PRAXIS plc

ANNUAL REVIEW 1987

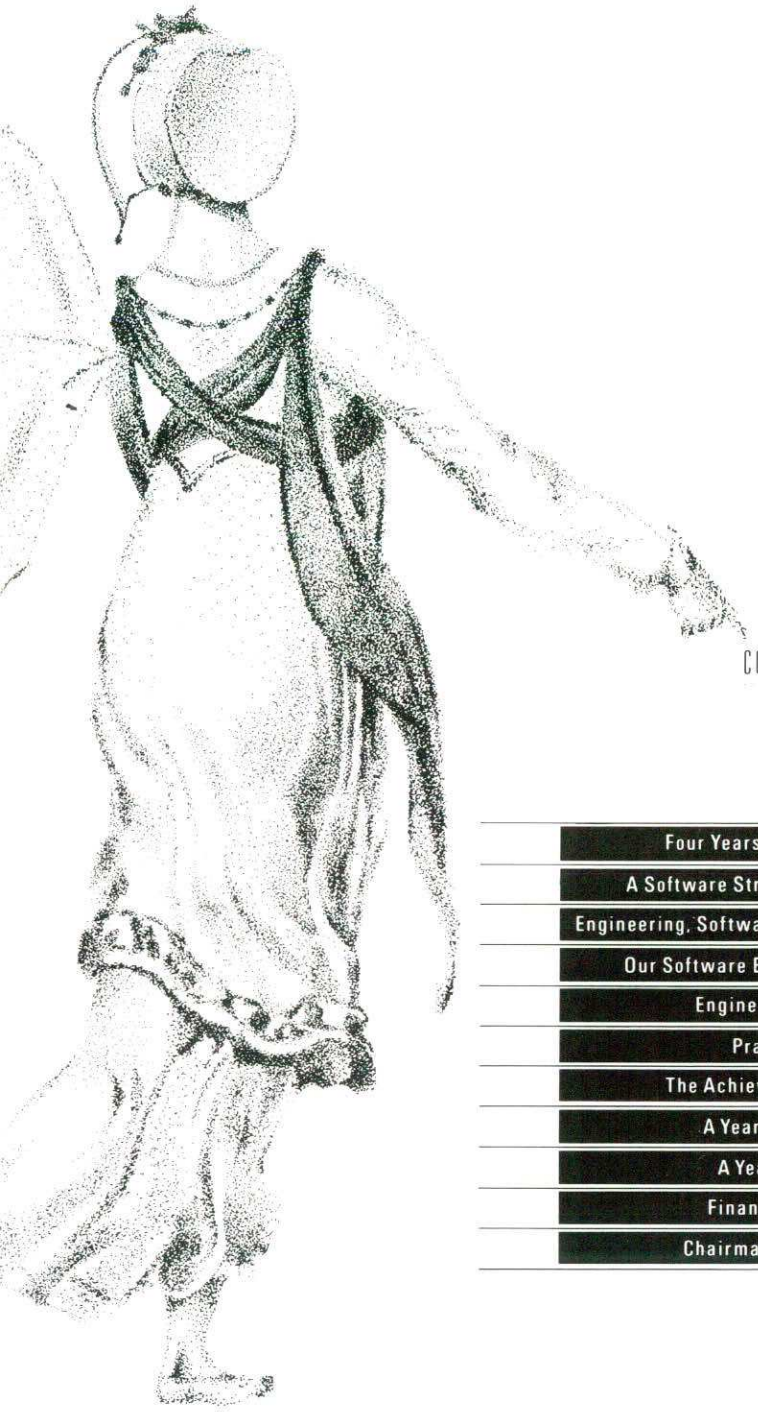
Praxis has completed four years of innovation, of growth, and of leadership in the field of Software Engineering. Each Annual Review provides us with the opportunity to record a year's achievements and to indicate the direction of our strategy for the future.

We view our successes and our plans in the context of national and world developments in software technology. Part of Praxis' mission is to help the United Kingdom maintain its position at the forefront of this technology, using the specialised skills and acknowledged professionalism of our own software engineers.

In this Annual Review, therefore, we show how the work we have undertaken in the past twelve months forms an important part of the process of building and strengthening a competitive software industry in this country.

In the first part of our survey of this Praxis business year we explain why the creation of national expertise in software engineering is so vital; in the second part we demonstrate how Praxis is playing a significant role in bringing that about.


1921-22 C. F. HAMMOND
1922-27 OFFICE MERGED WITH PRESIDENT
1927-28 R. H. HUTCHINSON
1928-30 J. A. HANNAY
1930-32 E. W. HANCOCK
1932-34 S. CARLTON SMITH
1934-36 T. FRASER
1936-38 J. H. BINGHAM
1938-40 J. G. YOUNG
1940-42 N. V. KIPPING
1942-44 H. A. HARTLEY
1944-46 J. E. BLACKSHAW, M.B.E.
1946-48 H. SCHOFIELD, C.B.E.
1948-50 J. E. HILL
1950-52 W. C. PUCKEY
1952-54 H. BURKE
1954-56 G. R. PRYCE
1956-58 H. G. GREGORY
1958-60 H. W. BOWEN, O.B.E.
1960-62 R. H. S. TURNER
1962-64 A. L. STUCHBE
1964-66 R. S. BROWN
1966-68 B. G. L. JACK
1968-70 R. E. HARVI
1970-72 DR. G. S. B
1972-74 B. E. STOKES
1974-76 L. P. SIMPSON



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They arrived at Bath. Catherine was all eager delight; – her eyes were here, there, every where, as they approached its fine and striking environs, and afterwards drove through those streets which conducted them to the hotel. She was come to be happy, and she felt happy already.

PRAXIS plc

Praxis is a software engineering company, founded in 1983 with the objective of becoming a leading developer and supplier of high-quality computer systems, and earning a national and international reputation for excellence.

In attaining that objective, our strategy is to recruit the most able professional staff, to provide them with the best possible methods and tools for the design and management of software systems, to demonstrate that these methods lead to the successful completion of demanding projects, and so strengthen the United Kingdom's reputation as a source of excellence in this branch of engineering.

Praxis is independent. The company is owned and controlled by its staff. From its inception, Praxis invested its own resources to develop a comprehensive quality system, covering all its activities. Over a year ago, we became the first independent company to achieve British Standard quality registration for all software development, production and consultancy.

Four years ago, Praxis began its first project: to assist ICL develop a UNIX service embedded in its mainframe operating system, VME. Now, with over eighty projects completed, we are continuing to apply the rigorous methods which stemmed from that early work. Our software development services still cover specialist work in the computer manufacturing industry; we also provide consultancy and software development methods studies; and we undertake contracts to implement complete systems in commerce, administration and industry. Praxis' reputation as one of the leading practitioners of methodical software development is based on the wide range of activities to which we apply our methods.

ELLA, our first software product, provides hardware engineers with the ability to control the complexity of VLSI chip design. Through the ELLA toolset, VLSI chip designers have access to the same techniques that software engineers are accustomed to use. Within two years of its introduction to British industry by Praxis, ELLA is being used by every major UK electronics group, and is being acquired by leading technical organisations worldwide.

Staff who join Praxis care about quality. We lay great emphasis on sound project management, clarity of design, and external scrutiny of all our work. Our projects therefore proceed in an orderly and predictable way. We set ourselves high standards in all that we do. In order to maintain those standards, all staff are provided with comprehensive support, professional training and attentive supervision.

Much has been achieved in four years. We are engaged on contracts that are technically challenging and commercially vital. We are using the most modern development methods and applying them to substantial problems. We are working within a supportive quality system to the highest standards of professional practice. We have attracted and continue to attract some of the most accomplished technical staff in the country.

Praxis is significant.

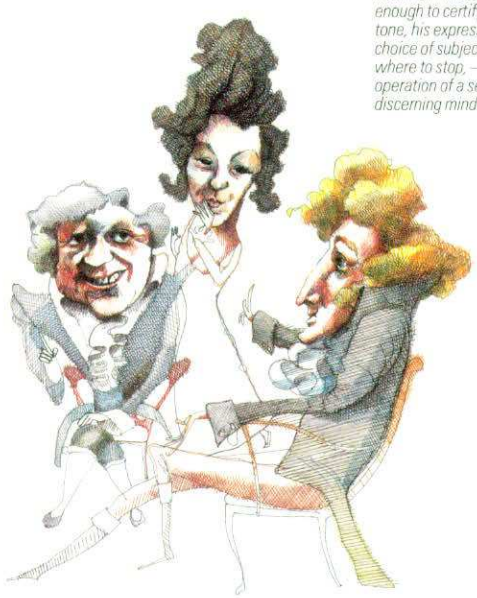
It is now widely acknowledged that this country's businesses, manufacturing industries, public services and domestic life are all vitally dependent on computing systems; the component of these systems which is most important, most costly and most difficult to produce is the software. The future of the software industry in this country is therefore of critical importance.

Praxis is working energetically to improve the effectiveness of the software industry in the UK. We understand the relevance of current knowledge in our field and we exploit that knowledge. By our active participation we continue to affect the policies which will maintain the competitiveness of our national software industry.

We aim to make the name of Praxis synonymous with all that is excellent in British software development. We are succeeding, through a strategy of working with the discipline of professional engineers to verifiable standards of quality. This way of working, essential for the development of systems engineered in software, was central to Praxis' foundation four years ago; we continue to follow it now. This strategy is beneficial for us, it is successful for our clients, and we believe it is of importance to this country. Our strategy anticipates the accepted professional practice of tomorrow.

▪ Praxis has always advocated the use of rigorous methods for the specification and design of software systems, and we use such methods to the benefit of our clients. The 1986 ACARD report on UK software *(1)*, the conclusions of the IT 86 Committee on Information Technology *(2)*, and the recent analysis of the computing services industry issued by the DTI *(3)* are unanimous in stressing the need for the UK software industry to adopt software development methods based on rigorous techniques. The Government, through the Central Computer and Telecommunications Agency, has standardised on the SSADM development method for the implementation of its administrative computing systems. Rolls-Royce and Associates Limited is issuing systems specifications expressed in precise mathematical notation; IBM(UK) is using mathematically formal methods for engineering their system software *(4)*.

He sat down with them, and improved their conversation very much. There could be no doubt of his being a sensible man. Ten minutes were enough to certify that. His tone, his expressions, his choice of subject, his knowing where to stop, – it was all the operation of a sensible, discerning mind.



The policies of these influential organisations are indications of the future direction of software development methods in the UK, methods already familiar to Praxis. We continue to champion their wider use: members of our staff chair the Alvey Directorate's Formal Methods Panel, serve on the British Standard Institute's VDM Standardisation Committee, and chair the British Computer Society's policy group on safety-critical systems.

▪ Praxis has always viewed software development as an engineering discipline. Through the British Computer Society's Professional Development Scheme we encourage all technical staff at Praxis to become Chartered Engineers. Engineering in software demands men and women with specialist abilities; these practitioners must be both technically proficient and professionally accountable. To meet these demands we must train and educate with determination and commitment. ACARD *(1)*, the DTI *(2, 5)* and the British Computer Society *(6)* all recognise the need for sustained professional training for all software engineers. Praxis is committed. We support and train our own staff and we continue to maintain close links with teaching establishments and the professional institutions. We advise and lecture at universities. Praxis helped to plan the new IEE/NCC Certificate in Software Engineering, launched this year, which is designed to provide a standard qualification for trainee software engineers.

▪ Customers for computing systems will increasingly demand assurances of the quality of the work that they commission. This year, for the first time, the Government issued requests to tender for standard computer systems where development to BS 5750 was mandatory. The Public Purchasers Group, which includes British Aerospace, British Telecom, the Civil Aviation Authority and the Central Electricity Generating Board, is committed to a policy of buying computing systems from those suppliers who can offer an accredited quality assurance scheme *(7)*. Both the Health and Safety Executive *(8)* and ACARD *(1)* recommend that software for safety-critical systems should be implemented only by professionally competent software engineers, supported by a quality system conforming to BS 5750. Under the Consumer Protection Act *(9)*, manufacturers are strictly liable for personal injury and damage to personal property caused by their products; this liability extends equally to products containing software. Praxis welcomes these moves and this attention to quality in software development; they are further confirmation of our beliefs in its importance. The Praxis Quality System conforms to BS 5750 and is shortly expected to achieve registration under the International Standards Organisation's new international quality system standard, ISO 9001.

Praxis' objectives are concise and clear; the strategy to achieve them consistent and certain. As time passes we find increasing evidence that our strategy anticipates and helps to shape the policies of influential organisations in industry and government. We will pursue that strategy. Our clients will continue to benefit from our professionalism; we hope that the country will benefit from our example.

But by coolly giving the reins a better direction herself, they happily passed the danger; and by once afterwards judiciously putting out her hand, they neither fell into a rut, nor ran foul of a dung-cart; and Anne, with some amusement at their style of driving, which she imagined no bad representation of the general guidance of their affairs, found herself safely deposited by them at the Cottage.

Engineers build structures and systems, and engineering involves the application of scientific principles to the creation of useful objects for the benefit of mankind. Engineering encompasses the processes of analysis, design, production and maintenance, all of which are related intimately with the strength, the performance and the durability of these objects.

Underlying every engineering discipline there is a scientific basis and, supporting that basis, mathematics. These mathematical foundations are powerful, for three main reasons.

First, they are descriptive; they allow the behaviour of a system to be described rigorously and unambiguously. Using the language of mathematics, an engineer can communicate the conceptual basis of a design to other engineers, with precision and accuracy.

Secondly, they are predictive; mathematics can be used for modelling the behaviour of a system in the real world. The model can be used to experiment in a way that may be impossible with the real system. A failure in the model is vital experimental information; the failure of a critical system is unacceptable. Therefore, mathematics gives engineers a safe way to study the behaviour of a system before it is constructed.

Thirdly, they are constructive; mathematics gives the engineer access to a wide vocabulary of description and analysis. Appropriate techniques enable different aspects of the system to be modelled and analysed in different ways. Complexity can be controlled because mathematics allows selected parts of the model to be examined at will. Work can be re-used since mathematical descriptions of the parts of a system can easily be stored and later re-combined for building different models in the future.

Powerful as it is, mathematics, by itself, is insufficient to ensure the success of an engineering enterprise. Engineering is concerned with the successful construction of large systems in an imperfect world, a world of faulty materials and human error. Engineering must also address the economic and logistic problems that are involved in any human endeavour. Therefore it concerns itself with the two issues that transform the mathematical basis into a complete system of construction: management of the development process and quality assurance.

For many years engineers have known that the successful management of large projects involves detailed analysis of the work to be done and the decomposition of that work into well-defined components, each with objective completion points. Clear milestones and regular monitoring of progress against a plan that identifies those milestones is the only way to measure, and hence to control, progress.

In order to construct systems successfully and reliably, quality must be monitored throughout the construction process. Controlling quality is an intrinsic part of every engineering project. Quality needs to be planned into the project from the outset, and the controls must be applied within the project rather than imposed from the outside. Quality cannot be added after a system has been constructed. Engineers have developed standards to ensure that well-understood methods and techniques are used; regular reviewing of the system during its construction ensures that all components have been correctly made; errors are detected and corrected at the earliest possible opportunity.

Engineering then is based on these three disciplines: mathematics – a language in which to express design; project management – a means to realise that design; and quality assurance – a method to ensure the fitness of the realisation. Engineering is successful. Massive projects are conceived which use new technology, applied by large teams. Those projects are completed on time, within exacting financial constraints and they work. The disciplines of engineering are well-proven.

These same disciplines can be applied to the construction of software; the result is software engineering.

Traditional engineering relies on the mathematics of continuous functions, because it is concerned primarily with systems that exhibit continuous behaviour. In contrast, the world that is to be modelled for computer systems is not continuous; it is made up of discrete parts. Software engineers therefore use methods based on the results of discrete mathematics to describe such systems. These methods, based on set theory and propositional calculus, may be either formal or systematic. In the formal methods, such as VDM or Z, the mathematics is evident. In the systematic methods, such as JSP, the mathematics is encapsulated in a more accessible form. These techniques give the same strength and power to software engineering as the analytic techniques do to traditional engineering: formal descriptions of the real world that can be built and verified, systematic models that can be specified clearly.

Whenever engineers achieve precision, where previously there was vagueness, they improve the quality and professionalism of their work. Praxis is using precise techniques in its daily work. We are using VDM to demonstrate the consistency of a large administrative database by specifying the permissible conditions for modifying the data. We are defining which operations may take place simultaneously in an industrial control system, using CSP. We are specifying the rules for a software configuration management system, using VDM. Other formal techniques we use include grammars for describing data structures and defining languages. We make regular use of methods such as JSP, JSD, SSADM, SADT and Data Analysis.

Again therefore she applied herself to the key, and after moving it in every possible way for some instants with the determined celerity of hope's last effort, the door suddenly yielded to her hand her heart leaped with exultation at such a victory, and having thrown open each folding door, the second being secured only by bolts of less wonderful construction than the lock, though in that her eye could not discern any thing unusual, a double range of small drawers appeared in view, with some larger drawers above and below them, and in the centre, a small door, closed also with lock and key, secured in all probability a cavity of importance.

The control of software projects demands a sound understanding of the development process so that the nature and content of each activity, as well as its dependence on other activities, is understood. Control implies measurement. Formal and systematic methods can assist measurement, since the methods themselves provide a means for checking the completeness and correctness of each step in the development process.

Software engineering differs from traditional engineering in the nature of the construction process. In software, the emphasis is on accurate specification and in implementing a design to satisfy that specification. The production process itself is minimal. Therefore software quality control and quality assurance must reflect that difference. It must concentrate on the verification of the specification and design processes.

The control and management of the software development process are as important as the development methods themselves. We at Praxis have developed our own set of standard techniques for the development of high-quality software. This collection of standard techniques, and the system of management procedures that support them, are the major components of our Quality System. They have been created by Praxis staff and are in use in every aspect of our company business.

The quality culture at Praxis is self-imposed rather than superimposed, because we recruit people who are committed to producing high-quality work, who can both use and contribute to standard techniques and who can create and sustain an intelligent system of management procedures.

The Praxis Quality System assures the visibility and control of our software development process, and the integrity and accountability of our administrative procedures.

It is important that there is an independent review of the scope and effectiveness of the Quality System. For this reason, Praxis is registered with the British Standards Institution under British Standard 5750 Part 1 and the Quality Assessment Schedule applicable to software development companies. This registration was granted to Praxis in June 1986, following an independent audit by the BSI. Since that time, the BSI auditors have made two unannounced visits to check that our Quality System is being properly applied and maintained. During those visits they found no discrepancies. Our clients are thus assured that the high standards we set ourselves are being maintained and used in practice.

Software engineering is the controlled application of mathematically sound methods to the construction of software systems. Praxis is a software engineering company.

We provide a full range of software engineering services: software development, consultancy, complete systems, methods studies and technical audits. The development of software is difficult. We place great reliance on the application of sound engineering techniques to assist this process: clear organisational responsibility and well-directed project management to ensure visible and predictable progress; proven design techniques to verify the correspondence between concept, design and implementation; and our own approved quality assurance procedures to confirm the integrity of the development process.

Software engineering services are provided by our Projects Group, under the direction of the Projects Director, George Owen, supported by his Sales Manager, David Allen, and his Business Managers, Clare Le Fèvre and Tim Huckvale. Together they ensure that projects always have clear objectives, are directed resolutely to achieve those objectives, and so are brought to successful completion. This success is achieved through detailed planning, regular monitoring, and precise control. All clients have full access to the planning, monitoring and control records for their projects. This gives them confidence in our abilities and respect for our integrity; both are significant factors in our success.

The technical expertise of our project staff is based on the use of systematic and rigorous techniques; this expertise is strengthened through regular training, and is supported by computer-based tools. The Praxis Technical Directorate, led by Martyn Ould, is responsible for the creation, development and growth of our technical skills. It provides frames of reference which ensure that every project selects the most productive techniques, that the techniques are applied effectively by trained software engineers, and that appropriate automated tools are available to support the constructive use of these techniques.

Our Quality System, which is maintained and continually improved by the Quality Director, Chris Miller, and his team, provides the environment in which staff can learn quickly and work effectively. The use of appropriate standards, created by Praxis staff, ensures that all projects benefit from the accumulated experience of the company. The reviewing of all work against these standards is a mainstay of our approach to quality. During the reviewing process, the expertise and proficiency of experienced staff assure the direction and accelerate the progress of every development. The reliability of plans and designs is improved, logic is verified, and areas of potential difficulty are made evident.

Software engineering often involves the application of known solutions to novel problems; all staff are therefore encouraged to broaden their experience by working in a variety of application areas. The analytic techniques that we use and the diverse experience of the teams who apply them thus ensure that we develop creative yet reliable solutions to difficult problems.

We have experience in many areas. Our particular strengths lie in those where the rigorous and clear definition of a problem leads naturally to an elegant and compact solution.

Our software engineering work is diverse. It spans all phases of the development process, from the conception of a new project to the enhancement of products already in service. We provide implementation skills, and develop complete systems in hardware and software; we advise on the formal techniques of software engineering, and provide tuition and guidance on the application of these methods; we evaluate computing systems, and select hardware and software to meet particular requirements; and we assist clients to improve their quality systems, by recommending the methods they should use and the organisational structure that is needed to support those methods.

The success of the services we provide is evidence of the success of the methods that we employ.

Clients who use our software engineering services include:

Abbey National Building Society

Alvey Directorate

British Telecom

Central Computer and Telecommunications Agency

Foreign and Commonwealth Office

GEC

ICL

Logica

Marks and Spencer

Ministry of Defence Royal Signals and Radar Establishment

Multitone Electronics

National Computing Centre

News International

Norsk Data GmbH

Northern Examining Association

Software Sciences

STL

WH Smith Television Services

Anne had not wanted this visit to Uppercross, to learn that a removal from one set of people to another, though at a distance of only three miles, will often include a total change of conversation, opinion, and idea.

Our work is concerned with the design of complex objects. Software systems are more complex than any other human construction because of the large number of parts they contain and the complex interactions between those parts. Consequently, they have very large numbers of states; this makes conceiving, describing and testing them hard. It is not in the building but in the specification, the design and the testing of the conceptual construct that the major challenges lie. That is why many of the general lessons that have been learned about the design of complex objects have been derived from the experience of the software engineer. These lessons show that any successful design method must allow the designer to divide any object into a hierarchy of groups of other objects to arbitrary levels of detail. The designer must be able to concentrate on the behaviour of any one selected group, ignoring for the time being the behaviour of other groups.

The complexity of the VLSI design process is similar to that for software. Silicon technology is capable now of producing chips which contain over a half a million active components, or gates. These gates are the fine grain of design detail, and their implementation marks one of the later steps in the design process. For a new device, VLSI designers must begin their work at the architectural level, expressing the design in terms of the behaviour that it must exhibit; this will be implemented in real hardware only much later. To assist them in their task they need tools that permit them to describe the nature of the design, test its operation, and control its implementation from the most abstract level of behavioural description down to the detailed operation of the individual gate.

ELLA is a toolset that provides this assistance; it supports the expression, verification and management of VLSI designs. It permits the designer to describe a design and simulate its operation at all stages of the design cycle, from conceptual specification to structural realisation, and so increase the productivity and reliability of the design process.

ELLA provides a complete support environment for VLSI design. It provides a language to express the design, a simulator to verify it, and a set of open interfaces that allow ELLA design information to be exported to other CAE tools, such as silicon compilers or layout tools. The language, the simulator and the interfaces are integrated through the ELLA database system, which automatically checks and controls the consistency of the design at all levels. Again, this improves the productivity of a VLSI design team.

A design expressed in the ELLA language is based on a network of connected nodes. Each node is defined in terms of its behaviour, and may be decomposed into other, more detailed, nodal operations. The design is not constrained to any particular implementation technology nor to any architecture, because all possible architectures can be expressed as a network of nodes.

The complete design, or parts of the design at any level, can be verified by simulation; the ELLA behavioural simulator allows the designer to animate any specified part of the design to any degree of detail. Each step in the design process can therefore be verified before proceeding to the next step.Consequently, architectural errors can be detected early in the design cycle. Unlike chip simulators based on sequential programming languages, ELLA simulates the actual design that will eventually be implemented in hardware; the model and the design are one and the same.

ELLA is being further developed by Praxis, in collaboration with the research group at the Royal Signals and Radar Establishment (RSRE) who invented ELLA. The applications for which ELLA is now being used are demanding. For example, it has been used to verify the behaviour of the VIPER processor developed by RSRE. VIPER is the world's first formally specified and verified 32-bit microprocessor, designed for safety-critical applications.

Experience of ELLA is now considerable. It is in regular use by all five major UK electronics groups: Ferranti, GEC, Plessey, Racal and STC, as well as by British Aerospace and British Telecom. ELLA is being promoted by the Alvey Directorate as the preferred method for communicating VLSI design information. This information flows between the systems companies using ELLA for system-level design, the ASIC facilities using ELLA to provide a pathway from system design to implementation detail, the library developers using ELLA to describe the operations of basic cells, and the chip manufacturers themselves. It is widely used by undergraduates and research workers in United Kingdom universities and polytechnics. This extensive use indicates the importance of the concepts embodied within the ELLA toolset.

Praxis are distributors of this product and have the worldwide marketing rights. ELLA is distributed in Europe and the United States of America and there are industrial and academic users on both continents. Since its introduction in 1985, ELLA has been sold to some sixty different organisations, where it is in use on well over one hundred individual VAX processors.

ELLA has been purchased by:

British Aerospace

British Telecom

Ferranti

GEC

LSI Logic

Plessey

Racal

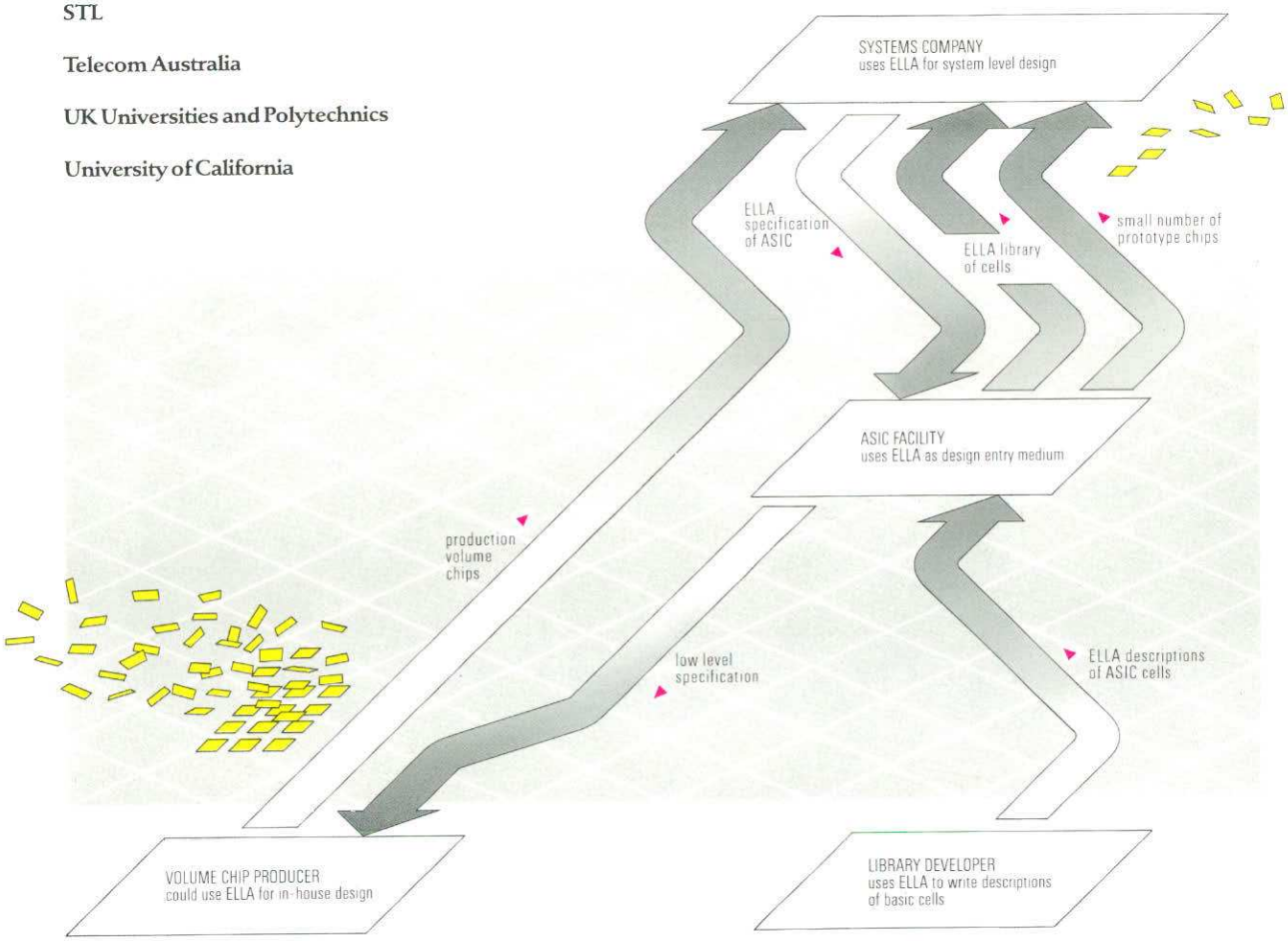
Spectra-Tek

STL

Telecom Australia

UK Universities and Polytechnics

University of California



The design of complex objects is difficult. It demands powerful tools. It needs a clear understanding of the relationships between abstraction, complexity and structure. Praxis has that clear understanding. With ELLA we provide the best of tools.

Our aim is excellence. We are driven by the desire to undertake demanding projects for discerning clients. We enjoy working together in Praxis, where our individual efforts are seen as valued contributions towards achieving our collective aim.

Clients expect us to provide the most capable engineers, and we expect to be capable of undertaking the most challenging work. To satisfy these expectations, we pay great attention to the development and training of each member of staff. We operate a comprehensive appraisal scheme which identifies, year by year, the training needs of each individual. Our training programme is designed to be wide-ranging, covering both technical and personal skills.

The programme includes weekly seminars on current technical developments, given by staff and guest speakers invited from industry, universities and research establishments. Full-time, internal training courses given by Praxis staff, on such topics as VDM and constructive program development, provide company-wide awareness and common understanding of the applicability of such techniques. General training on such topics as business analysis and development methods is provided by outside organisations. We engage specialist lecturers to give courses on appraising, interviewing, and the development of personal skills. These courses are developed specifically for us, and are designed to advance our particular style of working. Staff who have team leadership responsibility take part in the schemes run by the Leadership Trust to develop their insight into working relationships.

We are piloting the use of the British Computer Society's new Professional Development Scheme, incorporating it within our own appraisal system. The scheme provides a professionally supervised framework, within which software engineers carry out tasks of increasing responsibility, enabling them to qualify for full membership of the BCS and thence, eventually, to become Chartered Engineers.

We value our close links with academic establishments, and the interchange of ideas that these links bring. We contribute to both teaching and research in universities and polytechnics. Currently we are sponsoring a CASE student at the University of Manchester, who is applying the techniques of temporal logics to the definition of real-time systems. We are also supporting Anne Beck, one of our software engineers, on an MSc course at the University of Oxford. Her practical work will concentrate on the application of formal methods to the checking of circuit designs in ELLA. In addition, individual members of staff influence the academic direction at the Universities of Bristol, Manchester, Strathclyde and the Laboratory for Foundations of Computing Science at the University of Edinburgh. We welcome sabbatical visits from members of universities and polytechnics. Research students from the Polytechnic of the South Bank and the University of Aberystwyth are currently working with us.

As practising engineers, we believe that the experience gained through our work should be made available to the wider audience of our profession. Members of staff are encouraged to present papers at colloquia and seminars. We help to organise the IEE Summer School on Mathematics for Software Engineers, and we give lecture courses in software engineering for undergraduates. Through the Manpower Services Commission, we have given seminars to other professional engineering organisations on recent advances in computing. Individual members of staff publish papers and books on software development techniques and methods; some recent examples of publications are listed at the end of this Review. We support the British Computer Society by serving on its specialist committees.

Praxis staff share in Praxis' success. All permanent staff are encouraged to invest in the company whose prosperity they are helping to build. 87% of Praxis shares are owned by Praxis employees and over 90% of the staff own shares in the company. The company is therefore owned and controlled by its staff. Staff buy shares in the company through a special trust established especially to encourage this exceptional form of participation. Further shares are distributed each year to members of staff through a profit-sharing scheme; in this way staff benefit from the financial success they have helped to create. Staff pensions are invested in a number of separate money purchase schemes, selected according to individual preference. First-time house buyers receive financial assistance from the company.

We have an important role to play in the community in which we work. We give careers talks to children in schools and students in universities. School children, school leavers and other young people are offered temporary employment at Praxis, to enable them to gain first-hand experience of the world of work, in an enthusiastic environment. We organise open days, so that anyone interested in the computing industry can see the work we do and try the tools and equipment we use. We contribute to the Bath Community Trust and assist other local organisations by making equipment and expertise available for local community enterprise schemes.

High standards characterise all that we undertake. These standards are given purpose and direction through the leadership of the directors and senior staff, who encourage an innovative and open style of working at all levels. That innovation and openness is reflected in many ways: in our regular monthly meetings where all staff can discuss any aspect of the company's work; in the collaboration between our own staff team and the consulting architects who are planning the layout of our new offices; in our open debates on the relative merits of different pension schemes; in the facilities provided by our powerful, networked computer system designed by Praxis engineers; and in our innovative graduate recruitment days, planned and organised by younger members of staff to give newcomers a fresh view of Praxis.

Praxis is lively, enthusiastic and professional.

Praxis is:

Grant Aitken
David Allen
Richard Andrews
Helen Barnes
Andrew Barrow
Ian Barton
Vincent Baughan
David Bean
Anne Beck
Alan Bentall
Robert Brewer
Andy Boswell
Keith Broninski
David Brownbridge
Sally Bull
Lyn Challoner
Anthony Clements
Lucinda Cole
Julia Colin
Stephen Colwill
Peter Corcoran
Amanda Cullen
Paul Davies
Christine Davy
David Deans
Tim Denvir
Wendé Drinkwater
Bruce Elliott
Jean Elliott
David Ellis
Kevin Ellison
Cathy Evans
Gavin Finnie
Judith Ford
Susan Francis
Simon Guyett
Carmel Giblin
Anthony Hall
Michael Hartley
John Harvey
Colin Heyes
Brian Holmes
Jones Hsu
Tim Huckvale
Mel Jackson
Nicky Jefferies
Rita Jeffery
Alun Jones
Chris Jones
Sally Jubb
Kate Keir
Ann Kelly
Trevor King
Fiona Laird
Chandrika Lakhani
Clare Le Fèvre
Tim Magee
Tracy Marshall
David Martin
George May
David McDonald
Jennifer Miles
John Miles
Chris Miller
Diane Milton
Allen Mulford
Marc Munro
Jane Northcote
Martyn Ould
George Owen
Rachel Pardoe
Jonathan Pearson
Jo Perriman
Jim Pimpernell
Jeremy Prior
Andy Pryor
Karen Punter
Rosamund Rawlings
Colin Read
John Richards
Stephen Rickaby
Fiona Ricketts
Stephen Rivkin
Clive Roberts
Stephen Robertson
Lynn Robinson
Peter Rose
Paul Rouse
Michael Russell
Tim Rylance
John Saunders
Simon Seely
Andrew Smith
Fred Smith
Ian Steventon
Simon Tait
Martyn Thomas
Mark Townley
David Vaudin
Tony Voss
William Walker
Chris Warren
Huw Watts
Richard Wendland
Pete White
Ruth Wilde
Alan Williams
Jane Willis
Jim Wilson
Philip Wilson
Gerry Wolff

But then, is not it the same with many other professions, perhaps most other? Soldiers, in active service, are not at all better off, and even in the quieter professions, there is a toil and a labour of the mind, if not of the body, which seldom leaves a man's looks to the natural effect of time.

'I will drive you up Lansdown Hill to-morrow.'

'Thank you; but will not your horse want rest?'

'Rest! he has only come three-and-twenty miles to-day; all nonsense; nothing ruins horses so much as rest; nothing knocks them up so soon. No, no; I shall exercise mine at the average of four hours every day while I am here.'

The second part of this review is devoted to a more detailed description of some of the work that we have carried out during the year.

In the last twelve months much has been achieved in all areas of our work; accomplishments in recruitment, improvements in our professional standards, and the provision of advanced technical facilities are all as noteworthy as our mainstream technical activities.

1987 was the year in which our service work became recognised internationally: in October last year we began our first work in Germany; currently we are collaborating with Dutch industrial and academic partners in work for ESPRIT.

This year saw ELLA being used by all five major UK electronics groups. As its use spreads, ELLA is being used increasingly as the de facto standard mechanism for the interchange of VLSI design information in the UK.

ELLA is beginning to receive worldwide attention. This year, ELLA became available through US and Scandinavian distributors; sales in Europe include licenses for industrial and academic users in Finland and Sweden; ELLA has also been sold in Australia and America.

The first phase of the installation of our networked office computing facilities was completed in September. Every member of staff has their own terminal through which they have access to our own UNIX- and VMS-based software development environment as well as to external computers via national packet-switching networks.

The first phase of the major turnkey project that we are undertaking on behalf of the Northern Examining Association was successfully installed in January, as planned, and is now in use.

This year, we welcomed our hundredth member of staff, David Brownbridge, at the monthly staff meeting in February. We also received our first sandwich student from America, and were hosts to our first sabbatical visits from British postgraduates.

Early in 1987 we won our first contracts for consultancy and implementation work in the commercial data processing and industrial automation markets. We are bringing to these projects the same high standards that we have developed in our systems work.

In March we began the incorporation of the British Computer Society's Professional Development Scheme into our own appraisal and training system. A number of software engineers are now participating in pilot trials of the scheme, under the guidance of senior members of staff.

Praxis' experience in software engineering was the subject of two films made during the course of this year. In May, the NCC released 'Towards Formal Methods', a training video showing the use of formal methods in industry, including VDM in use at Praxis. At the same time the BBC Open University film unit spent two days at Praxis, filming the activities of Chris Miller, our Quality Director. The film, 'Approaches to Software Project Management', to be released early next year by the Open University, includes scenes that show the importance of quality assurance in the development of software.

Our Quality System, which has been in operation since Praxis started in 1983, successfully completed its first year of operation under BS5750 in June. No discrepancies were noted by the BSI examiners during their two unannounced surveillance visits during the course of the year.

Looking to the future and our plans for continued growth, at the end of the company year we set up a new group structure under a re-named holding company, Praxis plc.

In the pages that follow we describe some of the projects we have undertaken for clients during the course of the year; we also outline the ways in which we are increasing the power of ELLA. In every case, our clients have given approval for this description of their project to be included in this Annual Review.

The projects that we have carried out this year cover a wide area; they range from consultancy assignments of a few days' duration to turnkey developments involving tens of man-years of effort. Much of this project work can be divided into separate categories where the individual projects in each category are related by a common theme. These themes form the basis of our project descriptions.

Praxis as Consulting Software Engineers

One of the cornerstones of Software Engineering is the application of the appropriate computing science to industrial software development. Therefore we work closely with universities, we participate in government research initiatives and we act as consultants, combining theoretical knowledge with practical perception. Our advice is informed and, since Praxis is owned and controlled by its staff, is also independent and impartial.

- Monitoring Officers are appointed by the **Alvey Directorate** to assess the progress and technical direction of advanced British projects designed to exploit the results of previous research. In this role, experienced members of our staff are monitoring the FORMAP (Formal Methods Applied to Protocols) project which is applying formal techniques to the specification and testing of communications protocols, and the Analyst Assist project, which is exploring how modern software and hardware technologies can be used for requirements analysis.

- We used our practical experience of formal methods to undertake an independent evaluation of the results of another Alvey project, which had developed a set of prototype software tools to support VDM in a production environment. We devised test criteria both for the tools and their supporting documentation, as well as assessing the toolset against these criteria.

- Once a tool or technique has proved its worth in major developments, information about its use in industry is gathered by the **National Computing Centre** (NCC). The STARTS Guide, published by the NCC, contains a critical assessment of the methods and tools available for the development of large real-time systems. Each chapter in the Guide is prepared by a team of industrial experts and addresses a different aspect of the development process. We are helping to prepare the chapters on Design and on Integrated Project Support Environments.

These projects are small and they are important. The techniques and tools that we are using now and promoting today will be commonplace tomorrow.

Praxis as Software Engineering Toolbuilders

This ability to act as consultants is based firmly on practical, current experience of developing successful software systems. Some of these systems are tools, used to support the software development process. As in traditional mechanical engineering, where the most demanding skill is that of the toolmaker, so in software engineering. Tool-making demands that the purposes for which the tool is to be used are fully understood. This requires a knowledge of the materials which will be formed by the tool, and the sequence and order with which the tool will be used. Furthermore, the tool must be precise and reliable, in order that the products it shapes are consistent and exact.

- We are applying our detailed knowledge both of software and the software development process on a number of projects to build tools designed for use by software engineers. The first of these projects, and the most advanced, is the design of a powerful IPSE.

An Integrated Project Support Environment, or IPSE, is a computer-based development environment which supports managers and software engineers by providing directed use of a unified set of software development and project management tools.

Current IPSEs provide loose coupling between these tools, and act primarily as repositories of information about the project and its constituent parts. In our continuing involvement with **STC Technology Limited** we are planning the design of the next generation of IPSE in the IPSE 2.5 project. The main differences between this IPSE and its predecessors are its support for complete methods, both formal and informal, and its ability to take an active role in the development project that it supports.

We are providing, as the basis for this IPSE, a Process Modelling Language (PML), which defines the way in which a project is carried out. Using the descriptive part of the PML, specific Roles, Activities and Entities are defined and associated with each other. These definitions constitute the rules which govern the behaviour of the IPSE. Thus the IPSE will 'know' not only what development method the project is using, but also how it is used and who uses the different parts of that method. The algorithmic part of the PML is used to define how particular activities in the method are carried out.

This approach means that the IPSE is always able to guide the user to the next appropriate development step. Furthermore it can undertake, automatically, any operations which can be completed without further human intervention.

We are using object-oriented methods to design and animate the key features of this IPSE because their expressive power enables us to model the real world with great precision.

'How do you like Bath, Miss Elliot? It suits us very well. We are always meeting with some old friend or other; the streets are full of them every morning; sure to have plenty of chat; and then we get away from them all, and shut ourselves into our lodgings . . .'

▪ Whatever methods are being used, configuration management will play a central role in any IPSE where interrelated components are subject to change. In a collaborative project which we undertook with staff from **ICL Mainframe Systems,** we specified a project management system that supports the combined activities of project control, configuration management and quality control. This system was modelled using entity-relationship techniques and specified rigorously using VDM. The comprehensive definition that resulted from this project has been incorporated into our IPSE work for STC, where it continues to evolve.

▪ Any IPSE will only be as successful as the power and scope of the tools it supports. Much of the basic work on IPSEs has been carried out in Europe and European software engineers are in the forefront of IPSE developments. In order to ensure that this expertise is maintained, the **ESPRIT** programme of the European Community has developed a proposed standard set of interfaces to the kernel of an IPSE. This set of interfaces, known as the Portable Common Tool Environment (PCTE), has been defined syntactically in the C language and semantically in English. The purpose of the international project known as VIP (VDM for Interfaces of the PCTE), which we are leading, is to prepare precise definitions of the interfaces using the formal mathematical language VDM, so that designers throughout Europe and the world can build tools, confident that they will operate harmoniously with each other and the IPSE itself.

▪ This European lead is being exploited in another project in which our experience of IPSE design and formal methods is essential. We are collaborating with **Software Sciences Limited**, who are working with other European systems companies in a development programme initiated by the IEPG group of NATO nations. The purpose of this work is to develop a tool support interface, based on PCTE, which will meet a broader range of requirements and be acceptable to both the civil and military communities. The project is taking account of similar requirements defined in the CAIS programme, sponsored by the United States Department of Defense.

▪ All of the tools described above are general purpose; they are designed to offer a unifying framework within which individual or complete ranges of more specific tools or toolsets are supported in a consistent manner. One example of a toolset which will assist a specific design method is a computer-assisted support environment for the Government's standard analysis and design method SSADM (Structured Systems Analysis and Design Methodology). We have recently been awarded a contract by the **Central Computer and Telecommunications Agency,** part of HM Treasury, to design and implement a complete SSADM support environment.

Praxis and Quality Management

In any engineering development it must be possible to specify what is to be produced, when it will be completed, and how it will be tested. Quality management is the name given to the work of preparing these specifications and ensuring that the development process complies with them.

Because of our experience in developing and using our own Quality System to control both our ELLA software product and our bespoke software development activities, we are well-equipped to design and install quality procedures. We have done so for various clients, in this country and abroad.

- We were asked by a part of **Norsk Data** to examine the methods that they used to enhance, test and support their advanced CAD product, TECHNOVISION. A small team of Praxis consultants worked as part of their forty-strong software development and support group. The Praxis team made recommendations regarding the use of specification techniques and introduced new project control and reporting mechanisms to co-ordinate international software development and support activities. That group is now developing and extending the techniques and mechanisms that we put in place.

- In a similar project carried out for a UK electronics manufacturer, we implemented our earlier recommendations to set up a quality system. Together with the client, a combined hardware and software lifecycle model was developed; the Praxis team then derived the nucleus of the controlling documents and pioneered the use of the procedures for the quality system. This quality system is now in use by the manufacturer.

- A quality system has to be created by those who will ultimately use that system; universal or imposed solutions do not succeed. Nevertheless, all quality standards must be scrutinised externally. Praxis were engaged by **ICL** to provide independent verification that VME for the ICL Series 39 conforms to a set of security requirements derived from the US Department of Defense 'Orange Book'. We undertook the project in two phases; first, we prepared a test strategy which defined what tests were necessary and sufficient to guarantee any specified degree of security; then we prepared and executed a complete suite of tests conforming to this definition. All the tests were carried out independently by Praxis. Following the successful execution of these tests we were able to verify that VME did offer the specified level of security and integrity.

Praxis in Commercial and Industrial Systems

If the disciplines of software engineering are to be widely adopted then they must provide effective ways of assisting software development in business environments, which are characterised by a large organisational infrastructure. The projects we are undertaking in this domain demonstrate that there are appropriate techniques to provide this assistance.

'Perhaps you are not sitting in this room, and I am not sitting by you. These are points in which a doubt is equally possible. Not keep a journal! How are your absent cousins to understand the tenour of your life in Bath without one? How are the civilities and compliments of every day to be related as they ought to be, unless noted down every evening in a journal? How are your various dresses to be remembered, and the particular state of your complexion, and curl of your hair to be described in all their diversities, without having constant recourse to a journal?'

- On behalf of the **Abbey National Building Society** we are specifying, designing and building a system which will enable the relative costs of introducing and supporting various banking and savings products to be compared. We are working with the users of the system to capture their requirements, and will later be implementing those requirements within the Society's standard data processing framework. The project is being carried out using the Jackson System Development method.

- Another significant commercial user with well-established procedures for systems development is **Marks and Spencer plc.** We worked in close collaboration with Marks and Spencer staff to prepare a Business Specification for a project to speed the distribution of stock information from their IBM mainframe to individual stores.

- **British Telecom Insurance Services** (BTIS) commissioned us to develop a combined hardware, software and quality management strategy to improve their on-line insurance quotation service. We proposed the hardware and network connection technology BTIS should use; we also recommended how standards should be implemented to enable them to control the software development process.

- Production control systems can be represented by nested sets of control loops with time constants that range from fractions of a second for machine tool control, to years for long-range planning. Factory Control deals with those loops, such as shift planning, which respond in timescales of the order of days. On behalf of the **Manufacturing Business Centre of ICL**, we are specifying and designing a Factory Controller which is to be part of a complete CIM environment. Formal methods are being used to provide an accurate specification of the way in which the controller will operate. We are using an entity-relationship model to define the data and the CSP method to define the processing.

Praxis Long-Term Involvements

In the commercial sphere, success can be measured by the economic lifetime of a system. One measure of the success of the services that we offer is the high proportion of our clients who, having entrusted us to undertake a single item of development for them, later return to ask us to extend the scope of the task or to undertake further work.

In this way we come to develop close relationships with these clients. They benefit from the fresh insights we can offer into the interactions between the varying aspects of their enterprise.

▪ We have strong connections with **ICL**, for whom we have carried out complete development programmes over a number of years, taking full technical and managerial responsibility for the success of those developments. Our relationship with ICL is based on our extensive experience of the VME operating system and we continue to play a significant part in the evolution of this system, which controls both the 2900 range and the more recent Series 39 mainframes.

We continue to provide detailed technical support and enhancements for the C compiler which forms part of the UNIX interface to Series 39 VME that we have helped ICL to develop. We are also participating in the general VME development programme; one improvement that will be included in the next release, as a result of our work, is support for very large programs, or ones with a very large number of modules. We are also working on enhancing the mechanisms for transferring complex catalogue items between different machines. In all this work, we combine our own quality and project management methods with those in use at ICL. This ensures that progress on the projects under our control is well co-ordinated with the general VME development plan.

▪ Our association with **WH Smith Television Services Division** is based on our ability to provide them with staff who understand the application of computing technology to all aspects of a cable television operation.

Following our successful development of an interactive, computer-controlled cable television service last year, we are now in the process of modifying and enhancing the prototype software for production models. The hardware is being made more compact and the software enhanced to facilitate unattended operation in the field. These production variants are designed to operate as video jukeboxes.

WH Smith also provide more conventional cable television programme services based on pre-recorded material. In this area we have analysed and specified the requirements for an automated system for programme providers; this system assists programme presentation staff by monitoring the acquisition, editing and distribution of programme material. It also supports the control of tape libraries by tracking the state and location of all the media on which programmes are recorded.

A further service that we have provided to this part of WH Smith is to install, configure and manage their divisional, networked computer system. We provided this service on a consultancy basis, upgrading the system and extending the facilities as the network grew.

▪ Phased developments are a form of continued involvement in which the attention paid to early specification and design decisions is emphasised, since these decisions will affect everything that follows. A major turnkey project that we are carrying out for the **Northern Examining Association** (NEA) is just such a phased development.

This six-phase project, which we began in mid-1986, is designed to support the administration of the new GCSE examination, which will take place for the first time in the summer of 1988. The system is based on an ORACLE database of nearly one gigabyte which is supported on a network of VAX computers. These are distributed over the region covered by the five separate examining boards which constitute the NEA.

Following an initial period of analysis in which the objectives of the overall system were agreed, each phase is being specified and implemented in turn, the phases being overlapped to meet the timescales imposed by the cyclical nature of the examination process.

The first phase of development, which was successfully completed in early 1987 as planned, supports the mechanism for standardising the marks allocated by teachers involved in the continuous assessment of their pupils' coursework. By the end of the second phase, due for delivery in the summer of 1987, the full hardware and communications network will have been commissioned. The software that will be delivered at this point controls and monitors the extensive administrative arrangements that have to be made prior to the examination period itself.

In subsequent phases we will be delivering the software that registers the personal details of each of the anticipated 350,000 candidates, records the marks for some 1.6 million subject entries that they will have made, and finally distributes the results to over 4,000 schools and colleges which enter candidates for the examinations.

This application demands stringent control of the reliability and security of the data. One unusual feature of the implementation is that the database, normally resident at one node of the network, can be partitioned at any time. These partitions are transmitted to different nodes, processed locally and then re-integrated. This approach, which fully satisfies the requirements for data security, was designed specifically to achieve the high performance required in periods of intense activity, such as the one that occurs directly after the examination scripts have been marked.

▪ Our experience of capturing, analysing and recording sets of requirements is essential in our continuing involvement with the **Foreign and Commonwealth Office** (FCO). Last year, in association with Ashford Associates, specialists in the field of library automation, we compared the different ways in which the administration of the FCO Library might be automated in order to improve the service to borrowers as well as assisting the library staff. This year we have extended this work and prepared a detailed Operational Requirement, to CCTA standards, for the supply of computing equipment which will provide both a Library Information Service and a Library Management System. This document, which includes a detailed data model of the library system, is expected to be issued in the second half of 1987, and we hope to assist the FCO to evaluate the tenders which are submitted in response.

These projects illustrate the breadth of our skills and the wide range of problems to which we apply them. This year, as in previous years, we have continued to demonstrate that the combination of appropriate theory, careful management, and rigorous quality control can and does ensure the most effective means of engineering in software.

Throughout our work as software engineers, we expect to be assisted by automated tools that help us to produce correct designs. Engineers working in VLSI are equally demanding in their expectations and this year we have continued to strengthen their capabilities by extending the power of our VLSI design tool, ELLA. In this work we continue to collaborate with the original ELLA design team at RSRE.

ELLA was conceived as a means by which designs for very large and complex integrated circuits could be expressed, verified as correct, and then realised. This year our faith in that concept has been reinforced by the increasing demand for ELLA from UK government and industry, from academic establishments, and from the rest of the world.

▪ The growing importance of ELLA in government and industry is evident in the leading role that Praxis is playing in a major CAD project supported by the Alvey Directorate. The aim of the project is to provide a complete set of tools for designing chips containing more than a million active components. As part of this project, due to run for over two years, we are leading a collaborative team consisting of Ferranti, GEC, ICL, Plessey, Racal, RSRE Malvern and the Rutherford Appleton Laboratory. The project recognises that ELLA is the UK standard for expressing high-level VLSI design. ELLA is being used as the sole means of entering and passing design information to various lower-level tools and technologies being developed by the collaborators. The main aims of the work are to extend the interfaces to these tools, and to develop the ELLA language and toolset.

▪ ELLA was written originally in Algol 68 and first released under the VAX/VMS operating system. In order to make ELLA available to the increasing number of hardware design centres using special-purpose CAD workstations, we have developed a version of ELLA in C, running under UNIX, and suitable for machines such as the Sun and Apollo. We devised an elegant method to develop this new version, which was to write an Algol 68 to C translator, verify its behaviour, and then use it to translate ELLA automatically. This approach enabled the ELLA developments in Algol 68 to continue without interruption, and minimised the verification testing that had to be carried out on the new version. The C version of ELLA has already been ordered by the Department of Trade and Industry for distribution to Polytechnics and Universities through its Electronic Computer Aided Design programme. This programme is designed to ensure that young British engineers are familiar with the modern design tools that they will be using in industry.

▪ There are now some twenty separate industrial sites using ELLA in the UK, together with forty universities and polytechnics. We provide extensive support for this growing community. Experienced VLSI design engineers at Praxis can be consulted on the way to use ELLA to solve particular design problems. The ELLA User Group, now in existence for over a year, encourages designers to exchange ideas on their uses of ELLA and provides a forum where extensions to ELLA can be discussed. This year we have introduced specialised ELLA training courses, and these, together with the ELLA Tutorial and ELLA User Manuals, ensure that new users start to exploit the expressive power of the ELLA system very quickly.

'Yes, yes, I see you are. I see you know nothing of the matter. You have only knowledge enough of the language, to translate at sight these inverted, transposed, curtailed Italian lines, into clear comprehensible, elegant English.'

▪ There is worldwide interest in ELLA. Praxis has recently signed an agreement with ETS of Norway to distribute ELLA in Scandinavia, and a number of industrial concerns and academic institutions in Sweden and Finland are already using ELLA. Elsewhere in Europe, ELLA is being assessed by engineers at the Universities of Tübingen and Karlsruhe.

▪ In the United States, ELLA is distributed by ECAD Inc. ELLA has been sold to the University of California at Berkeley, and the Xerox Corporation is the first of a number of American industrial organisations which are evaluating ELLA.

ELLA is tangible evidence of our belief that the ability to express design concepts in a formal way, capable of impartial and rigorous verification, is one of the most powerful tools available to the engineering designer. Next year, as this year, we will continue to harness that power to solve the complex problems of VLSI design.

Balance Sheet at 30th June 1987

	1987 £	*1986* £
Fixed Assets		
Tangible Assets	814,750	476,299
Investments	—	6
Total	814,750	476,305
Current Assets		
Stocks	56,384	26,684
Debtors	912,189	362,443
Cash	18,373	114,938
Total	986,946	504,065
Creditors: Amounts falling due within one year	(1,050,702)	(479,199)
Net Current Assets	(63,756)	24,866
Total Assets less Current Liabilities	750,994	501,171
Creditors: Amounts falling due after more than one year	(159,261)	(89,368)
Provisions for Liabilities and Charges	(82,200)	(82,200)
	509,533	**329,603**
Capital and Reserves		
Called-up Share Capital	321,242	62,284
Share Premium	—	30,543
Profit and Loss Account	188,291	236,776
	509,533	**329,603**

Profit and Loss Account for the Period 1st July 1986 to 30th June 1987

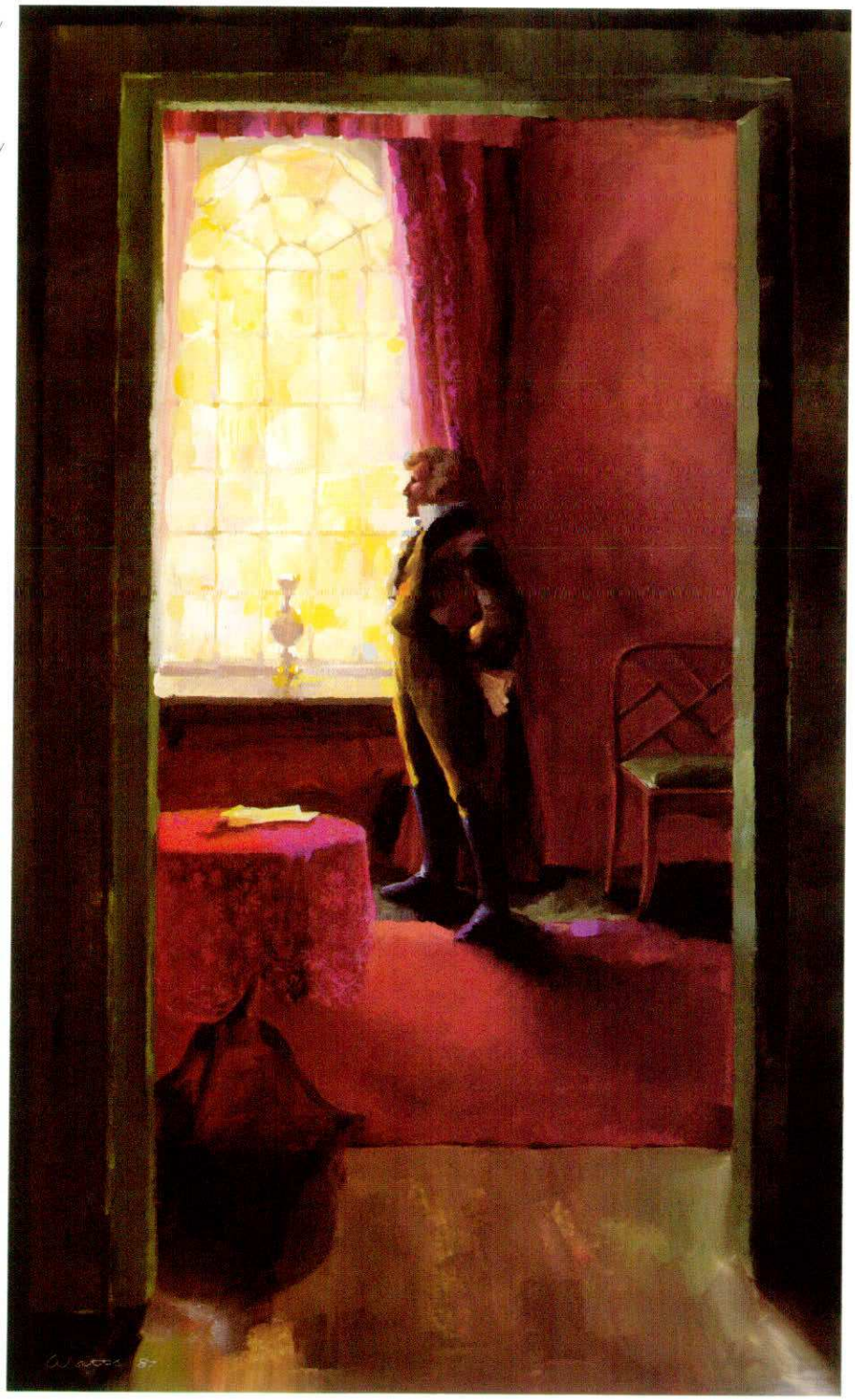
	1987 £	*1986* £
Turnover	2,880,653	1,926,836
Change in work-in-progress	29,700	15,601
Other Operating Income	3,395	8,926
Revenue	**2,913,748**	**1,951,363**
External Charges	96,983	127,391
Staff Costs	1,600,640	1,025,127
Depreciation	188,316	92,912
Other Operating Charges	714,708	539,568
Total Charges	2,600,647	1,784,998
Operating Profit	**313,101**	**166,365**
Contribution to Employee Profit Share	50,000	31,000
Interest Receivable	1,843	5,553
Interest Payable	49,908	29,710
Profit on ordinary activities before tax	**215,036**	**111,208**
Tax on profit on ordinary activities	(71,645)	(37,700)
Profit on ordinary activities after tax	143,391	73,508
Amount capitalised	191,876	—
Retained Profit brought forward	236,776	163,268
Retained Profit carried forward	188,291	236,776

These figures have been abridged from our audited accounts which have been sent to the Registrar of Companies.

The Auditors' Report was unqualified.

The 1987 figures are the consolidated figures for Praxis plc. The 1986 figures are for Praxis Systems plc. The two sets of figures are directly comparable.

Monday, Tuesday, Wednesday, Thursday, Friday and Saturday have now passed in review before the reader, the events of each day, its hopes and fears, mortifications and pleasures have been separately stated, and the pangs of Sunday only now remain to be described, and close the week.



Praxis has had another very successful year. Part of that success is shown in the figures on page 23 – profit up 86%, turnover up 50% – but I believe our real achievements lie elsewhere, in our continuing ability to recruit outstanding staff, in the quality of our services to our customers, and in the success of ELLA.

We have continued to invest heavily. Our capital investment in computers and office equipment (14% of turnover) and training (7% of turnover) are well ahead of the norms for our industry. We believe that this level of investment is necessary and strengthens our competitive advantages. We shall continue this pattern of investment.

During the year, we have used formal methods on more than a dozen projects, from data-processing applications to advanced research. Our experience shows that the use of formal methods leads to better control of quality, costs and timescales.

Our Industry has reached a watershed, where companies which can deliver assured high quality, as a matter of routine, will divide from companies which, for one reason or another, do not meet the increasingly stringent requirements of many sectors of our marketplace. The introduction of strict product liability in Section 1 of the Consumer Protection Act 1987, which comes into force on March 1st 1988, and the progress towards civil and defence standards for safety-critical software are examples of the pressures for greater rigour.

When Praxis was formed, in 1983, it was in the belief that a market existed for software developed with rigour and to certified standards of quality. Four years later, that belief has become certainty. There is a strong, and strongly growing, civil market for these services, and I now believe that within the next decade our industry will be dominated by those companies which have established the rigorous technical and quality cultures of professional software engineers.

There is another change occurring, in parallel with the increasing demand for rigour – a change which could have far more profound effects on parts of our Industry. The improvements in VLSI fabrication will soon permit one million transistors on a chip. Already the electronics systems companies are planning how they will exploit this new technology, with complete systems on a single chip, giving great reductions in cost, size, weight and power-consumption. The ESPRIT II programme has this as a main theme. Exploiting this new technology will be challenging, requiring new design skills and powerful CAE tools. The complexity of the VLSI designer's task is fast approaching that of the software engineer, and the designers of the new systems will need to combine a knowledge of VLSI design with the software engineer's rigorous approach to development.

Our investment in ELLA is designed to take us into this emerging market, where very few companies will have the combination of skills needed, and where the value of those skills will be very high. We are already providing consultancy to our ELLA customers on the most efficient use of ELLA to solve their design problems, and we shall soon be offering a full VLSI design service in ELLA.

Praxis is setting out on an exciting year. We shall be working to repeat ELLA's British success in America, and expanding our services business in Britain and overseas. Our reputation for quality, cost-effectiveness and timely delivery will open new markets to us. We shall contribute much and gain much. We expect to enjoy it.

In 1987 we invested £407,000 in providing computer, office environment and workstation equipment for our staff. This represents 14% of turnover during the same period, and an average of £4,500 for each member of staff. Our total training investment for the year is equivalent to 7% of turnover. Every member of staff received, on average, seven days of professional and career development training during the year.

Abbreviations

ACARD	Advisory Council for Advanced Research and Development
ASIC	Application Specific Integrated Circuit
BCS	British Computer Society
BSI	British Standards Institution
CAIS	Common APSE (Ada Project Support Environment) Interface Set
CASE	Co-operative Awards in Science and Engineering
CCTA	Central Computer and Telecommunications Agency
CSP	Communicating Sequential Processes
ELLA	Electronic Logic LAnguage
ESPRIT	European Strategic Programme for Research in Information Technology
IEE	Institution of Electrical Engineers
IEPG	Independent European Programme Group
IPSE	Integrated Project Support Environment
ISO	International Standards Organisation
JSD	Jackson System Development
JSP	Jackson Structured Programming
NCC	National Computing Centre
PCTE	Portable Common Tool Environment
RSRE	Royal Signals and Radar Establishment
SADT	Structured Analysis and Design Technique
SSADM	Structured Systems Analysis and Design Method
STARTS	Software Tools for Application to Large Real-time Systems
VDM	Vienna Development Method
VIP	VDM for Interfaces of the PCTE
VIPER	Verifiable Integrated Processor
VLSI	Very Large Scale Integration

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'Tool Interfaces in Integrated Project Support Environments',
A Hall
Proceedings 9th International Confefence on Software Engineering IEEE 1987

'ELLA – A CAE System for Truly Hierarchical IC Design',
J Miles
Colloquium on IC Design: Software Tools IEE 1986

'Defining Formal Models of the Software Development Process',
MA Ould and C Roberts
Proceedings 3rd Conference on Software Engineering Environments IEE 1987
(in press)

'Using JSP-COBOL with Oracle',
J Pimpernell
Jackson User Update June 1986

'Management of Complex Hierarchical IC Designs Within ELLA',
J Saunders
Proceedings 6th International Conference on Custom and Semicustom ICs
Prodex Saffron Walden Essex 1986

Company Details

We have this year established a group company structure with a non-trading, holding company, Praxis plc, and two subsidiaries: Praxis Systems plc, currently the sole trading company in the group, and Praxis Trustees Ltd, which administers the two staff share-ownership schemes.

Praxis plc is registered in England and Wales No 1728198

Praxis Systems plc is registered in England and Wales No 1883553

Registered office
(of both companies)
20 Manvers Street,
Bath, BA1 1PX.
Telephone: (0225) 444700.
Telex: 445848 PRAXIS G.
Facsimile Group 2, 3: (0225) 65205

Directors of Praxis Systems plc

David Bean* Managing Director
Kevin Ellison* Finance Director
Chris Miller Quality Director
George Owen Projects Director
Martyn Thomas* Chairman

* These are the directors of Praxis plc

Please address enquiries about our software services to
David Allen,
Project Group Sales Manager.

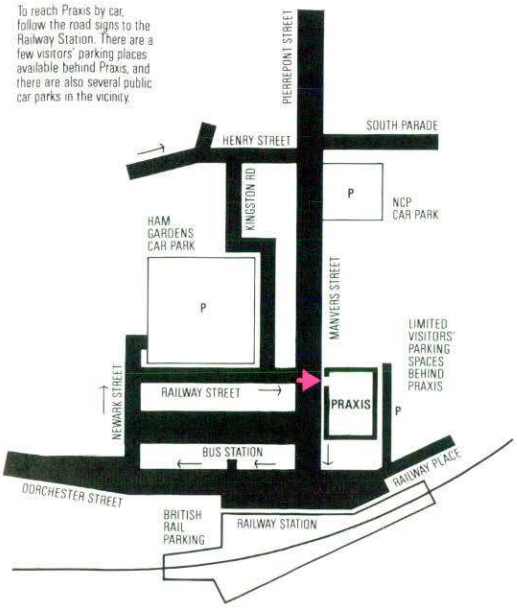
Please address enquiries about ELLA to
Stephen Robertson,
ELLA Account Manager.

If you would like to join Praxis, please apply to
Wendé Drinkwater,
Personnel Assistant.

PRAXIS

Computing Services Association

To reach Praxis by car, follow the road signs to the Railway Station. There are a few visitors' parking places available behind Praxis, and there are also several public car parks in the vicinity.



'It is a sort of pain, too, which is new to me. I have been used to the gratification of believing myself to earn every blessing that I enjoyed. I have valued myself on honourable toils and just rewards. Like other great men under reverses,' he added with a smile, 'I must endeavour to subdue my mind to my fortune. I must learn to brook being happier than I deserve.'

Jane Austen
Born 1775
Died 1817
Northanger Abbey and Persuasion were first published in 1818

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This Praxis Annual Review was written by George May of Praxis Systems plc

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