is very considerable, and the KE Group is establishing a good track-record of success, for which the reward is an exciting and stimulating programme of work.

March 1990 saw the completion of the Alvey IPSE 2.5 Project in which RAL was a partner. The project came to successful conclusion in terms of RAL's technical work which was undertaken jointly with the University of Manchester. This project provided a sizeable fraction of SE Group's resources and considerable effort was devoted during the year to finding continuation' funding for the lines of work started in the project. Proposals were prepared for SERC, the IEATP Programme

and ESPRIT. This time-consuming work has met with some success, and new programmes will be starting later in 1990.

The equational reasoning work, started by Dr Jeremy Dick, is continuing through an IEATP project on Verification Requirements for LOTOS Specifications. Part of this project is also using specification of graphics systems as a case study.

Both Groups have contributed to the EASE programme in various ways, including participating in the HEI Visits Programme; SE Group have been heavily involved in the Environment and other working groups.

The main perturbation in the Division was the departure of the Division Head, Dr R W Witty, on five year secondment from SERC as Head of the Systems Engineering Centre at ISPRA. David Duce ran the Division on a temporary basis from 6 November 1989 to the end of the reporting year. On 29 June 1990, Dr K G Jeffery from Central Computing Department was appointed to the permanent post of Head of Systems Engineering Division and David Duce received an Individual Merit promotion to Grade 6, effective from 1 July 1990.

In spite of the difficulties, the Division has produced very high quality technical work during the year and has strengthened a number of important collaborative links with academic and industrial research groups, as well as contributing to the EASE programme. The challenge for the future is to improve the technology transfer from the research programmes in the Division to the EASE programme.

## 2.2 KNOWLEDGE ENGINEERING GROUP

### 2.2.1 Staffing

- Gordon A. Ringland (GAR) (Group Leader)
- Wernher Behrendt (WB) (from October 1989)
- Helen R. Chappel (HRC)
- Graham J. Doe (GJD) (from September 1989)
- Julie A. Dugdale (JAD) (PhD. CASE student, Univ. of Buckingham, from March 1990)
- John E. Galletly (JEG) (visitor from Univ. of Buckingham)
- Charlie Y.L. Kwong (CKYL) (left November 1989)
- Simon C. Lambert (SCL)
- Michael D. Wilson (MDW)

### 2.2.2 Objectives for 1989/90

1. To maintain and extend a fully funded R&D programme in pure and applied AI. Where possible this will be done in collaboration with Industry.
2. To advance the field to benefit both general software development, and in particular knowledge based systems.
3. To promote and support the SERC's research and awareness programmes, for instance EASE.

### 2.2.3 Multi-Modal Interface for Man-Machine Interaction with knowledge based systems - MMI$^2$ (HRC, GJD, GAR, MDW)

MMI$^2$ is a five year research project drawing on 60 man years of effort that started in January 1989 with funding from the CEC under the ESPRIT initiative. The consortium undertaking the project consists of 2 software companies, 2 universities and 3 research laboratories; that is BIM (Belgium) as prime contractor, with Intelligent Software Solutions (Spain), University of Leeds (UK), Ecole des Mines de Saint-Etienne (France), SERC/RAL (UK), ADR/CRISS (France), INRIA (France).

The objective of the project is to develop a highly interactive multi-modal interface for human-machine interaction with knowledge based systems. More specifically, the project aims to build a human-machine interface which will:

- Incorporate multiple modes of interaction;

- Adapt to different classes of users;
- Provide intelligent, co-operative dialogue facilities.

The interface will provide simultaneous interactive use of modes suitable to support the developed skills of professional users, and natural communication modes well suited for naive users. These modes include: Natural Language typed at the keyboard (English, French and Spanish), Graphics with Direct Manipulation, Mouse Gesture, and Command Language.

The interface will initially be developed to accommodate a Prolog based Knowledge based system for local and wide area computer network design. This provides the requirement for intelligent dialogue, different classes of users, and the integration of multiple modes of representation and communication. The interface will be designed to be portable across a range of potential applications of knowledge based systems. Tools for the rapid adaptation of the interface will be developed in the later stages of the project.

The overall architecture of the project can be viewed as a three layer structure with the different interface modes represented by modules (or experts) in the upper layer. The central layer contains six experts to manage dialogue and the lower layer represents the application program. The six experts in the dialogue management layer may be imagined as being placed on the points of a pentagram with one in the centre. The central expert acts as a central switching facility to direct information packets between the other five dialogue management experts; the second communicates with the application; the third stores information about the state of the screen and user interface; the fourth constructs and manages a model of the user; the fifth manages the dialogue context; and the sixth manages the semantic information required to communicate between the user and the interface.

Whereas the first stages of the project reported last year mainly covered initial design, this year's work has mainly involved prototype implementations of the major components of the system to allow studies of their interaction to be undertaken. The Knowledge Engineering group at RAL have been involved this year in four tasks within the project which will be described individually.

#### 2.2.3.1 Common Meaning Representation (CMR)

The CMR is the language used to pass information between the experts in the overall architecture. It uses a typed first order logic that uses promiscuous rectification of events and relations, augmented by communication forces. Expressions in this language are then put into packets along with details of the mode (Graphics, English etc..) from which the information is derived, the time the packet was constructed and other information which may be relevant to later processing.

The formal specification of this language was produced in 1989, although the details of the predicates which can be included in it, the cases of those predicates and the set of communication forces which are admissible have all been further developed since then, as they will continue to be throughout the project.

#### 2.2.3.2 User Modelling

Following the progress made last year in establishing an architecture for the user modelling expert, work this year has implemented that architecture and incorporated stereotypical knowledge about users derived from experimental studies.

The architecture proposed will acquire information about the user, store that information and provide it to other experts when it is required. The acquisition takes place by three methods: i) stereotypical knowledge of users is derived from experimental studies and entered into the user model prior to use; ii) when the system is running the information passing from user to system and system to user is overheard by the user model and user's beliefs and preferences are extracted from this; iii) in the last resort, direct questions (such as 'what is your name?') are put to the user.

The information is stored in a network of stereotypes. The stereotypes at the top of the network represent general beliefs, goals, preferences and plans of most users. The stereotypes at the leaves of the network represent the individual users themselves. Between these are stereotypes of

increasing specificity. If a belief is not explicitly represented in a user's own stereotype model, then the stereotypes up to the top of the network are successively searched to find that belief. If the belief, or a contradiction is not found, it is assumed that the user does not hold it since the model of the world is closed and that which is not explicitly stated as true is assumed to be false.

As beliefs are added to a user's model they are tested against beliefs in the stereotypes from which that user inherits information. If they contradict any existing beliefs the stereotype which contains the contradictory stereotype is removed from the inheritable set. After information has been added to a user's model, and all contradictions removed, a list of rules is consulted to assess if the new set of information about the user implies that the user model should inherit information from stereotypes which it does not; and adds them if appropriate. This process maintains the truth of the information about users by implementing a non-monotonic logic; although at a cost for run time efficiency.

The beliefs, goals, preferences of user's, which are stored in user models, differentiate between knowledge, belief, and awareness. Logical closure under belief is not included since users clearly do not believe all the implications of any belief and often maintain not only beliefs whose implications are contradictory, but also explicitly contradictory beliefs.

The experiments to derive the stereotypical information about users and the content of the rules to assign stereotypes to user models have been conducted by our French partners at INRIA. The data from these experiments have been analysed and incorporated into the implemented user model.

The user modelling expert is now being tested in conjunction with other parts of the overall system.

#### 2.2.3.3 Graphics Mode

Much of this year has been spent implementing the architecture for the graphics mode to allow CMR packets produced by the system which contain numeric information to be displayed to the user as histograms, pie charts and line graphs. Users can then alter or query values in these representations through direct manipulation, which will then result in CMR packets being sent to the rest of the system.

At present the tools for producing graphics are being used in conjunction with other parts of the system to explore the structure of multi-modal dialogues.

It is planned to further develop this graphical interface in two ways. Firstly, to investigate the semantics underlying the manipulation act of changing or referring to components of graphical displays. For example, if a user types the English sentence Tell me more about <select> (where <select> is an act of selecting the title of a graph with a mouse) does the user wish to know about graph titles in general, this one in particular, or is the user using the title of the graph as a symbol to refer to the body of information displayed on the graph? Secondly, to develop a knowledge base which will automatically design layouts for graphs using the best principles from ergonomic and graphic design research.

#### 2.2.3.4 Gesture Mode

Leeds University have developed and implemented an algorithm for identifying design gestures of the class normally used to mark up manuscripts for editing when they are drawn on the screen using a mouse. At RAL we have developed the semantics of these design gestures so that the actions can be coded in CMR and transmitted to the rest of the system.

#### 2.2.3.5 Knowledge Representation in the KBS

As the CMR is used to represent the meaning of user and system actions at the interface, so there must be a language to represent the knowledge about the domain within the application KBS. This representation must not only be sufficient to support the reasoning about the domain which the KBS itself will perform, but also to allow the interface to interact with it in order to support co-operative dialogue and advanced explanation. A specification has been produced of a frame based representation language for the computer network being designed by the user and KBS, with the

major inference structure being one using a skeletal design within which modules are individually designed in detail.

### 2.2.4 An Expert System for the Water Industry (HRC, GJD, CKYL, SCL, GAR)

The Knowledge Engineering Group is undertaking a project for a consortium of water companies coordinated by the Water Research Centre, Swindon. This project is a development project which is intended for actual use by the Water Industry and provides the Knowledge Engineering Group with valuable experience of development in a practical engineering domain such as those that might be found in EASE. The aim is to develop a pilot knowledge-based system for assisting in the management of water supply systems. The project is divided into four phases: the Definition Phase, in which visits to sites of all the members of the consortium were made, common problems suited to a knowledge-based solution were identified and a pilot site was selected; the Prototyping Phase, in which knowledge acquisition and system development take place at the pilot site leading to a version of the system complete in coverage though not in depth; the Pilot Phase, in which the prototype is enhanced to yield a genuinely usable system at the pilot site; and the Platform Phase, in which the site-independent knowledge is abstracted and a platform constructed on which the other members of the consortium will be able to build their own applications.

The Definition Phase was completed in December 1989. Two or more Knowledge Engineering staff had visited sites from each of the nine consortium members and had conducted interviews with several members of staff. The interviews were a preliminary knowledge acquisition aimed at scoping the project: searching for common problems and opportunities for a knowledge-based system. A report was written and accepted by the consortium based on the findings of this phase. It identified three general classes of application which were found at the sites visited and which could benefit from a knowledge-based system (KBS) solution, namely assistance in dealing with non-routine abnormal conditions on the supply system, risk assessment and resource management. Furthermore, the Southern Water site at Otterbourne was chosen as the pilot site on account of the high quality of its experts and the typicality of its supply system and working methods.

The Prototyping Phase is now under way. A period of intensive knowledge acquisition lasting some three months took place with two principal experts at Otterbourne. Again the interviews were conducted by two or three Knowledge Engineering Group staff, recording what was said and afterwards typing up transcripts of the sessions. The transcripts were later analysed according to the precepts of systematic knowledge acquisition to identify objects - both material and conceptual - in the experts' view of the domain, the relations between objects and the kind of strategies and problem-solving methods used. The transcripts were used to create an intermediate representation of the domain in readiness for the system design and coding which followed. At this stage the knowledge acquisition was driven by a need to develop an understanding of the domain itself - how a water supply system operates - and of the place of the three applications within it.

When a suitable point had been reached, that is, when it was felt that enough knowledge had been acquired to allow a definition of the functionality of the very first version of the prototype, the building of the system began. An AI toolkit, GoldWorks II, had been chosen for the purpose. It is being run on a portable Compaq personal computer, which has the advantage that the software can be demonstrated to the experts in their own places of work. The design method adopted strikes a balance between unstructured rapid prototyping and rigorous top-down requirements-based design, in that it takes advantage of the debugging features and rapid development cycle of GoldWorks, but by means of a series of Design Notes assumptions have been made explicit and the design modu1arised. The system will comprise four components: a model of the water supply system, a situation assessor for reporting on the consequences of given courses of action, an option generator for suggesting actions to the user, and a graphical user interface.

The first working version of the prototype has been taken to Otterbourne for feedback from the experts, who received it favourab1y. It has also been demonstrated to the full consortium. The tasks

ahead are to enhance and extend the prototype in preparation for a period of trials and feedback with the consortium and the Southern Water experts in August.

### 2.2.5 Consultancy on a Study of Decision Making (SCL, GAR)

The Knowledge Engineering Group has been engaged to undertake consultancy on a study being carried out at British Telecom's Research Laboratories at Martlesham. The study is on the theory of decision making, and the Group's experience in knowledge representation and knowledge acquisition both in theory and practice are valuable. A number of documents produced by the study team have been reviewed, and some BT review meetings attended. The study is comprehensive in scope, dealing with both single-person and group decisions and normative and descriptive approaches. There is some possibility of a further role for the Group if the findings of the study lead to an attempted implementation of a KBS, as was at one time hoped.

### 2.2.6 MUVIT: Strategic Investment Decisions in IT (JAD, JEG, SCL, GAR, MDW)

The project, a collaboration between the University of Buckingham, RAL and STC, will produce a knowledge based tool to aid senior management in making and controlling strategic IT investments. Currently we are in the scoping phase during which we are acquiring knowledge from senior managers in STC to establish the concepts used and tasks performed in the domain. This will form the basis for a high level characterisation of the system and the subsequent detailed knowledge acquisition and prototyping tasks. The project forms the basis for JAD's PhD work which is funded by a CASE studentship at the University of Buckingham, with STC as the industrial partner.

### 2.2.7 The Gateway Project: Metrics for Know1edge-Based Systems (WB, SCL, GAR)

The Gateway project is a collaborative IEATP project (1751). The partners are Logica Cambridge, Integral Solutions Ltd. and the Rutherford Appleton Laboratory. The project started in April 1990. It aims to meet the need for better defined and more standard measures for evaluating the KBS elements of system performance; for standard and systematic guidelines for assessing the suitability of a knowledge-based approach and quantifying its feasibility; and for sound comparative evidence from evaluation to support the case for KBS in preference to some other approach. In this way the project is highly relevant to EASE because it will promote an increase in confidence towards KBS projects and will encourage uptake of KBS by allowing meaningful comparisons to other approaches.

There are three areas in which evaluation is appropriate and which are to be addressed by the project: system performance (software and hardware considerations), usability (interfaces, maintainability, user motivation, etc.) and organisational effectiveness (relation of the KBS to the milieu in which it operates).

Specifically, the objectives are as follows:

- to collate and analyse existing approaches and requirements within the three areas mentioned above, building on existing experience of knowledge-based systems, and to identify relevant existing measures;
- to develop and test a set of evaluation measures that cover performance issues in the three areas and are explicit and quantifiable;
- to work towards inclusion of them in a standard method for evaluation and assessment of KBS elements at all stages of the system life-cycle.

The project is drawing on evaluative measures for conventional systems where appropriate and modifying them for application to KBS. It will also develop measures for KBS-specific aspects. Software tools will not be developed from scratch but will be employed and evaluated where possible and minor adaptations will be made where appropriate. It is intended that comparative evaluation will lead to some absolute measures, thereby enhancing the predictive power of the methods, which is an important goal because of the need for prediction in the early stages of a system life-cycle when it is necessary to assess the potential for KBS involvement and to present evidence for its effectiveness.

The Work Packages into which the project is divided are as follows: Data Collection and Analysis, Synthesis of Metrics, Evaluation of Metrics, Further Synthesis, Further Evaluation, and Integration. Thus there are two cycles of synthesis and evaluation, which allows for feedback from the results of evaluation on real projects which it is hoped to be able to carry out. At present Work Package 1 is in progress: a wide-ranging survey of metrics and related topics in conventional software and knowledge-based systems has been carried out, and a conceptual framework is being developed in which metrics may be organised so that their utility in context will be illuminated and gaps in coverage revealed, thereby setting the scene for the synthesis of metrics which follows in the second Work Package.

### 2.2.8 Conferences Attended

**WB**

- One day seminar on software maintenance, RAL, 9th November 1989.
- One day Workshop on AI in Engineering, RAL, December 1989.

**HRC**

- IEEE Computing and Control Division Colloquium on AI in the User Interface, London, 27th April 1990

**JEG**

- Conference: Evaluation of CALL programs, University of Exeter, 20-22 September, 1989.

**SCL**

- International Conference on Artificial Intelligence in Industry and Government, Hyderabad, India, 23rd to 25th November 1989.

**GAR**

- UK IT 1990 Conference, Southampton, 19th to 22nd March 1990.
- Organised and attended one day Workshop on AI in Engineering, RAL, December 1989.

**MDW**

- Computers and Conversation Workshop, University of Surrey. September 1989.
- BCS HCI Group Meeting, Usability Metrics. London. May 1990.
- UK IT 1990 Conference, Southampton, 19th to 22nd March 1990.

### 2.2.9 Courses Attended

**WB**

- One day FrameMaker course, RAL, 10th November 1989

**GJD**

- Introduction to GoldWorks II, Artificial Intelligence Ltd., Watford, 12th-16th February 1990.
- Introduction to Common Lisp, AIAI Edinburgh, 5-9 February 1990.

**JAD**

- The Knowledge Engineering Intensive Course, Cognitive Applications Ltd, Brighton, 23rd - 24th April 1990.

**SCL**

- Introduction to GoldWorks II, Artificial Intelligence Ltd., Watford, 12th-16th February 1990.

### 2.2.10 Papers

#### 2.2.10.1 External


- Behrendt, W., Lambert, S.C., Martin, M., Montgomery, T.A., Poulter, K., Ringland, G.A. and Startin, K., Gateway Project (IED 1751): First Internal Deliverable: Survey Report, June 1990.
- Binot, J-L., Falzon, P., Perez, R., Peroche, B., Sheehy, N., Rouault, J. and Wilson, M.D. , Architecture of a Mu1timoda1 Dialogue Interface for Knowledge-Based Systems,

submitted to ESPRIT '90 Conference.
- Chappel, H.R., Kwong, C.Y.L., Lambert, S.C., Ringland, G.A. and Stimson, R., Report on the Project Definition Phase Water Distribution Expert System project report, December 1989.
- Chappel, H.R., Draft Specification of the User Model, MMI$^2$ project report MMI$^2$/RAL/9, February 1990.
- Chappel, H.R., Doe, G.J., Lambert, S.C., Ringland, G.A., Baker, M., and Stimson, R., Notes on Trials and Feedback, Water Distribution Expert System project report, June 1990.
- Doe, G.J., Chappel, H.R., Ringland, G.A., Wilson M.D., Notes towards a Definition of the Common Meaning Representation - a Modest Proposal", MMI$^2$ Project report MMI$^2$/RAL/8, October 1989.
- Doe, G.J. Draft Specification of the Domain Expert, MMI$^2$ project report MMI$^2$/RAL/11, February 1990.
- Doe, G J., Ringland, G.A. and Sedlock, D., A Meaning Representation Language for Multi-Modal Knowledge-Based Systems, submitted to ESPRIT '90 Conference.
- Dugdale, J .A., Ringland, G.A. and Wilson, M.D. Expert Identification Aid Document April 1990.
- Galletly, J.E., occam 2, Pitmans: London, April 1990.
- Galletly, J.E. et al, Intelligent analysis of comprehension passage replies using Prolog for grammar and meaning, accepted for publication in CALL journal.
- Lambert, S.C., Ringland, G.A. and Stimson, K. Report on Progress to the Consortium, Water Distribution Expert System project report, September 1989.
- Lambert, S.C. and Ringland, G.A. Notes on the Definition Phase and Site Selection, Water Distribution Expert System project report, September 1989.
- Lambert, S.C. and Ringland, G.A., Representing knowledge in financial expert systems, Proc. International Conf. on Artificial Intelligence in Industry and Government, Hyderabad, India, 23rd to 25th November 1989,publ. Macmillan, pp.122-134.
- Lambert, S.C. and Ringland, G.A., Knowledge representation and interfaces in financial expert systems, Proc. UK IT 1990, publ. IEE, pp.434-441.
- Lambert, S.C., Chappel, H.R. and Ringland, G.A., Outline of the Proposed Prototype Expert System, Water Distribution Expert System project report, March 1990.
- Lambert, S.C., Chappel, H.R., Doe, G.J. and Ringland, G.A., Technical Progress Summary Water Distribution Expert System project report, June 1990.
- Wilson, M.D., Specification of the Interface Expert, MMI$^2$ project report MMI$^2$/RAL/10, February 1990.
- Wilson, M.D. and Conway, A. Enhanced Interaction Styles for user Interfaces. IEEE Computer Graphics and Applications. (Submitted - 1990).

#### 2.2.10.2 RAL Reports

- Chappel, H., Ringland, G., Wilson, M., Cahour, B. and Falzon, P. User Modelling for Co-operative Advisory Systems based on Natural Language: a Literature Review. RAL-89-108.
- Wilson, M. D. Notes towards the Integration of Knowledge engineering and Software Engineering. RAL-89-109.

#### 2.2.10.3 Internal

- Dugdale, J.A. Progress Project Report for the Value in Information Technology, May 1990.
- Lambert, S.C., Ringland, G.A. UK IT 1990 Conference, Southampton, 18-22 March 1990 Systems Engineering Division Note 72, issued 18 April 1990.
- Ringland, G.A., Trip Report IJCAI August 1989, Systems Engineering Division Note 57, issued 5th September 1989.

#### 2.2.10.4 Talks Presented

- Behrendt, W., Some issues in the Comparison of Knowledge-Based Systems and Neural Nets, RAL Systems Engineering Division Colloquium, 30th March 1990.
- Chappel, H.R., Seminar on Frames and Frame Systems in the RAL Software Engineering Group's technical series, 1st December 1989.
- Doe, G.J. Enunciation Predicates in the CMR, Commission of the European Communities MMI project Review, Barcelona, Spain, 23rd March 1990.
- Doe G.J. The Common Meaning Representation for MMI$^2$ , RAL Systems Engineering Division Colloquium, 15th June 1990.
- Galletly, J. E. Cognate language learning using hypertext, presented at "Evaluation of CALL programs", University of Exeter, 20-22 September, 1989.
- Galletly, J.E. Genetic Colloquium Algorithms, RAL Systems Engineering Division, 11th May 1990.
- Kwong, C.Y.L., Evaluation of Knowledge-Based Systems, RAL Systems Engineering Division Colloquium, 15th November 1989.
- Lambert, S. C., Tutorial on Introduction to AI and Expert Systems at the International Conference on Artificial Intelligence in Industry and Government, Hyderabad, India, 23rd to 25th November 1989.
- Lambert, S.C., Seminar on Model-Based Reasoning given to Computational Modelling Division, 11th September 1989.
- Lambert, S. C., Seminar on AM and EURISKO in the RAL Software Engineering Group's technical series, 20th October 1989.
- Wilson, M.D., An Architecture for Intelligent Multi-Modal Interfaces, Computer Science Colloquium, Queen Mary and Westfield College London, March 1990.
- Wilson, M.D., An Architecture for Intelligent Multi-Modal Interfaces, Ergonomics Unit Colloquium, University College London, March 1990.
- Wilson, M.D., The Ergonomics of Knowledge Based Systems, Ergonomics MSc Lecture, University College London, April 1990.

#### 2.2.11 Objectives for 1990/91

1. To maintain a fully funded R&D programme in pure and applied AI. Where possible this will be done in collaboration with HEIs and Industry.
2. To advance the field to benefit both general software development, and in particular knowledge based systems relevant to the EASE community.
3. To increase information dissemination of our work through journal publications, conference papers and seminars.
4. To promote and support the SERC' s research and awareness programmes, particularly EASE.

Specifically:

- Obtain funding for one new R&D project For MMI, Water project and MUVIT:
- To have the first working system pass sponsors' review processes as specified in the project plans.
- Publish at least one refereed paper (journal or conference) for each running project.
- Organise two workshops in the AI for Engineers series.

### 2.3 SOFTWARE ENGINEERING GROUP (SEG)

#### 2.3.1 Staffing

- Prof David Duce (DAD) (Grade 7, Acting grade 6 and temporary head of division from November 1989)
- Dr Stuart Robinson (SKR) (Group Leader)
    - Formal Methods section
    - Juan Bicarregui (JCB) (Research Associate)
    - Brian M Matthews (BMM) (HSO)

- Dr Brian Ritchie (BR) (Fixed Term SSO)
- Dr J M Spivey (JMS) (Atlas Fellow on sabbatical in USA from October 1989 to October 1990)
- Dr Jim C P Woodcock (JW) (Atlas Fellow)
- Dr Chris M P Reade (CMPR) (Part Time Visitor)

- Environments section
- John R Kalmus (JRK) (Permanent HSO)
- Ian R Jenkins (IRJ) (Young Scientist on project training period)

During this year, a difficult year for formal methods groups due to lack of funding, the Software Engineering Group has remained at about the same overall numbers. With the IPSE 2.5 project completing, we have had the LOTOS and ZIP projects starting and have been active in submitting further research proposals that are about to come to fruition later in 1990. This should allow us to slightly expand our numbers.

The main changes this year have been that Mike Spivey has been away in the States on sabbatical and that Ian, a "young scientist", has joined us for 6 months from June 1990 to work on a browser for PCTE's OMS.

In August 1989 DAD received his chair from the University of East Anglia. BR received his Professional Review for C. Eng status; the interview panel have subsequently recommended to the BCS that he be awarded this. In June 1990 DAD and SKR formally received their C. Eng.

### 2.3.2 Objectives 1989/1990

Within the group, software quality is approached from the formal methods angle. Two overall objectives drive the work:

1. a general understanding of software quality this first strand is concerned with understanding which properties of a software product (remembering that this includes design and documentation, as well as source and object code) can and cannot be formally described, proven and measured.
2. the means to certify quality The technology to certify quality, from the formal methods standpoint, is the capability to prove that products possess certain formally specified properties. Included under this category are tools to aid in this process. SEG aims to make a contribution through the development of new proof techniques and through the development of tools which make the theoretical techniques accessible to a wider audience. The work being started within the LOTOS project (launched October 1989) and the ZIP project (launched March 1990) are seen to fall within this area.

### 2.3.3 Graphics Standards (DAD)

DAD has continued work on graphics standards. DAD and F R A Hopgood (FRAH) attended the ISO/IEC JTC1/SC24 meeting and the Computer Graphics Reference Model meeting. The meeting was not overly productive, but progress was made on the Reference Model at a subsequent meeting in January 1990. In collaboration with the LOTOS project and Graham Reynolds at the University of East Anglia, work has started to explore the extent to which the structure of the Reference Model provides a structure for a formal specification of a graphics system. This exercise has already produced some useful insights into the Reference Model which form a part of the UK comments on the Reference Model for the next meeting in July 1990.

DAD and FRAH resigned as document editors for the GKS Review at the October 1989 meeting following a decision to take the existing ISO 7942 document as baseline rather than a UK document which in their view provided a better structure from which to start the Review. Since that meeting DAD and FRAH have contributed to UK efforts to pursue some of the key ideas in the UK input to the GKS Revision, in the area of the relationship between GKS and the Computer Graphics Metafile and user extensible output primitives. This work has culminated in the production of two

new documents, known as GKS-P and GKS-Q which form part of the UK input to the GKS Review meeting in July 1990.

DAD and FRAH gave a 2-day tutorial on the Programmer's Hierarchical Graphics System (PHIGS), published as an ISO standard in 1989, at the Yugraph 90 conference together with invited lectures on Formal Methods in Computer Graphics and Super Workstations respectively. Prior to the Yugraph conference, the PHIGS tutorial was given at RAL as a part of the EASE Awareness Programme.

### 2.3.4 IPSE 2.5 (DAD, JCB, BR)

IPSE 2.5 was a major Alvey project to research and develop an Integrated Project Support Environment based on advanced distributed systems and man-machine interfaces, and incorporating support for both the practice and organisation of design tasks. A major objective was the development of an integrated framework for supporting the use of formal methods in software development, including formal specification and theorem-proving techniques.

The project began in October 1985 with three initial collaborators (ICL, STC and Manchester University). RAL joined the project in July 1986 and three additional industrial partners subsequently joined the collaboration. The industrial component of the project terminated at the end of 1989, the Manchester University{RAL component at the end of March 1990.

At RAL, Juan Bicarregui (JCB) and Brian Ritchie (BR) were engaged in the project, both spending a fair proportion of their time at Manchester. DAD was the RAL representative on the Project Review Board.

The Manchester/RAL part of the IPSE 2.5 project (Theme C) was concerned with the support of formal methods of software development and in particular with aiding formal reasoning itself. The intention was to build tools which enable a user to construct proofs at the workstation; modern workstations such as the SUN3 and SUN4 make it possible to design proof assistants which are much more usable than earlier tools developed around glass teletype interfaces.

Manchester concentrated upon the specification and implementation of a generic proof assistant; RAL concentrated upon implementation of a VDM Support Tool for both specifications and designs using BSI VDM. The resulting system was named Mural. Mural provides an environment where specifications (and the refinement of one specification by another) in the VDM support tool can be "translated" into theories in the generic proof assistant, where the proof obligations that justify a specification or design step can be discharged. Originally, the VDM support tool was intended to be "minimal", the main aim being to provide an existence proof that the generic proof assistant could be instantiated to support particular formal methods. However, with the withdrawal of the IPSE 2.5 theme responsible for generic formal methods support, the VDM support tool gained greater significance.

BR and JCB's work in the last months of the project was divided between developing an improved interface for constructing VDM specifications and developments, and implementing the translation mechanism for the generation of appropriate theories in the proof assistant from such developments, including proof obligations. Though the final support tool is not a fully-fledged support system for VDM (in particular, it only permits a restricted form of specification refinement), far more was achieved than was originally envisaged.

A first draft of a Book of Mural has been submitted to a potential publisher. This documents the system and the designers' experiences in implementing in Smalltalk from formal specifications. BR and JCB have contributed two chapters on the VDM support tool. Further work on this is anticipated.

Further, it is anticipated that Mural will be of use in RAL's contribution to the IED Raise User Trials project which is expected to start soon.

### 2.3.5 Knuth Bendix Techniques in Theorem Proving (JCB, BMM)

This work was initially funded by SERC's Computing Science Sub Committee. The ability to reason with equations (for example, to deduce conclusions from a set of equations), is important in a number of areas, such as specification of abstract data types and their validation; program transformation; synthesis of programs; program optimisation and solving equations. Dr Jeremy Dick had, over a number of years, developed a rich theoretical framework (at RAL) for equational reasoning and had developed a practical tool, ERIL (Equational Reasoning - an Interactive Laboratory), based on this framework. ERIL is a useful tool for experimenting with specification and prototyping of abstract data types, and is used by several research groups in the UK and abroad. ERIL is based on the use of rewrite rules for computing and reasoning with equations. The project formally finished last September and BMM produced the final report for SERC.

Building on work undertaken in his MSc, BMM carried out a series of experiments in using ERIL in various configurations for theorem proving, in September 1989. The results of this will be appearing in a lab report.

As part of the IPSE 2.5 and LOTOS projects , J CB and BMM designed a new higher-order matching algorithm for use within the Mural theorem proving system, using VDM specification, and rapid prototyping in Standard ML. This proved to give a significant improvement in the performance of the system. An account of the development of the algorithm has been written up and will be presented at the UNIF'90 workshop at Leeds in July 1990.

CMPR, DAD, SKR, BMM and JCB are involved in the SERC IED project Verification tools for LOTOS Specifications with RHBNC and Glasgow which started in October 1989. This continues the work undertaken in the ERIL programme.

### 2.3.6 Verification Techniques for LOTOS Specifications (JCB, BMM, DAD, CMPR, SKR)

This is a three year project funded by the IEATP. The consortium consists of Royal Holloway and Bedford New College (RHBNC), the University of Glasgow and the Rutherford Appleton Laboratory (SEG) and is "unc1ed" by British Telecom (BT).

Formal Methods of specification and verification are a technology which must become more widely used by UK companies if they wish to remain competitive in the long term in areas where they are becoming the industry standard. One such area is the formal specification of standards for open distributed systems, and in particular those related to Open Systems Interconnection (OSI) computer network architecture, for which the specification language LOTOS (Language of Temporal Ordering Specification) was adopted as an international standard in 1988 (IS8807).

LOTOS is based on the concept of specifying a system in terms of observable behaviour. In LOTOS events are used to denote the occurrence of something which the specification makes assertions about. LOTOS can express ordering constraints on events and through their structure the communication and change of information within a system. The ordering and structure of events are captured in two separate components of the LOTOS language. The first of these, the process calculus, is based on process algebraic methods (Milner) and the semantics are based on Milner's CCS (system of inference rules and labelled transitions of processes) and Hoare's CSP (operators for process composition). The second component, based on the data typing language ACT ONE, uses equational specification with initial algebra semantics.

The industrial use of LOTOS has focused on developing formal descriptions of OSI standards. Complete formal descriptions of several OSI standards now exist and are being progressed within ISO as technical reports. It is ISO policy that these texts will become definitive standards. The project uncle, British Telecom, is heavily involved in this work, and Glasgow University is already involved in LOTOS work involving the translation of ASN.1 into LOTOS.

If full benefit is to be obtained from the use of this formal specification language it is essential to be able to reason about such specifications and the implementations derived from them, in order to determine that the specification has the required properties, or verification requirements.

BT is already working on the verification of LOTOS specifications, using existing theorem provers. However, while research has been done on verification for different parts of the language, it has not yet been incorporated into an integrated whole. Term rewriting and equational reasoning are clear candidates for this work, as they are already widely accepted as a verification technology for the major constituents of the language, algebraic specifications and process algebras.

The equational reasoning system ERIL has been developed at RAL, with significant technical research input from RHBNC, and is particularly suited for experimental use as it is easily user configurable to allow experimentation with a wide variety of strategies. While it is felt that as it stands ERIL could be of significant use in discharging the verification requirements of LOTOS, the project members also believe that a long term research project such as this will allow significant further technical developments.

Therefore, the objectives of the project are

1. To derive the verification requirements of LOTOS (in particular, through three case studies). DAD, CMPR and BMM are undertaking one such study in the area of graphics standards.
2. To determine the limits of applicability of term rewriting and equational reasoning to discharging these requirements. The verification requirements and case studies will show the areas in which the theory of equational reasoning and term rewriting have to be developed in order to be a viable approach for discharging verification requirements of the kinds identified.
3. To investigate extensions to term rewriting and equational reasoning in the light of the LOTOS requirements.

The work in (2), undertaken by RHBNC, will also indicate directions in which the ERIL tool has to be enhanced to serve as a test-bed for these ideas. The development of the ERIL system in the light of this falls to RAL. The developed system will be assessed using examples arising from the case studies in the final year of the project.

The result of the project will be

i. an understanding of the ways in which equational reasoning and term rewriting are and are not applicable to the verification requirements problem. an experience of the use of LOTOS and of the language itself which should be of value to the standards committee.
ii. The main contribution of Rutherford Appleton Laboratory in the first year of the project has been in two areas: implementation of equational reasoning tools; and a case study in using LOTOS for specifying Computer Graphics.

**Implementation**

BMM has been designing and implementing a basic set of general tools for use with equational reasoning. This is being undertaken in the functional language Standard ML. Initial experiments in producing reasoning tools and interface tools were undertaken and a Knuth-Bendix Completion algorithm was produced. This has now been developed further with the use of the ML module system to produce an initial basis for a set of tools for equational reasoning. In addition an ERIL like interface has been placed on top of the tools to give a clean presentation of the tools to the user.

An initial design document was written and presented to the project meeting of the 13th March 1990.

Worthy of special mention is the development of an incremental mixfix parsing algorithm which allows the user to add and delete new function symbols to the equational reasoning system as he or she chooses, the function symbols having a free mixfix format. The parser for terms is then adapted dynamically to recognise the new symbol.

**Specifying Computer Graphics**

As a case study in the use of the LOTOS specification language, work has been undertaken in the formal specification of Computer Graphics Standards using the LOTOS language. LOTOS has been used largely for communication protocols, so this is a new area of use for the language. It is

intended that properties of the graphics standards can be demonstrated by analysing the specifications. All this work is still continuing.

Building on previous work of DAD and E. Fielding, BMM reformulated a description of GKS in OBJ into a ACT-ONE specification. This proved a straightforward task, but the specification was not strong enough to allow proof of properties.

DAD and BMM are describing the Computer Graphics Reference Model (CGRM) in LOTOS. An initial highly abstract description of the model has been produced, which shows some of the difficulties of describing a state-based model in a algebraic framework. This is now being modified, and the functionality of GKS output is being fitted into the model.

CMPR has been studying GKS input mechanisms, structuring the Logical Input Devices and Input Modes into LOTOS. He has also been working with James Purvis at Brunel University on GKS input/output expression in LOTOS.

### 2.3.7 ZIP (JCPW, SKR)

ZIP is a three year project employing research and development effort from the membership of British aerospace (Military Aircraft) Ltd (Lead), BP International Ltd, IBM UK laboratories Ltd, Logica Cambridge Ltd, Praxis Systems P1c, Rutherford Appleton Laboratory and Oxford University Programming Research Group. Work began on the first of February 1990. The RAL contribution involves SEG's (PRG) Atlas Fellow Jim Woodcock.

The work programme schedules activities for:

1. The standardisation of the Z notation, its mathematical toolkit, syntax [PRG] and machine processable representations [Praxis], taking account of further notation development resulting from research into refinement and concurrency.

   Z is a mathematical notation for expressing the specification of a computer system or program, which can also be used in the design process. A specification is the means of communication between a client (user) and a supplier (implementer); additionally it is a mode of communication between team members. To succeed it must be clear and unambiguous, which existing informal methods of specification are not. Formal notations have been developed in response to this need.

   In the last few years work has proceeded apace, both at the PRG and in industry, to agree a common abstract syntax for Z. With the publication of the Z reference manual (Mike Spivey, 1989), there is a basic reference for Z - the essential core of Z is now stable. Further research needs to be pursued, especially in the area of the specification of concurrent systems, and this could result in extensions to the notation. This research work forms the core of RAL's contribution to the ZIP project (through Jim Woodcock).

   Currently there is no public standard for Z. The Z notation is now sufficiently mature for the development of a standard, and has gone through the early development stages when the language was changing rapidly but has not yet suffered disparities. Such a standard needs to be subject to control so that changes are carefully documented and published in a regulated manner. The body to agree such a Z standard should include representatives from industry and academia. In the past, the extent to which involved parties had entrenched positions militated against agreement on programming language standards. That is, the standards were always too late! In the Z world, the time is ripe to agree a standard before such inflexibility develops.

   If Z is to become widely adopted then a fixed point of reference is needed for the notation. Other, older formal notations have suffered from a divergence in representation and use and consequently have become unwieldy, and exchange of documents has become difficult. Most people use some form of text processing system, and it must be possible to send machine-readable formal specifications from one organisation to another. It then becomes vital the writer and reader use the same language - a standard concrete syntax for Z is needed. One

additional requirement is for textual representations which can be substituted for Z symbols on devices which are incapable of displaying these symbols.

2. The application of Z in industry to provide case-study examples and heuristics for the methodical use of Z in a fully formal system and software development process. [Logica Cambridge]

   Although Z has a well defined notation, like many other formal methods there is little guidance as to the manner in which it should be used. This deficiency has been highlighted by the Alvey Formal Methods Advisory Group. Z needs to have a developed method if it is to become widely used.

   At present there is a great interest in Z, stimulated in part by DEF-STAN-0055, as is witnessed by the increasing numbers attending courses in Z (Praxis, Logica, PRG). Unfortunately, these converts to Z experience difficulty in applying the notation because they cannot be sure that their language use is correct. Moreover, they find writing Z arduous. One reason for this is that there is no available guidance on what constitutes a good Z specification, nor on how to approach specification problems.

3. The development of prototype tools adopting the standards of (12) and supporting the methods of (2). [BAe]

   The state of the art in tools supporting software development using Z is represented by a number of text formatters, editors, type-checkers, and prototype proof assistants. These tools have been developed by individuals and organisations to varying degrees of quality using various machine representations of the formal notation. These include the FORSITE tools (RACAL, System Designers, PRG, Surrey University, RAL) FUZZ (J.M. Spivey, RAL), BAe ZED, instance of Genesis (1ST Cambridge), IBM Z tools, ZEBRA Type-checking Environment (Bernard Suffrin, PRG) , use of the B tool (Jean-Raymond Abrial with PRG and BP), Logica Z Editor, Imperial College Z Editor and RSRE Z Editor and Type-checker.

4. The basic and applied research to support these standards, methods and tools. This to include work on concurrency and refinement [RAL, BP].

   The major products of these research and development activities will serve to promote the unification initiative and enhance the state-of-the-art.

### 2.3.8 ELO (BR, SKR)

The Esprit Elusive Office (ELO) project aims to investigate and provide state-of-the-art solutions to the software and hardware requirements for supporting distributed office working (or tele-working). The prime contractor is Empirica (FRG); together with ISI (FRG) , they are investigating requirements. SEL (FRG) are providing hardware and communications expertise. RAL's contribution to the project is largely in:the area of software support (together with Computer Lern Systeme (FRG) and Realace (EIRE)).

Since April, BR has been assisting Design Division's contribution to ELO, drawing on his previous experience in designing within an object-oriented environment to develop the ELO Integration Framework. It is planned to use existing toolkits and class hierarchies as far as possible to provide a starting point, though further work is required to provide the level of integration required by the computer-aided learning support planned by CLS, and the security services planned by Realace.

BR has taken part in a number of ELO meetings, both with software and requirements partners, and has helped shape the requirements upon the integration framework, and investigated possible approaches to solutions. This has included the investigation of some existing C++ class hierarchies.

### 2.3.9 EASE (SKR, JRK, IRJ, DAD)

The current Engineering Board supported research community tends to be split along Committee lines. This does not take into account computing solutions that often straddle several communities'

application areas. Therefore, CFC is taking an active role in facilitating cross-fertilisation between Committees, disciplines and industry in the computing area and, as part of this activity, the Engineering Applications Support Environment (EASE) programme has been initiated with the mission statement:

To stimulate and encourage engineers to use appropriate, state-of-the-art software and hardware to enhance their research

The programme itself involves many activities. SEG's participation in the programme is outlined in the sections below.

#### 2.3.9.1 The EASE Environment (JRK, SKR, IRJ)

Specifically, CFC wishes to encourage engineers to migrate to state-of-the-art integrated project support environments (IPSEs). These environments were assessed last year (by SKR and JRK, as part of the EASE programme) as not being viable until the mid 1990s and so a working party, involving SKR, has been exploring the means whereby a software environment that would provide a transition path to this technology could be devised. Part of this activity is the continued tracking of IPSE technology.

As part of this tracking process, JRK has undertaken an assessment of the Portable Common Tools Environment (PCTE) as a Tool Support Interface (TSI), using an Emeraude implementation of PCTE installed on a SUN 3 Workstation. JRK and SKR have made contact with potential suppliers of IPSE technology (Softlab and IPSYS) and have been involved in several visits / meetings to discuss our requirements for the Engineering Applications Support Environment (EASE) . A survey document summarising these various Environments activities has been produced.

SEG have recently (June 1990) taken on a Trainee Programmer, IRJ, to work on a 6 month project, supervised by JRK. IRJ's task is to write (in C) a user-friendly browser for the PCTE object store. The motivation for building this tool arose directly out of JRK's experiences during his assessment of PCTE.

#### 2.3.9.2 The EASE Information Directory (JRK)

A working party was set up in March 1990 to investigate the feasibility of an EASE Information Directory (EID), and has just submitted an Interim Report to IDHM. JRK, together with colleagues Deborah Thomas (DD) , Subodh Chandra (DCSD) and Bob Maybury (CMD), have been tackling two main areas of work so far. The first has been to establish what the HEI's requirements for an information service are: the second has been to find out what information services are already in existence and to determine the extent to which they satisfy those requirements.

#### 2.3.9.3 The EASE Survey (JRK, DAD, SKR)

Part of the EASE programme involves a survey of current IT practises and perceived future IT needs within the EB community. JRK, DAD and SKR have participated in this activity that involves an initial visit to a significant number of the HEIs in the UK, followed up by continued contact (to monitor the effect of the EASE programme).

During the visit guided interviews (using a questionnaire) are undertaken with members of the community and the findings thereby recorded. For example, JRK and Neil Calton (from DCSD) carried out the initial visits to Bradford University, Huddersfield Polytechnic, Sheffield Polytechnic and Sheffield University.

Using the Questionnaires from 10 such HEI visits (ie. about 100 in all), JRK made a very preliminary assessment of the findings of the HEI survey, in terms both of current practices and of requests for EASE provision. This formed the basis for short presentations which JRK made during the visits to Softlab and IPSYS. More detailed analysis is being undertaken within the EASE Environment and Information Directory activities.

### 2.3.10 Other EASE Activity

#### 2.3.10.1 BSI VDM (JCB, BR)

BR remains active on the BSI VDM committee, although his other responsibilities have overshadowed his involvement somewhat. His contributions over the past year have largely involved maintaining the source of the draft standard document. ISO has voted to accept the development of the BSI work as an ISO standard, so it is anticipated that this work will continue.

#### 2.3.10.2 IED Monitoring (BR, SKR, DAD)

BR is the Monitoring Officer for the IEATP project 1563, Foundations and Tools for Formal Verification (now named FST). The lead organisation is ICL Defence Systems Ltd. (project manager R. B. Jones), the other partners being Program Validation Ltd., University of Kent and Cambridge University. The project started in January, and will run for three years. The monitoring effort involves assisting in the production of a Project Plan, attending project meetings, and drafting quarterly reports on the technical and financial progress of the project.

SKR is the monitoring officer for three other IEATP projects (1150, 1253 and 1266) while DAD is monitoring the AniMate project.

#### 2.3.10.3 SL-GMS (JCB, BR)

JCB and BR are contributing towards an evaluation of the SL-GMS UIMS for the EASE programme. It is planned to determine the degree to which a high-quality interface can be constructed for an existing (preferably Fortran) program with as little alteration of the program structure as possible. A copy of SL-GMS has been obtained and installed; unfortunately, it lacks the Fortran bindings that are needed for this part of the evaluation. At the time of writing, SL's UK distributors have promised to send suitable bindings.

#### 2.3.10.4 SGML (DAD, BMM)

DAD and Ruth Kidd (DCS Division) have been exploring the applicability of ISO/IEC document interchange standards to the problem of exchanging technical documentation and other documents within the HEI and Research Council's establishments servers by the SERC/Computer Board Advisory Group on Computer Graphics (AGOCG). A joint paper was submitted to the AGOCG SGML Workshop in march 1990 on experiences with using the Standard Generalised Markup Language (SGML) to describe parts of the RAL GKS User Guide.

The Workshop recommended that some experiments be carried out using SGML and AGOCG subsequently endorsed these. DAD, BMM and RMK have subsequently devised a workplan for this and are in the process of mounting the German Research Network's (DFN) DAPHNE software at RAL. DAPHNE is a translation tool for converting documents described with SGML Markup to the markup of a target formatting system such as troff or LaTeX. This will be used as the basis for the experiments. So far, the DAPHNE system has been acquired, but the first version received was mis-configured and a replacement has only just been received.

#### 2.3.10.5 SEG Young Scientists Course (JRK, JCB, BMM, BR)

In March, the group gave a one day tutorial to a group of trainee Young Scientists entitled An Introduction to Formal Methods. The course covered the role of formal methods in software engineering, the fundamental concepts of specification and refinement, and an overview of some topics of current research in formal methods. It is hoped that the material from this course can be reused at some stage, perhaps through publication.

#### 2.3.10.6 LCF and ERIL (BMM)

BMM continues to distribute the Rutherford Standard ML / Cambridge LCF system, although requests for this system are declining. In addition BMM also supports the ERIL equational reasoning system.

#### 2.3.10.7 ARGOSI (DAD)

DAD contributes to the Department's involvement in the ESPRIT II project, ARGOSI. The project concerns the integration of graphics and networking standards. DAD's main contributions have been to a workpackage concerned with a classification scheme for applications in terms of graphics and networking requirements, and to some of the management aspects of the project.

#### 2.3.10.8 Eurographics

DAD is Treasurer of the European Association for Computer Graphics. During the year he was Secretary of the Organising Committee for a joint Eurographics/ESPRIT Workshop on User Interface Management Systems and Environments, held in June 1990 and is also co-chairman, with Carlo Vandoni at CERN, of the technical programme for the EUROGRAPHICS '90 conference to be held in September 1990.

### 2.3.11 Conferences Attended

**SKR**

- Introduction to Software Reliability, London, 23rd March 1990
- Software Methods for the 1990s, London, 9th May 1990
- NAMAS, Kingsgate House, London, 24th May 1990
- EASE-90, UMIST 18th-20th April 1990

**JRK**

- EASE 90 (UMIST, April 90)
- Which CASE Tool (Scandic Crown Hotel, Victoria, London, June 90)

**BMM**

- British Colloquium on Theoretical Computer Science, Manchester Univ, 28-30th March 1990.
- Model Based Specification Methods Tutorials - 2 tutorial days (17th-18th March) preceding the Third International Symposium of VDM Europe, Kiel,
- FDR, 19-21st March, 1990.
- SUN CASE tools seminar, Bristol, 16th May 1990.

**CMPR**

- Refinement Workshop at IBM Hursley 9 January 1990-11 January 1990
- BCTCS 6 at Manchester 28 March 1990-30 March 1990
- ACM Lisp and Functional Programming Conference, Nice, France 27 June 1990-30 June 1990

**JCB**

- Third International Symposium of VDM Europe: VDM 90,VDM and Z. Kiel, 17-20 April.
- Refinement Workshop, Hursley, 9-11 January 1990
- 6th British Colloquium on Theoretical Computer Science. 28-29 March 1990
- Second Software Quality Workshop, Dundee 26-27 June

**BR**

- VDM 90, Kiel, 17-20 April
- Eurographics Workshop on Object-Oriented Graphics, Konigswinter, 6-8 June. (submitted and presented short position paper)
- Second Software Quality Workshop, Dundee 26-27 June (submitted and presented paper)

**DAD**

- Integration, BCS Displays Group, February 1990
- SGML Workshop, Abingdon, March 1990
- Workshop on User Interface Management Systems and Environments, Lisbon, 4-6 June 1990.
- Yugraph '90, Dubrovnik, 18-22 June 1990.

### 2.3.12 Courses Attended

**SKR**

- Displaywriter 370, RAL, 10th April 1990
- TMI Time Management Course, Bristol, 7-8th June, 1990,

**BMM**

- CSP Course, Rutherford Appleton Laboratory, October 1989.
- TMI Time Management Course, Bristol, 7-8th June, 1990,
- CSP Course (Given by Jim Woodcock and Jeremy Jacobs of PRG, Oxford) (RAL, October 89)

**CMPR**

- CSP course at RAL 30 October-3 November 1989
- Time Management Course, Bristol 7 June-8 June 1990
- CSP Course (Given by Jim Woodcock and Jeremy Jacobs of PRG, Oxford) (RAL, October 89)

**JRK**

- Management I Course (JTS) (Bournemouth. September 1989)
- CSP Course (Given by Jim Woodcock and Jeremy Jacobs of PRG. Oxford) (RAL, October 89)
- FrameMaker Course (RAL, October 89)
- Management II Course (JTS) (Urchfont Manor. Devizes. January 1990)
- Advanced Software Testing Course (University of Liverpool. May 90)
- GRANTDSS Database Course (Swindon Office, May 90)

**JCB**

- TMI Time Management Course, Bristol. 7-8th June, 1990.
- CSP Course (Given by Jim Woodcock and Jeremy Jacobs of PRG, Oxford) (RAL, October 89)

**BR**

- CSP Course (Given by Jim Woodcock and Jeremy Jacobs of PRG, Oxford) (RAL, October 89)

### 2.3.13 Papers

#### 2.3.13.1 External

- Dick, A.J.J., Kalmus, J .R. and Martin, U. , Automating the Knuth Bendix Ordering, Acta Informatica.
- Bicarregui, J.C., Mural: a system providing support for the formal development of software Seminar at Brunel University: 12th December 1989.
- Ritchie. B. and Taylor, P., The Interactive Proof Editor: An Experiment in Interactive Theorem Proving in: G. Birtwistle and P.A. Subrahmanyam (eds.). "Current Trends in Hardware Verification and Automated Theorem Proving", Springer-Verlag. 1989.
- Ritchie, B., Machine support for reasoning about VDM developments. Second Software Quality Workshop. Dundee 26-27 June 1990.
- Reade, C.M.P., Formal Methods for Reliability with P. Froome in CSR Reliability Handbook. (Ed. P. Rook) Elsevier. April 1990.
- Reade. C.M.P., Formal Methods for Software Engineering (with Prof. Pat Hall, Brunel) to EFFEM Managers at Wokingham Crest Hotel January 1990.
- Reade. C.M.P., Tree Balancing, An Exercise in Rewriting and Proof QMW. London University for Maths & C.S. seminar series March 1990.
- Reade. C.M.P., Developments in Formal Methods CSR Conference, Brighton June 1990.

- Matthews, B.M. and Bicarregui, J.C., The Incremental Development of a Higher-Order Matching Algorithm - UNIF'90. Leeds, July 1990.
- Bicarregui. J. C. and Ritchie. B., Machine support for reasoning about VDM developments, Second Software Quality Workshop. Dundee 26-27 June 1990.
- Bicarregui, J.C. and Ritchie, B., Providing support for the formal development of software, in: "SDE&F 1: Proceedings of the 1st International Conference on System Development Environments & Factories", eds. N. Madhavji, W.Schafer and H. Weber, Pitman, 1990.
- Duce, D.A. and Kidd, R.M., The DAPHNE Document Types and AGOCG , The Use of SGML for the UK Academic and Research Community - Workshop Proceedings, March 1990.
- Duce, D.A., SGML Documents and Computer Graphics, Eurographics UK Chapter Conference, April 1990.
- Gallop, J.R., Day, R.A., Maybury, R. and Duce, D.A., Integration of Graphics and Communications in ARGOSI , BCS Systems Integration and Data Exchange State of the Art Seminar, February 1990.
- Hopgood, F.R.A. and Duce, D.A. , "PHIGS Tutorial Notes", Yugraph '90 conference, June 1990.
- Duce, D.A., Formal Methods in Computer Graphics, Proceedings of Yugraph '90, Automatika 31 (1-2), A.323-A.338 (1190).
- Duce , D. A. and ten Hagen, P. J. W. and van Liere, R., An Approach to Hierarchical Input Devices, Computer Graphics Forum, 9(1), (1990).
- Duce, D.A. and Hopgood, F.R.A., Introduction to the Computer Graphics Reference Model, BITS Newsletter 4 (1/2), pp 2-6.
- Reade, C.M.P., Balanced Trees with Removals: An Exercise in Rewriting and Proof Brunel Technical Report. July 1989.
- Arnold, D.B. and Duce, D.A., ISO Standards for Computer Graphics - The First Generation, Butterworths (1990).

#### 2.3.13.2 RAL Reports

Brodlie, K.W., Duce, D.A. and Hopgood, F.R.A., Second Generation Computer Graphics Standards, RAL Report RAL-89-097, 1989.

#### 2.3.12.3 Internal

- Reade, C.M.P.,Logic & Functional Programming: Some Cross-Fertilisations SEG talk February 1990.
- Matthews, B.M., SED Note 73, trip report on BCTCS '90
- Thomas, D., Kalmus, J .R., Chanda, S .K. and Maybury, R., EASE Information Directory Feasibility Study: Interim Report to IDHM, IDHM/P62/90, June 1990
- Bicarregui, J.C. and Reade, C.M.P. , Trip Report: Refinement Workshop, Hursley,
- Bicarregui, J.C. and Matthews, B.M., Trip Report: BCTCS Manchester.
- Ritchie, B., Esprit Proposers' Day, Brussels October 1989. SED note 62
- Robinson, S.K., EEWP/P5/90. EASE In-house Seminars & Education. Ease Environment Working Party Report.
- Robinson, S.K., EEWP/P6/90. Environments Report Ease Environment Working Party Report.
- Robinson, S.K., EEWP/P9/90. Software Development & Case Tools (with Ken Hartley) Ease Environment Working Party Report.
- Robinson, S .K., EEWP/P19/90 Help Systems and The Role of Hypermedia. Ease Environment Working Party Report.

### 2.3.14 Objectives for 1990/91

The overall objective of the EASE environment project is to develop a national IPSE for EASE by the mid 1990s. The environment is to be based on de facto standards and designed to stimulate and encourage engineers to use appropriate, state-of-the-art software and hardware to enhance their research. Its use is to be encouraged by being designed so that it can be populated by a set of

tools or modules with wide applicability. The software environment and information directory work can be seen as an ongoing commitment on the group throughout 1990/91

SEG research projects should lead towards increasing SEG's strength in

1. theoretical computer science
2. formal specification
3. proof techniques
4. tools
5. metrics

The ongoing ZIP and LOTOS projects will contribute to achieving these objectives whilst the anticipated RAISE User Trials project should broaden the group's area of expertise. We are keen to integrate the equational reasoning and proof assistant work which, although research proposals in 1989/90 attracted alpha ratings, have yet to attract funding.

## 3. DESIGN DIVISION

### 3.1 INTRODUCTION

Design Division consists of three groups - Applications Integration, Systems Interface and User Interface - together with the Transputer Coordination Unit which incorporates the London and South-East Regional Transputer Support Centre.

The objectives of Design Division are:

1. to provide effective support for programmes such as EASE and the Transputer Initiative which are targeted at the Engineering Community, and
2. to carry out an associated series of R&D activities supported from a variety of funding sources (SERC, DTI, CEC, as well as from industrial sources).

Specific highlights of the past year, which are detailed in the sections below, are:

a. Community Club in Modelling and Manipulation of Engineering Data established.
b. Clarification of and action on our role in the Automotive Design Programme.
c. IDAM proposal accepted by Esprit.
d. X tutorial run at EASE 90.
e. X-Toolkit Assessment under way.
f. ECSTASY Beta Test Version 1.5 distributed.
g. First Specification Phase of EKS completed.
h. Design of Interaction Framework for EWS completed.
i. Report and Seminar to Community on first UIMS Assessment.
j. ELO Phase 1 deliverable, the Integration Framework Specification, met.
k. Transputer Initiative loans pass 100 mark.
l. Two Transputer Centres (Sheffield and Strathclyde) operating as self-financing Centres with no further Initiative funding.
m. Joint British-Soviet Workshop on Transputer Systems in Moscow.

The Division expects that its main objectives in the coming year will be:

i. Reorganisation of structure to improve its basis for future work by having two Groups, each headed by a Grade 7. Overall work objectives are not expected to change.
ii. Support for the Engineering Community, primarily through the EASE Programme. This will include the provision of tools, assessment reports, and involvement in education, awareness and training.
iii. Continuation of R&D activities that provide a synergy with EASE Programme activities.

In addition to these broad targets, each Group and the Transputer Coordination Unit have identified their own specific objectives for 1990-91. These are detailed, together with a review of 1989-90 activities, in the sections that follow.

## 3.2 APPLICATIONS INTEGRATION GROUP (AIG)

### 3.2.1 Staffing

Staff in post:

- Bryan Colyer (BC) Group Leader (retired 31 May 1990)
- Jan Van Maanen (JVM) Section Leader, Interfaces
- Deborah Thomas (DT) Section Leader, Databases
- Kevin Duffey (KD)
- Kevin Lewis (KML)
- Mike Mead (MM)
- Alan Middleton (AJM)

### 3.2.2 Objectives for 1989/90

The objectives for the group were to contribute to the developments of standards in engineering data exchange, to increase the awareness of these standards in the academic community, to investigate how these standards can be implemented into a database as an aid to applications integration, and to contribute to the Automotive Design Project (ADP).

### 3.2.3 EASE Education and Awareness (BC, JVM, DT, MM)

A number of articles on the work and achievements of the group have been written and published in the Engineering Computing Newsletter. The articles deal with data exchange in general, results from the CAD*I project, a description of Standard for the Exchange of Product Data (STEP), a description of the Express language, the database implementation work and Computer Aided Acquisition and Logistics Support (CALS).

All members of the group participated in the EASE HEI visits.

### 3.2.4 Community Club (JVM, MM)

Staff of the Interfaces Section have been instrumental in setting up a Community Club on Modelling and Management of Engineering Data. The first open meeting of the club was held on 4 June with 25 attendees, and the first meeting of the Executive of the Club will take place on 31 July. After the open meeting, MM was appointed secretary of the Club. The aims of the Club are to assist engineering academic staff in solving their data modelling and data management problems and to provide a focal point where engineers can discuss problems and solutions. Industrial participation in the Club is being encouraged.

### 3.2.5 Automotive Design Project (JVM, DT, KML, MM, AJM)

Both sections of the group have given support to the ADP which has its Central Support Unit based at the University of Birmingham. A CADDS-4X system has been installed at RAL, and initial familiarisation with the system has taken place. A project has started to investigate the requirements of the ADP grantholders with respect to hardware, software and networking.

CADDS-4X is a system for Computer Aided Design which is widely used in the automotive industry. The RAL system is running on a Sun-4 SPARC workstation.

A project has started to investigate the requirements of the ADP grantholders with respect to hardware, software and networking (JVM, MM).

KML has just started work to provide the ADP with a central database in which to store all the results from the ADP projects. At present this work is in the definition stage and a questionnaire has been distributed to all ADP grant holders to determine what data they will want to store in the database.

### 3.2.6 STEP Participation and Software Development (JVM, DT)

DT and JVM attended a number of meetings of the STEP project. The main aim of attending the meetings is to ensure that the group remains abreast of the latest developments in data exchange and data modelling. During the year, JVM was appointed chairman of the STEP working group dealing with the physical file format and STEP implementations.

JVM and DT attended meetings of BSI AMT/4 which is monitoring the progress of STEP. DT also attended meetings of BSI AMT/4/ - /3 and AMT/4/-/6, the panels which are involving industry in the development of the Finite Element Analysis and Materials parts of STEP.

The file reader and parser, which was originally written for the CAD*I project was successfully converted to deal with STEP exchange files. The documentation of the program has been updated. A back-end to the file reader was written which provides an interface to the Nastran Finite Element program (JVM, AJM).

The Express compiler is finished except that it needs to be brought in line with the latest definition of the language. One output module of the compiler is a pretty printer which reads models written in the Express language and produces a properly spaced copy of the input. Another output module which will generate SQL statements from the Express model is in its planning stage (MM).

The software has been distributed to a number of academic and industrial organisations, both in the UK and overseas (see 3.2.7 below).

The STEP implementation committee are just starting to work on an applications programming interface (API) which will provide independence between applications using STEP and the storage method. This will be very useful for applications integration. KPD is working on a trial implementation to test out the feasibility of using an API accessing a relational database. A neutral database for electromagnetic and semiconductor modelling data has been created based on an EXPRESS schema and a mapping from EXPRESS to SQL. Genera1ised subroutines to access the database are in the final stages of development.

### 3.2.7 Organisations supplied with the Express compiler and/or the physical file reader

RAL retains the Intellectual Property Rights of the software written in the Group. Under licence, 21 organisations have been supplied with the software. These comprise: 10 UK HEIs, 3 overseas HEIs and research institutes, and 8 other organisations as follows:

- University of Cambridge
- Coventry Polytechnic
- University of Glasgow
- Engineering Design Research Centre
- University of Loughborough
- University of Manchester
- University of Sheffield
- South Bank Polytechnic
- University of Warwick
- Wolverhampton Polytechnic
- Technical University of Delft (Netherlands)
- Rensselaer Polytechnic Research Institute (USA)
- Universitat Stuttgart (Germany)
- CEGB
- Det Norske Veritas (Norway)
- General Dynamics (USA)
- Gesellschaft fur Strukturanalyse (Germany)
- JET
- McDonnell Douglas Corporation (USA)
- National Institute of Standards (USA)
- Saab Aircraft Division (Sweden)

### 3.2.8 EASE Information Directory

From April to June, DT spent 50% of her time leading the EASE Information Directory feasibility study. This is a project which is looking into the requirements of the EASE community for a wide range of on-line information. It is investigating what information is already available and will present a proposal to Computing Facilities Technical Advisory Group and Computing Facilities Committee in September for setting up a. service at RAL. The study is being undertaken by a cross-divisional working party, the other members being Bob Maybury (CMD) , Subodh Chanda (DCSD) and John Kalmus (SED).

### 3.2.9 ESPRIT

The group submitted three proposals under the ESPRIT programme, of which one was accepted. The project Integrated Design and Analysis Environment for Advanced Magnetic Devices (IDAM) will run for 2 years and requires an effort of 1.5 my per annum. The subject of the grant is the streamlining of data exchange between a number of packages which are required for the design of electromagnetic devices. These packages are designed for specific purposes like geometric design, structural or thermal analysis, or electromagnetic analysis.

Some initial planning work has been done by JVM and DT this year but it is envisaged that most of the work for this project will be taking place in the next two reporting years.

### 3.2.10 General

Mike Mead attended the MSc course on Computer Science at Brunel University on day release. He has successfully passed his second year exams.

### 3.2.11 Conferences and Meetings Attended

- 26-30 Jun 89, Frankfurt, ISO TC184/SC4/WG1 (STEP) meeting (JVM)
- 16-20 Oct 89, Albuquerque, ISO TC184/SC4/WG1 (STEP) meeting (JVM,DT)
- 22-26 Jan 90, Paris, ISO TC184/SC4/WG1 (STEP) meeting (JVM)
- 18-20 Apr 90, Manchester, EASE '90 Conference (JVM, KPD)
- 23-27 Apr 90, Reston, ISO TC184/SC4/WG1 (STEP) meeting (JVM,DT)
- 25-29 Jun 90, Gothenburg, ISO TC184/SC4/WG1 (STEP) meeting (JVM)

### 3.2.12 Courses Attended

- 21-25 Aug 89, Introduction to C Programming (KPD,DT)
- 6-8 Dec 89, Parallel Fortran Course (AJM, MM)
- 27 Mar 90, Object Oriented Programming (MM)
- 19-20 Apr 90, Parallel Fortran Course (KPD)
- 8-11 May 90, Relational Databases (KML)

### 3.2.13 Papers Published

- B Colyer, Data Exchange at RA, Engineering Computing Newsletter, Issue 14.
- D Thomas, Use of CALS for Product Data Exchange, Engineering Computing Newsletter Issue 14, 28 August 1989.
- J Van Maanen, The STEP Standard for Engineering Data, Engineering Computing Newsletter Issue 15, 26 September 1989.
- M Mead, Data Modelling Language "Express", Engineering Computing Newsletter Issue 16, 31 October 1989.
- J Van Maanen, Proposal for CCDE-Community Club on Data Exchange, 'Engineering Computing Newsletter . Issue 16, 31 October 1989.
- J Van Maanen, Community Club for Modelling and Management of Engineering Data (Meeting Report) , Engineering Computing Newsletter Issue 24, July 1990.
- J Van Maanen and J Leuridan, Methods for Exchange of Finite Element Analysis Data and Integration of Finite Element Analysis and Prototype Testing, accepted by International Journal on Computer Integrated Manufacturing'.

- D Thomas, J Van Maanen, M Mead (Eds) , Specification for Exchange of Product Analysis Data, Version 3. Published by Springer Verlag, 1989.
- D Thomas, Implementing the Emerging International Standard STEP into a Relational Database, Proceedings of the 8th British National Conference on Databases, July 1990.

### 3.2.14 Objectives for 1990/1991

The main objective for the next year is to make all aspects of the expertise of the group available to the academic community. We intend to disseminate our results and information as widely as possible, both in the fields of data exchange and engineering databases. In relation to this, the Community Club on Modelling and Management of Engineering Data will be supported wherever possible.

All software developed by the group will be made available to the academic engineering community as part of the EASE project.

Effort will be devoted to participation in STEP and similar activities relating to data exchange with the aim of keeping abreast of new developments in this area. Further effort will be given to developing an implementation of an Application Programming Interface to STEP based on a relational database and the results of this work will be disseminated to the UK academic community.

A significant amount of effort will be devoted to support of the Automotive Design Project headed by the University of Birmingham, which involves other academic institutions and automotive industry partners.

## 3.3 SYSTEMS INTERFACE GROUP

### 3.3.1 Staff

Staff in post during the year were:

- K Robinson (KR) Group Leader
- V A Burrill (VAB) Novel Interfaces Section Leader
- C A A Goswell (CAAG)
- I Wilkinson (IW)
- T A Watson (TAW) Window Management Section
- A V Shrimpton (AVS)
- D Mac Randal (DMR) Software Environments Section Leader
- K G Dancey (KGD)
- B P K Lee (BPKL) (joined 21 October 1989)

### 3.3.2 Group Objectives

The group's major interests are in providing tools, techniques and environments for the engineering community. The tools and techniques are directed at support for highly interactive user interface design; the environments provided are aimed at providing productive, integrated software for engineering applications development and execution. To this end, the Group undertakes a range of activities, from research (with a practical flavour), through advanced and conventional development, to support. Each activity is intended to act as a source of ideas and inputs for the others.

### 3.3.3 X Window Management System (TAW, KR)

TAW has provided consultancy services on X to a number of groups and projects within RAL. TAW and KR, with John Bovey of the University of Kent at Canterbury (UKC), gave a seminar entitled Introduction to X at the EASE90 Conference. TAW also gave a presentation on X to Design Division. Some work has been done in making software expertise available to provide a path to XllR4 from R3.

### 3.3.4 User Interface Design Toolkits (AVS, CAAG, TAW, KR)

There have been two main activities here. The first has been a continuing activity with the RAL toolkit WW. Some time has been spent by AVS on minor bug fixes, and on understanding and rationalising the WW code to ease maintenance. Some student work on circular menus has been generalised so that elliptical and semi-elliptical menus are now supported, with a fast find mechanism which enables choices to be made by movements in the horizontal plane only.

Some time has been spent on understanding, if not totally resolving, problems with inverse video and cursors under both X and SunView. CAAG has proved a valuable repository of background information about WW. Some tracking work has also been undertaken - compiling new versions of WW for X11R3, a new version of ten for general use, and generating SPARC versions of Spy for Support to distribute outside RAL.

The second activity has been an assessment of the toolkits available with X, jointly with staff in DCSD, for the EASE programme. These toolkits split broadly into two groups - those that are Xt Intrinsics based, and the rest. Of the rest, most are written in C or C++. TAW drew up the toolkit evaluation strategy and workplan, which then went through a number of iterations following comments within ID. A major activity following that was to design a questionnaire to gather user requirements for these toolkits. This was a fairly successful exercise, and much useful information has been gained; this information has been used to draw up a list of assessment criteria. Some time has also been spent on familiarisation with some of the toolkits on the evaluation list. An X Toolkits Working Party is being established (under the chairmanship of Professor Peter Brown at UKC), to direct the work and eventually report to the Computing Facilities Technical Advisory Group (CFTAG).

One spin-off activity has been that TAW has given a talk on toolkits to an IEE Colloquium in London.

### 3.3.5 Other EASE Activities (Whole Group)

Almost the whole group has been involved in the HEI visits.

TAW is Minute Secretary to the Computing Facilities Committee.

KR was a member of the Engineering Computing Facilities Executive (ECFE) for a while, acted as a monitoring officer for the UKC EMR, and was part of the team that discussed the proposal by Gosman's group at Imperial College of Science and Technology (ICST) for EASE funding. He has also been involved with contributing to the establishment of the heavily-revised EASE Schedules. Both KR and VAB have provided input on occasion to the EASE Environment design.

### 3.3.6 ECSTASY (KR, DMR, KGD, BPKL)

This project, funded by the Control and Instrumentation Sub-Committee via the Computing and Design Techniques for Control Engineering (CDTCE) Management Committee, is aimed at providing a common environment for control engineers, for both standard package access and control system algorithm development. The basic environment is developed at UMIST's Control Systems Centre under an SERC development contract, with other developments taking place in other HEIs. RAL's role is to provide management and technical support (but without overall project management responsibility), organise beta testing, and so on. Longer-term, user support responsibilities remain at RAL.

A new version of the ECSTASY 1.5 beta-test software arrived from UMIST in late 1989 and this second beta-test got under way. Direct user support was provided by KGD, with DMR as necessary. Like the first beta-test, this was a 3 month evaluation by 4 academic institutions in collaboration with some industrial partners. A number of problems were encountered with installation, but once these were fixed all the sites were able to carry out the test programme. This consisted of tackling a UMIST supplied problem, followed by a problem suggested by the industrial partner. As for the first beta-test, feedback from the sites was collected informally at a workshop held at RAL and more formally by means of a detailed questionnaire that was filled out by both

users and installers of the software. There were noticeably fewer bugs reported, most of the comments being about the overall system design, and overall performance of the system.

The work of integrating TSIM into ECSTASY has now been largely completed, with BPKL doing most of the programming, guided by DMR. The issues outstanding all relate to the way in which current TSIM users wish to access the TSIM facilities and the clash between that and the encompassing ECSTASY system. System documentation for the TSIM interface is now being produced.

Towards the end of the period of this report, the beta 2.0 software was received from UMIST, but the significant number of changes since the 1.5 release has made the system somewhat fragile. The problems so caused are currently being investigated. It is intended that the beta test will take place over the summer, with the autumn being used to generate a productised version based on the last PA Set release.

KR attends meetings of the CDTCE Management Committee and liaises at the management level with the CDTCE Coordinator and UMIST.

At a number of points in the year, problems were experienced with the basic IDUS service which affected our ECSTASY work. Particular problems were filestore corruptions on nfs6, and the time taken to obtain and install the FORTRAN 1.3 compiler from Sun, and its corresponding manuals.

### 3.3.7 Energy Kernel System (DMR, BPKL)

The Energy Kernel System (EKS) is an object-oriented programming (OOP) environment for building thermodynamic analysis software. The majority of the funding for EKS comes from the Building Sub-Committee although our work is funded through the EASE programme. Its main objective is to enable research teams currently investigating various aspects of building simulation, especially thermodynamic performance to use software easily and safely from other groups for those parts of the overall appraisal system that are not directly concerned with their research. A second objective was to enable a collection of validated components/sub-systems to be built up, so that the robustness and integrity of appraisal software could be improved.

This leads naturally to OOP and object-oriented databases (OODB). However, as the OOP approach to thermodynamic simulation is still unproven, it is important to show that the use of the EKS and its OOP approach will bring substantial benefits even in the construction of conventional simulation packages.

Phase 1 of the project, the development of the Prototype, is nearing completion. An initial class hierarchy design capable of supporting current state-of-the-art energy models was completed early this year. Three example problems of increasing complexity were selected, modelling site conditions, modelling the thermal processes within as wall and modelling a complete room including a piece of plant. The necessary classes were implemented for the Prototype, a simple model building program developed and the three test models built.

The experience gained building the Prototype has been valuable. The main findings were that, whereas control of the system and in particular control of the time-stepping turned out to be simpler than expected, the design of the information flow between the objects was much more complex than anticipated. The ONTOS database has proved useful, if a bit cumbersome, providing several facilities that simplify the development of the model building facilities as well as acting as a straightforward object database, but care has to be taken not to become locked into this product.

Though the main function of the Prototype was to act as a test bed for the EKS team, feedback has been obtained from other groups on both the design of the class hierarchy and the functionality required by the end users. Based on this feedback, an external evaluation of the Prototype and experiences in building it, a specification for the final EKS Demonstrator will be drawn up.

DMR acts as the project manager, with only minimal involvement by KR. He provides most of the technical input into the project with BPKL gradually building up expertise in the C++ area.

### 3.3.8 IT Applications Initiative (DMR, BPKL)

RAL has been providing support for the Environment Committee's IT Applications Initiative. Apart from direct support for the Coordinators of this program, the main task carried out has been the setting up of a "loan pool" of workstations. This involved obtaining eleven Sun SPARCstations and installing them in various departments around the UK. The intention is that these will act as a seed, enabling the exploration of IT tools and techniques by the departments concerned. Basic system administration courses have been run for individuals from the selected departments and a programme of visits by RAL staff will provide IT expertise and advice.

### 3.3.9 Extensible Graphics Programming (CAAG, KR, VAB)

This is a SERC-funded project to investigate ways with which extensibility can be built into a graphical programming environment.

Most of the detailed work is being done by CAAG, with occasional contributions from KR and VAB. During the year, the design of the User Interface construction tool has been refined. The WW toolkit on which the current work is based has been enhanced to provide the few remaining facilities needed to make the extensible tools being constructed useful. These include a text editing widget and various widgets for managing layout and screen menus. Integration of external command streams with graphical input is now supported by generic tools. Some work has gone into arranging for the graphical selection to be seamlessly integrated with both the WW widgets and the host window system.

A new graphical editor has been constructed, along with a graphical tool for connecting UNIX-style commands directly to a graphical environment. This provides a degree of convenience and flexibility not previously available in a graphical context. The construction of this new software technology has paved the way for the UI tool to be re-engineered into a solid tool for general use, which is now well under way. The general aim is to return to the UNIX philosophy by making small tools which do a simple job well, but allowing them to be combined in powerful ways. To this end, the new editor has hooks to allow it to be controlled by another program (which is normally another graphical tool operating on behalf of the user). A number of experimental " tools have been built which demonstrate various ways of making user interfaces configurable. From these tools, a mail tool and a USENET news browser have been built, though they are not developed enough yet to be useful in their own right.

A seminar on Extensible Graphical User Interfaces was presented at the University of Kent and a similar paper has been submitted for the conference The Many Faces of Design later this year.

Progress with facilities built on the WW toolkit have largely overcome the problems last year with the lack of the anticipated Object Oriented toolkit. WW continues to provide a flexible and appropriate environment for User Interface Innovation.

### 3.3.10 EuroWorkStation - EWS (KR, VAB, IW, CAAG, TAW, TC, MJP, CPW, BWH, DJJ)

This ESPRIT II project spans a number of groups within the Department, covering contributions from UIG in DD (TC, MJP) and Parallel Processing Group in CMD (CPY, DJJ, BWH), as well as this group. It aims to develop state of the art hardware and software for a European contender in the Stardent/Silicon Graphics market. The project is in several parts, and that with RAL involvement is to develop a board and associated software to enable quality 3D graphics interface to be developed. This part of the project is known as GRACE (GRaphics ACcelerator Engine), and RAL's role is to provide an Interaction Framework which will act as a vehicle for high-quality user interface design. The work covers a range of topics. These include:

a. a two-stage user requirements analysis;
b. development of a class hierarchy (The Kit) to provide a C++ library of "useful things";
c. provision of Xlib (on the client machine) and an X server (on the GRACE hardware);
d. extension of Xlib and the X server to cope with the 3D and other GRACE extensions; and

e. shortlisting of available novel input devices, and purchase and assessment of the chosen one - the VPL DataGlove.

The first phase of the requirements analysis was a broad brush approach at a wide range of possible uses the EYS could be put to, with a view to determining what range of facilities would be needed. The second phase was more detailed, but concentrated on far fewer possible applications. Everyone contributed to this part of the task, but with VAB taking the major part of the work. This phase of the project was one of the elements providing input into the development of a class hierarchy for an object-oriented toolkit, undertaken mainly by IY, with input from CPY. An assessment of the demands from a diverse set of sources graphics standards, other toolkits, environments such as Small talk , advanced graphics software such as Dore and RenderMan, as well as the requirements analysis, were used here. Implementation by IY on The Kit has begun on two class categories of Interaction and 3D. To enable the rapid prototyping of applications compliant with The Kit, an interface prototyper (Constructor Set) is being implemented within the OpenWindows environment using the NeWS toolkit (tNt). Support for lightweight processes and inter-client communication is being provided by integrating the necessary Chorus functionality into The Kit. A simple NeWS implementation of the Squeak user interface language was developed to provide a vehicle for experimenting with gesture.

BWH has looked after the building of the X server on the development environment provided (four months late!) by the Chorus Systems people. There has been a long learning curve associated with the Chorus distributed operating system, and how it relates not only to the X server but also to the specialised hardware. A deaf and dumb X server now runs on the Chorus machine - this can only receive events via an input file, and prints results via printf's rather than by displaying items on the screen. A sequence of more and more talking-and-listening servers is planned to enable the final system to be built on the target hardware/ software. DJJ has defined - a few times now - the interface the graphics hardware partners in Darmstadt should be working to, and has begun the simulation software development, with VAB's help, here at RAL. This will be built on top of that interface so that the higher levels of software can be built on Suns here at RAL before the porting exercise begins to the (indubitably flaky) hardware later in the (calendar) year.

MJP, with TC's help, has begun the evaluation of the DataGlove 3D input device, using the demonstration software supplied with the DataGlove. A number of ID staff have been put through the evaluation mill, with the objective, at this stage, of assessing the Glove against the mouse as an input device on a number of tasks. CAAG has interfaced the Glove to the Sun RS232 port, and DJJ has built on this work to show the orientation of the hand on the Sun screen.

Although names have been associated with specific parts of the project, it should be stressed that this has been an intensely cooperative project, with most people at least commenting at most stages. VAB has provided much of the day to day management on the project, with KR looking after the higher-level issues and the relations of the project externally, and to the RAL financial and administrative mechanisms.

### 3.3.11 The ELusive Office ELO (TAW, IW, KR)

Work on this project is reported fully in the UIG section of the report. TAW has been spending most of her time on this since April 1990, with various consultancy tasks being undertaken as necessary, mainly by KR, CAAG, and IW.

### 3.3.12 Open Days Information Service (AVS, KR)

AVS designed and implemented a route display program for the Open Days. This provides a distributed program with six remote stations connected to one or more master terminals, with the software being run by an experienced user. A wide range of information is provided for the visitor, including the demonstrations to be seen at each location and some interest-to-demo matching. Frame-grabbed images of the site are displayed at relevant places. Data for the map used was taken from the Prime-based Medusa system and then adapted.

### 3.3.13 Proposals

#### 3.3.13.1 Intelligent Front End (DMR)

There has been substantial interest in the Intelligent Front End (IFE) by the energy modelling community. Numerous universities, including some in Europe and the USA, have asked for the software; both the Building Research Establishment and the DTI Energy Technology Research Unit are looking at it with a view to adapting it for their simulation work; and the standards committee of the Building Environments Performance Assessment Club, (a community-initiated(!) community club), is interested in it to provide standard interface to the wide range of energy models. Several companies have also expressed an interest, to the point of being willing to participate in follow-on research projects. Unfortunately, as it :is built on top of some proprietary software, there are problems with its distribution.

It is intended to a) carry out a proper field trial of the system, in collaboration with industrial partners, b) enhance the capabilities of the system, and c) explore further the 'conceptual mapping' aspects. To this end, proposals have been submitted to the CEC Joule programme and SERC, but, in spite of the very positive comments received, to date there has been no funding forthcoming. (In fact the Joule programme was cancelled for lack of funding; recently the Commission have asked us to resubmit the proposal.)

#### 3.3.13.2 EWS2 (KR, VAB, TC, IW, CAAG)

A follow-on proposal to EWS was submitted to the Commission, which built on the work done in the first part of the project. Unfortunately this was not funded, for reasons which seemed to be more political than technical.

#### 3.3.13.3 EuroCoop (TC,KR)

KR has contributed to discussions on the preparation of this ESPRIT 2 proposal, reported fully under the UIG section. The proposal was agreed as technically suitable, but with only 23% of the requested funding. In the subsequent negotiations the RAL and Lancaster University bits fell (well, more were pushed, really) by the wayside.

### .3.14 Other Activities

As usual there are some items which do not fit cleanly into any of the above categories. They are presented in no particular order.

#### 3.3.14.1 IED Support

KR is Monitoring Officer for the PUMs project (now completed) and the UIDE project (just started).

#### 3.3.14.2 Exploitation of RAL Software

Believe it or not, we are now close to signing a contract with Pixel Designs Ltd to market ten, an activity that began at least as long ago as August 1985.

#### 3.3.14.3 Demonstrations (AVS,KR, and others)

The Alvey demonstration has been aired on several occasions including being video-taped for inclusion in the RAL video. SysIG staff are thus now stars of the TV screen, having conquered radio some time ago. AVS has all the demo software under her supervision.

#### 3.3.14.4 RAL Meetings (VAB,AVS,KR,CAAG)

AVS attends the User Services Meeting as one of the DD representatives, and reports from IDUUF to that meeting. KR attends the (infrequent) meetings of the Unix Liaison Meeting, of which CAAG is the secretary. VAB chairs IDUUF, and generally manages to keep the length of the meeting down to a reasonable length, no small achievement.

#### 3.3.14.5 EX Conference

KR is on the organising committee for this conference, which aims to establish an annual conference on the X Window System in Europe.

### 3.3.15 Conferences Attended

- TAW: IEE colloquium on Software tools for windows-based application development, March, talked about X toolkits.
- TAW, KR: EASE 90, April, UMIST, gave the Introduction to X tutorial.
- BPKL: EASE 90, April, UMIST
- DMR, KGD, KR: XTC workshops, UMIST, RAL - organisation
- DMR: SERC ITA Workshop, London, 16th Mar 90 - rapporteur
- DMR: BEPAC Meeting, Bath, 1st Jun 90 - exhibition & poster session
- IW: Computer Animation 89, London (8-9 November 1989).
- IW BCS Meeting: "Future Prospects for Constraint Languages," King's College, The Strand, London (27 March 1990).
- IW: Eurographics Workshop on Object Oriented Graphics, Konigswinter, Federal Republic of Germany (6-8 June 1990) Position paper presented.
- CAAG: Seminar on Extensibility at University of Kent - 2 February 1990

### 3.3.16 Courses Attended

- TAW: SERC Minute writing course, February.
- KR: 11/12 Sep OOD and Programming, London.
- VAB: C++: The Instruction Set, London, 1 week, August/Sept 1989
- VAB: Management I: SERC Internal course, Gt. Malvern, 11-15 December 1989
- BPKL: Seminar on "Software Maintenance", RAL 9 November 1989
- BPKL: C Programming Workshop, Instruction Set, London, 27 November 1 December 1989
- BPKL: Seminar on "Integrating human factors into software development", PRG and Dept. of Experimental Psychology, Oxford University, 15 February 1990
- BPKL; C++ Programming Workshop, Instruction Set, London, 19-23 February 1990
- BPKL: SQL/DS introductory & advanced courses, RAL, 9,16,23 March 1990
- BPKL: data exchange, parallel languages, parallel libraries & tools seminars at EASE 90, UMIST, 18-20 April 1990
- BPKL: "Issues in HCI Education & Training", BCS HCI SG Seminar, London, 25 June 1990

### 3.3.17 Papers

#### 3.3.17.1 External

- Clarke, J.A. & Mac Randal D.F., An Intelligent Front-End for Computer-Aided Building Design European Simulation Congress, Edinburgh, Sept 89
- Wright, A.J., Lockley, S.R., Clarke, J.A. & Mac Randal D.F. The use of OOP techniques in the UK Energy Kernel System for Building Simulation Mu1ticonference Simulation in Energy Systems, Nuremberg, FRG, 10-13 Jun 90
- VORTEXT: The Hard-backed Screen V A Burrell, J A Ogden Electronic Publishing - Origination, Dissemination and Design, 2(3) pp143-156 Ed. D F Brailsford, R J Beach, Pub. Wi1eys Oct 89
- M.A. Life, B.P. Lee & J .B. Long (1990) Assessing the usability of speech interfaces for future battlefield computers: a method and an illustration of its use Proc. of Voice Systems Worldwide 1990. New York: Media Dimensions. pp 121-125.
- M.A. Life, J.B. Long & B.P. Lee (in press) Human factors support for the procurement of interactive computer systems: the case of a structured method for the evaluation of future speech interfaces Special issue of Ergonomics (Cognitive Ergonomics), Taylor & Francis.

#### 3.3.17.2 Internal

- V A Burrill, Thoughts on EWS Applications, EWS Note 24, 19 Sept 89.
- V A Burrill, Requirements Analysis - General, EWS Note 26, 4 Oct 89.
- V A Burrill, EWS - Wind Tunnel requirements Analysis - Specific Note 36, 11 Oct 89.
- K Robinson, Outline Proposal for GRACE 2 , ESW Note 38, 3 Nov 89.
- V A Burrill,EWS Applications Requirements Analysis - Others EWS Note 41, 16 May 90.

- I Wilkinson, A Prototype class Hierarchy Design, EWS Note 56, Mar 90.
- C A A Goswell, Extensible Graphical User Interfaces , Software Development Note 66, 20 Dec 89.

### 3.3.18 Objectives for 1990/91

Get everyone in SysIG/UIG running X11, and consequently all our tools on X11.

**EWS**

- Design prototype Interaction Framework (IF).
- Prepare paper on IF.
- Prepare paper on input device assessment.

**EKS**

- Produce a specification of the prototype environment.
- Have at least 50% of the infrastructure in place.

**Extensibility**

- Complete work on "programming language" and tools.
- Prepare paper (?for CHI91).
- Develop assessment work.
- Prepare follow-up proposal - maybe.

**ECSTASY**

- Get it robust and with performance.
- Establish smooth-running support mechanism.
- Get involved with R&D towards ECSTASY2.

**X toolkits**

- Complete assessment and make recommendations.
- Prepare paper on toolkits.

**R&D proposals - ESPRIT, IED**

- possible topics
  - EWS follow up
  - remote group working
  - hypersomething - perhaps in a context
  - input device development and assessment.

## 3.4 USER INTERFACE GROUP

### 3.4.1 Staffing

Staffing during the period September 1989 - June 1990

- Anthony Conway (TC) Group Leader
- Dale Sutcliffe (DCS) (On Sabbatical Leave in Australia until 14 Dec 1989) Interactive Graphics (PHIGS) Section Leader and Acting Group Leader from 1 March 1990
- Peter Kent (PK)
- Martin Prime (MJP) Human Factors Section Leader
- Lakshmi Sastry (LS) User Interface Support Toolkits
- Yiya Yang (YY) (Joined as Atlas Fellow on 1 November1989)
- Garry Hearn (GDH) (Trainee Scientist for 6 months from 11 June 1990)

The above reflects the composition of the Group during the latter part of the period, following the return of DCS from sabbatical leave.

However, it is not far from the way the Group operated during the remainder of the period. By February 1990, it became increasingly obvious that more effort needed to be devoted to the

ESPRIT-II project Elusive Office (ELO) and that this could only be achieved by TC temporarily relinquishing his post as Group Leader in order to work full-time on ELO. As a result DCS became acting Group Leader as from 1 March 1990, initially for 4 months but then on an ongoing basis.

### 3.4.2 Objectives

The objectives identified for the Group at the beginning of the period were in the areas of UIMS, PHIGS and Human Factors as part of the EASE programme and participation in two ESPRIT-II projects EuroWorkStation (EWS) and Elusive Office (ELO). With the return of DCS from sabbatical leave, participation in a third project ARGOSI (Applications Related Graphics and OSI Standards Integration) was reactivated.

In the UIMS area, further evaluation of commercial UIMS was targeted with a particular emphasis on those UIMS which ran on top of X-windows. Referring back to the EASE Community on the first evaluation and identifying candidate sites for trials of selected UIMS were also included.

The PHIGS work was centred on the evaluation of commercially available PHIGS implementations together with consideration of the support tools necessary for successful use. Liaison with other ID and CCD Groups working on graphics should also take place.

The Human Factors work aimed at experimental work on the use of the DataGlove (in the context of EWS) and completing a study on the effectiveness of different types of menus.

### 3.4.3 UIMS Evaluation (TC, DCS, LS, MJP, GDH)

The first stage of the UIMS evaluation, carried out on behalf of CFTAG, was concluded with a seminar held at UMIST in September 1989. The results of the evaluation were reported by TC, namely that none of PA Set, BLOX or Tiger could be recommended for use by the community or in the EASE Initial Environment. MJP presented a paper at the seminar and updated his RAL Report on the relative merits of selected UIMS.

LS did some further work on Tiger (including implementing a small interactive application for drawing project plan bar charts), as there were some promising features, but this work was terminated when, after a period with no response from Team Engineering Inc (the suppliers of Tiger), it was finally discovered that Team Engineering were no longer operating as a company. The fact that this period coincided with the San Francisco earthquake complicated communications and generated many theories as to their fate!

While CFTAG had been disappointed with the conclusion of the first stage of the UIMS Evaluation, in June 1989 they had recommended further work in the area with particular emphasis on UIMS ran on top of the X-11 windows system. MJP and LS produced a new candidate list of UIMS.

Open Dialog from Apollo Computer had previously been identified as a potential UIMS operating over X-11 but had not reached a sufficient stage of development for inclusion in the first stage evaluation. The evaluation of this product was assigned to Colin Walls at UMIST who was providing effort for this project during the remainder of the Prime support contract.

The list of UIMS to be considered at RAL was reduced in the first instance to USEIT from UNIRAS (important on account of the CHEST deal), Te1eUse from TeleLogic and SL-GMS from the Sherrill-Lubinski Corporation. These all run on top of X-windows. Initial evaluations of USEIT and SL-GMS have been completed by LS and the evaluation of Te1eUse is continuing.

GDH recently joined the group as a trainee scientist and during his six months project will further evaluate USEIT using the APPLE program provided by Bryan Colyer.

When these evaluations are complete, it is planned to report back to the community again.

Arising from his work on the UIMS evaluation, MJP was invited to participate in a panel discussion on UIMS at Eurographics 89 in Hamburg in September 1989 and further gave a half day tutorial presentation on UIMS techniques as the original presenter was unable to attend. MJP also was invited to give a talk at an IEE Colloquium on UIMS in November 1989.

### 3.4.4 PHIGS (DCS, PK)

PHIGS (Programmers' Hierarchical Interactive Graphics System) is an ISO standard for defining 3-D models and viewing them. This project is concerned with supporting PHIGS for the EASE community initially placing emphasis on evaluating different implementations. PK has been working on the development of an evaluation procedure.

PK initially had to teach himself about graphics and PHIGS (hampered by a lack of books and training material on PHIGS) before gaining experience with SUN PHIGS. All the SUN examples and tutorials have been made to work. PK has written programs to test the speed of 2D vectors, 3D vectors, 3D text and 3D transformations.

This work falls within the remit of the joint Computer Board/SERC Advisory Group On Computer Graphics (AGOCG) and DCS has begun liaison with this group. He submitted a paper with Ruth Kidd (DCSD) on EASE Support for Graphics Standards outlining possible future activities, ranging from assessment of implementations to support toolsets to providing guidelines on successful use.

Graphics is covered in several places within Informatics as well as in CCD and so there is a joint CCD/Informatics meeting to discuss common issues in computer graphics. PK has attended four such meetings during the period of this report.

### 3.4.5 Human Factors (MJP)

Human Factors experimental work has been affected during the period by the HF Lab being used as an office for part of the time. Despite the cooperation of the occupant (YY), this has made the environment for experimental work less than ideal. This problem has now been resolved and it is planned to return the HF Lab to full and proper use.

For the ESPRIT-II EWS project,MJP has been evaluating the DataGlove as an input device from the HF point of view. He created test software and tested 15 subjects with the glove. The results have been analysed and a paper written. The EWS project is described in more detail in the SysIG chapter.

The menu style study described in the last annual report was completed and MJP has produced a paper which has been accepted for Interact '90 in Cambridge, UK in August.

MJP has also assessed the use of CD ROM technology using the Oxford English Dictionary on CD. On a different topic, MJP investigated the problem of excess noise levels caused by SUN workstations in offices and carried out initial studies on using sound absorbing materials to alleviate the problem.

It was satisfying that demonstrations based on the Human Factors work carried out by the group (and related work in SysIG) were selected for the RAL Open Days to be held in July 1990. MJP spent time tailoring the demonstrations and producing accompanying information material, with the result that some very professional demonstrations were produced.

### 3.4.6 ESPRIT-II Projects

With the return of DCS, the Group has been involved with three ESPRIT-II projects: EWS (EuroWorkstation), ELO (Elusive Office) and ARGOSI (Application Related Graphics and OSI Standards Integration). The first two started in January 1989 and the last in March 1989. EWS and ELO include staff from UIG and SysIG with the former project run from SysIG and the latter from UIG (TC is RAL Project Manager). ARGOSI includes staff from all four Divisions with DCS participating from UIG. EWS is described in the SysIG chapter.

#### 3.4.6.1 ELO (Elusive Office) (TC,YY)

ELO is concerned with the provision of the next generation of high power, portable workstations and was outlined in. the last annual report. RAL emphasis is upon a high-quality user interface and a framework for integration.

Work on the project was delayed owing to staffing problems for the first part of the period with the problem only being effectively resolved in March 1990 (see Staffing).

In spite of this the RAL contribution to the project seems to have been respected by other members of the consortium and the project has survived a number of review meetings. (There has been a presentation from RAL at each of these reviews.) During the year an extra (reviewer-suggested) task has been completed (namely, the ELOPE early prototyping exercise), good relations have been maintained with other partners (in particular, with CLS another software partner) and a major deliverable (A. 3 .1) completed. TC has been the RAL project manager and B Ritchie (SED), S K Robinson (SED), TAW (SysIG), KR (SysIG) and YY have all participated.

YY has contributed to the discussions on the functional split, the architecture and design strategy of the ELO integration framework. Since more than one person, each with an ELO system, may work together to carry out a task, issues related to computer-supported cooperative working (CSCW) are important. YY has been analysing MUSK (Multi-User Sketch Program) to study the structure and find possible places for modification and extension to gain expertise for this and other CSCW projects.

#### 3.4.6.2 ARGOSI (DCS)

ARGOSI aims to advance the state of the art in the transfer of graphical information across wide area networks, using formal standards, and was outlined in the last annual report. R A Day (DCSD) is the RAL project manager.

DCS has participated in various parts of the ARGOSI project. He has worked on the classification of applications according to their graphics and networking requirements, analysing the results of a postal questionnaire distributed to over 2000 people working for organisations with applications using graphics or networking, and contributing to the discussions on constructing a classification framework. He has made contributions to the related Study of Services required. DCS has also contributed to the specification and design of the application demonstrator and to the design of the graphics services required for that demonstrator.

### 3.4.7 COMETT (CEC Initiative for Co-operation between Universities and Industry regarding Training in the Field of Technology.) (TC, MJP)

The course on Human Factors Aspects of User Interfaces described in the last annual report (as part of a project coordinated by ZGDV, Darmstadt) was finished off and the interactive software was completed and installed. The course was presented by KR (SysIG), MJP and TC in Darmstadt in September 1989. Material was prepared for a demonstration and handout on the COMETT course for the Eurographics 89 conference in Hamburg earlier in September. There are plans for a follow-on to the COMETT project and to repeat the course for the EASE community.

### 3.4.8 Other Activities

#### 3.4.8.1 JFIT IEATP Standards Activity (PK)

PK has worked with staff at DTI and RAL to encourage the use of appropriate standards in grants approved by the joint programme and to draft a proposal for a research project on Standards.

#### 3.4.8.2 KIPS (DCS)

DCS spent the first half of the period completing his sabbatical year with the Division of Information Technology (DIT) of CSIRO in Australia. He worked at the Centre for Spatial Information Systems in Canberra. The visit was arranged as part of an exchange scheme with CSIRO DIT which had begun with the visit of Graham Freeman to Informatics Department in 1988.

DCS worked on the specification of KIPS (Kernel Image Processing Software). KIPS was designed to provide a simple, powerful, flexible and consistent environment for programmers developing image processing applications and for operators running such image processing applications.

KIPS consists of three defined interfaces and a dynamic set of tool kits and applications for operating on images.. The defined interfaces, each made up of specified functions together with their associated parameters and the data structures necessary to support them, comprise:

1. the Kernel: a set of device independent, low-level image handling and processing functions that allow a programmer to build applications that access, handle, process and display image data without requiring interaction with an operator;
2. the Operator Interaction Handler (OIH): a set of functions to allow programmers a standard method of programming operator interaction providing consistent user interfaces with form-based input on workstations (typically forming an interface to an underlying User Interface Management System);
3. the Operator Kernel Interaction Module (OKIM): a set of higher level functions built using the Kernel and the OIH to provide the facilities of the Kernel with an operator supplying the controlling parameters.

Tool kits, which can be specified by R&D or engineering groups using KIPS, are defined in terms of the interface functions and can be used for the subsequent building of applications.

A set of generic applications built using the interface functions will perform standard image access, handling, processing and display operations. Other applications to perform specific operations on images can be specified in terms of the interfaces and tool kits described above.

DCS was concerned with defining the overall architecture for KIPS, specifying the Kernel, its method of data access using a multi-dimensional format previously defined at DIT, and defining the display device model. In contrast to graphics systems, the central concept of KIPS was the image and operations on the image. Display devices were just handled as another kind of storage device with the special property that what was stored could also be viewed. More details are given in the paper on KIPS listed at the end of this chapter.

#### 3.4.8.3 Support Tool for Rapid Interactive Prototyping (STRIP) (YY)

YY, in her role as Atlas Fellow, has spent a significant part of her time on project STRIP to identify factors that influence the usefulness of software tools. Currently some support tools for designers have failed to provide adequate support at the appropriate conceptual and operational levels. In order to provide adequate support tools, the environment in which a support tool can be used and the tasks, which a support tool can assist with, need to be identified. After study of current support tools and software practice, the application environment and task for STRIP has been identified as the design phase of software systems in an object-oriented environment.

One attraction of the object-oriented paradigm is to provide safe software reusability. One special development activity in designing an object-oriented software system is to understand existing classes of a chosen environment and to extend them. Thus, the initial tool produced by STRIP will help understanding of the behaviour of classes. The requirements analysis and initial interface design have been carried out. Architecture issues are under investigation.

#### 3.4.8.4 Other Activities

TC has acted as Secretary of CFTAG and attended ECFE and CFTAG meetings.

TC and MJP have both been learning German during the period.

### 3.4.9 New Proposals

#### 3.4.9.1 Syncopate (alias EuroCoOp) (TC)

One proposal was put together for the second round of ESPRIT-II projects, entitled EuroCoOp. EuroCoOp was concerned with remote cooperative working supported by IT. The project proposal was given a good technical rating and funding was agreed. However, just before a Consortium meeting, the major UK partner (STC) decided that there was not enough effort for them and bumped RAL and the University of Lancaster from the project!

The work that was to have been done by RAL and the University of Lancaster has been put together as a new proposal, entitled Syncopate, and has been submitted to the Joint Research Council's Initiative in HCI/Cognitive Science.

#### 3.4.9.2 COMETT (TC)

Two proposals have been submitted to COMETT-II. One (entente) concerning training in IT and telecom standards is in association with CLS GmbH (Bonn) and the French Telecom University (Paris). The second is a follow-on to the project described earlier coordinated by ZGDV (Darmstadt).

### 3.4.10 Conferences and Seminars

- EASE UIMS and OOP Seminars (UMIST), 18-19 September 1989, TC,MJP
- BCS HCI SG Meeting on Visual Programming (London), 25 October 1989, TC
- Flat Panel Display Developments in Japan (London), 17 January 1990, YY
- Eurographics UK PHIGS Tutorial (Edinburgh), 9 February 1990, PK
- Scientific Issues and Implications of User Performance Testing (HUSAT, Loughborough), 15 February 1990, PK
- Compaq Meeting & Exhibition (London), 20 February 1990, TC
- Structuring Interactive Software (London), 26 February 1990, YY
- Computers and Writing III (Edinburgh), 6-7 April 1990, YY
- Eurographics UK 8th Annual Conference (Bath), 9-11 April 1990, DCS
- EASE 90 (UMIST), 19-20 April 1990, LS
- AI in the User Interface (London), 30 April 1990, LS
- Inaugural Meeting of Computer Supported Cooperative Working (CSCW) SIG (London), 10 May 1990, MJP
- PHIGS Tutorial (RAL), 30-31 May 1990, PK LS DCS
- PC User Show (London), 20 June 1990, TC

### 3.4.11 Courses Attended

- Framemaker Course (RAL), 7 November 1989, PK
- Advanced Reading Techniques (Swindon), 30 November - 1 December 1989, LS
- Management Course I (Devizes), December 1989, MJP
- Occasional Speakers Speakers' Course (Devizes), 1-3 April 1990, YY
- Object-Oriented Software Design (Bath), 9-10 April 1990, YY

### 3.4.12 External Papers

- P K Robertson, C J Moran, J Bosman, D C Sutcliffe, K C Anderson. Kernel Image Processing Software (KIPS) Proceedings of Image Processing and the Impact of New Technologies, 18-20 December 1989, Canberra, Australia
- Y Yang, Survey Steered Design: Evaluating User Recovery and Command Reuse Support by Questionnaire, Behaviour and Information Technology, November-December 1989
- Y Yang, An Experimental Rapid Prototype of Undo Support, Information and Software Technology (to appear)
- Y Yang, Current Approaches & New Guidelines for Undo Support Design, INTERACT'90, August 1990 (to appear)
- Y Yang, Interface Usability Engineering under Practical Constraints: a Case Study in the Design of Undo Support, INTERACT'90, August 1990 (to appear)
- M J Prime, User Interface Management Systems - a current product review Computer Graphics Forum Vol 9 (1) March 1990
- M J Prime, Are all menu systems the same? An empirical study INTERACT'90, August 1990 (to appear)
- A Conway, M D Wilson, Enhanced Interaction Styles for User Interfaces, IEEE Computer Graphics and Applications (to appear)

### 3.4.13 Objectives 1990/91

**UIMS Evaluation**

- Complete evaluation of UIMS based on X-Windows
- Produce report of evaluation of UIMS based on X-Windows
- Report back to the community on the results of the evaluation

**PHIGS Evaluation**

- Complete PHIGS evaluation test suite
- Assess at least two portable PHIGS implementations
- Consult engineering community over use of PHIGS

**Human Factors**

- Return HF Lab to functioning state and produce Future Programme of Use
- Carry out (at least) one HF study using the HF Lab

**ELO**

- Complete work on Task A.3.I
- Attend appropriate project meetings and produce work for project as detailed on Project Plan in Technical Annexe

**ARGOSI**

- Complete work on classification of applications and production of classification framework
- Contribute to second part of study of services
- Comment on development of prototype application and its relationship to graphics services

**COMETT**

- Submit proposals for follow-on programme:
  a. continuation of Darmstadt-led COMETT-I work
  b. entente

**Syncopate**

- RAL + University of Lancaster component of EuroCoop to be submitted to Joint Research Council Initiative in Cognitive Science/HCI.

## 3.5 TRANSPUTER COORDINATION UNIT

The Unit runs the programme for the SERC/DTI Initiative in the Engineering Applications of Transputers including the London & SE Regional Support Centre.

### 3.5.1 Staffing

Staff in post at end of June 1990:

- Mike Jane (MRJ) Coordinator of the Initiative
- Cyril Balderson (CB) Deputy Coordinator, Unit Leader and Supplier Liaison
- Raymond Fawcett (RJF) Loan Pool Coordination and Support Centres Liaison
- Terry Mawby (TPM) Publicity and Promotion
- Linda Reed P/T (LJR) Loan Pool Manager Support
- Richard Parkes Support Centre Manager (left September 1989)
- Paul Shortall Support Centre Manager (left March 1990)

Paul Shortall and a Transputer

Large View

### 3.5.2 Objectives

1989-90: To carry out the Initiative programme in accordance with the Report of the CFC Working Party on Engineering Applications of Transputers, October 1986; taking into account the recommendations of a Market Survey, commissioned by the Initiative, and reporting during the first part of the year. In addition efforts will be made to target Continental Europe for the Awareness Programme.

#### 3.5.2.1 London & SE Regional Transputer Support Centre

1989-90: To establish the Centre as self-sufficient in funding with a good base of demonstration software, a regular supply of paying visitors and a full Course Schedule.

### 3.5.3 Coordination Function (MRJ)

To put into effect activities based on the policy of the Initiative as defined by MRJ acting on the advice of the Steering Group, the Transputer Applications Management Group (TAMG). To carry through support activities already committed, and to monitor the effectiveness of the programme.

### 3.5.4 Programme Support (MRJ, CB, RJF, TPM, LJR)

CB is Secretary to TAMG and RJF is secretary of the Directors Meeting, and was also Chairman of the Managers' Meeting. As a formal meeting this Managers' Meeting is now being replaced with specific interest meetings, usually to be held at Suppliers' premises. CB also liaised between the DTI and the Support Centres in drawing up a Project Monitoring scheme in line with requirements for DTI partial funding of the project. CB also arranged purchase of equipment for the Loan Pool and the Transputer Support Centres. Loan Pool applications have been dealt with by RJF and the resulting loans by LJR. The 'Public Face' of the Initiative is handled by MRJ at the official level, and TPM, principally through the Mailshot, but also by attendance at exhibitions, conferences etc.

### 3.5.5 Suppliers' Liaison (CB, TPM)

CB has been primarily responsible for liaison with Suppliers of Transputer equipment, encouraging them to assist and benefit from the facilities offered by the Initiative. Typical activities are in negotiating sponsorship or special deals to have new equipment available in Centres at the lowest possible cost; support of the Initiative Training Courses through company's sales promotion etc and encouraging companies to submit technical material to the Mailshot for publication. Sponsorships negotiated in the period were:

- Apollo (Loan Pool)
- Acorn (Loan Pool and one Centre)
- Rockfield Software (Centres)
- 3L (Loan Pool and Centres)
- Rapid Silicon (Loan Pool and Centres)
- DSL (Loan Pool and Centres)
- Transtech (Loan Pool and Centres)
- Meiko (Loan Pool)

The list price value of these is £255K. TPM also has strong involvement with companies in obtaining material for the Mailshot. Four Mailshots were sponsored by Companies during the period.

### 3.5.6 Centres Liaison (RJF)

RJF monitors activities in the 6 Support Centres and fosters cooperation between them. RJF has been collecting Demonstration Software for use in all the Centres, and arranging exchange of training materials between Centres.

### 3.5.7 Loan Pool (RJF)

The Loan Pool coordination activity (RJF) is primarily the pre- and post-loan phase wherein loan applications are received and assessed against guidelines, and submitted to TAMG for approval or rejection, and also in the obtaining of deliverables in the form of reports for publication, and software for provision to the Software Exchange Library. The period has seen 36 Loan Applications of which 34 were approved.

### 3.5.8 Publicity and Promotion (TPM)

TPM has been responsible for putting the Initiative in the Industrial and Academic Shop-Window. The Initiative Display Stand is to be seen at Exhibitions and Conferences around the UK and elsewhere. There are again two major events demanding much effort and support from the Laboratory and the Support Centres, (a) The PC User Show in June and (b) the Initiative Conference and Exhibition to be held at Southampton in July.

TPM continues as the Editor of the Initiative Mailshot, which has continued to grow in stature and acceptance by the Community. This year has seen the introduction of sponsored editions where the production costs are covered by a Supplier who gets direct promotional advantage as a result. The circulation has grown from 2100 to almost 2900 during the 9 month period of this report. It is interesting to note that 170 of these issues are sent to 116 Libraries to ensure even wider readership. The breakdown of the current circulation is as follows:

| Area | Academic | Non-Academic |
|---|---|---|
| UK | 1400 | 712 |
| Non-UK | 610 | 164 |

TPM also administers a video loan pool based on the Initiative's own video and one from Paisley College which is a tutorial on the Transputer. This has now made some 64 loans.

### 3.5.9 Loan Pool Management

The Loan Pool was provided with an injection of new software and hardware products at the end of the Financial Year (value £250K), thus enabling us to offer academics the latest technology. This has resulted in an increase in activity albeit not quite on the scale expected. LJR has attended formal training in the use and maintenance of IBM PCs, which has helped greatly in the management of the Loan Pool, and was involved in some difficult software installations for Transputer boards in Sun Workstations.

### 3.5.10 London & SE Regional Transputer Support Centre (MRJ, CB, RP, PJTS, LJR, RJF, TPM)

MRJ is Head of the Centre and Chairman of the Operations Meeting.

The post of Manager was held by RP until September 1989, and by PJTS from then until March 1990. Since that date, the duties have been split between the main users and the Coordination Team, with CB putting in some 40% of effort.

LJR has assisted both with PC and Filestore management.

RJF is developing the available base of demo software and acts as Secretary to the Operations Meeting.

TPM maintains the Publicity programme for the Centre including a standing exhibit.

1989-90 has proven to be a rather difficult year for the Centre due mainly to a lack of continuity in its management. Despite this it has been possible to make modest earnings with some £12.8K coming from consultancy and training courses. The number of paying visitors has been very disappointing, as with the other Centres. In the RAL case we have had insufficient effort to address the direct needs of the Centre (eg marketing and involvement in long term consultancy work). However there is always a great interest shown by the many visitors (non-paying!) that we attract. The awareness component of the Initiative Programme as expressed through the Centre, can be seen to be very fruitful. The Centre remains a popular place for important visitors to the Laboratory.

### 3.5.11 Conferences and Exhibitions

The Initiative Exhibit has been shown at a number of events during the past 12 months, usually in support of a Transputer component at the Conference, and occasionally to market the Initiative per se.

- Alvey Vision Club, Reading
- Transputer Fair, Londonderry, Belfast, and Belfast Airport
- BIRA Conference on Transputer Applications, Antwerp
- PC User Show, Earls Court
- Beauty of Physics Exhibition, Leicester

### 3.5.12 Courses Attended

- Maintenance of PCs - LJR
- Advanced Reading Techniques - RJF
- Management I - RJF
- Minutes of Meetings - RJF
- Marketing Skills - MRJ, CB, RJF, TPM
- Occasional Speakers - RJF

- Management of Stress Workshop - RJF, TPM

### 3.5.13 Papers

SERC/DTI Initiative in Engineering Applications of Transputers, Joint UK/Soviet Workshop on Parallel Proce1ssing. MRJ - June 1990.

### 3.5.14 Objectives for the Next Year

#### 3.5.14.1 Initiative

In 1990-91, to carry the programme forward, identifying how various activities might be dealt with in post-Initiative times ahead, and setting up any necessary liaison and training to enable this.

#### 3.5.14.2 RAL Centre

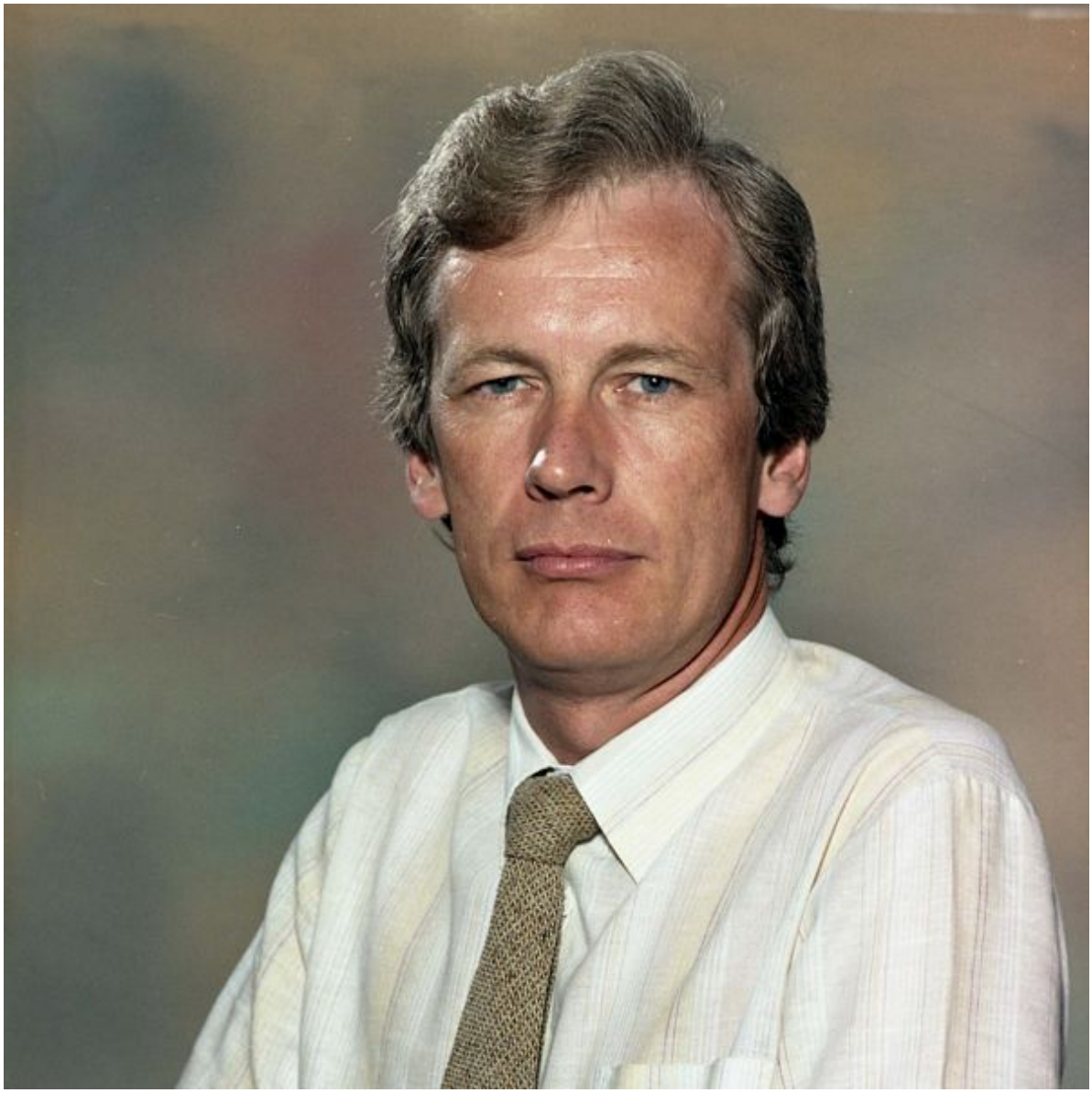
1990-91: To integrate the Centre with the main EASE activities of the Department whilst, at the same time, continuing to satisfy the original objectives set for the Centre (ie seek both paying visitors and consultancy contracts from, principally, local industry, and offer a full Course programme). The Centre should, in time, move to being a parallel processing Centre rather than just concentrating on Transputers to satisfy the broader needs of the EASE Programme.

## 4. COMPUTATIONAL MODELLING DIVISION

### 4.1 INTRODUCTION

### 4.1.1 Staff changes

The period of this report commenced with the appointment of a new Division Head, David Boyd. The group structure of the Division has remained unchanged. Both Chris Greenough and Chris Wadsworth were successful in achieving Grade 7 appointments to lead their respective groups. Conor Fitzsimons joined us from Trinity College Dublin to strengthen our effort in Computational Fluid Dynamics and Francis Yeung and Dayal Gunasekera (a Visitor from Swansea) left us having made valuable contributions to the work of the Division.



**David Boyd**

**Large View**

The Division has hosted visits from Dr Theo Kalamboukis from the University of Athens to work on the ACCORD project and from Dr Duncan Stevenson from CSIRO in Australia on an exchange programme, as well as offering a temporary home to two trainee scientists, Andrew Reay and Rob Woodward.

### 4.1.2 Technical Highlights

The principal strength of the Division remains the close interworking of physical modelling, numerical analysis, visualisation and parallel processing skills developed and applied through a number of engineering application areas. The current focus is on semiconductor device modelling, electromagnetics and fluid dynamics. Approximately two-thirds of the Division's resources have been committed to the EASE programme and the Transputer Initiative and the remainder to a number of projects under JFIT and ESPRIT.

Significant achievements within EASE and the Transputer Initiative have included:

- establishing a Community Club in CFD and initiating an EMR contract in visualisation for CFD
- issuing Release 3 of the Finite Element Library to NAG Ltd for distribution
- issuing the first trial release of the Image Processing Algorithms Library to NAG Ltd

- running tutorials on data visualisation and the use of transputers at EASE90
- carrying out an assessment of superworkstations for CFTAG
- developing a number of essential enabling software tools to permit the application of transputers to engineering problems
- completing the implementation of two engineering applications on transputers under an IBM Joint Study agreement
- an initial analysis of the feasibility of defining virtual parallel architectures as an approach to architecture-independent parallelism
- implementing the TOSCA and OPERA packages on the Stardent GS2000 multi-processor superworkstation
- assessing and documenting the suitability of the DAP for engineering applications
- initiating a complete revision of the EASE Schedules
- contributing to the initial definition of the EASE Environment

Staff from the Division have also made significant contributions to the ESPRIT projects EVEREST, ACCORD, ARGOSI and EWS, and have secured funding for and started work on the BRIM and VAR projects under the JFIT programme. A further submission to ESPRIT during the period has subsequently received approval for the BECAUSE project.

All groups have now established series of technical reports, many of which will see a wider circulation as EASE Technical Reports.

The Division made the major contribution to a very successful visit by the SERC Chairman to Informatics Department in February, and contributed several demonstrations for the RAL Open Days in July.

## 4.2 MATHEMATICAL SOFTWARE

### 4.2.1 Staffing

- Chris Greenough (CG) (Group Leader)
- John V Ashby (JVA)
- C John Collie (CJC)
- Ron F Fowler (RFF)
- George Goodsell (GG) (Joined 4.9.89)
- Dayal Gunasekera (DG) (Visitor from University College Swansea working on the ESPRIT EVEREST Project)
- Theo Kalamboukis (TK) (Visitor from Athens School of Economics and Business Science - Working on ESPRIT Parallel Processing Project ACCORD)

### 4.2.2 Objectives for 1989/1990

The main purpose of the group is to promote the use of up to date mathematical techniques and software within the research community and to provide a focus of computational techniques and software from which the research community can request advice and assistance. This is achieved by being actively involved in research and development programmes, by providing software and expertise and by planning and participating in workshops and courses on mathematical software.

The major objectives of the group for this year have been:

- Specification of the EASE Environment
- Contribution to the EASE Schedules
- Completion of the ESPRIT EVEREST Project
- Completion of the ESPRIT ACCORD Project
- Development of Release 4 of the NAG/SERC Finite Element Library
- Support of EVEREST and TAPDANCE for the community
- Development of new EC funded research programmes

### 4.2.3 Engineering Applications Support Environment (EASE) (CG, JVA)

During the year the Engineering Computing Facilities Executive (ECFE) was disbanded and the day-to-day monitoring of the EASE Programme taken over by the Informatics Department Heads Meeting (IDHM).

CG was a member of ECFE until its demise and has contributed to the discussion of the EASE Environment, the EASE Information Directory Service and the consideration of EMR contracts.

As a member of ECFE and Informatics Department, CG represented EASE on the IUSC Computer Algebra Steering Committee. He continues to provide a link between the IUSC Computer Algebra Support Project and EASE.

With the demise of ECFE two new working parties have been set up: the EASE Schedules Working Party and the EASE Environment Working Party. CG is a member of the former and JVA of the latter. The EASE Schedules Working Party has undertaken to review the EASE Schedules and produce an up to date document containing details of all the Computing Facilities Committee's recommended software, hardware and standards. The EASE Environment Working Party has undertaken to define and formulate a work programme that will lead to the initial EASE Environment with a number of applications demonstrating its usefulness.

### 4.2.4 NAG/SERC Finite Element Library (CG, CJC, GG)

#### 4.2.4.1 Completion of Release 3

Release 3 of the Library is now complete and with NAG Ltd awaiting distribution to the community. Documentation has proven the most time consuming task. Release 3 of the Library adds six new Level 1 Programs and twenty new Level 0 routines.

The new programs are:

- Axisymmetric Plane Stress (Segment 1.2)
- Eddy Current Analysis (Segment 3.3)
- Potential Free Surface Problem (Segment 3.4)
- Convection/Diffusion Equation (Segment 4.2)
- Nonlinear Magnetostatics (Segment 5.1)
- Nonlinear Electrostatics (Segment 5.2)

These new programs add to the range of applications described in the Level 1 Documentation. They introduce the use of complex numbers, geometric nonlinearities (mesh movement) and nonlinear differential operators with solutions using point iteration and Newton-Raphson techniques.

The new Level 0 routines cover:

- Assembly Routines
- Complex Arithmetic Routines
- New Utility Routines

The use of these routines is illustrated in the new Level 1 programs.

To accompany the release, articles have been written for the Engineering Computing Newsletter and the NAG Newsletter.

A training course is being planned for later in the year.

#### 4.2.4.2 Developments of Release 4

Although Release 3 has taken much longer to complete than hoped developments for Release 4 of the Library have continued. The initial contents of this release have been drawn up and include four new Level 1 programs and their associated Level 0 routines. The programs will include:

- Simple Plate Element (Segment 1.3)
- Navier-Stokes Solution Velocity/Pressure formulation (Segment 5.3)
- Navier-Stokes Solution Stream Function/Vorticity (Segment 5.4)

- Nonlinear Heat Conduction (Segment 5.5)

Additions will also be made to the Level 0 Library. These will include:

- Skyline solver
- Sparse solver
- New utility routines
- New shape functions
- Pre-processing routines (mesh generation, bandwidth reduction etc)
- Post-processing routines (display, gradient recovery etc)

In addition to the development of new programs and Library routines the documentation of the Library will be completely revised and typeset using LATEX.

#### 4.2.4.3 Gradient Recovery Routines

The idea of gradient recovery in the finite element method is to compute, by post-processing from a standard piecewise polynomial finite element solution, an approximation to the gradient which is of a higher order of accuracy than that of the finite element gradient itself. This is of great importance to many engineering problems since the numerical solution is often computed in some potential whereas the quantity of real interest is the field associated with that potential. The gradient recovery process will allow engineers to obtain the best numerical representation of these physically important values.

The theoretical error analysis for two-dimensional problems has been extended to three dimensions and the software embodying these techniques has been designed and the first implementation produced.

#### 4.2.4.4 PARFEL: The PARallel Finite Element Library

During the year a new version of the Library has been developed for computers with concurrent architectures. The main goal of PARFEL is to enable users of the serial Library to transfer their programs to machines with a MIMD architecture with little modification.

PARFEL is an extension of the serial Library which includes routines that handle data partitioning and distribution over local memory MIMD systems such as the Intel Hypercube or NCUBE. The prototype version of PARFEL was written using a basic home-grown simulation of a MIMD machine on a Prime system which demonstrated the feasibility of the approach. With the demise of the Prime, work moved to the Sun and the use of the Intel Hypercube Simulator which simulates the behaviour of both the Mark I and Mark II Hypercubes. This transfer has lead to improvements in PARFEL and work is in hand to implement the Library on the Intel Hypercube Mark II at Daresbury which will allow benchmarking to make place.

As Transputer based systems are very important to the engineering community a Transputer version of PARFEL is being developed using 3L Parallel Fortran. This version should be ready early next year.

### 4.2.5 ESPRIT Device Modelling Project - EVEREST (CG, DG, RFF, JVA)

EVEREST is a four-year project supported by ESPRIT which is investigating suitable computational algorithms for the analysis of semiconductor devices in three dimensions, and developing a software suite implementing the most effective of those algorithms.

The partners in this project are drawn from some of the major industrial and academic research and development teams in Europe. They are:

- Analog Devices (Ireland)
- Philips (The Netherlands)
- SGS Microelettronica (Italy - now SGS-Thompson)
- STC Technology Ltd (United Kingdom)
- Rutherford Appleton Laboratory(United Kingdom)

- NMRC (Ireland)
- IMEC (Belgium)
- University of Bologna (Italy)
- Trinity College Dublin (Ireland)
- University College Swansea (United Kingdom)

The activities of the project have been divided into five Workpackages: Physical Models and Validation (SGS), Discrete Problem Formulation (Philips), Mesh Generation and Refinement (UCS), Solution Procedures (Philips) and Software Suite (RAL). The coordinators of each Workpackage are shown after each title.

#### 4.2.5.1 Project Achievements and Developments

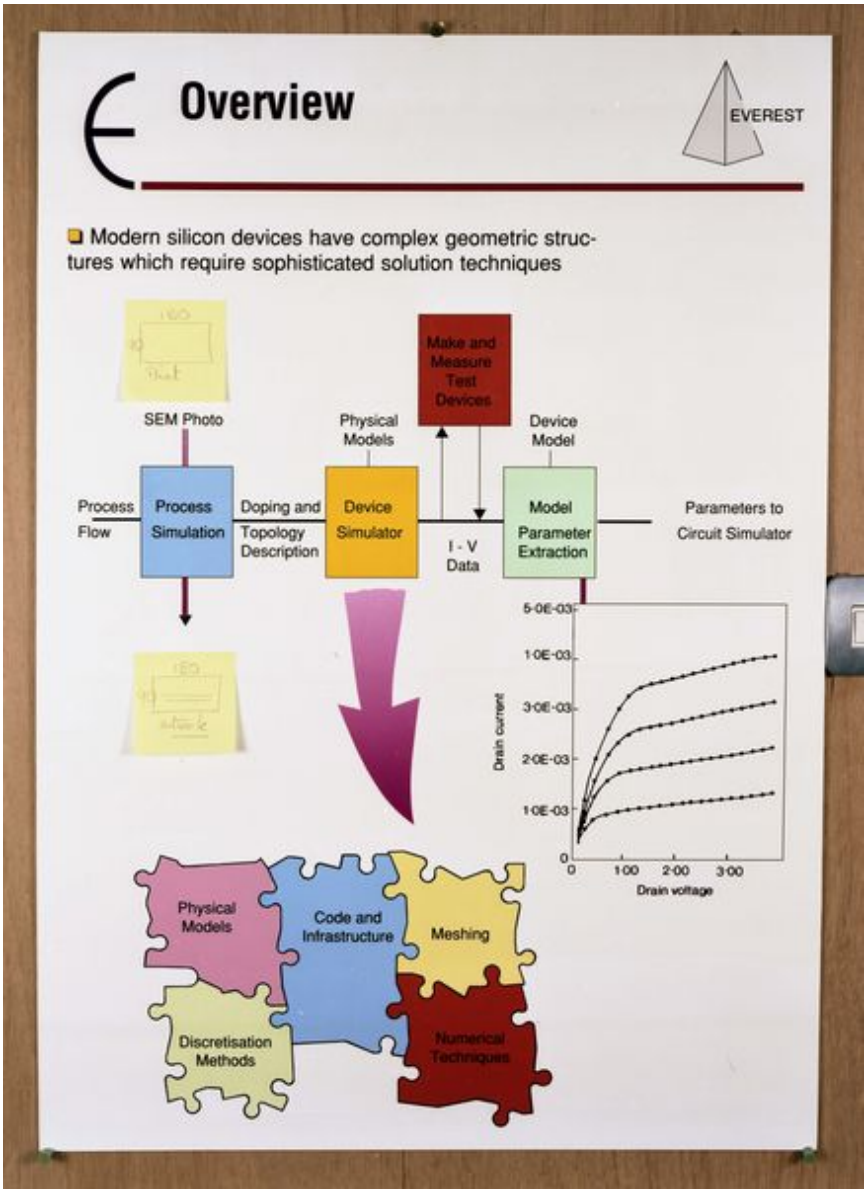
The major objectives of the project during this year have been:

- Completion of Parameter Extraction Software
- Review of Physical Modelling
- Assessment of Multigrid and Mixed Finite Element Methods
- Implementation of Three-Dimensional Adaptive Solver
- Assessment of the impact of parallel processors

The main focus of RAL effort has been in the implementation of the three-dimensional adaptive solver. CG has continued to be the coordinator of the software development within the project and RFF has played an important role in implementing the EVEREST Suite on the Stellar GS 2000.

RFF and DG have continued developing the Solver Module of the suite, DG having responsibility for the discretisation and linear algebra, and RFF concentrating on the physical models library and integration.

RFF has implemented the EVEREST Suite on the Stellar GS2000 making use of the multi-processor nature of the machine. This has required some modifications to the programs but the performance gains have been good. However much work is still required to make effective use of the four processors in the linear algebra routines.




**EVEREST Display Board**

**Large View**

### 4.2.5.2 ESPRIT Conference and Exhibition

In late November the EVEREST Project made a number of presentations at the ESPRIT Conference and had a stand in the Conference Exhibition. Both CG and RFF were involved in the preparation of the conference papers and the exhibition display posters and software.

The main focus of the presentations and the exhibition were the advances in numerical simulation made by the Project. The University of Bologna made an excellent presentation on their work in Workpackages 1, 2 and 4 as implemented in the simulator HIFIELDS-3D. As director of Workpackage 5 CG made a presentation on the developments of the EVEREST Suite.

In the Conference Exhibition the display stand was centred around a live demonstration of the EVEREST Suite on an FPS 350 Graphics Super-Workstation (really a Stellar GS 2000). The EVEREST Suite was shown running a selection of problems solved during its development in a continuous cycle. The demonstration was supported by display boards and many handouts.

Although the number of visitors to the stand was small (as one might expect for such a specialised application) the display and demonstration was thought very successful by the Commission.

### 4.2.5.3 THRUST Workshop

THRUST is a training course on semiconductor simulation software supported by the European Community through the COMETT Programme. As with all acronyms THRUST is well and truly contrived: Training in Hands-on experience in the Real Use of Semiconductor software Technology.

The purpose of the course was to introduce the participants to the capabilities and limitations of state-of-the-art process and device modelling programs. The emphasis was on the practical aspects of using simulation software and there was ample opportunity for the attendees to evaluate commercially available software. The course was made up of a number of formal lectures presenting important aspects of process and device simulation and a large number of practical sessions in which the software was used to solve a selection of pre-prepared problems. These problems were designed to illustrate the important advantages and limitations of the simulation packages.

The course was organised by the Professor Sean McKee of Strathclyde University with help from Dr A.J. Walton of Edinburgh University. CG was a member of the founding committee and was involved in developing the course programme.

RFF attended this full course as a member and CG attended the final day to give a presentation on the EVEREST Software Suite. During the week RFF mounted the suite on the computing system being used by the course and gave demonstrations. While the course was primarily aimed at two-dimensional simulations, the EVEREST Suite was the only three-dimensional simulator available during the course.

The course was intended for process and device engineers working in industry and about 15 people attended.

### 4.2.6 ESPRIT Parallel Processing Project - ACCORD (CG)

During this year the ESPRIT Project ACCORD comes to an end. The Department has been involved in two parts of this project: the Vector Field's demonstrator and the APPEAL Library. Members of the Parallel Processing Group have been involved in the implementation of the Vector Field's demonstrator ABEL. This is a parallel implementation of a boundary element package on the IBM 6150 with Transputers attached. This demonstrator was display at the ESPRIT Conference in November 1989.

CG has continued to be involved in the APPEAL Library of ACCORD at a low level. APPEAL is a library of numerical routines addressing the solution of large sparse systems on vector and concurrent machines. CG has been active in developing standards for this project and in testing each new version of the serial library on the Cray and Stellar. The major effort of the project has been toward vector machines, in particular the FPS M64 series although the base version of the library provides some very useful numerical routines for serial architectures.

The APPEAL library will be made available to the SERC engineering community during the next few months.

### 4.2.7 Support of the EVEREST and TAPDANCE Suites

EVEREST and TAPDANCE are two major software suites resulting from ESPRIT and ALVEY projects. Under the EASE+ initiative these suites are being supported for the microelectronics community.

In a response to a recent article in ECN over thirty academics have requested access to this software. Plans are in hand to make the software available and to provide suitable training courses in their use.

As a result of the ESPRIT project EVEREST five members are attempting to set up a User Club to fund the support and development of the EVEREST Suite. This activity would be based at RAL and would complement the effort being funded by EASE+.

Enquiries to simulate specific device types have been received from a number of industrialists and academics and these applications are providing very useful tests for the programs.

The two-dimensional mesh generator AQUABAT has been embedded in TAPDANCE to complement the existing ESCAPADE generator. This has allowed the investigation of mesh adaption using TAPDANCE and the device simulator DEVMOD.

### 4.2.8 Conferences Attended

1. 6th ESPRIT Conference and Exhibition, Brussels, 27 November to 1 December 1989 (CG, RFF)
2. EASE 90 Conference, University of Manchester, 18-20 April 1990 (RFF)

### 4.2.9 Courses Attended

1. UCINA Workshop on Parallel Processing, University of Oxford, 3 April 1990 (CG, JVA, RFF)
2. UCINA Workshop on Semiconductor Device Simulation, University of Oxford, 20 June 1990 (CG, JVA, RFF)
3. THRUST Workshop on Process and Device Simulation, University of Strathclyde, 2-6 July 1990 (CG, RFF)
4. Exploiting Transputers, Tutorial at EASE 90, University of Manchester, 18-20 April 1990 (RFF)

### 4.2.10 Papers and Reports

1. Goodsell, G. and Whiteman, J.R., A Unified Treatment of Superconvergent Recovered Gradient Functions for Piecewise Linear Finite Element Approximations, Int. J. Numer. Meth. Eng., 27, 469-481, 1989.
2. Goodsell, G. and Whiteman, J.R., Pointwise Superconvergence of Recovered Gradients for Piecewise Linear Finite Element Approximations to Problems of Planar Linear Elasticity, Numer. Meth. Partial Differential Equations, 6, S9-74, 1990.

#### 4.2.10.1 ESPRIT EVEREST Reports

**Project Reports**

1. Greenough, C., Report on Data Base Implementation, EVEREST Report, RS.3.2.
2. Fitzsimons, C.J., Li Jin and Gunasekera, D., Report on Adaptive Solver Implementation, EVEREST Report, RS.3.24.
3. Gunasekera, D., Hunt, C.J. and Greenough, C., Final Release of Solver Documentation, EVEREST Report, RS.3.26.
4. Fowler, R.F., Combined report on the uses of parallel computer in the EVEREST Suite, EVEREST Report, R2.4.l (R4.1.1 and R4.1.2).

**Workpackage S Reports**

1. Gunasekera, D. and Greenough, C., Proposal for the User Interface of the Geometric Modeller, EVEREST Report, RAL/5.30.
2. Gunasekera, D. and Greenough, C., Proposal for the Solver/Mesh Generator Interface, EVEREST Report, RAL/5.3l.
3. Greenough, C. and Gunasekera, D., Future Developments of the EVEREST Suite, EVEREST Report, RAL/5.32.
4. Gunasekera, D., Equivalence of Eisenstat's implementation of the pre-conditioned conjugate gradient method and the incomplete LDU preconditioned conjugate gradient method for a class of problems, EVEREST Report, RAL/5.33.
5. Ashby, J.V., Gunasekera, D. and Greenough. C., User Documentation for the BLOCKS Geometric Modeller, EVEREST Report, RAL/5.34.
6. Gunasekera, D., Implementation of the time integrator in the Solver Module, EVEREST Report, RAL/5.35.

#### 4.2.10.2 Rutherford Appleton Laboratory Reports

1. Goodsell, G., Gradient Superconvergence for Piecewise Linear Tetrahedral Finite Elements, RAL-90-031, March 1990.

#### 4.2.10.3 Mathematical Software Group Notes

1. Ashby, J.V., Generating RAL style documents in LATEX, MSGN/1, March 1990.
2. Greenough, C., Index of Mathematical Software Group Notes, MSGN/2, April 1990.
3. Greenough, C., Format and Distribution of Mathematical Software Group Notes, MSGN/3, April 1990.
4. Goodsell, G., Application of Gradient Superconvergence Techniques to Semiconductor Device Modelling, MSGN/4, October 1989.
5. Goodsell, G., Gradient Superconvergence in the Finite Element Method - Part I: Two Dimensional Problems, MSGN/s, January 1990.
6. Goodsell, G., Gradient Superconvergence in the Finite Element Method - Part II: Three Dimensional Problems, MSGN/6, January 1990.
7. Greenough, C., The NAG/SERC Finite Element Library Future Developments - Release 4, MSGN/7, April 1990.
8. Greenough, C., ESPRIT Project EVEREST: Index of Project Reports, MSGN/8, April 1990.
9. Greenough, C., ESPRIT Project EVEREST: Index of Workpackage 5 Internal Reports, MSGN/9, April 1990.
10. Goodsell, G., The Mathematica Computer Algebra Package, MSGN/10, May 1990.
11. Fowler, R.F., The Use of Parallel Computers in the EVEREST Project, MSGN/11, May 1990.
12. Fowler, R.F., Report on the THRUST course at Strathcy1de University, 2-6 July 1990, MSGN/12, May 1990.
13. Greenough, C. and Hunt, C.J., PARFEL - An Extension of the NAG/SERC Finite Element Library for Multi-Processor Message Passing Systems, MSGN/13, March 1990.

### 4.2.11 Objectives for 1990/1991

Over the next year the Mathematical Software Group will continue its programme in research and development and the provision of software and expertise to the EASE community.

With the completion of Release 3.0 of the NAG/SERC Finite Element Library and the two ESPRIT Project EVEREST and ACCORD the Group will promote the results of these projects as well as continuing new development within the ESPRIT Project BECAUSE.

The EASE Programme will play an important role in the development of the Group's programme, particularly with the definition of both the EASE Schedules and the EASE Environment.

Specific objectives for the year will include:

- Contributions to the EASE Environment in mathematical software and libraries.
- Specification and production of an EASE Environment Demonstrator.
- Completion of Release 4.0 of the NAG/SERC Finite Element Library.
- Distribution of Release 1.0 of the Parallel Finite Element Library PARFEL on the Hypercube.
- Promotion and support of the NAG/SERC Finite Element Library with user courses and seminars.
- Promotion and support of the semiconductor software EVEREST and TAPDANCE coupled to developing and running user courses and seminars.
- Start the ESPRIT Project BECAUSE.
- Secure funding from the Basic Long Term Research (BLTR) Programme within JESSI for Semiconductor Simulation.
- Secure new funding for the development of mathematical and numerical techniques and software from SERC, ESPRIT and BRITE/EURAM.

Most of these objectives will produce both software and reports which the Group will make available to the engineering community.

## 4.3 ENGINEERING APPLICATIONS

The Engineering Applications Group is concerned with the assessment and exploitation of new computer architectures for engineering design and analysis. This may include supercomputers such as the CRAY X/MP; the STARDENT GS2000 and TITAN workstations; and parallel machines like the AMT DAP and transputer arrays. The experience gained in this work is used to provide guidance to members of the UK academic community within the EASE framework. Other projects are in the form of consultancy work and make use of the Group's expertise to provide assistance outside the SERC Engineering Board area.

### 4.3.1 Staffing

Staff in post at end of June 1990:

- Jim Diserens (NJD) Group Leader
- Chris Harrold (CSH)
- Morgan Chow (CC)


**Retirement: Jim Diserens with Bill Trowbridge (left) and Zienkiewicz Finite Element Method, June 1990**

**Large View**

### 4.3.2 Achievements 1989/90

The main EASE projects during the past year have been:

#### 4.3.2.1 Porting of TOSCA to the STARDENT Computers (CC and NJD)

This work comprised taking the 3D electrostatic/magnetostatic package TOSCA and implementing it on the STARDENT computers, whilst making use of the vectorisation and high speed graphics rendering capability as much as possible. A version of TOSCA has been mounted using X-Windows. However, further work is required to achieve faster graphics using the AVS visua1isation package.

#### 4.3.2.2 Work on the AMT DAP (CSH)

A study of solution of sets of linear equations involving dense matrices has been carried out and applied to the BIM2D magnetostatic program. A new fast matrix multiply algorithm has been developed using a recursive procedure.

An evaluation of the DAPIX visua1isation graphics has been carried out.

The work on the DAP has now been brought to a conclusion and the machine is being transferred to Particle Physics Department.

#### 4.3.2.3 TEAM Workshops (NJD, CC and CSH)

The Group have participated in the TEAM (Testing Electromagnetic Analysis Methods) workshops. This is an international collaboration to prepare and run a series of benchmark problems for verification of electromagnetic computer programs. A Workshop and Seminar was organised by the Group and was held in Oxford in April.

#### 4.3.2.4 Particle Tracking Space Charge Program for RFQ Accelerators (NJD)

Further development of the RFQTRAK space charge program for RFQ accelerators has been done under contract from Los Alamos. This uses the CRAY X/MP computer. It is run in conjunction with an interactive graphics pre and post processor written by Vector Fields Ltd.

#### 4.3.2.5 Study of Octupole Magnet Fields (NJD)

This was a study of the magnetic field distribution in an octupole magnet designed for insertion into the ISIS ring. Both PE2D and TOSCA packages were used in this analysis.

#### 4.3.2.6 Wave-Particle Interaction Program (CSH)

This was a pilot study to assess the suitability of the DAP for this package which simulates the interaction between a time varying wave in space and a collisionless plasma containing 100,000 electrons which undergo Brownian Motion in phase space. First indications were that the DAP is well suited to this type of problem.

### 4.3.3 Conferences and Meetings Attended

1. EASE 90, Manchester, April 1990. (NJD)
2. TEAM workshops and International Seminar in Electromagnetic Field Analysis, Oxford, April 1990. (CC, CSH, NJD)
3. IUSC Working Party on CAD/CAM (NJD)
4. DAP Group Meeting, Bracknell, May 15th, 1990 (CC, CSH)

### 4.3.4 Courses Attended

1. TOSCA course at Vector Fields Ltd., Kidlington. February 1990 (CC)
2. Open University course (Physics) (CC)

### Papers and Presentations

1. Electromagnetics as a Benchmarking Tool. Presentation to EASE 90. (NJD)
2. Porting of an Electromagnetic Applications Package to the Stardent Supercomputing Workstations. EAG Note no 1. (CC, NJD)

3. Fast Matrix-Matrix Multiplication on the AMT DAP. EAG Note no 2. (To be presented at Parallel'90, Southampton, September 1990. (CSH)
4. An assessment of the AMT DAP510. EAG Note no 3. (CSH)
5. Use of the AMT DAP in Linear Magnetostatics Solving Dense Systems of Equations. A Hybrid Method for Solving Dense Systems of Equations (CSH)

**Objectives for 1990/1991**

To continue to assess the best ways to utilise the latest parallel and vector machines in the mounting of engineering applications packages. Emphasis will be on finding the best numerical techniques for each system. The hardware involved will include a wide range of architectures, for instance the STARDENT, FPS workstations and transputer arrays.

## 4.4 PARALLEL PROCESSING

The Parallel Processing Group (PPG) undertakes projects and development work on the systems aspects and programming techniques of parallel processing, as well as monitoring and assessing developments in the field generally. Advice and assistance is also given on porting applications to parallel systems. PPG also supports the programme of the SERC/DTI Initiative on the Engineering Applications of Transputers and of its London and South East Regional Support Centre located at RAL, both of which are coordinated in separate Units in ID.

### 4.4.1 Staffing

- C P Wadsworth (CPW) Group Leader
- H K F Yeung (HKFY) left March 1990
- D J Johnston (DJJ)
- B W Henderson (BWH)
- A M Reay (AMR) - Atlas Trainee, January-June 1990
- R J Woodword (RJW) - Atlas Trainee, June-December 1990

Francis Yeung

**Large View**

HKFY moved to Daresbury Laboratory on promotion to Grade 7. CPW was promoted to Grade 7 in February 1990.

### 4.4.2 Objectives 89/90

Current interest is focussed mainly on scalably parallel architectures such as ones with distributed memory, eg the transputer and hypercube machines. A medium-term goal is the integration of the transputer and/or other parallel systems into the EASE programme. The "ease" with which this can be achieved may well depend on the rate at which the community develops the ability to exploit parallel processing without the need for explicitly parallel programming. The long-term goal is to provide an effective environment for developing applications on and for parallel systems.

Part of the Group's work centres on the porting of applications to parallel systems, with particular aims both to gain practical experience of the most useful parallelisation techniques and to consolidate an understanding of user needs for an effective applications environment for parallel systems. This work is typically undertaken jointly with an applications team, eg with other groups internally, or via Transputer Centre contacts, or on consultancy to an external applications party.

The major objectives for 1989/90 have been as follows (in no particular order):

1. Provide technical expertise to the ESPRIT EuroWorkStation (EWS) project in Design Division;
2. Pursue the IEATP collaborative proposal Fortran for Scalably Parallel Systems through to a formal offer and get this project (BRIM) started;
3. Decide on and develop further applications for the 6150/transputers as specified in the Joint Study agreement with IBM;
4. Support the RAL Transputer Centre and the Transputer Initiative Co-ordinator with technical expertise as required;
5. Undertake further developments of tools for transputer systems as resources permit;
6. Assess the issues to be faced in providing machine-independent parallel software, and in standards for parallel software.
7. Establish one further externally-funded project.

### 4.4.3 EWS Project (BWH, DJJ)

Since September 1989 PPG has been providing additional effort for the ESPRIT EWS project run by Ken Robinson in Design Division (see that Division's report for a fuller report). This has principally involved BWH and DJJ, each part-time, with a small amount of input from CPW (on the class hierarchy for the project).

BWH has constructed an X11 (version 4) server for SUNs, using the MIT release, and evaluated performance on a SUN 3/80. The CHORUS operating systems, providing a distributed real-time kernel with support for multiple threads and IPC, was installed on SUNs and test programs written to try out the message passing and threads mechanisms.

BWH then ported several Xclients and Xlib onto CHORUS, enabling the graphics requirements of clients to be fulfilled by a remote X11 server on a SUN. The CHORUS system was shown to be reasonably compatible with Unix System V.

The standard X11 server was then ported onto CHORUS, which required production of a special access frame and simulation of input devices and their output. Xclients were created to test the operation of this server.

DJJ first surveyed the major graphics standards to determine those most relevant to the (3D) needs of EWS, then designed a hierarchical graphics interface to support the chosen standards in a consistent manner. DJJ has organised RAL's discussions with FhD-AGD (Darmstadt) to determine the interface between respective parts of the project and identify the functionality of the 3DGRP

hardware and software. The latter has been tested locally on a SUN by writing a simulator for 3DGRP.

### 4.4.4 BRIM (CPW, DJJ)

Last year's report deferred estimates of when this project might eventually receive its formal offer/announcement from IED. This eventually happened in December 1989 and project formally started on 1 April 1990.

The project was given the short name BRIM, signifying its four partners: Brunel University, RAL, Intercept Systems and Meiko. The aim is to develop the techniques needed to detect and extract parallelism from Fortran programs for multi-transputer target system.

Progress to date has focussed on the requirements for an intermediate language PDF (Parallel Distribution Format) for the project. The project at RAL involves CPW and DJJ, with Stuart Robinson (Systems Engineering Division) as a research consultant.

### 4.4.5 IBM Joint Study (BWH, HKFY)

This Joint Study involves the IBM 6150 workstation and the transputer. Three 6150s have been provided by IBM on loan for the duration of the project (November 1988-0ctober 1990). The general aim is to explore the potential for enhancing the capabilities of an advanced graphics workstation (6150) with a reconfigurable parallel compute server (transputer). Work during 1989/90 has concentrated on porting and parallelising further applications after successfully completing the first example BIM2D in 1988/89.

Two substantial packages have been ported: Apple, and Onda. Both are moderate-to-1arge sized packages (20,000-50,000 lines) which previously ran on minicomputers and/or mainframes. APPLE is an electromagnetics design package similar to BIM2D. Onda is a river modelling package developed by Sir William Ha1crow and Sons for area water authorities.

BWH helped Vector Fields and Brian Colyer to generate an Apple demo for the ACCORD project at the ESPRIT Conference in Brussels in November 1989. The Apple port follows a similar approach to that for BIM2D, with the I/O and graphics remaining on the workstation and the transputers (32 currently) carrying out the compute intensive tasks such as (parallel) Gaussian elimination and generation of contour maps. The demo has been shown subsequently to many visitors, including the SERC Chairman, members of the RAL Visiting Panel, and the Industrial Directors of the three ERCIM organisations.

BWH has continued to refine the demonstration version. The graphics have been enhanced from using the ww interface to a standard XII interface, hence XApple as name of current demo. A four transputer version has also been generated for occasions when the larger 32 transputer system is unavailable.

HKFY undertook a major port of the Onda package, with some assistance from Halcrow in the form of updates to the application-specific routines (which are used unchanged). A parallel strategy was devised, then implemented and tested. Several problems were encountered particularly in the limited amount of memory per processor on the system used for testing. With some re-thinking, a working version was completed for a four transputer system with 1 MByte memory per processor. The strategy followed and some performance figures are reported in a paper presented at the Transputer Initiative Conference (TA90) in Southampton in July 1990.

With the move of HKFY to Daresbury, PPG has little effort remaining for further work under the Joint Study. Fortunately all the goals of the Joint Study have been achieved with six months still to run. A final report summarising the project remains to be completed by October 1990.

Further work with the 6150 has in any event become redundant. Towards the end of the period reported IBM announced a new RS/6000 range of workstations with about ten times the performance of the 6l50. One has been ordered and delivery is now expected in August 1990. Further work using a workstation/transputers combination will continue with the RS/6000.

Two lessons have become increasingly apparent from the work with APPLE and Onda. First, the speed of the interface between the 6150 and (the first) transputer (50 KBytes/sec) is an increasingly limiting factor both on overall performance and on full effectiveness of the demos generated. Fortunately higher performance host interfaces are now available for (some) transputer boards. One is a must for the RS/6000. (Indeed, higher performance transputers would not go amiss either, by at least a factor of 10!). The second lesson is that substantial applications require lots of memory when ported to transputer systems (particularly in the absence of virtual memory on transputers). A minimum of 4 MBytes per processor is becoming the norm in this community generally.

### 4.4.6 Transputer Technical Support (DJJ, BWH, CPW)

Logically this may be divided into support for the Transputer Centre and support/advice to the Transputer Initiative Co-ordination Team, though in practice it is sometimes difficult to distinguish the two roles.

#### 4.4.6.1 Transputer Centre

PPG supports the Centre through provision of courses, participation in discussions with prospective industrial customers, consultancy for customers, and day-to-day support to users including dealing with many telephone, email, and postal queries.

Courses have continued at approximately the same level built up to in 1988/89. The two existing course Transputer Awareness (half day) and Exploiting the Transputer (one day) have each been given four times. DJJ has developed a new course Parallel Fortran (2 days) which has now been given three times, with BWH helping in the practical sessions. In addition a 3-day unit for the Atlas trainee scientists was given, which resulted in a further trainee (RJW) joining PPG for a 6-month project.

Among the companies with whom discussions have taken place are:

- *Pablo AS/XCon (Norway)
- *Halcrow
- *Vector Fields
- *T2 Systems
- David Martin & Co
- Transport Studies Group
- Mandamian
- Colin Coleman & Co
- IT World

The asterisks indicate those companies with whom there has been specific follow-up this year. A number of academics have also visited to discuss their applications:

- Simon Lavington (Essex)
- Neil Hoose (UCL)
- Klaus Neumann (Loughborough)
- Roy Campbell (Illinois)

User support, and answering queries, has at times threatened to swamp the effort available this year, given that those providing it (DJJ, BWH) have increased commitments to other projects. Measures have needed to be taken to ensure that the time taken up is kept to a reasonable proportion.

#### 4.4.6.2 Transputer Initiative Co-ordination (CPW, HKFY, BWH, DJJ)

All members of PPG provide support and technical advice to the Co-ordinator on miscellaneous matters from time to time. In particular this year: DJJ has opened discussions with Birkbeck College about the pull-through of their work into demonstrators and is liaising with Raymond Fawcett on this and other demonstrators for the Initiative; CPW provided technical liaison for completing the

QUB/Brunel/Liverpoo1 EMR contract; CPW has continued as a member of TAMG; BWH has taken over (from HKFY) the support for Apollo transputer kit in the Academic Loan Pool; CPW gave presentations about the Initiative to the NAG Users Association annual meeting in York, and to the IEE SERTS Conference in Cirencester.

#### 4.4.6.3 Standards Workshop (CPW, HKFY, BWH)

A Workshop on Software Standards for MIMD Machines was organised for the Transputer Initiative at Cosener's House on 1-2 March 1990. As with the previous Workshops, this took the form of invited presentations followed by three parallel subgroups (Language, Libraries, Systems) and reports back to a general session. CPW was programme organiser and chaired the Languages subgroup.

CPW compiled most of the workshop Report with inputs from HKFY, BWH, Cyril Balderson, and Raymond Fawcett who acted as notetakers in the subgroups. The major recommendation (being implemented) is the establishment of two Working Groups on high-level and low-level standards respectively.

#### 4.4.6.4 Demonstrations (BWH, DJJ)

The range of demonstrations described in last year's report continue to be available and most are demonstrated regularly. Two new demonstrations have been added this year:

- XApple electromagnetics
- Cyclic Mandelbrot demo

The first was developed by BWH with Vector Fields (see 4.4.5). DJJ developed the second at short notice - assisted by midnight oil! - for an exhibit at Leicester Museum of Science and Technology where it ran unsupported (by us) for a month. This demo cycles through a number of features embedded in DDJ's previous interactive demo. The demo even boots itself automatically when the host PC is switched on!

Among those to whom demos have been given, in addition to courses and the companies mentioned above, are:

- SERC Chairman
- Prof Enderby (RAL Visiting Panel)
- ERCIM Industrial Directors
- BBC Schools Section Head
- SGS-Thomson
- EMRWFC visitors (4)
- Prof Georgesen (Romania)
- NZ/Austra1ia British Council group

### 4.4.7 Transputer Developments

PPG's involvement in the EWS project has implied rather less effort being available for specific transputer developments, though a number of tasks have been undertaken. Two Atlas trainees joined PPG for 6-month projects (one continuing to the end of 1990).

#### 4.4.7.1 XCon/Pablo Consultancy (CPW, BWH)

XCon is a Norwegian company based in Oslo who have developed a transputer-based image compression algorithm for a client company, Pablo AS, in conjunction with a proposed geographical data base for the city of Oslo. The XCon prototype uses a custom-built transputer board, incorporating FIFO-buffers in the host interface for higher bandwidth, and was hosted by a PC running Xenix.

Following discussions with the Centre Manager, CPW, and BWH, the Transputer Centre were contracted by XCon to port the prototype to an Apollo workstation as host (with a view to using the richer user interface capabilities in further developments). BWH undertook the work, porting the

host server/driver and incorporating the driver into the Apollo's particular device driver system. This was completed in 15 man-days exactly as estimated to XCon!

#### 4.4.7.2 T2 Systems Ltd (DJJ)

DJJ collaborated with Patrick Pope of T2 Systems, a user of the Transputer Centre, in converting disk driver software to C to run under the GENESYS system on Transtech's NT1000 boards (ex-Niche) in SUNs.

#### 4.4.7.3 Parallel Worm (DJJ)

DJJ has polished his prototype parallel worm program for exploring transputer networks. A paper is being prepared for submission to Transputing 1991, the first world conference of Transputer and Occam User Groups to be held in the US in April 1991.

#### 4.4.7.4 Trainee Projects (AMR, RJW)

AMR started a 6-month project in January 1990 extending BWH's idle-time monitoring tool, in particular enhancing the user interface. At the time of writing the final report of the project is being completed.

RJW joined PPG towards the end of the period reported and will be working on configuration aids for transputer programs, supervised by DJJ.

#### 4.4.7.5 DTI Parallel Software Evaluation

PPG received two products, the 3L parallel languages and Helios-PC, for evaluation under this programme operated by the University of Southampton for the DTI. An interim report mainly addressing our experiences with 3L Parallel Fortran was written for a meeting of the programme participants in April 1990. Shortage of available staff effort has limited evaluation of Helios, though CPW has written a book review for a journal.

#### 4.4.7.6 Parallel Programming Environment (CPW)

Achieving a stable environment for portable parallel software, across a significant range of parallel architectures, is increasingly seen as critical for the widespread exploitation of parallelism. CPW has continued to spend much time cogitating these matters, though rather less this year in getting thoughts down on paper. A position paper was provided for the Workshop in March (see 4.4.6.3) and talks given at the IEE SERTS Conference in Cirencester and at EASE 90. The Working Groups being established following the Workshop will be addressing many areas where standards can help.

### 4.4.8 Research Proposals (CPW, HKFY)

PPG joined with Visualisation Group in the IEATP collaborative PRIPS proposal Parallel Reconfigurable Image Processing Systems submitted in December 1989 led by NAG. The proposal was technically approved quite rapidly but then ran into difficulties when one of the industrial partners withdrew. Attempts to rescue the proposal are continuing.

CPW and HKFY each attended meetings in the lead-up to finalising the proposed ESPRIT programme on the European Microprocessor Initiative (EMI). A joint position paper was presented by HKFY at one of the EMI Workshops in Brussels in February. The programme has apparently now been approved in outline, though no further details are to hand yet except that the name has been changed to the Open Microprocessor Initiative (OMI). CPW has been invited to join an Industrial Working Group tasked with defining the Work Programme for a Call for Proposals.

Some details of the long-awaited DTI/SERC Parallel Applications Programme (PAP) emerged towards the end of the period. CPW assisted DRSB and MRJ in the preparation of RAL's part in Oxford's bid. Response to the outline bids is awaited.

Further discussions on common interests and possible joint activities with the IBM UK Scientific Centre, Winchester, are being pursued.

### 4.4.9 Conferences

1. NAG Users Association, York 6-7 Sept 1989 (CPW) (invited talk)
2. BCS PPSG Workshop on Parallel Compilation, Oxford 13-15 Sep 1989 (CPW)
3. IEE Conference on Software Engineering for Real Time Systems, Cirencester 19 Sept 1989 (CPW) (invited talk)
4. IED Parallel and Novel Architectures Club London 19 Dec 1989 (CPW)
5. SERC/DTI Transputer Initiative Workshop on Software Standards for MIMD Machines, Coseners 1-2 March 1990 (CPW) (Programme Organiser)
6. Computational Science Initiative Workshop on the Intel Hypercube Daresbury 6 March 1990 (CPW, HKFY)
7. Seminar on IBM RS/6000 London 29 March 1990 (CPW)
8. EASE 90 UMIST 18 - 20 April 90 (CPW) (talk and tutorial) (DJJ) (tutorial) (BWH) (talk)
9. Workshops on European Microprocessor Initiative (EMI) Brussels 26-27 April 1990 (CPW) 1 February 1990 (HKFY )
10. Occam User Group 11th Meeting Edinburgh 25-26 Sept 1989 (DJJ)
11. ECS Annual Seminar Edinburgh 27 Sept 1989 (DJJ)
12. ESPRIT Conference Brussels 25-30 Nov 1989 (BWH)
13. Par.C Introduction Seminar Liverpool January 1990 (BWH)

### 4.4.10 Courses Attended

1. MSc (day release) in Computing Science, Brunel, Thursdays (DJJ)
2. C++ Programming Workshop, London, 22-26 January 1990 (DJJ)
3. Management 1 , Bournemouth, 4-8 June 1990 (DJJ)
4. Chorus Training Seminar, Paris, 16-19 October 1989 (BWH)

### 4.4.11 Papers

#### 4.4.11.1 External

1. C P Wadsworth, H K F Yeung, On EMI Requirements for Embedded Systems, position paper, EMI Workshop, Brussels, 1 February 1990 (also PPG Note 23).
2. C P Wadsworth, On Parallel Virtual Architectures, position paper, SERC/DTI Workshop on Software Standard for MIMD Machines, 1-2 March 1990 (also PPG Note 24).
3. C P Wadsworth, Book review of "The Helios Operating System", to appear in International CIS Journal, 1990 (also PPG Note 32).
4. H K F Yeung, ONDA: a river modelling system, in Applications of Transputers 2, eds: D J Pritchard and C J Scott, IOS Press, 1990 (also PPG Note 31).
5. D J Johnston, Experiences of Transputer Assembler Programming, Transputer Initiative Mailshot, September 1989 (also PPG Note 12).
6. B W Henderson, A Simple Idle-Time Monitor for Transputer Networks, Transputer Initiative Mailshot, October 1989 (also PPG Note 20).
7. B W Henderson, Par.C System a C Compiler for Transputers, Transputer Initiative Mailshot, April 1990 (also PPG Note 21).
8. H K F Yeung (with B Ralston and F Thomas (IBM)), Flood Prediction: a Study in Fortran Optimisation and Connectivity, Supercomputer J, Elsevier, July 1990.

#### 4.4.11.2 Internal

1. EWS/29: Stimulus and Response - an Exchange of Faxes between DJJ and M Mehl (Darmstadt), 3.10.89, DJJ
2. EWS/35: Review of the CHORUS Instruction Course, 24.10.89, BWH
3. EWS/40: The SUN 3/80 Workstation, 22.11.89, BWH
4. EWS/49: Collecting alpha-release of CHORUS, 16.2.90, BWH
5. EWS/50: GPP to 3DGRP Software Interface Specification, 9.2.90, DJJ
6. EWS/52: Translation of a paper on GIPIS' X Term, 27.2.90. BWH
7. EWS/58: Graphical Interface Specification, 21.3.90, DJJ
8. EWS/64: Response from DJJ to Michael Kokula's new XIP Proposal,18,4,90, DJJ

9. EWS/65: Minutes of a meeting at CHORUS, 25.4.90, BWH with V A Burrill
10. EWS/68: Implementation of X and CHORUS, 22.5.90, BWH with V A Burrill
11. EWS/73: Building an XII-Server and Clients on CHORUS, 27.6.90, BWH
12. PPG/15: 386 Device Driver and Afserver for Vector Fields, 20.9.89, BWH
13. PPG/16: User Guide for the "3L Parallel Fortran" System running on Vector Fields 386 Machine, 20.9.89, BWH
14. PPG/17: IBM 6150 Workstation and Transputer Combination - Software (development version), 9.10.89, BWH
15. PPG/18: Trip Report - the 11th Occam User Group Meeting and the 2nd Annual Edinburgh Concurrent Supercomputer Workshop, 8.11.89, DJJ
16. PPG/19: RAL/IBM 6150 Joint Study Report: Summary of Progress in the Last 12 Months, 1.11.89, HKFY
17. PPG/22: Report of IED PNA Club Meeting - 19.12.89, 22.1.90, CPW
18. PPG/25: The Hydra or Multi-headed Worm (extended abstract), 5.3.90, DJJ
19. PPG/26: Transputer Implementation of BIM2D, 11.7.89, HKFY
20. PPG/27: Transputer Implementation of Onda, 12.3.90, HKFY
21. PPG/28: ID/IBM Joint Study Project Overview, 21.3.90, HKFY
22. PPG/29: Assessment of ID/IBM Joint Study Project, 27.3.90, HKFY
23. PPG/30: Onda: extended abstract for TA 90 conference, 21.3.90, HKFY
24. PPG/33: 3L Parallel Fortran and Helios: Progress Report for DTI/Southampton PSEP, 3.4.90, CPW
25. PPG/34: Handout for the Onda demonstration, 21.3.90, HKFY
26. PPG/35: A Simple Idle-time Monitor for Transputer Networks (extended abstract), 4.5.90, BWH
27. PPG/38: XCon reports, 18.6.90, BWH
28. PPG/39: Summary of Final EMI Workshop, Brussels, 26.4.90, 8.5.90, CPW
29. TAMG/P22: Interim report on Workshop on Software Standards for MIMD Machines, 9.5.90, CPW

#### 4.4.12 Objectives for 1990/91

The general directions outlined in 4.4.2 will continue with increased emphasis on the techniques and methods, including standards, needed to bring about a mature parallel programming environment, and the integration of parallel processing systems into EASE.

Specific objectives for 1990/91 are as follows:

1. Provide technical expertise to complete the ESPRIT EWS project in Design Division;
2. Carry out our part in the BRIM project, contributing to the definition and implementation of its intermediate language PDF;
3. Pursue the PRIPS proposal through to a revised consortium if feasible (with Visualisation Group);
4. Complete the IBM Joint Study and pursue extension if indicated;
5. Pursue routes to support further work on parallel applications, including the DTI/SERC PAP bid;
6. Continue the technical support provided to the Transputer Centre and to the Transputer Initiative Co-ordinator, including contract consultancy to clients of the Centre;
7. Undertake further technical developments on transputers that widen their availability to the end user, including work for Apple Mac and the new IBM RS/6000 workstation as hosts;
8. Extend PPG expertise to at least one other parallel architecture besides transputers (probably Intel iPSC/860 hypercube);
9. Continue to assess the issues to be faced in providing machine-independent parallel software, including standards, as steps towards the integration of parallel processing into EASE.
10. Seek one further externally funded project (possibly an OMI proposal).

### 4.5 COMPUTATIONAL FLUID DYNAMICS

#### 4.5.1 Staffing

The group was greatly strengthened by the arrival on 17 April 1990 of Dr Conor Fitzsimons (CJF) to join Manjit Boparai (MKB) and Alan Bryden (ADB), who is the group leader.

### 4.5.2 Objectives

CFD is a major applications area supported by several committees of Engineering Board, viz Electromechanical Engineering (EMEC) , Process Engineering, and Environment. There is also funding from-Science Board for some fundamental developments.

The overall objective is to provide the computing infrastructure required by the Engineering Board CFD community to enable them to exploit modern computing techniques, and to keep the community informed on what is available. The mechanism to achieve this is to establish a Community Club in CFD which will help to set priorities, identify particular topics for investigation, and disseminate the results.

### 4.5.3 Achievements

#### 4.5.3.1 CFD Community Club (ADB, CJF)

The CFD programme under EASE was originally proposed jointly with EMEC who agreed to fund a CFD Co-ordinator. However there were delays in appointment of the Co-ordinator because of the proposal within EMEC for a LINK Programme in CFD. It was eventually decided not to wait for the EMEC Coordinator to be appointed but to proceed with setting up the Community Club which held its first meeting at RAL on 22 March 1990. It was attended by more than 60 people.

A Steering Group for the Community Club has been set up with representatives from the three Engineering Board Committees funding work in CFD and from Science Board. There are also members to provide links to ERCOFTAC (the European Research Community On Flow Turbulence And Combustion), and MOD. It will hold its first meeting on 17 July.

There are now more than 130 people registered with the Community Club.

#### 4.5.3.2 Visualisation in CFD (CJF, MKB)

There has been close contact with the Visualisation Group, which has led to two contracts being awarded by CFC on Visualisation in CFD.

One is a pilot development in use of advanced visualisation systems in real engineering applications in CFD. An invitation to bid was issued in January 1990, and eleven bids were received. The contract was awarded to Dr Weatherill of the Civil Engineering Department, University College, Swansea. It will run for two years from 1 October 1990.

The second concerns the placement of the Ardent TITAN computer. Following an invitation to bid in August 1989, it was agreed that the TITAN would be placed in the ABACUS Unit at Strathclyde University for six months, and thereafter in Professor Gosman's group in the Mechanical Engineering Department of Imperial College London.

On the technical side MKB extended some of the work carried out in her MSc thesis by writing an interface to enable FAMResult (the post-processing section of the FEGS software suite) to be used to visualise output from a flow in a cubical cavity.

#### 4.5.3.3 Workshops

It was agreed at the Community Club meeting that a series of workshops will be held. The first is on 19 July at RAL on Visua1isation in CFD, when many of the bidders for the contract mentioned above will describe their work. Seventy-five people have replied to attend the workshop.

#### 4.5.3.4 Evaluation of CFD Software (MKB)

MKB is investigating the use of the PHOENICS code in a variety of problems in CFD. The aim is to determine the feasibility of implementing algorithmic changes in a commercial code like PHOENICS without access to the source code. It is expected that this will lead to a set of criteria against which other commercial codes can be evaluated.

During the period MKB has investigated the effect of changing the following items: Boundary Conditions, Physical Properties (density, laminar kinematic viscosity, turbulent kinematic viscosity, temperature), Dependent Variables, Array Dimensions, Discretisation, and Grid Generation.

### 4.5.4 Conferences and Courses

1. Workshop on MIMD Machines, Coseners House, 1-2 March 1990 (ADB)
2. PHOENICS Introduction Course, CHAM, Wimbledon, 5-9 March 1990 (MKB)
3. EASE 90, UMIST, 1-20 April 1990 (ADB, CJF)
4. ERCOFTAC Spring General Assembly, UMIST, 27 April 1990 (ADB)
5. CFD Research in Aerospace Committee, IEE, London, 2 May 1990 (ADB)
6. CFD Applications on Stardent Computers, Guildford 7 June 1990 (ADB, CJF)
7. Parallel Processing for Fluid Flow,, London 27 June 1990
8. Advanced Reading Techniques, December 1989 (MKB)
9. PROFS Course, 3 January 1990 (ADB)
10. PROFS Course, 28 March 1990 (ADB)
11. Minute Writing Course, 28 June 1990 (CJF)

In addition, ADB took part in EASE visits to Queen Mary Westfield College, London, Polytechnic of East London, and Thames Polytechnic, as well as several visits to other HEIs to discuss their CRF requirements.

### 4.5.5 Publications

Internal CFD Group Notes:

1. A Draft of CFD Community Club Activities in the Next Twelve Months. (CJF)
2. Report on the Seminar on CFD Research in Aerospace Industries. (CJF)
3. Notes on Visit to CHAM Ltd and subsequent Actions. (ADB)
4. Notes on Visit to Bristol University Aerospace Engineering Department. (ADB)
5. Report on Community Club Meeting on CFD. (ADB)
6. Implications for RAL Programme. (ADB)
7. Report on ERCOFTAC General Assembly. (ADB)
8. CFD Software from NETLIB. (ADB)
9. Visit to Strand Software. (CJF)
10. Topics for CFD Community Club. (ADB)
11. Benchmarking the FPS 500EA. (CJF)
12. Application of PHOENICS to a variety of problems in CFD. (MKB)
13. Programme of Workshops. (CJF)

MSc Thesis:

- Calculation of Three Dimensional Unsteady Laminar Flows, Linacre College, Oxford. (MKB)

### 4.5.6 Future Programme

#### 4.5.6.1 Common CFD Software

**Evaluation of PHOENICS**

This work is already under way. It will be completed by the end of the calendar year.

**Provision of Software for the Community**

The Advisory Group recommended that encouragement should be given to the use and development of common software in CFD. The Abingdon Workshop on CFD recommended that there should be the provision of a variety of mesh generators and a greater pulling together of effort in complex postprocessing.

Dr Yuan Jiansheng (Beijing) is visiting RAL for one year to write a geometrically flexible three-dimensional mesh generator. It is planned to collaborate with Dr Yuan in this task, and thus ensure that the resulting software will be of use to the CFD community.

How we intend to address the recommendation on post-processing is discussed under the heading of Visualisation.

#### 4.5.6.2 The Community Club

Paragraphs (a-c) below outline the programme of meetings for this year which have been agreed with the Steering Group. Paragraph (d) mentions those which have been agreed with the Steering Group for next year. Paragraph (e) concerns the collation of results from the questionnaire circulated to Community Club members earlier this year.

a. Workshop on the Accuracy of Numerical Modelling The Workshop on the Accuracy of Numerical Modelling will take place on 15-16 November 1990 at Coseners House under the chairmanship of Prof K W Morton (Oxford). Planning for this meeting is well in hand and an announcement will appear in the September issue of ECN.
b. Workshop on Grid Generation Planning of this meeting will start in late August. The meeting is planned for a date in January 1991.
c. Plenary Meeting This meeting will form part of EASE '91. The planning for this will involve liaison with the Organising Committee of the EASE Conference.
d. Future Events The Steering Group has also agreed that future meetings should address the topics of parallel computing, turbulence modelling, and code validation and evaluation.
e. Directory of Software Developers and Users At the start of the Community Club many members filled in a questionnaire in which they outlined their involvement in CFD. This data will be collated in a database in such a manner that it can be accessed easily.
f. Steering Group CJF is the Secretary to the Steering Group of the Community Club. The Group meets quarterly. The work involves organising the meeting, preparing position papers, and minuting the meeting.

#### 4.5.6.3 Visualisation

The main activity is to monitor the work on the EMR contract in Visualisation in CFD at University College, Swansea and to monitor the placement of the Ardent TITAN at Imperial College, London. Part of this will involve ensuring that the overlap between these two contracts is minimised. It is intended to arrange a meeting with UCS and Imperial and the Visualisation Group at RAL in September to. outline complementary work programmes. ,/p>

RAL staff will work closely with UCS to ensure that the results of the EMR satisfy the recommendation from the CFC that the visualisation system be capable of interfacing to a wide range of CFD systems.

#### 4.5.6.4 Test Data

**NASA Ames**
RAL staff will liaise with NASA Ames Laboratory in the provision of their computational data to CFD researchers.

**ERCOFTAC**
We will continue to cooperate with the ERCOFTAC Technical Committee, through Dr Peter Voke (QMWC, London) in identifying the technical problems involved with the provision of computational and experimental data, generated in Europe, to the CFD research community.

## 4.6 VISUALISATION

### 4.6.1 Staffing

The staff in Visualisation Group are:

- Julian Gallop (JRG)
- Image Processing
  - Bob Maybury (RM)
  - Martin Carter (MKC)

- Image Interpretation
  - Edwin Hancock (ERH)
- Image Generation
  - Janet Haswell (JH)
  - Rajka Popovic (RP)

Duncan Stevenson from the Division of Information Technology, CSIRO is with the group for 6 months from June 1990.

### 4.6.2 Objectives 1989/90

The group was formed with a brief that was not previously explicit in the department - to be responsible for the visua1isation of complex data and models. The main objectives therefore were to:

- gain a better understanding of the visualisation subject area, so that future work in support of the EASE programme and other funding sources could be defined
- make specific facilities available:
  - software - UNIRAS, PHIGS+, Dore
  - Stellar and Ardent superworkstations
- begin to carry out assessments (superworkstations, visualisation software, and solid modelling)
- consolidate the work on IPAL and define future work
- consolidate the work on object identification and define future work

### 4.6.3 Visualisation Software (JRG, JH, RP, DRS)

Increasingly the group will be investigating flexible visualisation systems, producing software where needed and cooperating in solving specific application problems. Until now, the group has been solving specific problems with lower level graphics systems and windowing system libraries (see "Visualisation Support for CMD projects" below).

AVS2 was installed on the Stardent ST2000 (ex-Stellar) (JH) and has been made to work with the spaceball (JH). Some experience is being gained with it. It has the potential to be a good flexible system for visua1isation and Stardent have concluded deals with other suppliers including DEC, which promises well. Since then additional modules from Stardent have been installed.

However, since the field is still volatile, information on other visualisation systems is surveyed and disseminated. JRG has given presentations at CG89 and at the SERC workshop at Daresbury in June 1990. JRG, JH and RP gave a tutorial at EASE 90 (see below).

JH has continued to gather information on software, claimed to be visualisation software, from both commercial and public domain with a view to future use at RAL or by EASE or other projects.

### 4.6.4 Visualisation support for CMD projects (JH, RP)

The Stardent ST2000 provides XFDI, PHIGS+ and AVS graphics and visualization packages. So, when the EVEREST package was ported to Stardent ST2000, its postprocessor module which uses RAL-GKS graphics library could not work. RP was asked to solve this problem. There were three alternatives:

- to port RAL-GKS library to Stardent;
- to rewrite postprocessor module and use one of available libraries;
- to simulate GKS calls used in postprocessor through one of available libraries.

The decision was made to leave EVEREST postprocessor unchanged and to concentrate on GKS implementation. Since the RAL-GKS X-driver was not ready and there was not sufficient time for porting, RP opted to simulate GKS calls using PHIGS+ routines. 44 GKS routines, used in EVEREST postprocessor, were implemented through PHIGS+ calls and successfully tested. This enabled completion of EVEREST's porting to Stardent ST2000.

When the TOSCA post-processor was ported to the Stardent ST2000, JH provided the graphics support. TOSCA on other systems uses the GINO graphics library. The idea was to change as little TOSCA code as possible. Initially, emulating GINO using PHIGS+ was attempted. This showed up several deficiencies in the implementation of PHIGS+ and was not continued. The final (and successful) emulation method was to port Brian Colyer's package which emulates GINO using ww and to port the X11 version of ww. X11 is not precise in its requirements for colour support in an X server and indeed problems were encountered and solved.

### 4.6.5 Data Visualisation Tutorial for EASE90 (JRG, JH, RP)

JRG, JH and RP prepared and presented the EASE 90 tutorial on Data Visualisation. The tutorial was split between them. JRG gave the Introduction to Visualisation in Science and Engineering. RP presented Hardware and Basic Graphics Software for ViSC. JH presented Visualisation Software. 25-30 people attended the tutorial.

The tutorial included slides and videotapes. The single video for RP's presentation was a compilation from a variety of sources in both PAL and NTSC.

The tutorial also included demonstrations of AVS on the RAL Stardent ST2000 which was at EASE 90 for the exhibition.

The transfer of the ST2000 was organised by the group.

### 4.6.6 Image Processing - IPAL (RM)

The Alvey project has now been completed and written up as a final report. However the work to get the library into shape for the release of the mark 1 version has continued. A subset of the C code has been out on test release to a small number of sites. This has produced useful comments and action is proceeding to modify the code in order to satisfy the testers. The libraries have been written up and it is intended that this will be issued as a joint NAG/RAL report. Even this process led to useful feedback and structure definitions were simplified. Work is proceeding in two areas. One is to provide wrappers to allow the Fortran library subroutines to be called from C. The other area is an investigation of possible user interfaces to the library.

In December a presentation was made to the visiting IT research review committee (JRG).

### 4.6.7 Image Processing Standardization (RM)

It was decided to devote part of the IPAL Advisers meeting on 23rd March to the subject of standardization of image processing. Dr Krolak of the University of Lowell, who is driving the American effort was in Europe and was willing to speak. The advisers meeting was subsequently cancelled but the opportunity to discuss such a key issue seemed too good to miss. The majority of the original attendees were interested in a meeting devoted to standards issues and after being given wider publicity, the meeting went ahead chaired by Chris Cartledge. A useful and at times quite lively meeting followed and it was clear that there is a strong UK interest in this matter. One consequence was the setting up of an BSI Imaging Panel under IST/31/-/6. This panel is chaired by Adrian Clark of Essex University and held its first meeting on 10th April 1990 at the BSI. This meeting discussed the proposed new work item N427 and made recommendations as to what the UK response should be. (RM attended) The meeting looked for possible UK input and suggested that the report on the NAG/SERC Image Processing Library could be used for this purpose. The report will be tabled at the Imaging Study Group meeting in Ottawa.

### 4.6.8 Parallel Reconfigurable Image Processing Systems (RM, JRG and CPW)

A proposal was submitted to the SERC/DTI JFIT programme, the other partners being NAG, Meiko, University of Essex and MRC Edinburgh. The proposal was approved by the appropriate JFIT committees, but Meiko have withdrawn from the consortium. Other solutions are at present being sought but the rules regarding the funding of industrial resources committed to the project make this a frustrating exercise.

The proposed work aims to exploit dynamically reconfigurable parallel processing in the context of image processing.

### 4.6.9 Vision by Associative Reasoning (ERR)

This is a collaborative project involving BAe, RSRE, University of York and University of Surrey. Progress through the various levels of SERC-DTI approval has been painfully slow. This was mostly due to the ambiguous position of RSRE in its transition to agency status.

In April a SERC-DTI grant to the value of £158,000 was finally awarded to RAL with ERR as Principal Investigator. Work has now begun on the project with some studies of relaxationa1 dynamics on Hopfie1d networks. A paper describing this work is in preparation.

### 4.6.10 Two-Dimensional Object Recognition - Alvey Project007- (ERH)

Several items were completed in connection with this project although it officially ceased on 30 March 1989.

In December ERH made a presentation to the visiting IT research review committee. In addition, papers describing two pieces of research work conducted as part of the project were also completed.

One of these described some work by ERH which demonstrated the Bayesian basis of a hitherto heuristic but highly popular vision algorithm - Canny's edge detector. This work is important for several reasons besides the novel interpretational basis that it provides. Firstly it endows Canny's algorithm with an adaptive capability. Secondly, and perhaps of more importance, its idea of applying the hysteresis algorithm iteratively. This has been shown to have some very tangible performance gains.

Finally, a paper describing work on discrete relaxation was selected as a long paper at the IEEE Computer Society 10th ICPR in Atlantic City, USA. This represents a real achievement since the paper was one of the top 20 of the 700 conference contributions.

### 4.6.11 Development of a Transputer based Photon Counting Detector for Space Applications (MKC)

The project is aimed at developing a photon counting detector supporting detector development in the SOHO CDS experiment in particular, and also work in a range of other application areas. The main thrust of the work over the last year has been directed towards developing a prototype photon counting detector demonstrating the performance achievable with this device and paving the way for a future flight system. The prototype detector has been built in the laboratory and the Transputer processing system and software developed allowing on-line data analysis and real-time image processing.

Exciting preliminary results showing the potential of this detector have been published. It has been demonstrated that the resolution is limited only by the channel spacing in the curved microchannel plate used in the image intensifier. The prototype system provides a valuable tool for the study of the image intensifier and the enhancement of the data processing algorithms. A collaboration with Kings College London has been instigated to study some of the characteristics of microchannel plates.

Future work will be aimed at continuing to improve the performance of the system through both software and hardware development and to produce a device for field testing on a telescope as well as extending the application area into UV and X-ray detection through development of the intensifier and CCD system.

In connection with the photon counting project, but supporting more general detector development, we have also been involved in setting up a general image processing facility, based around Transputers, for real-time detector applications.

### 4.6.12 Superworkstation Assessment (JRG, JH, RM, RP)

The last few years have seen the emergence of significantly more powerful workstations available to scientists and engineers. Superworkstations, the term we have selected from the many hype terms on offer, actually expresses the situation quite well, as the computational and the graphical aspects of a workstation are uprated. Typically the cpu includes vector processing capability, although some systems are competitive even without this. The graphics processor typically allows 24 bit graphics and an accelerator for 3D.

The work started in November 1989. The purpose was to report to CFTAG in June 1990. After the project started, we were requested in addition to provide an interim report to CFTAG in April.

The strategy, used in other hardware assessments, of using a questionnaire and benchmarks was adopted here also. To help establish the criteria for inclusion in the assessment, RP compiled a table of manufacturer's supplied product specifications.

RP designed the questionnaire and analysed the results. The questionnaire for Superworkstation Assessment was based on the one designed for the Workstation Assessments. We put more emphasis on the graphics part of the system and took into account new features offered by superworkstations. The questionnaire was sent to five suppliers and altogether six different systems (Stardent's ST2000 and ST3000, Hewlett- Packard's DN10000, Silicon Graphics' 4D Power Series, Megatek's Sigma 70 and Evans & Sutherland's ESV series) with all their variations were covered.

RP obtained and ran a set of benchmark tests on four systems (Stardent's ST2000, Hewlett Packard's DN10000, Silicon Graphics' 4D 240 Power Series and Evans & Sutherland's ESV). They consisted of some computational performance tests (basic arithmetic operation, matrix calculations) and some application performance tests (two mesh generation programs, one multigrid mesh program, magnetohydrodynamic code, SOR - successive over-relaxation and the Navier-Stokes program).

JH was responsible for ensuring the benchmarked systems were installed. Three systems were loaned to the department for a period of at least a week. One of these (the Silicon Graphics) turned out to be large for a workstation and had to be sited in the computer room. A fourth system, the Stardent ST3000, could not be loaned to the department so JH benchmarked it at the Stardent UK office. The Stardent ST2000 was of course already here.

JH was also responsible for preparing and running graphics benchmarks. One, Xperf, tests the performance of the X11 interface. This is very comprehensive and is also a good test of reliability. Most systems failed some of the tests. The other, spheres, was written by JH and tests the advanced 3D capabilities of the systems. Unlike the other benchmarks, this needs careful porting when benchmarking a new system.

RM coordinated the report production, with RP providing substantial sections.

A presentation on the work was given at EASE 90 in April. The project reported to CFTAG in April and June and the results of the assessment will be published in an appropriate technical series (RAL Report and/or EASE Technical Report).

### 4.6.13 Superworkstation Management (JH)

JH has continued to manage the Stardent ST2000 and there is increasing use of the system for applications, mainly in CMD. Release 2.0, the first major software upgrade, was installed. When the X terminals were installed, work was needed on the ST2000 system to allow them to boot. Visual/3, a CFD Visualisation system from MIT was installed.

Further interactive devices, a spaceball and a set of dials were added to the ST2000.

The TITAN system was loaned to the ABACUS Unit at Strathclyde for them to mount application software and report on the suitability of the system for this purpose. The system is to move to Imperial College, where a CFD group will use it.

### 4.6.14 Solid Modelling Assessment (RP)

As a result of previous research an internal report is due to be issued. Before any other assessment work is continued, some feedback on specific requirements within the EASE programme is expected.

### 4.6.15 Graphics Software on Parallel Architectures (RP)

At the Parallel Computing 89 conference in Leiden, RP presented a paper Ray Tracing on the SCRIP Machine, which she wrote jointly with Dr Graham Megson. The paper was published in the conference proceedings book.

### 4.6.16 Graphics Standardisation (JRG)

Although the ISO graphics standards GKS-3D and PHIGS are capable of expressing 3D concepts directly, they fall short when complex surfaces are required. PHIGS PLUS is an extension of PHIGS which allows polygonal and curved surfaces to be defined directly and also the lighting and shading that enables them to be viewed effectively. An ISO working group (ISO/IEC JTC1/SC24/WG2) is responsible for ensuring the progress of PHIGS PLUS towards being an ISO standard. In the process, technical improvements can be made. JRG is on the BSI and ISO groups responsible for PHIGS PLUS. Among the technical improvements are to make it more suitable for data visualisation and for use as the graphics system underlying postprocessors for STEP.

### 4.6.17 ESPRIT ARGOSI project (JRG, RM, R A Day, D A Duce, D C Sutcliffe)

This is the first full reporting period for the ARGOSI project, which engages the attention of staff from all the divisions in Informatics.

Within CMD, the main activity of JRG and RM during the reporting period has been the Classification Workpackage, with the other Informatics project staff. The main purpose is to analyse applications which need graphics over networks and to analyse and classify their requirements, which may be expressed in terms of current standards or recommendations for new ones.

Some visits were undertaken, but in this reporting period, information has been gathered chiefly by means of a postal questionnaire designed by the workpackage, with the document being produced by Graham Reynolds of the University of East Anglia. The questionnaire was analysed at UL with software by DAD. Some preliminary results were presented at the April Project Review.

The Workpackage is due to end at end of September.

JRG is the Workpackage leader.

### 4.6.18 Joint Appointment (ERH)

ERH continued his joint-appointment as Associate Lecturer in the Department of Electronic and Electrical Engineering at Surrey University. This involved contributions to the teaching in all three undergraduate years and at M. Sc level. Some lectures on pattern recognition in the final year Machine Intelligence Course were especially well received, being upheld as examples of lucid presentation in the Departmental Staff-Student Liaison Committee.

### 4.6.19 Middlesex Polytechnic MSc in Computer Graphics (JH)

Towards this MSc, intensive work on the dissertation has taken place with the intention of submitting this early in the next reporting year.

### 4.6.20 Conferences attended

1. Parallel Computing 89, Leiden, Aug-Sep 89. (RP)
2. How to maintain long lived software, RAL, Nov 89. (RP)
3. EASE 90, Manchester, Apr 90. (RP)
4. SPIE conference on Instrumentation in Astronomy VII, February 1990. (MKC)
5. ECCV, Antibes, April 1990 (ERH)
6. JCPR, Atlantic City, June 1990 (ERH)

7. System Integration and Data Exchange (RM)
8. State of The Art Seminar - Wednesday 28th February, 1990 (RM)

#### 4.6.21 Courses attended

1. Job Appraisal Interviewing, at Central Office, Swindon, February 1990. (JRG)

#### 4.6.22 Publications (internal)

1. Superworkstation Assessment Project Meeting (SA Note 1) (JH)
2. Assessment Project Meeting 2 (SA Note 2) (JH)
3. Assessment Product Information (SA Note 3) (JH)
4. Assessment Product Information 2 - Geometry and Imaging (SA Note 4) (JH)
5. Engineering Board areas (SA Note 5) (RP)
6. Assessment Project Meeting 3 (SA Note 6) (JH)
7. Assessment of Superworkstations for EASE Paper for CFTAG (draft 2) (SA Note 7) (JRG)
8. Assessment Project Meeting 4 (SA Note 8) (JH)
9. Assessment Project Meeting 5 (SA Note 9) (JH)
10. Assessment Project Meeting 6 (SA Note 10) (JH)
11. Recent LINPACK performance report (SA Note 11) (JRG)
12. Table of manufacturer's supplied specifications of superworkstation range of computers (SA Note 12) (RP)
13. Assessment Project Meeting 8 (SA Note 13) (JH)
14. Assessment Project Meeting 9 (SA Note 14) (JH)
15. Product Information 3 - Stardent's GS3000 (SA Note 15) (JH)
16. Brief Notes on meetings with Suppliers - 30 January to 2 February 1990 (SA Note 16) (JRG)
17. Meeting with Stardent - 12 February 1990 (SA Note 17) (JRG)
18. Assessment Project Meetings 10 and 11 (SA Note 18) (JH)
19. Benchmarks - Comments to date (SA Note 19) (JH)
20. Assessment Project Meeting 12 (SA Note 20) (JH)
21. Meeting with Evans and Sutherland - 5 March 1990 (SA Note 21) (JRG)
22. Meeting with Megatek - 9 March 1990 (SA Note 22) (JRG)
23. IBM RISC System/6000 (SA Note 23) (JRG)
24. Table of manufacturer's supplied specifications of superworkstation range of computers (1st update) (SA Note 24) (RP)
25. Assessment Project meeting 5 April 1990 (SA Note 25) (JRG)
26. Assessment Project meeting 3 May 1990 (SA Note 26) (JRG)
27. Assessment Project meeting 10 May 1990 (SA Note 27) (JRG)
28. Assessment Project meeting 18 May 1990 (SA Note 28) (JRG)
29. VGN 1: Series of Group Notes (JRG)
30. VGN 2: Relationships between Image Synthesis and Analysis: towards unification? (JRG)
31. VGN 3: ANSI Image Processing Proposals - January 1990 (JRG)
32. VGN 4: First European Conference on Computer Vision (ERH)

#### 4.6.23 External Publications

1. M K Carter, A Transputer based image photon counting detector, Instrumentation in Astronomy VII, Proc. SPIE, Vol. 1235, 1990.
2. Hancock, E.R. and J. Kittler, Iterative Hysteresis Linking, Submitted for publication, 1990.
3. G. T. Condo, E R Hancock, et al, Charge exchange production of the $a^-$ (1320) in association with Delta at 19.3 GeV, accepted for publication in Physical Review D, 1990.
4. E. S. Ackleh, E R Hancock, et al, A search for a short lived axion decaying to $e^+$ $e^-$ in a 20 GeV photoproduction experiment, SLAC-PUB, 4473, 1989.
5. Hancock, E.R. and J. Kittler, A Label Error Process for Discrete Relaxation , Proceedings 10th International Conference on Pattern Recognition, IEEE Computer Society Press, pp.523-529, 1990.

6. Hancock, E.R. and J. Kittler, Edge Postprocessing - A Comparative Study, Proceedings of the Fifth Alvey Vision Conference, Reading, pp.343-347, 1989. .
7. Hancock, E.R. and J. Kittler, A Comparison of Dictionary-based Relaxation Processes, Progress in Image Analysis and Processing, published by World Scientific, 1990.
8. Hancock, E.R. and J. Kittler, Edge Labelling by Discrete Relaxation, Proceedings IEEE International Conference on Image Processing, Singapore, Vol.1, pp.343-347, 1989.
9. Hancock, E.R. and J. Kittler, Discrete Relaxation, publication in 'Pattern Recognition', 1990.
10. Hancock E.R. and J. Kittler, Edge-labelling using Dictionary-based Probabilistic Relaxation, IEEE Transactions on Pattern Analysis and Machine Intelligence, 12, pp 165-181 1990.
11. E R Hancock, Several conference reports in the IAPR Newsletter. These are reprinted in IEEE PAMI Technical Bulletin.
12. J R Gallop, Comparison of. systems for visualisation, Proceedings of Computer Graphics 89, pp21-27.
13. J R Gallop, R A Day, R Maybury, D C Sutcliffe, Integration of Graphics and Communications in ARGOSI for BCS Displays meeting on 28 February 1990.
14. J R Gallop, Graphics Standards and Visualisation, Proceedings of the Eurographics Workshop on Visualisation, April 1990.
15. J R Gallop, The Superworkstation Assessment, report to CFTAG meeting of June 1990.
16. R A Day, D A Duce, J R Gallop, R Maybury, D C Sutcliffe, The ARGOSI demonstrator for ISO/IEC Graphics and Networking Standards, Submitted to Eurographics 1990.
17. R A Day, D A Duce, J R Gallop, R Maybury, D C Sutcliffe, The ARGOSI demonstrator for ISO/IEC Graphics and Networking Standards, Submitted to Esprit Technical Week (to be held in November 1990).
18. D A Duce, J R Gallop, R A Maybury, Status of ARGOSI Classification Workpackage , for 1st ARGOSI Project Review, ARGOSI TECHNICAL NOTE 9, 9 October 1989.
19. D A Duce, J R Gallop, D C Sutcliffe, Status of ARGOSI Classification Workpackage , for 2nd ARGOSI Project Review, ARGOSI TECHNICAL NOTE 19, 27 March 1990.
20. J R Gallop, Summary of ARGOSI Classification Interviews, ARGOSI TECHNICAL NOTE 21, 17 May 1990.
21. R Maybury, Alvey Project MMI/127 - IMAGE PROCESSING ALGORITHMS LIBRARY Final Report to the Alvey Directorate.

### 4.6.24 External seminars Given

- Data Visualisation, EASE 90. (JRG, JH, RP)
- The CFC Superworkstation Assessment at EASE 90, April 1990. (JRG)
- Computer Graphics Standards at Computer Graphics Suppliers Association at Maidenhead, April 1990. (JRG) (and Dr A. Mumford, University of Loughborough)
- Visualisation in Informatics Department at RAL at the SERC Laboratories' Visualisation Workshop at Daresbury, June 1990. (JRG)
- Relaxation Processes for Vision, University of Bristol, November 1989. (ERH)
- Vision as a Distributed Process, University of Buckingham, April 1990. (ERH)
- A Label Error Process for Discrete Relaxation, Long paper at IEEE Computer Society 10th ICPR, Atlantic City, USA. (ERH)

### 4.6.25 Objectives for 1990/91

Considering visualisation software, there are signs that flexible visualisation toolkits are beginning to emerge. In the coming year, the group will work with other groups with visualisation needs and in doing so understand where the new software falls short. Our initial impression is that some commercial systems could act as a basis for a useful visualisation system for RAL and EASE. The EMR at Swansea and the TITAN loan to Imperial College are opportunities for this. Where possible, we will work with other interested parties in UK academia, under the AGOCG umbrella.

It is planned that Mark 1 of IPAL will be completed and that it can begin to be exploited by interested parties in the EASE community.

Software for which the group is responsible will need to work in the EASE environment and thus occupy the group's attention.

The JFIT project Vision by Associative Reasoning will complete its first full year within the period and we will also be joined by an ERCIM fellow (Michal Haindl) during this time.

Contributions to standardisation of image processing will take place, participating in BSI and ISO work.

Assessments of hardware suitable for visualisation will continue to be needed.

The superworkstation equipment for which the group is responsible will continue to be managed and will be upgraded as needed.

All aspects of visualisation and imaging require significant resource and parallelism will need to be harnessed to an increasing degree in the future, depending on funding.

## 5. DISTRIBUTED COMPUTING SERVICES DIVISION

### 5.1 INTRODUCTION

DCS is primarily a service Division. It serves the communities supported by the bodies which fund the Department. It also serves the other three applications Divisions within Informatics. Finally it makes its expertise available to the rest of RAL. Its main functions are

- Support: both technical and managerial - of projects, programmes and user communities, including the hundred or so members of Informatics Department;
- Awareness: assessing products and making the information available to potential consumers within our user community;
- Development: taking new products and ideas, adapting them and integrating them into our working environment;
- Research: at least potentially in the areas of distributed systems, communications and graphics.

As this report period ends the Open Days are rushing towards us. K F Hartley and F M Russell have been responsible for Informatics Department's contribution, mainly by maintaining interest and ensuring that those responsible for specific items - handouts, display boards and demonstrations - deliver on time. At the end of June it seemed unlikely that everything would be ready, but at the time of writing we now know that it was and was very successful.

The major innovation during this year has been our involvement in the British Computer Society's Professional Development Scheme. This has not been without its problems, particularly a late start and declining enthusiasm of the participants. It has also involved substantial extra work for the co-ordinator, supervisor and participants. There are indications that as we become more familiar with the scheme and the Industry Structure Model evolves the Scheme will meet the needs of IT staff, particularly new young members of staff and those wishing to take positive action to change the direction of their career development.

Reviewing the objectives for the DCSD in last year's Report makes somewhat dismal reading.

EASE+ funding has been secured for the present financial year but following a very successful series of presentations to ITAB's technical committees the Board reacted rather negatively and postponed a final decision until September.

The Alvey Programme is now finally completed but the files, and many others, have still not found their way into the Archive.

The funding situation is still difficult but not impossible. The period without SUN maintenance was not as bad as was feared and SUN were extremely co-operative about getting machines back onto maintenance. During this year the performance of IDUS under new improved releases of system software and the memory requirements of X have posed more serious problems. Our network is now sufficiently complex that it is very difficult to identify where the bottlenecks are with any confidence.

Informatics did participate fully, stylishly and effectively in the RAL Open Days, though they took place two weeks after the end of the report period.

The technology in H V Jenkins' office has not been updated mainly because no Department-wide decision has yet been made on the way forward. In fact HVJ left at the end of the year having completed her BTEC course and being recommended to someone starting up a new company by one C J Pavelin.

K F Hartley has been leading a working party to define the EASE Software Environment. A proposal and workplan were completed to schedule and accepted by CFTAG. The next phase, implementation, is likely to dominate the next twelve months.

KFH regularly attends the Inter-University Software Committee (IUSC) on behalf of EASE. This is one of a large collection of committees and working parties which bring together the views of HEI Computer Centres and present them to the Computer Board and CHEST. Several fruitful areas of common interest have developed between IUSC and EASE, including X terminals, algebraic software and finite element packages.

The highlights of the year must certainly include the organisation of EASE 90 on top of a full programme of Education and Awareness events. MSG staff worked extremely hard to arrange the event at relatively short notice, and are now hard at work on EASE 91. The initial' round of HEI visits is now 90% complete and most of the 700 plus questionnaires safely recorded in a database. For SSG the highlight was in February when no less than five members of the Group were all recognised as Achievers at one time. TSG has had a very successful year. GKS validation continues and progress is being made with CGM activities and the by-now ritual thanks and praise were given by CFTAG for further assessment reports. This should not obscure the fact that no two assessments are the same and that each requires considerable energy and ability from the team to achieve the high standard that everyone has come to expect. System Admin has worked heroically to keep IDUS running at all given the rate at which people and skills have been lost from the Section.

For the record it should be noted that this was the year of the final ending of our involvement with Prime Computers. Primes have been an integral part of our support of the engineering community for more than a decade. Their final passing was marked with due ceremony, bringing together many of those involved over the years. Truly this marked the end of an era.

### 5.1.1 DCS Achievers

Our scheme for ritually embarrassing members of the Division who have achieved over and above what might be expected has continued. The following have been honoured in this way during the past year:-

**A J Lucas & W J Hewitt**
a particularly arduous assessment
**A S Jaroslawska**
getting the fire-proof safe
**N J Watkins**
setting up Directory Services machine
**K Goswell**
user interface to Directory Service
**A P McDermott**
Profs on SUN service

**J J S Cullen**
getting the Linotron working
**I J Johnson**
CRAY/Sheffield Link
**R A Day**
the above achievers and getting ARGOSI up to strength
**S K Chanda**
obtaining his PhD in his own time
**P D Athawes**
Prime shut-down
**M E Claringbold**
presentation of DCSD views on PDS to senior management.

### 5.1.2 Courses

- BTEC Business and Finance (2nd Year), Abingdon, HVJ
- Time Management, RAL, December, KFH

### 5.1.3 Conferences: KFH

- SGML Workshop, Abingdon, March
- Re-usable software, London, May
- SERC/IBM Conference, RAL, May

### 5.1.4 Divisional Objectives for 1990/91

- Obtain section leaders for TSG.
- Successfully complete the PDS Pilot Scheme.
- Establish the causes of the poor performance of IDUS and, if funds allow, improve it.
- Complete the HE I visits and analyse the results.
- Obtain a new Divisional secretary and provide up to date equipment.

## 5.2 TECHNICAL SERVICES GROUP

### 5.2.1 Staff

At the start of this period (October 1989), the group membership was:

- R E Thomas
  - M E Claringbold
    - S K Chanda
    - A J Lucas
    - W J Hewitt
  - R Tillotson
    - K M Lewis
    - D S Barlow
    - I Day (nee Vollmer)
    - A S Jaroslawska
    - P D Athawes
  - R M Kidd
    - P L Popovic
    - B D Cooper
    - J P Barnett: trainee scientist

Congratulations to SKC on gaining his Ph.D, and to ID on her wedding.

Congratulations also to RMK, AJL and WJH on their promotions.

JPB completed his six-month assignment with PLP and moved to SSG.

William Lui (KWL) joined in January to work with PLP on Graphics. RT transferred to Systems Support Group (SSG) at the end of February. Nicola Watkins (NJW) joined TSG from SSG at the same time, to work in Assessment. KML moved to Design Division in April.

At the beginning of June, the group membership was:

- R E Thomas
  - M E Claringbold
    - S K Chanda
    - A J Lucas
    - W J Hewitt
    - N J Watkins
  - No one in Post
    - P D Athawes
    - D S Barlow
    - I Day
    - A S Jaroslawska
  - R M Kidd
    - P L Popovic
    - K W Lui
    - B D Cooper

### 5.2.2 Objectives 1989/90

The Group has three sections: Assessment, Systems Administration and Text/Graphics.

The main objectives are as follows:

**Assessment**
Evaluation of various hardware systems, as directed by the Computing Facilities Committee Technical Advisory Group (CFTAG). Publication of results.

**Systems Administration**
Support for SUNs in the Department. Operation of Department Service. Closure of Primes. Department Security. Assistance with Grant Model development.

**Text/Graphics**
Support for Text and Graphics systems within the Department and the Engineering Applications Support Environment (EASE) community. Maintenance, validation and development of RAL GKS.

### 5.2.3 Server Evaluation (MEC, AJL, WJH, NJW, RET)

The Assessment Section began an evaluation of servers in October, with the intention of producing a report for the December meeting of CFTAG. Nineteen potential suppliers were identified and invited to take part by answering an Operational Requirement and providing a machine on loan to test in a network of up to 10 clients (of various makes). It was considered essential that machines should run Unix, fully support SUN's Network File System (NFS) and Yellow Pages, and be capable of connecting to the Joint Academic Network (JANET). Only four suppliers, DEC, MIPS, Solbourne and SUN agreed to take part; the main problem with the others seemed to be lack of Coloured Book software to connect directly to JANET. When the machines were benchmarked at RAL, it was found that only SUN was able to meet all the mandatory requirements.

With these disappointing results, the Report presented to CFTAG was accepted as interim, and the team were asked to extend the exercise (since several suppliers had reported that they would be able to take part in the near future). In the event, the only extra tests which could be undertaken concerned various other servers from the SUN range. CFTAG therefore decided to accept the report at this stage, but noted that it would be possible to provide a network with a connection to JANET by means other than via a central server. They have therefore asked for the evaluation to

be repeated in the last quarter of 1990, but with the JANET mandatory requirement removed. Meanwhile, a public version of the report has been prepared and is being circulated (RAL-90-032).

### 5.2.4 X-terminal Evaluation (MEC, AJL, WJH, NJW, RET)

In January, work began on the evaluation of the X terminal, the new peripheral which fits between the ASCII terminal and the workstation, giving a graphical interface instead of the earlier character based interaction. An initial difficulty was identifying the UK distributors, with a new name appearing almost weekly. The majority of these have had problems with supply, so it has proved quite difficult to arrange for the loan of machines. Thus it was possible only to provide an interim report to the April meeting of CFTAG. The final report covers seventeen machines, of which nine were benchmarked (although several turned out to be the same one under a different name!). The June CFTAG meeting approved three of the terminals assessed, but advised that X terminals were more likely to be of use attached to multiuser machines, rather than connected to a client/server network. A public version of the report is being prepared.

During this exercise, there has been a considerable interchange with the Inter-University Software Committee (IUSC) Working Party on Workstations, which is undertaking a similar exercise on PC-based X-terminal emulation software. It will be interesting to compare the results.

### 5.2.5 Workstation Evaluation (MEC, AJL, WJH, SKC, RET)

A second evaluation of 15 workstations was completed during the third quarter of 1989. A public version of this report was produced in October (RAL-89-1l0) and this has been widely circulated. A short article was provided in the Engineering Computing Newsletter (ECN) , and several individual versions of the full report were generated for those Higher Educational Institutes (HEIs) engaged in tender exercises.

Following a request from CFTAG, the SUN3/80 was benchmarked further and, as a result, added to the approved list. Three other workstations have been benchmarked since the reports: an 8Mb Acorn with improved operating system, a Solbourne 4/500 (the first of the SUN clones) and the Data General AViiON/300 (not a new machine but having a new version of the operating system). The results will be included in the current exercise, which started in June. This will not cover all contenders, but will concentrate on the newcomers. It is noted that there has not been such a quantum leap in workstation power during this period (compared with the previous 12 months). However, there are strong indications that another significant increase is about to take place.

### 5.2.6 Benchmarking Software (SKC, WJH)

Improvements and enhancements to the benchmarking suite are under constant review. Several programs/packages in the Finite Element (FE) area have been tested on the various workstations available in ID and can now be incorporated in the benchmarking suite; these are LES (the linear equation solver from BIM2D), DFT, BERSAFE and UPSET (from SKC's thesis work). Work is almost complete on producing a Software Engineering benchmark based on ERIL.

A collection of GKS benchmarks has been gathered and made suitable for benchmarking. Successfully developed on SUN, they still have to be proved on a loaned machine.

### 5.2.7 Server Accelerator Board (AJL, WJH, NBMC)

A server accelerator board from Legato (called the Prestoserv) has been made available on loan from its UK distributor, Computer Marketing Services (CMS). This board improves throughput by increasing write speed and reducing processor overhead. Early results show that it does indeed speed up writes by over 200%, but the number of writes actually performed in our network is sufficiently small that the overall gain is much less. It is being considered as one of the possible ways of improving the Network File System (NFS) response.

### 5.2.8 Department Computer Service - Operations (RT, ID, ASJ)

ID, ASJ and occasionally RT have maintained the service by dumping the servers, restoring lost files, general housekeeping, maintaining printers and solving problems as they arose. ASJ took on

most of the work of adding and deleting users, monitoring the use of filestore and reading system mail. Both ASJ and ID have been trying hard to persuade users to reduce their private filestore and making more use of project related filestore. ASJ has been updating the list of offenders for the Management Meeting (IMM), but it is hoped to solve all problems by friendly persuasion!

ASJ has been undertaking the usual security checks which seemed particularly worthwhile when they revealed some attempted security break-ins. but no success for the hackers. There have also been several cases of files being created in unusual directories, but so far nothing malicious has been found (see later comments on security).

### 5.2.9 Computer Room (RT, ASJ, ID)

ASJ organised the dump tapes so as to keep the right ones in the fire safe. ID prepared a plan for the room. and this has now been implemented. The servers are now in a horseshoe shape, making them much more easily accessible. ASJ arranged the disposal of further unwanted items: an Olivetti 3B2. racking and cables. She has also managed to make the 'storage area' look much tidier and smaller. Photographs have been taken for use on RAL Open Day Display boards.

### 5.2.10 SUN OS Upgrade (ID, RT)

ID and RT completed the upgrade of the servers. discless clients and some of the other disced Suns to release 4.0.3. The latest Fortran compiler was installed at the same time. ID has now upgraded all but one disked Sun to Release 4.0.3, and the work should be completed during the summer (currently delayed because of requirements for some software to remain at the previous version). The policy has been to make most disked Suns dataless clients with swap space on local disks; the exceptions being maple, elsie and laurel in Lab11 which will still be standalone machines.

ID installed the new Sun4 server, nfs1 (replacing an old SUN2) , which is now serving 8 clients. Its files tore has been completely given over to the X11 software.

### 5.2.11 System Changes (ID, RT, ASJ, DSB)

ID and RT moved the Yellow Pages master function from nfs2 to nfs3. RT,ID and ASJ altered the broadcast address throughout the local ethernet. working with NBMC. DSB prepared the NAG library for installation on Suns.

RT and ID planned and completed the merger of the Pyramid 98X and Workcenter (nfs4), with the aim to make nfs4 look almost like pyr-a. As usual ASJ was keeping everyone sane by keeping track of the many backup tapes involved in this transaction. The old pyr-a is being removed, and this should increase network reliability.

### 5.2.12 Labs 10 and 11 (RT, ID, ASJ)

ID organised the removal of further obsolete equipment from Lab 11 and its further tidying. RT and ASJ took over Lab 10 from Technology Department and prepared plans for its eventual use, meanwhile making it available for the server assessment.

ID worked out a design for a permanent ramp in Lab 11 in collaboration with R18, which was to be in place by the end of March, but has now been vetoed by Health and Safety because there is insufficient room to provide a slope which adhered to accepted standards. Plans are now in hand for another more convenient temporary ramp.

### 5.2.13 Training Machines (ASJ, DSB)

ASJ and DSB have been helping to set up the training set of machines for demonstrations, especially with regard to technical advice on network connections. The demos have taken place in several locations around the country, as well as within RAL.

### 5.2.14 Support (KML, DSB)

DSB receives and deals with about 250 queries a quarter, most of them straightforward, including reports of hardware faults. DSB made available documentation for users of the new Fortran

compiler. DSB, KML and RT have been working on the distribution of software to other sites.

KML several times reviewed the deliveries to the Central Server sites, eventually providing most items which Sun had not supplied, with the exception of SunOS 4.0.3 upgrade tapes.

There have been requests from external sites for Ralpage, X25, spy, ten, and Coloured Books software to be placed on cartridge tape and distributed. DSB has actioned these requests. Tapes and manuals for Nag Mark 13 Fortran Library were produced and distributed to the remaining licence-holders. DSB organised this activity.

### 5.2.15 SUN Maintenance (RT, KML)

KML and RT passed lists to Sun of desktop machines to be removed from maintenance as an economy measure, and eventually agreed with Sun that the machines could be fully maintained again from 1 January 1990. Meanwhile ID, ASJ and DSB had to shuffle around the broken parts to keep as many systems as possible running. In the end 8 systems were unusable.

As last year, much effort was put into trying to reconcile the lists of maintained SUNs produced by us and SUN, in order to pay the maintenance bill. The problems caused by this each year are getting beyond a joke. It has therefore been decided to ease the situation by splitting the contract into three: Grant-related (given to Swindon), external to RAL (small number), and RAL site. This last includes non-Informatics machines, and we intend to go out to tender for this part. However, things have been delayed by the changeover from Harwell to RAL of the contracts team. The old contract (very long) exists on a word processor which RAL does not use, and it is impossible to transfer. Hence it has to be retyped. This has yet to be completed. A 6-month extension of the current contract has been requested to give more time to sort things out.

### 5.2.16 Security (PDA, RET)

The Department Security Policy paper was at last produced, discussed at an open meeting, further refined by Division Heads and then issued. This has been a long involved process. However, the policy is now clear, and implementation notes have also been issued. The paper itself excited considerable comment, especially with regard to the Risk Analysis, and the Director requested copies be sent to all Department Heads in RAL and all Laboratory Directors in SERC! The next main job is to find time to explore the CRAMM software obtained from the Central Computer and Telecommunications Agency (CCTA), and also to plan for a security audit later this year. CRAMM attempts to automate the process of performing a Risk Analysis.

PDA is producing a Security Administrator's Guide, which will Cover all aspects of the requirement in the Department.

There were a couple of attempts by external people to break into the system. Neither was successful. One of the attempts was traced back to Switzerland. Others showed that various Universities had been successfully penetrated. We informed the managers.

### 5.2.17 GKS Validation (RMK, PLP)

The main preoccupation in the graphics area has been the preparation for the validation of RAL GKS by the National Computing Centre (NCC) testing service. This has involved running the NCC test suite with all of the RAL GKS workstation drivers, then locating and fixing bugs (both in the test suite and the GKS implementation). PLP and RMK have been working on this. Several update generations of the RAL GKS libraries were made in the process.

In addition, pick input has been added to RAL GKS. This now brings the implementation up to full level 2b functionality. Central Computing Department (CCD) had written general-purpose utility routines to handle pick input, and RMK incorporated these into the implementation on the Sun.

PLP tested the RAL GKS Computer Graphics Metafile (CGM) drivers (written by CCD) using the NCC test suite and produced an internal note on the results. He also revised the PostScript driver and fixed the problems discovered since its local release. This, together with a number of other bug fixes and new files, was then added into the 1.30 version of the RAL GKS Master Source.

### 5.2.18 GKS Support (RMK, PLP, JPB)

PLP arranged the transfer of the latest RAL GKS Master Source across to CCD and provided assistance in the building of the UNICOS version of RAL GKS for the Cray.

At the request of Starlink staff, PLP arranged for the transfer to a DEC Station of all the sources necessary to generate the 1.20 release. This was later used for a successful build of the RAL GKS libraries on this machine.

JPB successfully ported GKSMVIEW, a program written by CCD for viewing GKS Annex E metafiles and CGMs, to our SUNs. Following this he made a number of improvements, always ensuring that machine independence was retained. Some new features were introduced, e.g. ability to switch input metafi1es, an additional output workstation (with a view to use the PostScript driver and thus provide a hardcopy facility) etc. JPB also enhanced the user interface, making the best possible use of the GKS input devices, and wrote two GKS Installation Project Notes, containing the necessary technical and user information. This concluded JPB's 6 month Trainee Scientist project.

### 5.2.19 Advisory Group on Computer Graphics - AGOCG (RMK)

RMK was involved in the setting up of the AGOCG Graphics Newsletter, and is on the Editorial Board for this. She also joined a working party looking at versions of GKS for use on PCs. The aim was for CHEST to negotiate a bulk deal for an implementation. This proved to be an interesting exercise as there isn't even a standard Fortran compiler in use in the academic community - CHEST have deals for three different ones and none of those allow cross-linking to C! So a side-effect of this work will be a new CHEST deal for a C compiler which will work with one of the Fortrans.

As part of her work for AGOCG, RMK visited University of Manchester Computer Graphics Unit to discuss the merge of their GKS-3D system with the current RAL GKS sources. (The Manchester GKS-3D was based on an early release of RAL GKS.) This project at Manchester is funded by the Computer Board through AGOCG.

### 5.2.20 CGM (KWL)

KWL joined RAL in January and is working with PLP in the graphics team. He has successfully ported the RAL-CGM package to our Suns. This was written by CCD and allows the translation and viewing of files in all three CGM standard encodings. Having familiarised himself with the software as well as with the CGM standard and our computing environment, KWL produced the first user documentation of RAL-CGM. He then taught himself PostScript and has been developing a PostScript output driver for the same package. The backbone of the driver together with several basic output primitives have already been written and tested. This work on RAL-CGM is part of a larger project initiated by AGOCG to provide checking, translation and viewing tools for use with CGM files.

FRAH and DAD requested facilities for the translation of CGM files generated by SunPHIGS into PostScript. This was required for the slides/notes for a PHIGS tutorial which FRAH and DAD gave in June. PLP put together a set of utilities which handle this translation based around GKSMVIEW. This is an interim solution (as it limits the CGM to the elements which can be handled by GKS), and the utilities will be changed to use RAL-CGM once KWL's PostScript work is complete. However, the present version works well and has allowed FRAH and DAD to produce their tutorial material.

### 5.2.21 FrameMaker (BDC)

BDC joined the section in early September. He was involved initially in learning UNIX and related text processing systems such as FrameMaker and troff. During October and early November BDC arranged courses in FrameMaker and wrote and distributed course material. Four morning courses were held in collaboration with C. Kwong. BDC then took over user support for FrameMaker, including arranging for the provision of documentation for FrameMaker users. After gaining more experience of various aspects of FrameMaker, including using it with X-Windows, printing

PostScript files and making Hypertext documents, he gave individual tutorials to six individuals who had been unable to attend the courses last year.

BDC installed FrameMaker Version 2.0 and configured it for use as an experimental service. He also wrote documentation on the configuration of the various versions and how to use version 2.0. BDC liaised with Contracts and our FrameMaker supplier over the purchase of an additional six licences. This now gives us a total of 16.

BDC arranged a UNIX for Secretaries course given by UMIST on 20 March, and assisted Systems Support in setting-up course facilities. He also wrote a review of the course material prepared by UMIST.

### 5.2.22. Standard Graphics Markup Language - SGML (BDC, RMK, RET)

BDC was involved in studying the possible use of the ISO standard SGML, and SGML-based text formatting systems such as DAPHNE, with a view to serving the future text-processing needs of the Department. RMK and DAD have managed to obtain a copy of DAPHNE (for TEX!) and have been investigating its capabilities.

The question of using SGML was considered at a Workshop at Coseners in March. This was organised by AGOCG, as there is a need for the distribution of graphics documentation in machine-readable form. RMK and DAD wrote a paper for this workshop, describing an attempt to mark-up part of the RAL GKS user documentation into SGML. RET and KFH attended this workshop.

Membership of the SGML User's Group was applied for.

RET is a member of the RAL SGML Working Party, which is looking at possible uses of SGML within the Laboratory. A report will be presented shortly to RAL Office Systems Panel (ROFSP), and this is likely to propose that the next RAL Annual Report be prepared using SGML.

### 5.2.23 Documenters Workbench - DYB (RMK, RT)

RMK continued to handle the support and maintenance of DYB. The main achievement in this area was the (final!) solution of the problems with differing LaserWriter page offsets. The breakdown of the two remaining old-style LaserWriters resulted in Sun replacing them with new-style printers. This meant that the four service printers were all of the same type, and so (with much help from RT) RMK was able to install the necessary changes to DWB and TranScript to use the new-style page position. This ends the long-running page position saga!

There was a rash of troff queries in March - largely caused by several people preparing papers and foils for an ESPRIT review meeting!

### 5.2.24 Printers (BDC)

In June, BDC started looking at printers, with a view to recommending a high-speed, double-sided postscript printer for use in the department.

### 5.2.25 Primes (PDA)

The major task during the year has been preparing for the closure of the systems at RAL. Regular meetings have been held and PDA has been involved in these, advising and arranging for the tasks to be carried out in the time-scales available. The main area of concern has been the retrieval of data, especially from the Technology community (RLPC and RLPF). There was still some work outstanding at the time of shutdown of these machines (December) and it needed to be scheduled for action before the main Prime (RLPA) closed down.

In the end, more than 600 Mbytes of data were retrieved for users and then written to IBM formatted tape. On line data were transferred to other machines, sometimes using file transfer (FTP), but generally by writing tapes. The service on RLPA and RLPH closed on time and the machines were taken out of user service at the end of March.

### 5.2.26 Finance (RET)

RET continued to keep a check on the Department's finance state. It was apparent that it would be almost impossible for spend to keep within the set limits, since most of it was generated by existing commitments. One money-saving action was the removal of desktop Suns at RAL from maintenance for the last quarter of 1989.

During the first quarter of 1990, RET spent much time trying to monitor the Engineering Board (EB) spend. In order to do this more effectively, he learnt SQL on the IBM so that he could generate his own reports from the Finance Database. However, even this does not give enough information to be useful, since the various delays in the system mean that there is approx 4 weeks between a bill being paid and its appearance in the Financial Data System (FDS). By that time, it is too late to do anything. Attempts at persuading Bill Paying to send all invoices to the Department Head (as Associate Director for EB) for counter-signature failed, as they forgot to include the non-Informatics ones.

From April, there was a major change to all the project codes (now called Cost Centres) as a prelude to the introduction of MSA. MSA promises to provide more control, but it is not clear yet who will be allowed access. RET has spent much time generating Cost Centres for the Department, in the face of repeated policy changes from Finance (most of which involved starting from scratch again).

### 5.2.27 Management of the Departmental Service (RET, RT, ID, RMK)

One of the major concerns this year has been the state of the filestore. Regular reports of the top 20 occupants were requested and Systems Administration were actioned to visit all those with holdings above 20Mb, and a "warning" level of 10Mb has been set also (for user filestore, not project).

A change request form for Lab 11 has been produced by ID. However, there is now little problem with space in Lab 11, following the various rearrangements.

The problems with performance have been discussed on a number of occasions. It is clear that more data is required to find out why the service sometimes appears to go very slowly. SSG have begun to prepare the necessary tools to undertake this task (see separate report).

A new plan for 1990/91 was prepared and this has been accepted with little change by Division Heads. In addition, plans for the introduction of an X service (ie provision of window systems based on X11) were discussed, but the need for at least 8Mb memory, and the large number of SUN 3/50s, has made planning difficult. Third-party memory has been considered, but this is difficult to install and there are potential problems with maintenance.

ID joined the Management team when RT was transferred.

### 5.2.28 Grant Modelling (PDA)

The Grant Forecasting Model has progressed. The prototype has been tailored to accommodate all of the Boards. Tutorials have been held at RAL and PDA has assisted in these. During the period, representatives of Engineering, IT, ACME, Science, Bio, MSEC, Teaching Company and APS (all from Central Office), have attended these talks. The move to IBM started with investigations using SAS/SQL. PDA arranged for the transfer of the CPL,SPSSX and Fortran on RLPA to IBM code and this was completed on time (and validated). The grants database, QMF and SAS are being used to check out the model on the IBM in order that the boards at Central Office can assess the IBM version. The main emphasis is on Engineering, Science and MSEC boards at this stage.

### 5.2.29 Trainee Scientist Course (NJW, RET)

As usual, CCD asked Informatics to run the three-week section of the Trainee Scientist course which was devoted to Unix. On this occasion, NJW acted as tutor. The training SUNs were set up in Atlas, and the trainees undertook a small project after having a course on Unix and C. The format followed the previously successful formula of dividing the trainees into groups, presenting them with a vague open-ended specification, telling them they had to produce a proper specification quickly,

and then some programs and documentation to implement it. At the end of the course, RET and NJW ran "acceptance tests" to see how well the project met the specifications they had produced.

Over the years, the effective time available for this work has been eroded, due to pressure of time. As well as losing a day per week owing to day-release commitments, the period chosen started on a Bank Holiday! Everyone agreed that time was really too short to do the work justice. This has been passed back to the organisers.

### 5.2.30 Meetings

- Unix Service Meeting (USM) - RT (chairman to Feb) , RET (chairman after Feb) , ID, MEC, DSB (secretary).
- Unix Liaison Meeting (ULM) - RET, RT.
- Engineering Computing Facilities Executive (ECFE) - RET, PDA (secretary).
- Advisory Group on Computer Graphics (AGOCG) - RMK (secretary).
- CFTAG - RET.
- CFC - MEC (secretary).
- Sun Progress Meeting - RET, RT (chairman), KML (secretary).
- IUSC Working Party on Workstations - RET.
- RAL Office Systems Panel (ROFSP) - RET.
- RAL Training Advisory Panel - RET.
- FSC - RET.
- IMM - RET, RT, RMK, NBMC, ID.
- RAL GKS Technical Meetings with CCD Graphics Group RMK, PLP (secretary).
- Joint CCD/ID Graphics Meetings - RMK.
- EASE/SUS/Assessment Meeting - RET (chairman), MEC (secretary), AJL, WJH, SKC, NJW.
- Informatics Department Unix User Forum (IDUUF) - WJH (secretary).
- Meetings with Sun Contract Administration Section and Swindon Office to produce maintenance schedules and decide when machines are to come off the contract - KML.
- Government Unix User Group - RET.
- RAL DEC Users Meeting - AJL.

### 5.2.31 Conferences/Exhibitions

- Maintaining Long Lived Software , RAL, November, RMK, PLP
- Publishing Standards in the Real World, BCS, London, December, BDC
- Text Processing at CERN, Eric van Herwijnen, RAL, February, RMK, BDC, RET
- Systems Integration and Data Exchange, BCS , London, February, RMK, PLP, KWL
- AGOCG SGML Workshop, Coseners, march, RMK, RET
- EUUG, Munich, April, RET
- Which Computer Show, Birmingham, April, MEC
- European Unix Show, London, June, MEC
- YUGRAPH90, Yugoslavia, June, PLP
- SGML Seminar, UMIST, June, BDC
- Distributed Window Systems, Edinburgh, June, KWL

### 5.2.32 Demonstrations

- Tutorials to Engineering Board, Teaching Company, MSEC, APS Board, Science Board, BID, IT Directorate, ACME, RAL, November (several days), PDA
- Epoch archiver, Thame, February, MEC, RT, ID, NBMC
- IBM RS/6000 workstation, London, March, MEC,ET
- SUN OpenLook, Coventry, March, RET
- Dorotech, Paris, March, RET

### 5.2.33 HEI Visits

- Salford University, November, MEC.ID
- Manchester University, November, MEC, ID
- Wo1verhampton Poly, November, KML

- QMWC, November, RT
- Open University, November, PDA
- Oxford Poly Tech, November, PDA
- Edinburgh University, January, RMK
- Napier Poly, Edinburgh, January, RMK
- Manchester Polytechnic, February, MEC
- UMIST, February, MEC
- Heriot-Watt University, February,RMK
- Stirling University, March, RMK
- City University, May, RET
- Kingston Poly, June, AJL
- Middx Poly, June, RET

#### 5.2.34 Training Courses

- PDS Training, Swindon, October, MEC, RET, RMK, RT
- Framemaker Workshop, RAL, October, MEC, BDC
- Framemaker Workshop, RAL, November, AJL, RET, PLP, BDC
- Advanced Reading, Swindon, November, RT, ID
- UNIX for Programmers, Instruction Set, November, BDC
- Basic Management Skills, Urchfont, February, WJH
- Minute Writing, Swindon, March, WJH
- Guide for New Users, RAL, March, ASJ
- CMS Course, RAL, May, SKC
- Advanced Unix Tools, Instruction Set, June, BDC

#### 5.2.35 Papers

- EASE Workstation Assessment June-September 1989 RAL-89-110, RET, SKC, MEC, RAD, WJH, AJL
- The DAPHNE Document Types and AGOCG, March 1990, DAD, RMK
- Report on the BCS Displays Group Meeting on "Systems Integration and Data Exchange", Graphics Newsletter, Issue 6, May 1990, PLP
- EASE Central Server Assessment October 1989, February 1990, RAL-90-032, RET, NBMC, MEC, RAD, WJH, AJL, NJW
- Reports on Workstation and Server Assessments for Engineering Computing Newsletter, RET

#### 5.2.36 Objectives for 1990/91

a. Publish at least two further Assessment Reports;
b. Identify and Correct Performance Problems on the local ethernet;
c. Reduce all individual files tore holdings below 20 Mbytes;
d. Complete change to Sun Maintenance contract arrangements;
e. Produce Security Administrators Guide;
f. Use CRAMM to compare risk analysis data;
g. Complete validation of RAL GKS, together with GKS-3D additions;
h. Use SGML on at least one serious project;

### 5.3 SYSTEMS SUPPORT GROUP

#### 5.3.1 Staff

The personnel of the Group is currently:

- R A Day (RAD) Group Leader
  - N B M Calton (NBC) Leader of Distributed Systems Section
    - I J Johnson (IJJ)
    - J J S Cullen (JJSC)
    - A P McDermott (APM)

- R Tillotson (RT) Leader of Protocol Support Section
  - K Goswell (KG)

RT joined the Group in March 1990, transferring from Operations Section in TSG. KG changed from full to part-time working in February 1990, following the birth of her child.

Until March 1990 N J Watkins (NJW) also worked in the Group, in the area of protocol support. She then transferred to Assessment Section within TSG.

J P Barnett (JPB) joined the Group as a Trainee Programmer for the period January - June 1990.

### 5.3.2 Objectives

Systems Support Group (SSG) has the remit to provide support for the systems and communications facilities used by the Department and the projects it undertakes. These facilities are in the areas of support for LAN based communications and for distributed systems services, for access to WAN based facilities, and for other systems services such as print serving.

The following Sections list the projects in which the Group has been involved over the period of this Report.

### 5.3.3 Central Servers(NBC, NJW)

NBC continued to monitor developments with Yellow Pages from Pyramid. Further work on the RAL version was frozen as Pyramid's own version will be available at OSx 5.0.

NBC provided assistance to Assessment section during a Central Server evaluation. This included producing the operational requirement for manufacturers and providing technical help with benchmarking the machines for NFS performance. NJW assisted by providing functionality test suites for X.25 and Coloured Books on the machines.

### 5.3.4 Remote Access to Supercomputers Project (IJJ, NBC, RAD)

IJJ has spent most of his time on projects involving high-speed networking. In particular, he has continued to work on the Remote Access to Supercomputer Project (RASP), which involves connecting Suns at Sheffield University to the Cray and IBM in Atlas. NBC and RAD were involved in the management of this project.

The work with Sheffield has involved the setting up of a 64 Kbit/s (KiloStream) private link between a Sun workstation situated in the Department of Mechanical Engineering, and a Sun fileserver at RAL. The fileserver has been connected to the Hyperchannel network, to which the Cray is also connected. Using this equipment it has been possible to provide the researchers at Sheffield with much improved access bandwidth to the Cray, and also to allow them to use forms of access (eg via NFS) not currently possible over JANET.

NBC has continued to liaise with the researchers at Sheffield and to arrange meetings, take minutes, order equipment and provide assistance to the people at Sheffield. NBC took up equipment to set up a small Ethernet segment in the Mechanical Engineering Dept. to connect together a Sun, Hitech and later a Sparcstation.

IJJ has continued to provide specialist support for this project, including visiting Sheffield in January to upgrade their machine from SunOS 3.5 to SunOS 4.0.3: this had been held off pending the availability of SunLink X.25 6.0 which was needed for SunOS 4.0.3. The researchers at Sheffield have found improvements in the turn-around times for their Cray batch jobs. IJJ is examining methods to improve the interactivity in the work cycle.

NBC has been collecting together information and reports to make up a project report on RASP. Major sections of the report have been written by RAD and IJJ, and NBC is now editing the report and filling in some of the gaps. The document will be passed to IJJ and RAD for further comments and additions.

NBC has been running some programs to obtain NFS statistics on the Sheffield machine for use in the report. He has also been running some further performance tests along the KiloStream line and will put these figures into the report too.

Access to the IBM and Cray at RAL is required by the Sheffield Sirius project and NBC, RAD and IJJ have been providing advice on equipment. NBC submitted a request to the EMEC Committee at Swindon and as part of a grant announcement money has been awarded for a software and memory upgrade on the Sun fileserver used at the RAL end of the link. NBC has been processing the purchases, which are: a copy of the hyperchannel driver - allowing the Sun Operating System to be upgraded to SunOS 4.0.3; copies of Sun's Internet Routing software; and a memory upgrade to 8 Mbytes for the Sun.

NBC provided advice to Prof. Hayhurst at Sheffield when funds became available for the purchase of another machine at Sheffield: a Sparcstation was selected. Dr Osman, Prof. Hayhurst's RA has asked for help in connecting the Sparcstation to the IBM. IJJ has helped in setting up IP routing from the Sparc to the IBM at RAL, and NBC tested FTP on the line.

RAD has monitored developments associated with the SERC Chairman's wish to see fast access to the Cray supercomputer provided to Engineering Board users in general. He has attended a number of meetings on this, and gave a talk at a meeting of grant holders interested in such facilities. This was based upon the technical possibilities available, and the experience gained through the Sheffield work.

### 5.3.5 Other Wide Area Networking(IJJ, RAD, NBC)

IJJ (with RAD initially) has assisted CCD with the testing of special-purpose hardware known as IP Routers for high-speed networking over Wide Area Networks. This is an important technology that the JNT wish to promote so that effective use can be made of the upgrades to JANET, which are providing line speeds of up to 256 K bps. The testing has variously involved connecting IP Routers back-to-back through high-speed serial lines and connecting IP routers to Suns, in both cases directly and through X.25 exchanges, thus simulating the most likely hardware configurations to be employed.

Having been involved in the initial technical work, RAD subsequently set up an informal collaboration with CCD to investigate further the use of IP routing over X.25. It is likely that this work will be extended to include a link between Daresbury and RAL.

NBC and IJJ visited the Clinical Research Centre (CRC) which is part of the Medical Research Council (MRC) at Northwick Park Hospital, Harrow. They met with the head of computing services at CRC, Francis Rysavy and Geoff Gibbs of the same group and discussed shared interests in networking Suns over WANs and running services based on the TCP/IP protocols.

Overall the visit was very useful and stimulating. It identified a number of areas where it would be very valuable for SSG to collaborate with CRC CS.

### 5.3.6 Distributed Computing(IJJ, NBC)

Investigation of methods for Distributed Computing has been held up by the non-availability of the Network Computing System (NCS) software. NBC was unable to get hold of a copy of the NCS tape. Part of the problem was due to the upheaval arising from the takeover of Apollo by HP. Recently, IJJ has made contact with HP-Apollo and expects to receive a copy of NCS soon.

In connection with the RASP project, IJJ has started investigating the features provided by UNICOS, the version of UNIX running on the Atlas Cray.

SSG wish to investigate compute serving possibilities on the Cray and NBC put together a case for SSG to have time on UNICOS for testing connectivity etc. This was to be sent to CFC but the matter was raised at the RAL IP Group meeting who agreed that SSG should be allocated userids on the Cray.

### 5.3.7 Linotron(JJSC, NBC)

NBC introduced JJSC to the Linotron systems on nfs1 and louis and attempted to liaise with Repro. and Scientific Admin. on developments. JJSC spent a lot of time getting to grips with the code for the Linotron, teaching himself C at the same time. There were several problems with both hardware and software which prevented successful spooling of documents to the Linotron. Most of these have now been fixed.

NBC and JJSC have been looking at the possibility of having a connection to the Neutron Division Ethernet village. A plan has been agreed and a Sun will be installed in R3, so that the system should be usable once the Ethernet link is enabled.

CCD now have a public domain network printserver which consists of lpd on a PC. NBC and JJSC investigated how this might be incorporated into a Linotron service. It has been decided that this is currently not a viable option.

A trial service will be started in August 1990.

### 5.3.8 NFS Topics (NBC)

NBC has obtained nhfsstone, an nfs assessment tool from Legato Systems Inc., and has been examining this software with a view to use in assessment. NBC has carried out some tests with a view to putting together a meaningful set of benchmarks to complement our existing NFS suite.

NBC discussed NFS testing with Assessment section and arranged with CMS Ltd. for a loan to carry out an evaluation of the Legato NFS accelerator board. NBC ran the nhfsstone benchmarks on Sun3 and Sun4 servers both with and without the accelerator board. The conclusion was that the board works as specified, but that it would not substantially improve the performance of the IDUS fi1eservers due to the nature of the work these perform. A report is being prepared.

There are plans to run NFS over WANs e.g. from Daresbury and this has brought the problem of site-wide UNIX uids into focus. NBC has been coordinating the policy on uids. Having talked to Operations and found that there was no firm policy NBC wrote a paper for the LAN management meeting on a policy for the distribution of user ids. NBC's paper was discussed at the first RIPG meeting at which there was general acceptance.

### 5.3.9 News (NBC)

NBC has altered the newsclean script to deal with all the new news groups which have come in. He has also installed a patch to allow a quick start-up option which does not check for new groups. A bug with mailing to moderated newsgroups was also fixed.

### 5.3.10 Mail (NJW, JJSC)

For the first part of the period of the report NJW provided support for the IDUS Mail Service. This consisted of dealing with queries about the system, and of testing various new versions of X.25 and Coloured Books software released by Sun.

Since NJW's departure, JJSC has taken over general mail support and maintenance. All user queries to date have been successfully dealt with. This has involved getting to grips with the sendmail configuration files, liaising with the NRS people about the database and learning how to install a new configuration file on our mailserver.

JJSC has been involved with plans to move the mail system so that the current machine can be upgraded. This has required the installation of the new Sun X25 software (V6.0) and Coloured Books (2.0) onto another fileserver and testing it. There is still one bug in the X25 software that Sun are working on, but this will not affect the operation of the system when it is set up as the new (temporary) mailserver.

The first attempt to move mail between fileservers had to be abandoned when complications arose. JJSC has now discovered the source of the problem and a new attempt will be made soon.

### 5.3.11 Directory Services (RAD, KG, RJ, NJW)

RAD, KG, RT and NJW have spent time on a Pilot project set up to experiment with the provision of Directory Services in the UK academic community. Directory Services (often known as X.SOO) are a set of OSI services designed, among other things, to provide a human-accessible Directory Service to provide contact information for members of the community. This is seen as of particular importance in the area of electronic mail - with the expansion in the use of electronic mail it has become critically important that Directories exist to allow users to look up mail addresses of potential correspondents. In this sense X.SOO Directory Services perform a similar function as the telephone directories published by British telecom and other PTTs, along with their Directory Enquiries services.

Within the Pilot project there are a number of separate Directories connected together via OSI. KG and NJW set up a Sun system to provide the service at RAL, and KG installed and debugged the X.SOO software. RT now administers this system, and has written procedures in conjunction with KG to handle the data for the system. KG has developed a graphical user interface to the system, to allow Unix users to browse the Directory.

RAD runs the RAL part of the Pilot project, a joint undertaking between Informatics and CCD. He also defined a protocol for IBM users to access the Directory. This was implemented on the Directory Sun by NJW, and subsequently maintained and enhanced by RT.

### 5.3.12 IDUS Work(APM, NBC, JPB, JJSC, IJJ, RAD)

NBC and APM were involved with changes to the IP addresses of machines on the ID Ethernet LAN. Tests were carried out prior to switching the whole network over. After further tests in which some problems were identified, NBC oversaw the change to a new IP broadcast convention.

NBC has been looking into ways of monitoring and improving performance on the ID Ethernet. He made out a case for a Trainee Programmer to write a set of utilities that would be useful. NBC wrote an IMM paper which formed the starting point for the work of the trainee - JPB. The latter developed a set of graphical tools to display in a convenient form the raw output of various utilities available in Unix to monitor system status. He also worked on a scheme to archive performance data for later use.

NBC has started to evaluate a copy of Sun's SunNet Manager.

NBC has been looking at ways of providing a modem connection to the ID LAN via one of the Bridge EtherPADs. APM set up one of the EtherPADS in the machine room and telephone lines have been installed in the Comms area. Demonstrations of modems which could provide a call back facility have been carried out. These should improve the security of the system, and also make reclaiming telephone charges a less complex task. NBC is now arranging for modems to be purchased and a dial-up service initiated.

JJSC, supervised by IJJ, has been trying to install NSE (Network Software Environment). JJSC studied the NSE documentation to get some understanding of the capabilities of the product. Installing NSE did not go as smoothly as desirable because of bugs in the install scripts. Problems existed in trying to determine what files would be modified when the system was installed on the YP master server - another Sun was used to try and trace the scripts as they were executed.

APM has compiled and installed a new version of tn3270 into lusr/ralfbin for Sun 3s. A compiled version for Sun 4s available in lu/publicfbin.sparc. APM has modified keymapping files and manual pages and has written shell scripts for use with the X Windowing system. APM has also written a paper comparing tn3270 with SIM3270 (a proprietary product that was tested earlier).

IJJ has installed compilers and other utilities from the GNU project of the Free Software Foundation. The initial impetus for this was to provide an up-to-date C++ compiler to be used by the X Toolkit evaluation team. These compilers have since proved to be useful to other users of IDUS and are now part of the service.

NBC has put up working Sun3 and Sun4 versions of mon.

NBC has written a script (rload) on nfs4 to provide the load average and number of users on Suns in Lab 11 designated as compute servers.

NBC wrote an IMM paper on evaluation of the Clearpoint memory boards which were installed in two Sun 3/50s.

The Department is considering the replacement of the Displaywriters used by the secretaries for word processing with more modern equipment that is integrated into IDUS. RAD is providing advice on the technical issues involved, and this may involve work by other members of the Group at a later stage.

APM has continued to act as the LAN Ethernet manager. As well as the regular tasks he has tidied up the cabling in the Human Factors Lab Video Room, made room on one of the EtherPADs for dial-in modems, and helped with Open Days planning.

### 5.3.13 X Window System (NBC, APM, RAD)

NBC has been providing managerial effort for the X toolkit evaluation. This has included chairing progress meetings and writing the minutes. He has also looked at the availability of some commercial toolkits and obtained the ET++ distribution.

APM has been heavily involved with the X windows Toolkit Evaluation, and has had to learn to programme with Athena Widgets. APM started writing a tutorial on Athena Widgets and has been developing a test application as the focus of this work.

A user requirements questionnaire was sent out to sites and NBC typed in the data and produced a summary paper. APM then used this as the basis of a paper analysing the results in more detail and picking out the essential and desirable criteria.

NBC spent some time discussing the provision of an X service as part of IDUS with Design Division before ULM took up the issue (RAD has now produced a paper).

APM has installed OpenWindows version 2 (Beta) on a SparcStation.

APM has installed X.desktop on a Sun 3/60. Due to difficulties inherent in this program he has not yet been able to put it into a public area.

As part of his work under the ARGOSI project, RAD has contributed to work within the community on the production of a suitable mapping with which to run X Windows over OSI networks. This is important on two counts. In practical terms it is necessary to define a mapping that can be used over WANs such as JANET, which do not use TCP/IP. It is also necessary to have a viable OSI mapping to ensure that the forthcoming attempt to standardise X Windows within ISO stands a good chance of success.

RAD is secretary of a group set up by the JNT to co-ordinate activity in this area, and which acts as the technical advisory group to the relevant BSI committee.

### 5.3.14 Esprit ARGOSI project (RAD, KG)

ARGOSI (Applications Related Graphics and OSI Integration) is an ESPRIT II project concerned with the harmonisation of ISO Standards in the areas of graphics and OSI. It is aimed at identifying the needs of distributed graphical applications, and providing input to the Standards bodies where necessary to ensure that these needs are met. The project is also developing a demonstrator to show that Standards in these two areas can be successfully combined in a realistic application. RAD gave a talk about the project to the Department early in 1990.

RAD is RAL project manager for ARGOSI, and also contributes in a number of technical areas on the OSI side. He has participated in the Classification Workpackage which aims to classify real applications according to their graphics and OSI requirements. He was Workpackage leader for the Connectivity Workpackage, which provided an initial estimate of the feasibility of using international PDNs as part of the demonstration. He has also contributed to work on providing an OSI mapping

for X Windows (see above), and on the development of a functional profile for FTAM to support the handling of Computer Graphics Metafiles (CGMs).

KG has mounted and tested the ISODE FTAM system. She is also working on the enhancement of this to enable it to be used in the demonstration.

### 5.3.15 JNT Contract to Evaluate Ethernet Bridges(RAD)

RAD has continued to carry out this contract which provides the academic community with technical advice and recommendations on the suitability of various Ethernet bridge products as ways of linking LANs. The work has consisted of gathering information from suppliers, and in carrying out in-depth tests of products. Regular summary documents are published within the community based on these tests.

This work is scheduled to end in October 1990, due to the increasing involvement of the Group in new areas of work.

### 5.3.16 Automotive Design Programme (ADP) (RAD, RT, NBC)

The Group has been given effort to provide communications support for this Programme, based at Birmingham University. So far it has been unclear exactly what the Programme's requirements are. RAD has been monitoring events, and RT and NBC have made a number of visits to HEIs involved in the Programme to enquire about the facilities they require.

### 5.3.17 Engineering Design Centres (EDCs) (RAD, KFH)

The Design Management Committee is setting up a series of EDCs at HEIs throughout the country. RAD provided the Committee with a technical assessment of the communications aspects of this project, and has subsequently provided advice on the hardware and communications aspects of HEI bids.

### 5.3.18 Other Items

NBC has made some changes to the Postscript business card programs for the DAO and has produced various logos.

RT provided a mail responder to enable readers to obtain electronic copies of the text of Engineering Computing News, which was handed over to Management Services Group.

KG and RT installed the ibrowse interface to the X.500 Directory on a JNT Sun for the RAL Open Days.

The BCS PDS started on January 1st this year. NBC is a supervisor and participant. IJJ, APM, RT and KG and JJSC are participants. All have had to produce career development plans. RAD is a supervisor only.

NBC took part in 4 HEI visits which were organised by D Lomas.

RT has taken part in 3 HEI visits organised by G A Lambert.

RAD has taken part in 2 HEI visits organised by J W T Smith.

### 5.3.19 Meetings

- NBC is SSG's representative at IMM and is also secretary to that meeting.
- RAD, NBC and IJJ attend the RAL IP Group meeting. RAD chairs this Group; IJJ is secretary with NBC having taken on this role as backup.
- APM used to represent SSG at the USM but has now handed this over to JJSC.
- APM attends the Site LAN Management Committee, as does RAD.
- APM wrote the minutes for SSG meetings until the change in format at the last restructure of the Group.
- RAD is secretary of the JNT SIG on X Windows. RT also attends these meetings.

- RAD, KG, NJW and RT have all attended various meetings of the Academic Community Directory Group. KG also attends the the IGOSIS Group on Directories.
- RAD is a member of IUNC, acting as SERC/EASE representative.
- RAD attends the liaison meetings between Sun and the JNT, on behalf of EASE. He also attends other JNT meetings from time to time where there is an overlap of interest.
- RAD attends various meetings associated with the ARGOSI Project.
- RAD attends the JNT Lower Layers Advisory Group as part of his work on the evaluation of Ethernet bridges.
- RT is secretary-elect of the EASE Toolkits Working Party, the first meeting of which will be in August 1990.

### 5.3.20 Conferences

- Networkshop 18, Newcastle, JJSC, RAD, IJJ
- Seminar on DRIVE and PROMETHEUS Programmes, London, RAD
- BCS Displays Group meeting on Systems Integration, RAD
- IUNC seminar on network management (paper given), RAD
- SERC Visualisation Workshop (paper given), Daresbury, RAD

### 5.3.21 Courses

- tcp/ip, London, NBC, KG
- Selection and promotion interviewing, NBC
- Introduction to C programming, Preston, JJSC
- Introduction to X.25/PAD, Exeter, JJSC
- Introduction to X.400 and MHS standards, London, JJSC
- SNMP course, London, RAD
- AT&T C++ seminar, IJJ
- X-windows course, London, APM
- X.500 course, London, RT

### 5.3.22 Papers

The following are the main reports of a technical nature written during this period by members of the Group.

- The New NFS and YP Evaluation suite - CTN/P40/89. (NBC)
- Allocation of User and Group Ids for Unix systems on the RAL LAN LMC/P1/90 (NBC)
- A summary (NBC) of the OSF Distributed Computing Environment RFT - OSF/P6/89
- Report on a Visit to the Clinical Research Centre, Harrow - DCSD/TR28/90 (NBC, IJJ)
- Evaluation of TCP/IP and NFS on the IBM 3090 - CTN/P42/89 (NBC, IJJ)
- MCP Performance - CTN/P43/89 (IJJ)
- IP Routing for RASP CTN/P45/90 (IJJ)
- Connecting Suns to the Cray CTN/P48/90 (IJJ)
- Running the KiloStream Link CTN/P39/89 (IJJ)
- Initial Evaluation of the Cisco MGS/2 as an IP Router over X.25 Networks - CTN/P46/90 (IJJ, RAD)
- Reports on Ethernet Bridges as part of JNT Ethernet Bridge contract (various) (RAD)
- Esprit Project 2463 ARGOSI: Final Report for Workpackage 2 (Connectivity) (RAD)
- Specification of Email Service to be Provided by the Directory Server _ Version 1 - DSP/TN/P7/90 (RAD)
- Mapping of X Windows over OSI Networks - a Position Paper ATN/P13/90 (RAD)
- A FTAM Functional profile for CGM Access - Position Paper - ATN/P23/90 (RAD)
- Directory Services An Overview of Available Implementations CTN/P4l/89 (KG)
- Instructions for Directory Migration to a Sun4/330 - DSP/TN/P3
- QUIPU-specific and Local Aspects of the Directory - Description and Recommendations - DSP/TN/P4/90 (KG)
- A Tutorial Guide to Ibrowse - IDUS/P2l/90 (KG)
- Electronic Mail Interface to the X.500 Directory Service DSP/TN/P6/90 (NJW)

- Sunlink X.2S Version 6.0 CTN/P38/89 (NJW)
- PC-NFS - Installation on a PC - CTN/P37/89 (APM)
- Comparison of Tn3270 and SIM3270 - CTN/P44/90 (APM)

#### 5.3.23 Objectives for 1990/91

- Produce report comparing different distributed computing software systems currently available.
- Understand IDUS performance problems and implement improvements.
- Introduce an X Windows service into IDUS.
- Complete the X Toolkits evaluation and produce report.
- Introduce an X.400 mail service into IDUS.
- Bring the Linotron Print Service to stability.
- Bring the RAL X.500 Directory Service to stability.
- Contribute (within ARGOSI) to the implementation of the CGM document type into ISODE FTAM, and produce a suitable functional profile for EWOS.
- Provide wide-area IP service facilities to Informatics Department, and contribute to technical work to ensure availability to EASE Departments.

### 5.4 MANAGEMENT SERVICES GROUP

#### 5.4.1 Staff

- Geoff A Lambert (GAL) Group Leader
- Sheila G Davidson (SGD)
- Peter J Hemmings (PJH)
- Susan C Hilton (SCH)
- Janet R Smith (JRS)
- John W T Smith (JWTS) Departed 31.03.90
- Carol Barnes (CB) Departed 11.07.90
- Peter M Cutler (PMC) Arrived 02.07.90
- Lynn A Oldfield (LAO) Arrived June 90

#### 5.4.2 Objectives for 1989/90

The objectives of the Group continue to provide those services for Informatics Department which it is sensible to centra1ise. Some are provided on behalf of the whole Department, ego The majority of the EASE Services, The Departmental Administrative Officer, others for specific projects, such as ESPRIT 962.

#### 5.4.3 Publicity Services (SCH, SGD)

Sheila Davidson (SGD) remains responsible for the production of the Engineering Computing Newsletter. This has now developed into a routine monthly event with everyone involved in the production cycle working, the majority of the time, to an agreed timetable.

The original objective of a significant increase in the circulation has been achieved. Well over 5000 copies are distributed each month. The range of articles has increased with the major portion originating from members of the user community. Obtaining articles is a time consuming activity but SGD has become highly proficient at chasing up any hint of a good story. The concept of regular monthly items from special interest groups is now firmly established, but plans to update the presentation are taking longer than was originally anticipated.

Susan Hilton (SCH) was diverted from her original tasks to commence producing the Graphics Newsletter. This is now also produced monthly, in parallel, with the ECN, and after the initial teething problems were resolved production of this is now handled by Janet Smith (JRS).

Production of the EASE glossy has proved to be a long winded process with (SCH) being diverted onto other more pressing activities whenever progress was made. The major difficulty was obtaining any agreement on the form this product should take. At long last CFC agreed on a general format and production of the initial draft is now taking shape.

Revision of the EASE schedules was passed to a special committee and again now that specific responsibilities have been defined some real progress on the task has been made. It is intended that this document will also be available to the community over the network and the layout has been designed specifically to facilitate this.

### 5.4.4 Education and Awareness (GAL, JWTS, SCH)

Education and Awareness has been defined as one of the high priority areas of the EASE programme. In December 1989 Professor Nicholson, late of the Control Engineering Department of Sheffield University, agreed to take on the role of Education Co-ordinator. After three changes to his Contractual terms of reference, when he became in turn, Education Co-ordinator, EASE Co-ordinator, then EASE Monitor, he too took the path of his predecessor and resigned. This adds confirmation to the fact that:

- EASE Co-ordination can seriously damage your health and cause premature retirement.

GAL assumed this responsibility again and to date has not retired, yet!

The major activity of the Education and Awareness team (GAL, JWTS, David Lomas (UMIST) plus invaluable assistance from SCH) has been the visits to the Engineering Departments of all HEI's in the UK. One objective of this activity was to attempt to measure the impact and effectiveness of the EASE policy. The major instrument in obtaining this information was a questionnaire, designed by the committee, which proved to be a long iterative process which ended up satisfying nobody. The real problem was that it was never made clear what information was required, and worst of all, when obtained, how it was to be analysed.

However, regardless of the problems the majority of the sites have been visited, with over 700 interviews taken place covering some 75 HEI's. Some analysis of the data has already taken place, and in part has been acted upon, but if the good will generated by the initial visit is to be capitalised upon, follow up activity is essential. This will form a major activity during the coming months.

E & A events form another significant activity of the Group and everyone ie.(GAL, SGD, SCH, JRS, JWTS, and David Lomas) have all made contributions. Events include:

| Function | Event | Date | Location | Attendance |
|---|---|---|---|---|
| Tutorial | SUN System Admin | 17.8.89 | RAL | 6 |
| Workshop | UIMS | 18.9.89 | UMIST | 85 |
| Workshop | OOPS | 19.9.89 | UMIST | 70 |
| Tutorial | SUN O/S Introduction | 20-21.9.89 | UMIST | 12 |
| Tutorial | SUN O/S Introduction | 22.10.89 | UMIST | 10 |
| Tutorial | SUN System Admin | 31.10.89 | RAL | 8 |
| Seminar | How to Support Long Lived Software | 9.11.89 | RAL | 80 |
| Tutorial | SUN O/S Introduction | 15.11.89 | Leicester | 14 |
| Tutorial | SUN System Admin | 16.11.89 | Leicester | 8 |
| Seminar | AI Techniques for Engineers | 6.12.89 | RAL | 90 |
| Workshop | SGML | 5-7.3.90 | RAL | 35 |
| Tutorial | Introduction to UNIX | 10.3.90 | RAL | 10 |
| Seminar | CFD Community Club | 22.3.90 | RAL | 60 |
| Tutorial | Introduction to SUN O/S | 28-29.3.90 | RAL | 12 |
| Seminar | Computer Algebra | 3.4.90 | Sheffield | 70 |
| Tutorial | Introduction to SUN and | 4-5.4.90 | Sheffield | 14 |

| | | | | |
|---|---|---|---|---|
| | UNIX | | | |
| Seminar | Integrated Knowledge Based and Conventional Systems | 11.5.90 | Edinburgh | 40 |
| Workshop | Introduction to PHIGS | 29-30.5.90 | RAL | 25 |
| Seminar | SGML | 5.6.90 | Manchester | 50 |
| Tutorial | Introduction to SUN O/S and UNIX | 19-20.6.90 | RAL | 6 |
| Tutorial | Introduction to SUN O/S and UNIX | 25-26.06.90 | RAL | 6 |

The event of the year deserves special mention - EASE 90 which was held at UMIST from 18-20 April. This was attended by some 280 people over three days, included 58 speakers plus a large exhibition, was put together in less than 4 months, and by general agreement was an outstanding success. This would not have been possible without the wholehearted efforts of Susan Hilton, Janet Smith and Sheila Davidson who all deserve special recognition for all their hard work. It is now intended that there will continue to be an annual EASE event and plans for EASE 91 to be held in Birmingham on 25-27 March are now well advanced.

### 5.4.5 File Server Project (GAL)

GAL has visited all Server sites prior to installation of the equipment to discuss the terms of the contract and resolve any problems. Installation was successfully completed at Essex. Leeds, Strathclyde, Bangor and Bradford Universities; Bath were allocated a Server during the last round but installation has been postponed due to lack of finance.

All sites were offered places on the System Administration Courses and almost without exception these have been accepted. This highlights the value of this activity especially as the course content is specifically targeted towards the needs of our community, and, important to all, the course is free. It is worth noting that the value of our System Admin Courses has spread beyond those sites where CFC funded Servers have been located. Nearly 50% of the course attendees have come from Institutions running SUN Servers paid for from Computer Board, other grant, or Institution funds.

### 5.4.6 CFTAG and ECFE (GAL, RET, KFH)

GAL acted as Secretary to the Computing Facilities Technical Advisory Group (CFTAG) until December 1989. KFH, RET and GAL were members of the ECFE until it was disbanded in June. Even with the demise of these Committees the level of follow-up action continues undiminished.

### 5.4.7 ESPRIT 962-EVEREST (GAL)

GAL provided management support to the project. The project was a contributor to the ESPRIT Conference and Exhibition in Brussels in November 1989, having both an exhibit and hosting a workshop.

The project's final review was held in June 1990 but due to the failure of two of the partners to complete aspects of their individual contributions, a further final review is scheduled for November 1990.

As usual the project has necessitated the production of vast amounts of paper, the technical reports and the financial and manpower reports. All made inroads to the loss of the rain forests.

### 5.4.8 Prime Shutdown (GAL, PDA)

GAL was responsible for the rundown, shutdown end disposal of all the Informatics Department Prime facilities. Pat Athawes was responsible for all the day to day activity and achieved the almost impossible task of retrieving the vast amount of data which had been archived during the 12 years of the ICF. Further details are given in 5.2.25.

Final shutdown was marked in the traditional manner with a wake attended by some 50+ people who had made various contributions to the success of the project. The final switch-off was performed by Professor A MacFarlane, who had been Chairman for the ICF Programme Committee.

**Prime Closure: Ken Robinson, Bob Hopgood, Eric Thomas, Jim Hailstone, Cliff Pavelin, Pat Athawes, Geoff Manning, Alistair McFarlane, Howard Rosenbrock,Mike Jane, Jed Brown, Paul Bryant**

**Large View**

**Alistair MacFarlane turns off the last Prime**

**Large View**

**Len Ford, David Boyd, Bill Trowbridge, Paul Bryant and Brian Colyer looking at a photo of the Acceptance Celebration for the first Prime 400**

**Large View**

### 5.4.9 SERC Professional Development Scheme (PDS) (GAL, KFH)

The first cycle of the scheme was completed at the end of June, with 16 members of the Division participating. KFH remains the Co-ordinator of the Informatics participants, with Professor Hopgood as the Super Co-ordinator and GAL acting as Secretary of the organising Committee.

### 5.4.10 Departmental Administration Officer (CB, LAO)

Carol Barnes has continued to provide a day to day administrative service for all staff in the Department. The constant battle to keep ahead of all the Department's accommodation moves remains a feature of her work.

At least the level of the workload in the DAO's office has been (LAO) has been recognised and Lynne Oldfield a welcome addition to the section, CB remained Secretary of the Informatics Division Heads Meeting, and of SERC Suggestions Scheme Local Awards Committee.

### 5.4.11 Informatics Department Mailing List Project (PJH)

This work predominated between June and December. PJH developed a facility meeting a wide range of departmental requirements. The aim of this project is to maintain information about departmental contacts. Subject interests, committee memberships and newsletter distribution requirements are recorded. Two large mailing lists were issued to establish the initial data. Facilities include ability to display lists of users, to view details of any user, and to define subsets within the list. It is possible to produce individually addressed letters to members of the subset, and typed address labels for every member of the subset. Data can be created, edited or removed. There is the facility to make selections of users, such as all Transputer users in the North West.

### 5.4.12 Informatics Department Finance Project (PJH)

Some maintenance work was necessary chiefly to circumvent a bug in a new operating system. Opportunity was taken to improve the layout of reports after attending a course on Postscript.

This project developed programs written in a mixture of Fortran and REXX on the IBM CMS service and C and Postscript on the IDUS service.

### 5.4.13 Informatics Department Central Computing Representative (PJH)

PJH attends CCSUM (Central Computers Site Users Meeting) and now represents the whole of the Informatics Department. The structure of accounts used by the department had not been changed for many years and no longer represented the structure of the department's work. A new structure has been worked out which will be implemented during the summer of 1990.

### 5.4.14 RRS Resource Officer (PJH)

This work began in October. PJH works for the Deputy Director as the Resource Officer for Rutherford Research Services.

The work of the Resource Officer for RRS has three aspects: bids, monitoring and approval. The work on bids is for the RAR allocations and Forward Looks. Monitoring covers the use of resources, out turn and surpluses. Approval covers advice on new projects and reviewing the RRS programme. The job requires liaison with Finance Division, Contracts, Departmental Resource Officers and Programme Managers. PJH attends the laboratory finance subcommittee.

### 5.4.15 UMIST Contract (GAL)

As well as general responsibility for all EASE contracts GAL has been specifically responsible, with RET, for supervising the contract at UMIST. This is now coming to its end and has proved of considerable value to the project.

### 5.4.16 Conferences Attended

EASE 90, UMIST, April 1990, GAL, SGD, JRS

### 5.4.17 Training Courses

- BCS PDS Supervisors, Swindon, October 1989, GAL
- SERC Management II, October 1989, CB
- Framemaker, RAL, November 1989, PJH
- SERC Finance, Swindon, February 1990, CB
- UNIX/EASE New Users, RAL, February 1990, SGD,SC
- SERC Summer School, RAL, July 1989, PJH
- UNIX System Admin, RAL, August 1989, PJH
- Marketing Rod, Karlsruhe, March 1990, PJH
- UNIX, RAL, March 1990, SCD, SCH, JRS
- Newsletter Seminar, Oxford, April 1990, SGD
- SERC Management, London, May, CB
- SERC Grants DB, Swindon, May, SCH, JRS
- Safety Training, RAL, May, PJH

### 5.4.18 Papers External

- ESPRIT 962 Consolidated Interim Report No.7 (GAL)
- ESPRIT 962 Consolidated Interim Report No.8 (GAL)

#### 5.4.19 Objectives for 1990/91

- Complete HEI visit programme and produce report.
- Produce EASE glossy.
- Reorganisation of group.
- Run-down existing UMIST contract.
- Distribute EASE definition and Schedules.
- Organise EASE 91.
- Organise Education Programme with at least 50% of events remote from RAL.
- Create database of speakers at Seminars. Workshops and Tutorials for future use.
- Expand use of NISS Bulletin Board to advise Community of EASE Events.

### 5.5 IT DIVISION UNIT

#### 5.5.1 Staff

During the report period the staff of ITDU remained constant

- F M Russell
- A J K Lubbock

However, the name of the Unit changed to reflect the changes that took place in the Department of Trade and Industry in April, 1990. For the historical record it is worth noting that the Alvey Programme was run by the Alvey Directorate in Millbank Tower. This was jointly manned by SERC and DTI staff, together with industrial secondees. Towards the end of its life its headquarters were moved to Kingsgate House, Victoria Street, still as the Alvey Directorate but now firmly part of the DTI. This was seen as an anomaly by the DTI Mandarins and so it was renamed the Information Engineering Directorate (IED). RAL staff supporting IED were therefore placed in the IED Unit. The latest change was when it became IT Division (ITD); note the significant change from Directorate to Division. This consolidated the process of absorbing Alvey into the DTI. The IED Unit was therefore renamed the ITD Unit. This has caused a certain amount of confusion as the SERC body responsible for IT matters is, and always has been, the IT Directorate (ITD). These arcane name changes do represent a significant difference of opinion - SERC sees IT as very much more of a directed programme than DTI.

#### 5.5.2 Objectives for 1989/90

The objective of the IED Unit is to provide a home in Informatics Department for Informatics Department staff who spend much of their time at Kingsgate House, and whose duties do not fit naturally into the structure of Informatics Department.

#### 5.5.3 IED/ITD (FMR, AJKL)

The main objectives set for Mike Russell this year have been achieved. He completed the selection and appointment of Monitoring Officers for all the projects in the first and second calls. Many of these projects are now running and the MOs are producing their reports on project performance. A list of potential monitoring officers has also been generated for possible future use.

The reports produced by the MOs are used to judge the performance of the projects. These reports are analysed by Mike Russell for signs of possible project difficulties and he reports any such indicators to the Director of Systems Engineering of the ITEAP in the SERC/DTI IT programme. All projects are defined in terms of deliverables and these are set out in the Level 2 plan of the project. A major initial task of the MO is to ensure that a satisfactory Level 2 plan is received from the Project Officer. Delays in producing this plan are an early sign of possible problems. The production of deliverables is an excellent indicator for monitoring project performance but the MOs have to use their skills to monitor the success of team work and collaboration between partners in the projects.

Reports by the MOs for the remaining projects in the Alvey programme also are included in the coordination analysis made by Mike Russell. To ensure that the Mas set acceptable standards for the projects two one-day seminars were organized by the RAL ITD unit. These seminars covered many aspects of monitoring and included inputs from experienced Mas. As a result of the first seminar the guide book on monitoring prepared by the DTI was altered to reflect the special problems of monitoring IT projects.

Tony Lubbock has continued to work for Adrian Wheldon, who is now based at Swindon, on helping to manage the External Interfaces and Special Systems parts of the Systems Engineering components of Joint Framework for Information Technology programme. There continues to be some activity generated by remaining Alvey IKBS and Systems Architectures projects, particularly managing extensions to these projects. For new projects AJKL is mainly concerned with preparing the final proposals and ensuring that the necessary contracts are let as quickly as possible.

### 5.5.4 Mica (FMR)

Individual research has been conducted by Mike Russell into solid-state recording processes. This work has been funded on a 50% basis by RAL during the past year. Earlier work suggested that the recording processes involved two distinct mechanisms. One depended on inelastic scattering to produce ionization which then caused a proportionate decoration of the track by an impurity present in the mica. Detailed study of the tracks has confirmed that a second process is involved that is independent of ionization. This is a major finding and calls for a new approach to track recording. In this new process the energy for modifying the lattice to record the track comes from relaxation of the lattice itself rather than from the particle.

This new process has assisted in explaining many of the lines in mica which previously were not understood but had been shown not to be caused by charged leptons. These lines are consistent with the propagation of energy and momentum through the lattice in a coordinated way by solitons or supra ballistic phonons(SBPs). To test this hypothesis an experiment was devised by Mike Russell and is currently under way in collaboration with a group from Frankfurt. The energy in the solitons or SBPs is obtained from an incident energetic particle, by relaxation of stored energy in the lattice or by combinations of these.

A collaboration to test the ionization dependent recording process in an artificial mica in the laboratory was set up with a group in Shanghai. The troubles in China have caused this work to be halted.

The second recording process is consistent with the triggering of a phase transition in a polyphasic material. Although the initiation of a phase transition in liquid/vapour systems by charged particles is known, evidence for this process in the solid-state is new. Such a process may allow for external control over phase transitions in any polyphasic material, including metallic alloys. Action has been taken to gain patent protection for this process. A laboratory test of this process should be attempted and is now under consideration.

### 5.5.5 Open Days

Mike Russell was asked to take on the early work on co-ordination of Informatics Department's contribution to the RAL Open Days, which are to take place just after the end of the Report Period. He attended all the early meetings of the RAL Open Days Panel and instigated the actions necessary for the production of display material of all kinds, as well as helping to define the overall shape of the Open Days. Later on he was helped by KFH and most Informatics Staff in what was a very successful venture.

### 5.5.6 Conferences

IEATP Conference, Southampton, March, AJKL

### 5.5.7 Papers

Decorated track recording mechanisms in Muscovite mica. FMR

### 5.5.8 Objectives for 1990/91

- To direct the monitoring officer programme for the SERC/DTI JFIT programme.
- To analyse the MO reports for signs of potential difficulties in project performance.
- To advise the Director of Systems Engineering of potential and real problems in project performance.
- To direct and coordinate the RAL/Frankfurt collaboration on SBPs.
- To devise and initiate a laboratory test of the new process for initiating phase transitions in the solid-state.

Informatics
Informatics Department

# The Alvey Programme



## Workstations

There was always a strong interest in single-user workstations from the MMI, Software Engineering and IKBS communities.

The major initiative was the introduction of the SUN single user workstation in large numbers in the community, together with arrangements for central support etc. This involved Peter Kent and A B Smith. Activities included:


**Sun, Whitechapel and PERQ Workstations: Martin Prime and Peter Kent 1985**

## Large View

- defining a standard configuration SUN for users, based on the benchmarks that had been run on the SUN and other machines and information from the users;
- helping users to sort out their specific requirements and then progressing their orders;
- negotiating discounts on SUN hardware and maintenance charges;
- looking after the SUN and Whitechapel computers at RAL and arranging for dispatch and loan of equipment to grant holders in Universities;
- advising potential grant holders of the latest SUN equipment and the SERC policy on central purchase and maintenance of SUN equipment;

- benchmarking SUN equipment in order to update the standard configuration SUN as new SUN products were announced;
- trying to get the SUN's at RAL working satisfactorily on the ethernet;
- organising the first SERC SUN user group meeting at RAL.

The group also supported Whitechapel workstations to some degree - 22 were purchased for assessment by the IKBS Director and Tony Lucas managed the allocation and distribution of these. It also handled central purchase of Orion workstations (P Kent) and ICL Series 39 for large IKBS architecture projects (Cliff Pavelin).

A C D
Atlas Computing Division

# Distributed Computing Systems



## DCS Project List

Below is a nearly full list of the projects funded under the DCS Programme. Some small projects have been omitted and ones that include two funding awards have only been included once.

- S Abramsky: An Applicative Programming Methodology for Concurrent and Distributed Systems.
- Prof D Aspinall: The Use of Microprocessors in Information Systems.
- Dr J M Bacon: An Investigation of Software Structures to Facilitate Distribution.
- Dr J Bell, Mr N Willis and Dr J Kerridge: An Evaluation of Alternative Implementations of Multi-processor Communications Mechanisms.
- Dr K H Bennett: A Feasibility Study of Loosely Linked Computers.
- Dr K H Bennett: A Distributed Filestore.
- Dr K H Bennett: A Reliable Network-Transparent Filestore for a Collection of Personal Workstations.
- R Bornat: Pascal-M, A Language for the Design of Loosely-Coupled Computer Systems.
- Mrs H Brown, S E Binns and J D Caul: Typesetting and Text Processing Server for the Cambridge Ring.
- Prof P J Brown and Dr P H Welch: Compiling Servers for the Cambridge Ring.
- Dr F W Burton and Dr M R Sleep: Distributed Evaluation of Applicative Programs on a Highly Interconnected Network.
- Dr D W Bustard and Dr J Elder: The Design. Implementation and Application of Languages for Distributed Computing.
- Dr D W Bustard: Portable Pascal plus Compiler.
- Prof G D Cain and R C S Morling: Local Area Data Network for Instrumentation Applications.
- D Coleman, J W Hughes: Developing a Program Methodology for Multiprograms.
- Prof G F Coulouris: Distributed System Requirements for Effective Man-Machine Interaction.
- R J Cunningham and Dr J Kramer: Computer Assisted Methods for Developing Verified Software.
- Dr J Darlington: Development of a General Purpose Applicative Language Machine and Applicative Language Environment.
- Dr L C W Dixon: The Advantages of a Parallel Computation Facility for Global Optimisation.
- Dr R D Dowsing, Dr P W Grant: The Specification and Implementation of Programs on a Multi-microprocessor.
- Prof D J Evans. Dr I A Newman: An Investigation of the Relationship between Algorithm Structure and Parallel Architectures.
- Prof D J Evans, Dr I A Newman, Dr M C Woodward: A Research Vehicle for Investigating the Use of Closely Coupled Distributed Syslems.
- Prof J P Fitch and Dr P J Willis: A Feasibility Study of a Tree Structured Arrangemenl of Processors.
- Dr J A Gordon: Secure High Speed Data Transmission.
- Prof R L Grimsdale, Dr F Halsall: The Design and Implementation of a Multi-microprocessor System.
- Prof R L Grimsdale, Dr F Halsall: The Design and Implementation of a Broadband Local Area Network.

- Prof R L Grimsdale and Dr F Halsall: Decentralised Resource Management in a Tightly-Coupled Multicomputer System.
- Prof R L Grimsdale and Dr D J Woollons: Advanced Techniques for the Computer Generation of Images.
- Dr J R Gurd and Dr I Watson: A Multilayered Dataflow Computer System.
- F K Hanna: Distributed Computing Systems for Interactive Knowledge Bases.
- Dr P Henderson: Purely Functional Operating System.
- S E Hersom: Development of Optimisation Algorithms for Parallel Computation.
- P L Higginson: A Study of Protocol Requirements for Mulit-Media Messages and Intercommunicating Office Machines.
- Prof C A R Hoare, J E Stoy: Software Engineering.
- Prof C A R Hoare, J E Stoy and M K Harper: Distributed Computing Software.
- J W Hughes, M S Powell: Multi-processor Software Engineering.
- Dr J R W Hunter, Dr K Baker and Dr A Sloman: Interactive Software Tools for Distributed Computing Systems with an Application to Picture Interpretation.
- D Hutchison, W D Shepherd: A Feasibility Study into the Complexity of Gateways for Connecting Ethernet to Ring Networks.
- D Hutchison and W D Shepherd: Direct Comparison of Ring and Ethernet Type Systems.
- Dr R N Ibbett, Dr D A Edwards and Dr C J Theaker: A High Performance Optical Fibre Based Local Area Computer Network.
- Prof J K Iliffe: Design Studies for Active Memory Arrays.
- Dr C C Kirkham, Dr J R Gurd: Development Software for a Prototype Data Flow Computer.
- Prof P T Kirstein: Communication Protocols in the Context of X25 Computer Networks.
- Dr P E Lauer: Design and Analysis of Highly Parallel Distributed Systems.
- Dr P E Lauer: A Computer Based Environment for the Design and Analysis of Highly Parallel and Distributed Computing Systems.
- N Martin: Message Services and Directory Development.
- R M McKeag: Collaborative Research into Parallelism.
- A J R G Milner: Applications of Flow Algebras to Problems in Concurrent Computation.
- Dr I Mitrani: Modelling and Performance Evaluation for Distributed Computing Systems.
- Dr I Mitrani: Modelling and Performance Evaluation for Distributed Computing Systems.
- Prof R M Needham: Distributed Computing using Wide Band Communications.
- P E Osmon: Implementation of a High-level Dataflow Language.
- I Page: DISARRAY - An Evaluation of an Array Processor for Bitmap Displays.
- Prof Y Paker: Computer Aided Multi-microprocessor Systems Modelling, Simulation and Evaluation.
- Dr G D Plotkin and A J R G Milner: Semantics of Non-Deterministic and Concurrent Computation.
- Prof B Randell: A Project to Investigate the Design of Highly Concurrent General-Purpose Computing Systems.
- Prof B Randell: Reliability and Integrity of Distributed Computing Systems.
- Dr J D Roberts: Transformation of Programs for Tightly Coupled Distributed Systems.
- J A Sharp: A Dataflow Program Design Environment - Its Implementation and Use as a Research Vehicle.
- N H Shellness: An Architecture for a Multiple Computer System.
- Dr M R Sleep: Instruction Sets for Data Flow Architectures: A Comparative Study.
- Dr M R Sleep: The Potential of Pure Combinatory Code for Distributed Computing.
- Dr M R Sleep: Programming an Extensible Array of Transputers using a Naturally Extended Functional Notation.
- Dr M S Sloman: Communications for Distributed Process Control.

- Dr M S Sloman and Dr J Kramer: Specification and On-Line Management for Distributed Real-Time Systems.
- Dr D G Smith: Overload Control in Processor-Based Systems.
- Prof D A Turner: A Denotational Language for Dataflow Machines.
- Prof D A Turner: An Applicative Language Machine and Operating System.
- W W Wadge: LUCID as a Data Flow Language.
- Dr I C Wand: MODULA Distribution and Promulgation.
- Dr I C Wand: Distributed Operating System for Time-Sharing.
- Dr I C Wand: Operating System for a Network of Personal Computers.
- Dr I C Wand: Unix X25 Interface.
- WDr C Whitby-Strevens and D May: A Building Block System for Distributed Computing.