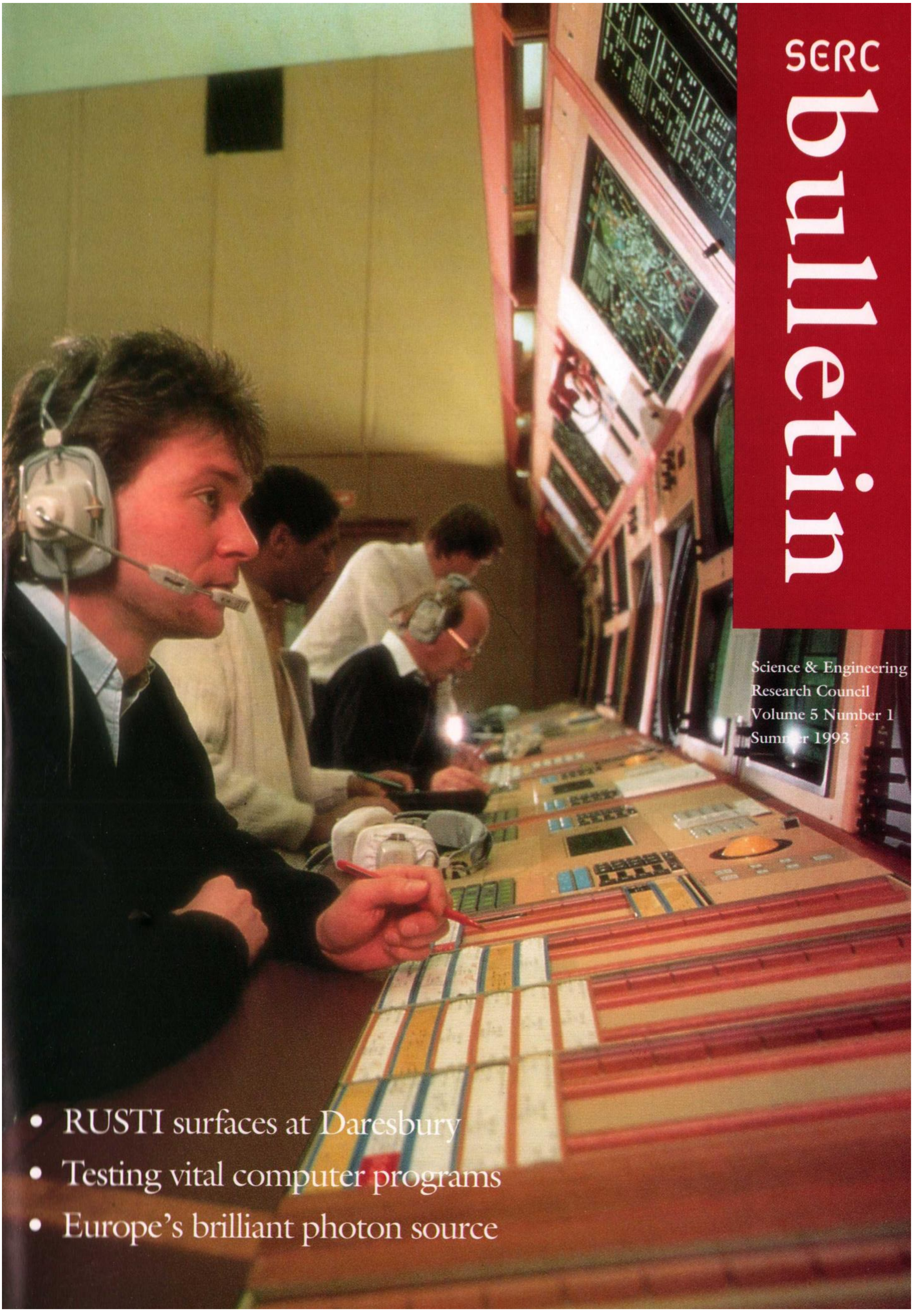

SERC bulletin

Science & Engineering Research Council
Volume 5 Number 1
Summer 1993

- RUSTI surfaces at Daresbury
- Testing vital computer programs
- Europe's brilliant photon source

SERC

The Science and Engineering Research Council is one of five research councils funded through the Office of Science and Technology. Its primary purpose is to support research and training in universities through the provision of grants and studentships and by the facilities which its own establishments provide for academic research.

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Survey holds surprises

This is my first edition as Editor of SERC Bulletin. I am taking over the job from Juliet Russell, who edited the Bulletin for 13 years and will concentrate on dealing with the expanding number of SERC's other publications.

In the previous issue of SERC Bulletin, we thanked those readers who had taken the trouble to fill in the readership survey forms that were circulated in the Autumn 1992 edition. So far we have analysed nearly 900 of them and we thought readers might like to know the overall results.

What surprised and pleased us most was the average readership of around 10 people per copy. This would give the Bulletin a total readership of 100,000 if the sample analysed were representative of all recipients.

More than 75% of the respondents were satisfied with the balance of subject coverage, although there were a significant number of pleas for more engineering and chemistry and more news about policy and funding. These and other comments have been noted for future issues.

About 90% of people were happy with the technical content of articles and the present format. Respondents were overwhelmingly against any suggestion that there should be a newspaper-style Bulletin.

Finally, most respondents were content with three issues of the Bulletin a year, although 18% wanted more frequent publication.

We will do our best to meet the requests – but Bulletin readers can help, too. If you are involved in SERC-supported or related work and if you have any news or items of interest, contact your committee representative at SERC Swindon Office with the details and ask for the article to be passed on to me. The more we hear about the latest science and engineering news, the more we can put in the Bulletin.

Articles should be a maximum of 800 to 1000 words – and not so technical that A-level students and non-scientists have to struggle to understand the subject. Short news items and SERC-related events are also welcome, as are pictures and slides, in colour or black and white.

Julian Richards
SERC Swindon Office, tel (0793) 411804

Director's appointment

Dr Tony Hughes, Director Programmes and Deputy Chairman of the Science and Engineering Research Council, has been appointed a member of the Northern Ireland Higher Education Council (NIHEC), which will advise the Northern Ireland Department of Education on the planning and funding of higher education in the Province. The Chairman of NIHEC is Sir Kenneth Bloomfield.

IN THIS ISSUE

Front cover picture

Study in concentration – an air-traffic controller watches over his computer-generated display. But as computer programs in 'safety critical' areas such as air-traffic control become more complex, is there any way of proving their reliability? Theorem proving offers one solution. A team from Edinburgh University is working on the automation of theorem proving. **See Page 22**. (Picture courtesy of the Civil Aviation Authority).

Professor Alec Boksenberg

Boksenberg appointed as first Director of Observatories

Professor Alec Boksenberg has been appointed Director of Observatories by the Science and Engineering Research Council. The appointment follows a review of the management of the Royal Greenwich Observatory, Cambridge, and the Royal Observatory Edinburgh, last year.

Professor Alexander (Alec) Boksenberg FRS, aged 56, is distinguished for his invention and development of new instruments for ground-based and space astronomy and for his contributions to research in observational astronomy.

Since 1981 he has been Director of SERC's Royal Greenwich Observatory, where he led the construction of the Isaac Newton Group of optical telescopes in the Canary Islands, for use by the astronomical communities of the UK, the Netherlands and Spain.

A graduate of London University, he was a Professor and Head of the Optical and Ultraviolet Astronomy Research Group in the Department of Physics and Astronomy of University College London before he entered SERC. He now holds several other distinguished posts in astronomy, including Visiting Professor, University College London and Honorary Professor of Experimental Astronomy, University of Cambridge. He has published more than 200 papers on topics in astronomy.

Professor Boksenberg took up his appointment in March. He is responsible for the work of the Royal Greenwich Observatory and the Royal Observatory Edinburgh, and for the observatory sites in the Canary Islands and Hawaii.

In the next few months, he will be drawing up plans, for approval by the Council, to achieve greater harmonisation of the work of the four observatories.

Commenting on the appointment, Sir Mark Richmond, Chairman of SERC, said: "Bringing the management of the two observatories together under the Director Observatories will ensure they can more easily help and support each other in the exciting science which lies ahead, and maintain their positions as world-class astronomical institutions".

The review, carried out by a panel under Dr Tony Hughes, Deputy Chairman of SERC, considered the responsibilities of both of SERC's Royal Observatories, with the aim of rationalising their roles within a unified management structure.

Professorship for Council member

Dr Susan Iversen, a member of the Science and Engineering Research Council, has been appointed Professor of Psychology and head of the Department of Experimental Psychology at Oxford University. She will take up the post on 1 October.

Dr Iversen is a Fellow of Jesus College, Cambridge, and is presently Director of Behavioural Sciences at the Neuroscience Research Centre at the Merck Sharp and Dohme Laboratories, Harlow. She joined the research centre in 1983 from the Department of Experimental Psychology, Cambridge, where her special interest, as Reader in Physiological Psychology, was in the function and disorders of the brain.

At the Harlow research centre, Dr Iversen established the behavioural pharmacology laboratory, which now has 30 scientists and assistants.

She served on SERC's Animal Sciences and Psychology Subcommittee from 1983 to 1985 and was appointed a member of the Council in September 1991.

Dr Iversen is involved in scientific charities which support medical research and care of patients in the community and is co-author, with her husband Dr Leslie Iversen, of *Behavioural Pharmacology*.

Changes to Studentships

SERC has made various changes to its studentship schemes.

Postgraduate awards - Northern Ireland

From the 1993-94 academic session, SERC will assume responsibility for making postgraduate awards to students from Northern Ireland who wish to undertake postgraduate study at an institution in Great Britain.

Similarly, the Department of Education Northern Ireland will take responsibility for making awards to students from the mainland who wish to undertake postgraduate study at an institution in Northern Ireland.

Studentship Nominations

A common closing date of 31 July now applies to all types of quota studentship nominations, except overseas awards, which have a revised closing date of 31 March. With Cooperative Awards in Science and Engineering (CASE) where difficulties in meeting this deadline have arisen because of protracted negotiations with a partner, nominations can be received up to 15 September, as long as SERC has been alerted by 31 July that the award will be taken up.

'Appeals' awards

Due to the unprecedentedly high level of take-up of quota awards for the 1992-93 academic session, and resultant decline in the number of awards available for appeals, Council has decided to suspend the appeals exercise until further notice. Consequently, there will not be any appeals awards made for the 1993-94 academic session.

A small pool of CASE awards may be available in certain subject areas and information about these will be provided by the relevant subject committee secretariats at a later date.

Substitutions

The deadline of the facility to 'substitute' a fresh candidate for quota students who withdraw before taking up their award has been extended until 30 September. It is anticipated that the take-up of awards will more closely match the distribution intended as a result of this move.

CASE contributions

The minimum levels of the mandatory contributions made by the cooperating body are to be increased for 1993-94.

Minimum levels are:

a) to the academic department - £1200.
To be paid at the start of the award for new awards, and on the anniversary of the start of the award for existing awards with effect from 1 April 1993.

b) to the student - £1800.
All new CASE students will receive a minimum mandatory contribution of £1800 from 1 October 1993 from the cooperating body. In addition, CASE students will also continue to receive a £250 enhancement to their award from SERC. New students will thus receive at minimum an extra £2050 enhancement to the basic award from participating in the CASE scheme. Firms and organisations already collaborating in a CASE award will be encouraged to offer at least the new rate.

Full details of these changes are given in the SERC 1993-4 Studentship Handbook, distributed to university and college registrars and university careers officers. Further copies are available from Postgraduate Training Support Section at Swindon Office, tel (0793) 411041.

Increased access to the Synchrotron Radiation Source

Although a small number of academics supported by SERC's Engineering Board have been using the Synchrotron Radiation Source (SRS), they have found it difficult to gain beam time on the oversubscribed stations.

In autumn of 1992, the Engineering Board committed funds to enhance the capabilities of the new station 16.2 at the SRS. In return for this support the Engineering Board Research community is to be given better access to its facilities during the next few years, up to a maximum of 400 shifts.

Applications to use the SRS should be made as part of a normal research grant application and submitted to Engineering Board for the 15 October closing date. These applications will be peer reviewed by the appropriate subject committee.

In parallel to this, applications will also be assessed by Daresbury Laboratory staff for suitability of SRS use. Provided the use of the SRS is considered suitable and the application is funded by the subject committee, the application for beamtime will be supported, provided requests for any one station do not exceed 10% of available beam time over the allocation period.

In order to raise awareness among engineers of the SRS, a workshop was organised for coordinators and staff within Engineering Board. A study weekend was planned at Daresbury Laboratory in May, to which interested academics were invited. The event, which included a tour of the SRS, gave examples of the use of techniques associated with synchrotron radiation when applied to engineering research and also gave further details on how to go about applying for access.

For more information regarding applications for beamtime, contact Dr Neil Pratt, at Swindon Office (0793 411484).

Review of Engineering Board education and training programme

Education and training programmes in SERC's Engineering Board should be geared to provide the highly skilled, technically innovative engineers that British industry needs to create the wealth upon which this country depends.

To do this, the number of training schemes should be rationalised and a greater investment made in modular training at the Masters level.

These are some of the recommendations from a comprehensive review of the programmes published in March. The report was prepared by the Education and Training Committee of the Engineering Board, under the chairmanship of Professor James Powell, of Brunel University.

In 1992-93, the Engineering Board will spend about £50 million, or one-third of its total budget, on its education and training programme. The same relative level will be maintained over the next five to 10 years.

The report has been adopted as the blueprint for the Engineering Board's education and training programme for the next decade and is supported by SERC. Full implementation of the policy will depend on agreement of the details within SERC and on the level of financial resources made available.

The three major conclusions to be drawn from the report are that:

- There is a continuing need to maintain the highest quality, and the opportunity for innovative research training for engineers;
- The Board, through its Education and Training Committee, should be more proactive in providing a well rounded and marketable education for postgraduate students;
- The Board should enter into an even more positive partnership with industry and commerce in the education and training process.

The main recommendations are summarised as:

- The Board should implement a Total Quality approach accross all of its programmes;
- Support for doctoral students should be rationalised into two schemes, one aimed at the traditional research PhD, the other leading to an engineering doctorate award;
- The Board should encourage the development of part-time learning at the Masters level by supporting the development costs of individual postgraduate learning modules, to be financed by a reduction in support for full-time Masters-level training;
- Training vouchers should be supported for all SERC-supported PhD doctoral students, to be used to pay for attendance at short courses which aim to broaden their range of skills;
- New academic appointees should be able to apply for earmarked studentships linked to starter grants;
- Part-time engineering PhD students employed by industry should have access to training vouchers to enable them to attend technical courses relevant to their studies.

Copies of the report may be obtained from Miss D Ackland, SERC Swindon Office, tel (0793) 411000 ext 2092.

Cell workshops

The European Science Foundation's network on Cell Stress Genes and their Protein Products is holding a series of study workshops.

Advanced workshops: Stress-induced post-translational protein modification (autumn 1993); Stress proteins in infection and immunity (autumn 1994 and spring 1995); Regulation of expression of cell stress genes (spring 1995); and Cell stress and the nervous system (spring 1995). *Specialised study workshops*: Aspects of ubiquitin-dependent protein degradation (spring 1994); Micromolecules and the cell stress response (autumn 1994) and Physical stresses and plants (autumn 1995).

For more details send an SAE marked European Science Foundation: Cell Stress, to Professor R J Mayer at the Medical School, Queen's Medical Centre, Nottingham NG7 2UH, fax 0602 422225.

Scheme expands

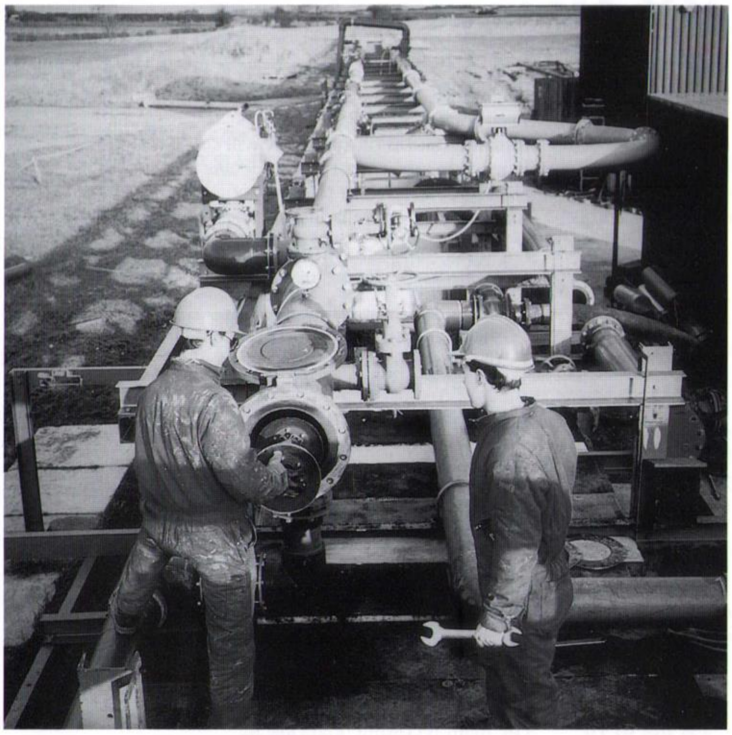
Two more pilot engineering doctorate centres are to be funded by SERC's Engineering Board from 1 October 1993 to run the four-year engineering doctorate programme of industrially-related training. The centres will be at Cranfield Institute of Technology, for Manufacturing Engineering, and Brunel and Surrey Universities, for Environmental Engineering.

The new doctorate scheme was reported in the summer 1992 edition of the Bulletin (Volume 4, Number 10). The original three centres were at the universities of Warwick; UMIST and Manchester; and Swansea, Cardiff and the North East Wales Institute. The centres had their first intake of 10 students each on 1 October 1992.

With the two new centres, there will be provision for an intake of 50 engineering doctorates from this October, with the foundation being laid for at least 200 students being trained at any one time.

The Engineering Board will be reviewing the pilot programme to assess whether further expansion of the scheme is justified.

Partnership scheme for industrially-related training



One of the PTP projects on pigging technology for the effective design and operation of pipeline pigging systems. (photo: BHR/ Cranfield Institute of Technology)

The first students have registered for a postgraduate training pilot scheme aimed at testing the practicality and benefits of placing groups of students in an industrial research environment.

Jointly funded by SERC and the Department of Trade and Industry (DTI), the Postgraduate Training Partnership (PTP) scheme complements the SERC engineering doctorate programme (see SERC Bulletin Vol 4 No 10, June 1992), and is aimed at providing research training relevant to a career in industry.

The scheme involves groups of students carrying out research for higher degrees such as an MSc or PhD by undertaking practical research projects in an Industrial Research Organisation (IRO), working in partnership with a university.

Under the pilot, each of five centres enrolled ten students on 1 October 1992 and will take a further ten on 1 October 1993. The possibility of intakes in future will be dependent upon a successful initial evaluation of the scheme. Although the students spend up to 75% of their time at their IRO, they are registered at the university partner institution as SERC students.

To encourage the recruitment of students of high quality, the SERC maintenance award offered is a basic stipend of £7,000 for the 1992-93 academic session, with subsequent increments. The industrial partners are encouraged to supplement the SERC award, but this is not mandatory.

First pilot centres

Nearly 60 bids were made for the five centres to be established, covering a very broad range of topic areas, industrial sectors and public and private research organisations.

The five partnerships selected as a result of the assessment exercise are:

- EA Technology and the University of Manchester Institute of Science and Technology (UMIST);
- SIRA and University College, London;
- British Textile Technology Group (BTTG) and the University of Leeds
- Water Research Centre (WRc) and Imperial College of Science, Technology and Medicine, London (ICSTM);
- British Hydromechanics Research (BHR) Group and Cranfield Institute of Technology.

Each of the partnerships has its own features and those selected cover a broad spectrum of research associated with a range of industrial applications. A key element in all the partnerships is the multidisciplinary nature of research topics selected for the students. A significant benefit for the academic institutions is the opportunity to extend their own research base and to improve their contacts with UK industry.

EA Technology and UMIST

EA Technology, based at Capenhurst, Chester, provides research, development and technology transfer services to users, generators and distributors of electricity. The company's research themes include environmental technology, process industries, power systems, buildings engineering, and metals and materials. There is a close correspondence between UMIST's departments and the research teams at EA Technology. This relationship in subject coverage and research groupings was underpinned through previous collaboration in several areas, many directly linked to industry.

Topics this year include building ventilation systems, the use of magnetic barriers for separation and chemical reactors, the application of "artificial nose" techniques and the integration of small-scale generation with the electricity distribution system. Students, known as Research Associates, work with engineers and scientists in an industrial environment as appropriate, and most importantly, work to the same disciplines and deadlines.

SIRA and University College, London

The field for this partnership is measurement, instrumentation and control technology, based on cross-disciplinary research and opportunities for technology transfer to create new products and better processes.

The strengths of SIRA are in optics, instrument development systems engineering and the application of advanced information technology to the management and control of production processes. Most of SIRA's members are small manufacturers of instruments or major process companies.

UCL has strong, complementary capabilities in optics and radiation science, analytical techniques, detectors, image analysis, data handling and other aspects of measurement and control technology. The College has created a Centre for Advanced Instrumentation based on its Departments of Physics and Astronomy, Medical Physics and Bio-Engineering, and Electrical Engineering. The link between UCL and SIRA through the partnership will significantly enhance the operation of this centre.

The projects within the partnership will be aimed producing transferable technology for a broad range of areas, including remote sensing, pollution monitoring, medical instrumentation, advanced automatic test equipment, production automation and control systems.

BTTG and University of Leeds

BTTG, as the former Wool Industries Research Association, has had academic links with the university since 1919. The university has a strong biotechnological and engineering research group. It also has one of the largest engineering faculties and schools of biological sciences in the UK, a combination of specialities in textiles and colour chemistry and dyeing.

BTTG provides research and industrial problem solving and is a proven exploiter of technology. Research activities constitute more than half of BTTG's efforts. Among projects undertaken by the first group of students are metal ion biosorption by natural biomass; novel non-yellowing antioxidants for textiles and polymers; chemically modified biomass for the removal of aqueous metal pollutants; an artificial intelligence route to colour measurement; and electrostatic damage to electronic components.

WRc/ICSTM

The impetus for this partnership was the privatisation of Britain's water industry and the planned £24 billion capital expenditure programme in the next 10 years to meet current and expected regulations and standards. In addition, harmonisation of regulatory constraints and emerging business needs at a European level offer a significant opportunity for the introduction of technologically-based products and services and career opportunities for the students from this partnership.

WRc is an independent company controlled by its staff, providing research, evaluation, consultancy and engineering expertise to customers. The Imperial College of Science, Technology and Medicine's contribution to the partnership is provided by the Departments of Civil, Chemical and Mechanical Engineering, and represents a multidisciplinary approach to the two main themes of the partnership, process plant technology and pipeline technology.

Among the first projects are computer modelling of waste-water treatment; quality assurance of plastic pipe welds; membrane filtration in potable water; nutrient removal in waste-water treatment; and the simulation of the recovery of contaminated sediments.

BHR Group and Cranfield Institute of Technology

BHR carries out research, product development, consultancy and technology transfer activities predominantly for the fluid-process-based industries. Collaborative projects with industry bring together manufacturers, contractors and end users from different industrial sectors to guide and fund longer term generic research. This research provides the ideal environment for higher degree project work.

Cranfield Institute of Technology is one of the largest European centres for research in applied science and provides almost one-third of all British postgraduates registered in mechanical aerospace and manufacturing engineering. The Cranfield schools involved in the partnership will include Mechanical Engineering, Industrial and Manufacturing Science, Biotechnology, and the Royal Military College of Science, School of Mechanical, Material and Civil Engineering, at Shrivenham.

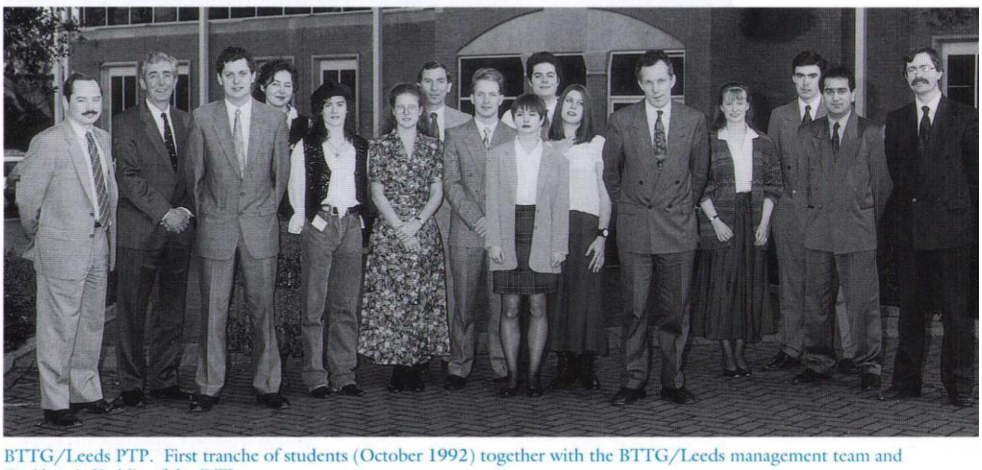
These schools have complementary skills to BHR. The initial series of projects under the partnership include fluid mixing and mass transfer; process intensification; sealing technology; separation technology; process simulation; and concurrent engineering in the fluid process industries.

Supervision and management arrangements

Within each partnership student supervision is undertaken jointly by an academic and an industrial supervisor. Each partnership is also supported by project directors at both establishments, who report periodically to a management committee.

The PTP scheme will be reviewed during early 1994 to assess its success and make recommendations about future intakes.

Further information on the Postgraduate Training Partnerships, from Mrs A Durniat, Engineering Division, SERC Swindon Office, tel: (0793) 411429.



BTTG/Leeds PTP. First tranche of students (October 1992) together with the BTTG/Leeds management team and Dr Alastair Keddie of the DTI.

Modelling the flow of water over floodplains roughened with an array of vertical rods was an important component of the Blackwater study. (photo: HR Wallingford)

Model approach to river engineering

River flooding in Britain causes millions of pounds worth of damage every year. At the SERC Flood Channel Facility (FCF) at HR Wallingford, which has formed the focus for river hydraulics research in Britain since 1985, work is being carried out to reduce the problem. This article describes a research project currently being carried out by a team led by Professor Robert Sellin, of Bristol University, using the FCF.

The SERC Flood Channel Facility at HR Wallingford showing a model two-stage meandering channel used during the River Blackwater study. (photo: HR Wallingford)

Research performed already has enabled engineers to improve estimates of the carrying capacity of river channels – thus reducing the occasions when flooding occurs. Work has concentrated on straight and meandering channels with such success that the FCF is being upgraded for a further programme.

SERC and the Ministry of Agriculture, Fisheries and Food are jointly funding the purchase of a sediment circulation system, which will give the engineering community the opportunity to study sediment transport in rivers. The world-wide applications of this work will be enormous.

The problem

In its natural state a river normally constructs for itself a channel capable of carrying a flood flow which reaches the higher level about once a year. This "bankfull" discharge is also referred to as the dominant discharge.

However, discharges occurring in the river and exceeding this amount will result in flooding of the surrounding area, the floodplain, and this natural process is not compatible with the development of such areas for residential and industrial uses. It has therefore become customary to require river engineers in the UK to provide a 50-year standard of service where there is significant floodplain development.

This means the construction of a channel designed to carry a flow (the 50-year flood) several times greater than the natural case referred to above. This results in a channel that is considerably oversized in relation to the natural equilibrium between erosional and depositional processes, and will therefore require continuous maintenance.

Recently, river engineers have been following the lead given by nature; adopting a two-stage channel design to solve this problem. In this case the "floodplain" is deepened and narrowed compared with its natural cousin and the inner channel capacity will probably have a return period of only about six months. The problem is that the hydraulics of two-stage channels is complicated and no reliable design methods exist for a meandering geometry of this complexity.

An advantage of using the two-stage channel is that it is relatively easy to meet a whole range of environmental objectives at the same time. For this reason SERC has been supporting research into the behaviour of two-stage channels, both the natural as well as man-made, in recent years. Most of this work has been carried out at the FCF and has been concerned with regular channels of either straight or meandering form.

Most recently tests have been carried out at the FCF by the Civil Engineering Department of the University of Bristol into a new two-stage channel design for a reach on the River Blackwater, near Farnborough, in Hampshire. This work has been sponsored jointly by the National Rivers Authority (NRA) and SERC.

The new channel

The construction of a new trunk road has necessitated the construction of a totally new river channel over a length of half a kilometre. The new Blackwater channel has been designed to include a meandering inner channel, with medium sinuosity, and a wider upper channel, the berm, of low sinuosity. The design has been based on the following criteria:

- Adequate flood discharge capacity (whole cross-section).
- Some measure of overbank (berm) storage.
- Satisfactory morphological behaviour (channel stability and sediment transport equilibrium).
- Low maintenance costs.
- Provision of a good habitat for suitable plant and animal species (especially fish and birds).
- A river corridor which will enhance the visual environment and is accessible for compatible leisure uses.

The new channel design capacity resulted from mathematical hydraulic modelling of the whole river valley and catchment to determine the effect of the new road construction on the river flows.

Hydraulic model study

The hydraulic model study enabled flow conditions representative of both high return period floods and more common flows in the channel to be studied in detail. The large size of the FCF (60 x 10m) meant that an undistorted model scale of one-fifth natural size could be used, which is rare in river models and minimises the uncertainty of scale effects.

This is the first study carried out on the FCF of a realistic river channel

The River Blackwater, Hampshire, where the joint SERC/NRA project is taking place.

geometry and therefore a lot of attention was given to establishing flow mechanisms and velocity distributions under a range of surface roughness conditions. Extensive video filming of dye plumes means that there is a very clear picture of flow exchanges between main channel and floodplain area. Areas of flow recirculation, always a risk in artificial meandering channels, have been identified.

The bed of the inner channel in the model was lined with 8mm ballast, being a one-fifth scale representation of the material to be used in the prototype. This material has been selected to provide a stable armouring to the natural river deposits in which the channel is constructed. It is therefore not intended to be mobile in the model.

Shallow depressions were formed in the bed material at the apex of the bends, intended to provide pools for fish during low flow in the river. These depressions had no effect on the flow conditions in the channel at the greater flow depths investigated.

The floodplain surfaces in the model were roughened using different gravel sizes and more significant hydraulic roughening based on arrays of vertical rods held in frames located above the top water level. One of the new parameters explored in this compound channel model was the effect of modelling the berm with a 1/30 crossfall falling towards the middle of the channel. This is important for maintenance needs, providing a drier and firmer surface for equipment on the higher parts while, at the same time, encouraging the development of marsh conditions on the margin of the inner channel.

Field monitoring programme

The new channel in the River Blackwater is due for completion in May this year. A four-year programme of field measurements and surveys will follow, again funded jointly by SERC and the NRA, to explore the objectives listed above and to provide data to compare with the model results.

Permanent instruments will monitor discharge and water level values enabling accurate stage-discharge relationships to be obtained under different maintenance regimes and seasonal factors. Current meter measurements will provide checks on the model data when conditions in the river are suitable. Parallel investigations will be made by channel morphologists and conservation staff.

Professor Robert Sellin
Bristol University

Dr P J Meakin
SERC Swindon Office

Inside the NSF tower. The central terminal is visible at the top right of the picture.

Daresbury's tower of strength

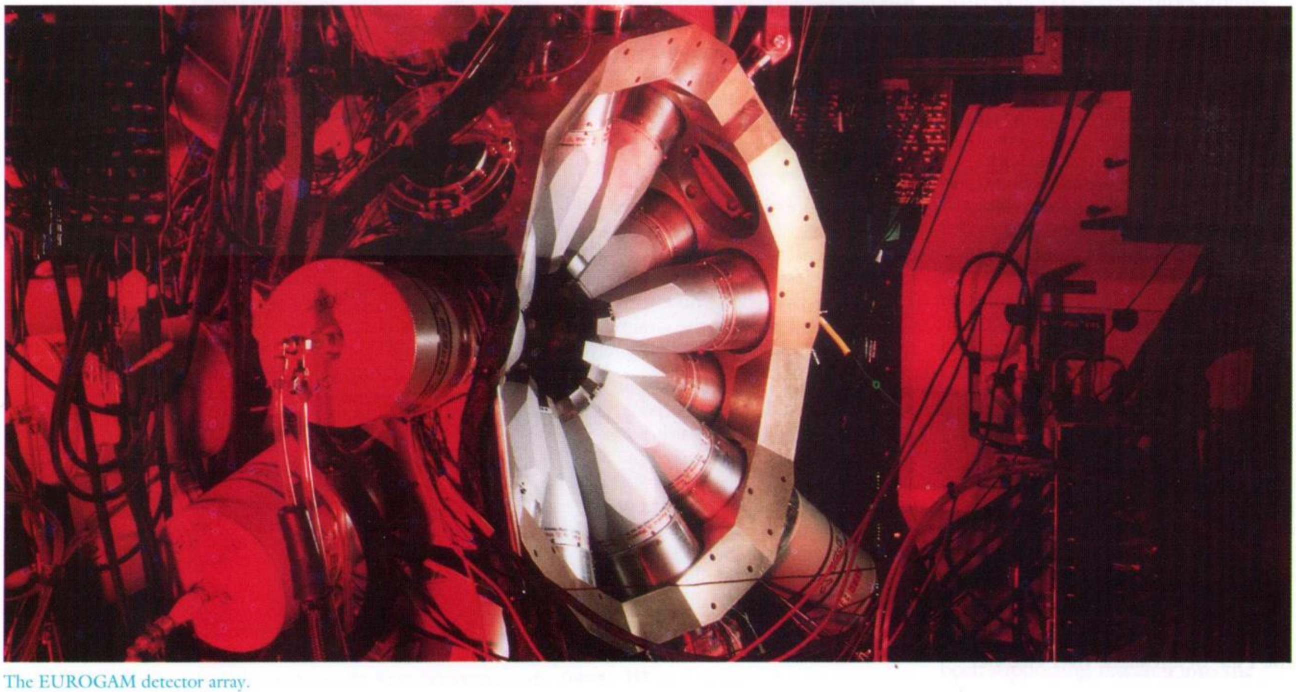
Following the recent closure of the Nuclear Structure Facility (NSF) at SERC's Daresbury Laboratory, Dave Warner and Tony Buckley look back at some of the scientific highlights of its 10-year working life.

The last experiments at the Nuclear Structure Facility (NSF) at Daresbury Laboratory finished on 29 March 1993, signalling the closure of the major British facility for nuclear structure research.

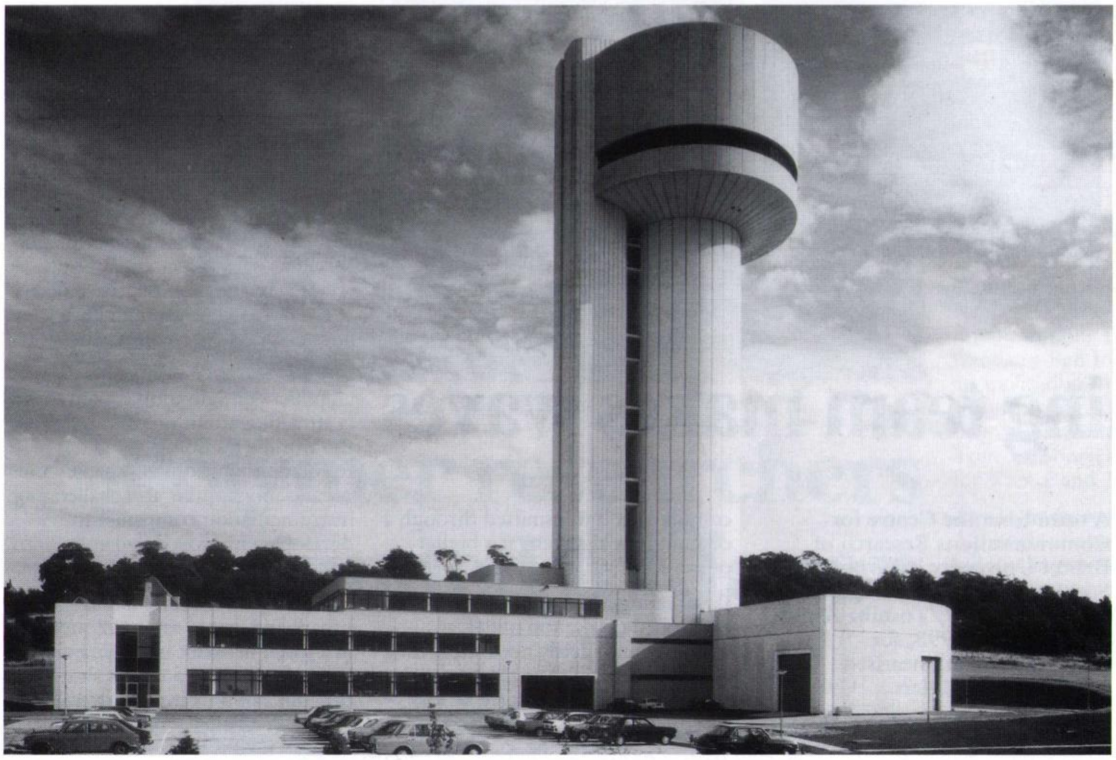
Construction work on the NSF began in 1974 and commissioning was completed at the end of 1981. Experiments began at the start of 1983 and the NSF soon established itself as a world-class centre for nuclear structure research of the highest quality.

Positive charge

The NSF was one of the world's highest voltage tandem Van de Graaff generators and used a two-stage process to accelerate ion beams, hence the tandem name. Beams, injected at the top of the "tower" as singly-charged negative ions, would accelerate through a vacuum tube towards a terminal in the centre of the structure. This terminal, with a positive charge of approximately 20 million Volts, was housed in a steel pressure vessel filled with pure sulphur hexafluoride, an insulating gas, at seven times atmospheric pressure. Here, the ions would be stripped of some electrons



The EUROGAM detector array.



The Nuclear Structure Facility at Daresbury Laboratory.

by a thin carbon foil, or cryogenically-pumped gas cell, and re-accelerated as positively-charged ions towards the experimental areas at ground level.

The NSF accelerated more than 80 different ion beams for experimental use during its lifetime, ranging from protons to uranium. A particular feature was the ability to accelerate rare isotopic beams, as well as radioactive beams of ^{3}H (tritium), ^{14}C (carbon) and polarised beams of ^{6}Li (lithium), ^{7}Li and ^{23}Na (sodium).

Inner structure

Perhaps the most important discovery made on the NSF was that of superdeformed nuclei. These nuclei, when formed from the fusion of lighter elements, rotate very rapidly and the pattern of gamma-rays emitted as they slow down provides detailed information about the inner structure of the nucleus.

The development of a series of high-efficiency gamma-ray detectors culminated in the collaboration between Britain and France to build EUROGAM, the world's most sensitive gamma-ray spectrometer. This multi-detector array uses the most modern electronics. Initial commissioning began at Daresbury early in 1992 with the first experiments in October of that year. New physics is already beginning to emerge from analysis of the huge datasets collected.

EUROGAM will transfer to French nuclear structure facilities with the closure of the NSF.

Another major achievement of the NSF was the surprising discovery of a new region of nuclear deformation centred around the nucleus ^{80}Zr (zirconium), which had been thought to have a spherical shape. New dispersion relationships between the real and imaginary potentials in nucleus-nucleus collisions were found, as were highly deformed nuclei with a molecular-like structure.

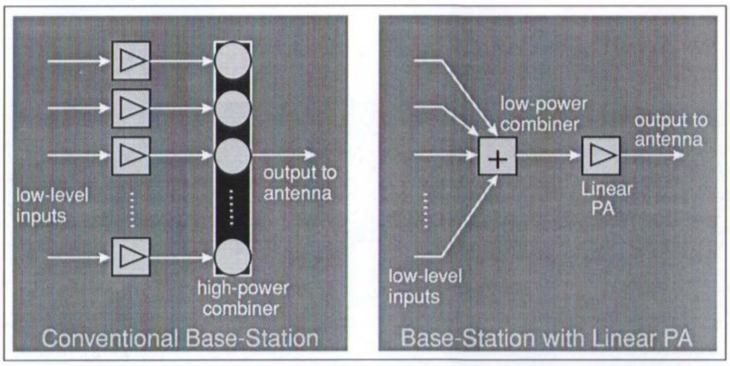
Ion beams

New examples of proton radioactivity were found and ultra-sensitive laser spectroscopic techniques were developed which, combined with the availability of heavy ion beams, allowed precise measurements to be made of the fundamental properties of nuclei far from the line of stability.

Towards the end of the 1980s, the NSF's special capabilities were applied to the measurement of ^{36}Cl (chlorine) and ^{26}Al (aluminium) in samples of geological and biological interest. This accelerator-mass-spectrometry technique was an exciting application of methods developed for use in nuclear physics to problems across a wider area of scientific study.

These, and many other scientific advances achieved at the NSF during its 10-year experimental lifetime, are a tribute to the efforts of the staff involved in its construction and operation.

Dr D D Warner and A G Buckley
Daresbury Laboratory



Block diagram of a conventional base-station (left) using high-level power combining; and a low-level power combiner (right) with broadband linear power amplifier.

Winning team makes waves

A team from the Centre for Communications Research of Bristol University has won the South/Southwestern Regional Final of the CBI/Toshiba Award for Invention 1993, for developments in linearised broadband amplifiers.

Professor Joe McGeehan and his team of Peter Kennington, Mark Beach, Andrew Bateman, Ross Wilkinson and Jim Marvill, have developed a prototype which is likely to find many applications in radiocommunications networks, particularly mobile radio and satellite-based systems. The group is now discussing a licensing deal with a major electronics company.

The team's work is funded by SERC through its Communications and Distributed Systems Committee.

In present cellular and personal communications networks (PCNs), a major part of the cost is accounted for by the base-stations, where each individual speech/information channel is amplified before being combined and transmitted through a common aerial system at a higher power level.

Base-station aerial sites are positioned on the top of tall buildings and ideally need short runs of cable between the hardware and the antenna, because of signal loss and expense. The base-station hardware takes up the space of a small room which, in expensive city-centre building developments, greatly increases the cost of the system.

Another disadvantage of conventional high-power combiner techniques, using cavity and hybrid combiners, is that they are neither flexible nor transparent in terms of modulation type or the network frequency plan. They also require regular recalibration by highly-trained engineers.

In the Bristol team's solution, channels are combined at a low level, where losses are easily and cheaply accounted for, before being amplified in the new "superlinear" broadband amplifier. Using novel control techniques, a conventional feedforward power amplifier is maintained at optimum performance in the normal environmental working conditions that are found in cellular and PCN base-stations.

The prototype operates over the cellular frequency bands at 900MHz and has third-order intermodulation products better than 70dB. And instead of taking up the space of a room, the superlinear amplifier would occupy one equipment rack.

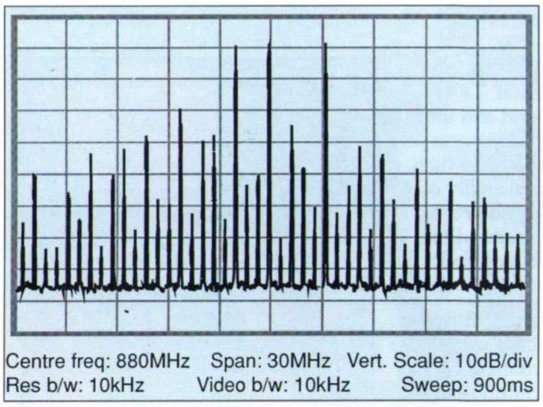
The performance of the new amplifier configuration is such that it is attracting attention from many of the world's leading telecommunications companies and organisations and is also challenging instrumentation companies to develop an improved dynamic performance for spectrum analysers.

Also, because the amplifier is broadband, it can assign frequencies in a given network on a dynamic basis. Recent research has shown that this can improve the overall spectrum efficiency of cellular and PCN networks by about a factor of two.

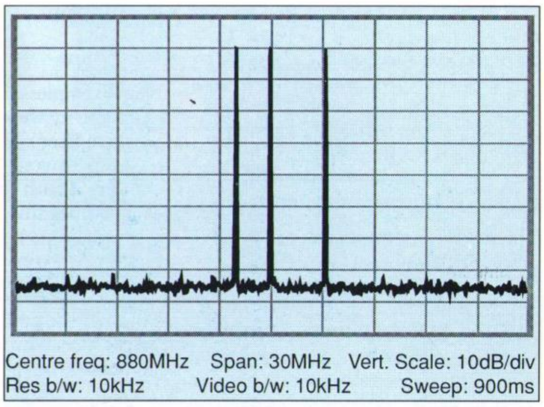
The transparency and flexibility of the amplifier allows base-stations to accept different modulation types, thereby allowing a smooth transition from present to new modulation technologies.

The ability to handle different modulations with the same amplifier and to assign frequencies on a dynamic basis within the network has been the subject of considerable interest in the telecommunications industry.

Professor Joe McGeehan
Bristol University



Open loop response (no correction) of main power amplifier with three tone test signal. (As shown on graticule of spectrum analyser, centre frequency of amplifier is 880MHz, frequency span is 30MHz, vertical scale is 10dB/division).



Closed loop response (with feedforward correction) with identical three tone test. (Same spectrum settings as for open loop response).

Dr Dick Jones delivers a lecture during his visit to Japan.

Polymer researchers funded by Japan

A group working on silicon-based polymers at Kent University claim to have become the first British academic researchers to be funded by a Japanese government agency. This exciting collaboration, and the problems that led to it, are described here by the group's leader, Dr Dick Jones.

For the past two years, research into syntheses of polysilanes and polygermanes for microlithographic applications has been in progress at the University of Kent at Canterbury, funded by a grant from SERC's 21st Century Materials Initiative. These polymers, which have silicon or germanium rather than carbon backbones, have interesting electrical and optical properties, as well as being ceramic precursors.

Quite early in the research it was evident to the group, working within the Centre for Materials Research at Kent, that the syntheses were not as easy as had been thought. Normally, they involve the use of molten sodium in boiling toluene. As well as scale-up being dangerous, the reactions proved difficult to reproduce and there was a lack of information about the mechanisms to help solve these problems.

Typically, and mysteriously, the reaction systems turn blue at the end of the reaction. The Kent group's explanation of this was published in a recent issue of *Nature*, and has led to the rationalisation of a number of other mechanistic puzzles. These have been the subjects of several papers pointing the way forward to better control of the reaction.

During the summer of 1991, Dr Jenny King, of SERC Swindon Office, who looks after the 21st Century Materials Initiative, heard from the British Embassy in Tokyo through the Department of Trade and Industry (DTI), that the Japanese government, through its New Energy and Industrial Technology Development Organisation (NEDO), was inviting firms and institutions to take part in a 10-year programme of research and development into silicon-based polymers.

One of the groups in various organisations that she passed the information to was that at Kent. Dr King stressed the short timescales involved and the difficulties of submitting an application in Japanese, but Dr Jones with Drs Bob Benfield, Harry Cragg and Tony Swain, working together with translator Ben Jones, managed to fax an application to the British Embassy by the closing date. This was delivered in person to NEDO by Tom Salusbury, the First Secretary for Science and Technology.

The Japanese response was prompt. Although not prepared to meet the full funding requested, the Japanese authorities were interested in the results that had been obtained to date and expressed a wish to participate in the continuing research.

So Dr Jones was flown to Tokyo for a presentation of the work to the Japan High Polymer Centre. Further travel within Japan was made possible through the efforts of Dr Robin Sowden, of the British Council, who arranged additional lecture engagements to industrial and academic groups.

Following detailed negotiations with representatives of NEDO, Dr Jones returned to Britain with a funding commitment that, it is hoped, will span many years.

This is the first time that the British Embassy, working with the British Council in Tokyo, and hand-in-hand with DTI, SERC and British researchers, has successfully brought to fruition a research collaboration that will be part-funded by a Japanese government agency. It is hoped that this first experience will lead both countries to seek further research collaborations.

University challenge

SERC and the Economic and Social Research Council (ESRC) are jointly challenging universities to put forward ideas about cities and sustainability. The aim is to find out how to limit the damage cities inflict on their inhabitants and the planet. The two research councils have invited universities to apply for research funds. They have published a report, prepared by Paul Ekins, of Birkbeck College, London, and Ian Cooper, of Eclipse Research Consultants, Cambridge, which attempts to define the issues that the research should tackle.

Preference will be given to proposals that take proper account of the interaction between technology and people and are put forward in cooperation with local authorities, businesses and communities. Nicholas Lawrence, SERC's Director for Clean Technology, particularly wants new approaches that cross the traditional barriers between engineers and social scientists.

A report outlining the research agenda is available from Pam Simms in the Clean Technology Unit at SERC's Swindon Office, telephone (0793) 411011.

Ring cycle: some experiments are already taking place at the ESRF, which has a dramatic position between the Isère and Drac rivers, on the outskirts of Grenoble.

Brilliant future for brightest photon source

The European Synchrotron Radiation Facility, which opens in 1994, will provide unique and exciting new tools for a wide range of scientific, engineering and medical research. It is described here by Mike Hotchkiss of Swindon Office and Jerry Thompson, Chairman of the ESRF Machine Advisory Committee.

Seen from the air, the building housing the European Synchrotron Radiation Facility (ESRF) resembles a gigantic frisbee wedged between the converging Isère and Drac rivers. Immediately behind is the domed cylinder containing the research reactor of the Institut Laue Langevin (ILL) and the outskirts of the city of Grenoble. In the distance are snow-capped mountains. The ESRF is the latest major European facility for scientific research.

The idea of an advanced synchrotron radiation source to serve Europe originated in a report from the European Science Foundation in 1977 and was subsequently pursued until, in 1985, it was agreed to proceed with the ESRF. The Grenoble site was chosen because of its proximity to the ILL neutron source, with prospects of scientific and technical collaboration and sharing of infrastructure.

Building began in 1988 and is now ahead of schedule and within budget, representing a remarkable achievement of technological, scientific and political cooperation between 12 European states. When it comes into regular operation in 1994 the ESRF will be the world's brightest source of X-rays, providing powerful new tools for probing matter ranging in scale from individual atoms to the structures of whole viruses or industrially important materials.

The essential objective of the ESRF is defined as being "to construct and operate, for the use of the scientific communities of the Contracting Parties, a synchrotron radiation source and associated instruments". The source, a storage ring of 845 metres circumference for 6 GeV electrons (or positrons), is already providing X-ray beams of unprecedented brilliance and the first scientific experiments are in progress, using experimental facilities in the process of construction.

Britain, through SERC, has participated fully in this multinational project from its beginning, playing a leading role in the machine design and contributing 12% of construction costs, which amount in total to more than £400 million. Britain will contribute 14% of the operating costs. The other countries participating are Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland.

The United Kingdom has its own domestic Synchrotron Radiation Source (SRS) at SERC's Daresbury

"Public" Beamline	Purpose	Source
1 Microfocus*	Micro-diffraction, small angle scattering	Undulator, 4–30 keV
2 Materials Science*	Small molecule crystallography, high pressure	Wiggler, 4–60 keV
3 White Beam*	Laue protein crystallography, high pressure energy-dispersive scattering; monochromatic option	Wiggler, 4–60 keV
4 High Brilliance*	Real-time small-angle scattering, monochromatic protein diffraction	Undulator, energy tunable around 12 keV
5 High Energy*	Gamma-ray diffraction, small angle scattering, Compton scattering	Wavelength shifter, up to > 120 keV
6 Circular Polarisation*	Dichroism in EXAFS, SEXAFS, spin-dependent photoemission	Helical undulator, 0.5–4 keV
7 Surface Diffraction*	Surface structural studies, phase transitions, growth mechanisms, liquid surface diffraction	Undulator, 5–25 keV
8 Dispersive EXAFS	Time-resolved structural studies	Tapered undulator, 5–25 keV
9 Troika or "Open" Beamline*	Multiple experimental station for test experiments	Undulator, 5–20 keV
10 Bending Magnet "Open"	"Open" beamline for test experiments	Bending magnet, up to ≥ 30 keV
11 Mössbauer	Nuclear Bragg scattering	Undulator, about 14 keV
12 Magnetic Scattering	Magnetic scattering	Asymetric Wiggler, 3–40 keV
13 Surface Science	SEXAFS and standing wave techniques	Undulator, 2–30 keV
14 Medical Beamline	Shared facilities for angiography, computer tomography	Wiggler, up to > 33 keV
15 Powder Diffraction	Powder diffraction for structure determination	Bending magnet, 5–40 keV (undulator later)
16 Topography	Topography, high resolution diffraction	Multiple Wiggler, 6–60 keV
17 Anomalous Scattering	Anomalous diffuse scattering in materials science	Wiggler, 2–35 keV
18 EXAFS	Materials science, mapping of heterogeneous samples	Bending magnet, up to ≥ 20 keV
19 MAD	Multiple wavelength anomalous diffraction for phase determination	Bending magnet, 5–25 keV
20 Protein Crystallography	Macromolecular crystallography (initially on BL4)	Undulator, energy tunable around 12 keV
21 X-ray Inelastic Scattering	High resolution (5-100 meV) inelastic scattering at energy transfer	Undulator, 12–17 keV
22 X-ray Microscopy	Imaging by X-ray microscopy	Wiggler, 2–6 keV
23 X-ray Absorption Spectroscopy for Ultra Dilute Samples	Highly dilute systems in materials science and biophysics	Undulator, energy to be decided

ESRF beamlines approved for the first phase. (* Beamlines due to be operational at start up in 1994.)

Laboratory, which will continue to provide the bulk of synchrotron radiation requirements of the UK's scientific community. The ESRF will be used principally for those experiments which will exploit its high brightness or require X-rays of more than 30 keV energy. Other European countries also possess major domestic synchrotron radiation sources, notably Germany and France, while Italy and Sweden have such sources under construction.

Synchrotron radiation

Photons (electromagnetic radiation) provide the most widely used probes for the study of matter. With far ultraviolet radiation, one can explore atoms, molecules and surfaces in great detail through photoelectronic processes, while X-rays, because of their short wavelength and penetrating power, can be used to examine at atomic resolution the structures of molecules and larger complexes, such as biological macromolecular structures, crystals, amorphous materials, surfaces and interfaces.

Synchrotron radiation is produced when a charged particle is deflected from its straight path by a magnetic field. In a practical synchrotron radiation source, electrons (or positrons) are accelerated, usually first in a linear accelerator and then a booster synchrotron, before being injected into a storage ring. The electrons in the storage ring are constrained in a roughly circular path by bending magnets. At each of these bending magnets, synchrotron radiation is produced.

Continued overleaf

CRG Beamline	Purpose	Source
D2AM (France)	Diffuse scattering / multiple wavelength anomalous scattering	Bending magnet # 2
GILDA (Italy)	General purpose X-ray beamline for absorption spectroscopy and powder diffraction	Bending magnet # 8
IF (France)	Interface studies	Bending magnet # 32
Swiss/Norwegian	General purpose beamline for diffraction and absorption spectroscopy	Bending magnet # 1
GRAAL (Italy)	Gamma-ray beamline (no "public" users)	Bending magnet # 7

CRG beamlines approved for the first phase. All are due to be operational at start-up in 1994.

Continued from Page 15

The radiation is emitted in a continuous band of wavelengths extending from the infrared, through the visible and ultraviolet regions to a cut-off which, for storage rings with energies of a few GeV, is well into the X-ray region. In the vacuum ultraviolet and X-ray spectral range, its intensity far exceeds that achievable with conventional sources, such as gas discharge lamps and X-ray tubes. Synchrotron radiation also has the advantages of being plane polarised and being emitted in a narrow cone tangential to the electron beam.

Advanced synchrotron radiation sources

In advanced facilities such as the ESRF, the most important radiation sources are magnetic "insertion devices" – of which there are two main types known as "wigglers" and "undulators" – through which the electron beam passes in special long, straight sections in the storage ring. An insertion device usually comprises two parallel rows of magnets of alternating polarity which induce a wobble in the axial electron beam, thereby producing radiation that is more intense than can be obtained from a bending magnet. An insertion device may be tuned to produce radiation optimised to a particular experiment.

Science potential of the ESRF

The ESRF will provide a host of new opportunities for studies in biological science, chemistry, materials science, physics, engineering and medicine. A few examples of such opportunities are: solving important problems in crystal nucleation and growth; understanding the structure and properties of layers of only one or two atomic planes in thickness; elucidating structural and morphological processes during phase transitions in polymers (e.g. melting, crystallisation and the reversible processes when rubber is stretched); solving the structures of viruses and other complex biological assemblies and macromolecules; understanding the structure and mechanism of biological fibres such as muscle; observing processes within live cells; and examining three-dimensional strains in large castings or welds.

The particular features of the ESRF storage ring are high energy and low emittance, enabling the use of undulators to produce X-ray beams of unprecedented intensity and brilliance - and also with variable circular polarisation. These characteristics will make it possible to obtain useful X-ray data from tiny specimens of volume as small as one cubic micrometre, or from very dilute solutions. It will be possible also to study, for example, the inner core electrons of atoms, strains within bulk materials, specimens at elevated temperature and pressure enclosed in massive cells, and, most exciting of all, to observe chemical or biological processes as they take place.

Techniques that will greatly benefit from the low emittance include spatially resolved X-ray spectroscopy and diffraction (microprobe experiments); macromolecular crystallography of minute crystals; diffraction from very small samples, such as those in a high-pressure cell, and from surfaces and interfaces; and time-resolved small-angle scattering from tiny samples. Circularly polarised beams from undulators or wigglers will be used, for instance, to explore subtle magnetic effects and to combine dichroism with spectroscopy.

ESRF experimental facilities

Within the annular ESRF building, beamlines employing the latest optics for transporting X-rays to experimental stations are being built tangentially to the storage ring. Two kinds of beamline are planned for the first phase, ending in 1998: 30 "public" ESRF-funded beamlines, of which 26 will be illuminated by insertion devices and four by bending magnets; and a number, yet to be determined, of "CRG" beamlines, all of which will use bending magnet radiation. The latter will be provided and funded externally by Collaborating Research Groups (CRGs) which will be entitled to use their beamlines free of charge for two-thirds of the available time.

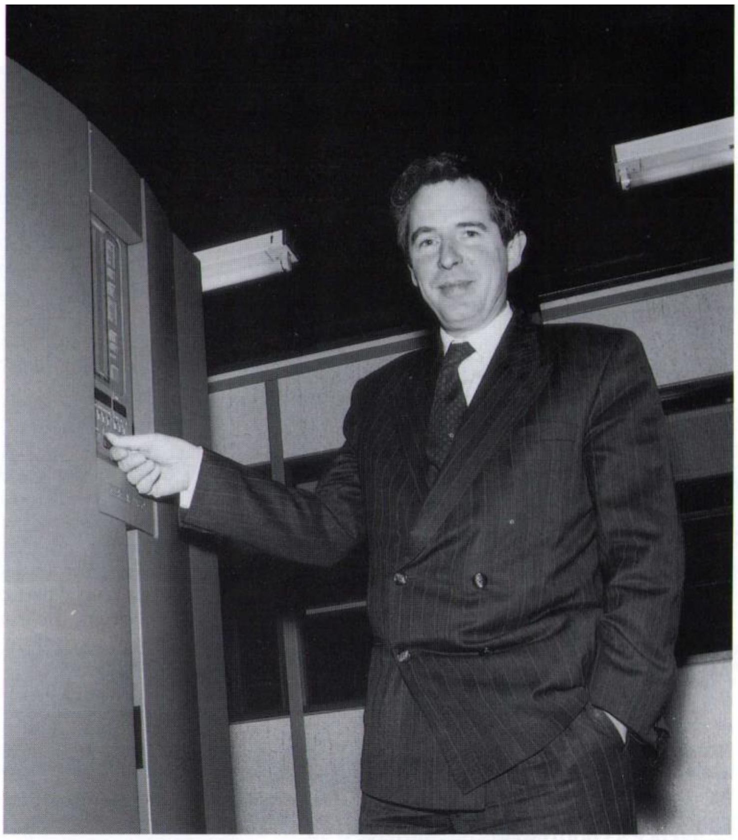
The ESRF will open for regular operation in 1994 with seven beamlines, operating for 6000 hours per year, 80% of which will be allocated through peer review. Scientists from ESRF member states will be eligible to bid for free access to the public beamlines and also for free access to the CRG beamlines for one third of the available time, subject to peer review.

Peer review committees are being established initially for "hard condensed matter", "soft condensed matter", "chemistry", "life science", "surfaces and interfaces" and "methods and instrumentation". Funding for travel and subsistence costs will be available to successful applicants.

Those interested in using the ESRF are advised to contact Colin Jackson, at the SERC's Daresbury Laboratory in the first instance (Tel: 0925 603223; Fax: 0925 603174). Now is *not* too early to start preparing proposals.

Mike Hotchkiss
SERC Swindon Office

Jerry Thompson
Daresbury Laboratory



Press for action: William Waldegrave, Chancellor of the Duchy of Lancaster switches on the new Cray supercomputer.

Cray has the power

One of Britain's most powerful computers, the joint Research Councils' Cray Y-MP8I/8128, was inaugurated by William Waldegrave, Chancellor of the Duchy of Lancaster, during a visit to SERC's Rutherford Appleton Laboratory (RAL), in February.

The new supercomputer, which is housed at RAL's Atlas Centre, replaces a five-year-old Cray X-MP/416. It has about three times the power of the earlier Cray and is being used for the most demanding computations in a broad range of science and engineering projects sponsored by Britain's five Research Councils. In order of usage of the Cray, they are SERC, Natural Environment Research Council, Agricultural and Food Research Council, Medical Research Council and Economic and Social Research Council.

Major projects include oceanographic and atmospheric science, which will help our understanding of climatic behaviour and global warming; studies of the structures of new materials and industrial processes; molecular modelling; and the realistic simulation of aerodynamic and fluid-flow problems in engineering applications.

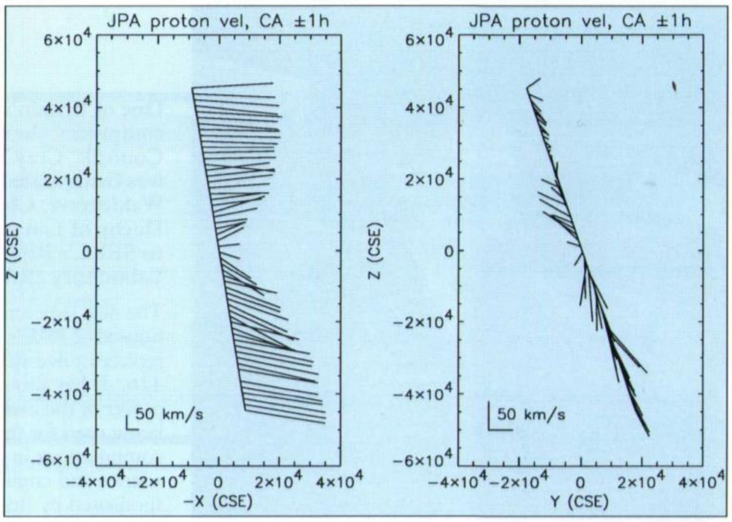
The Cray Y-MP is an eight-processor supercomputer with 128 million 64-bit words of memory and 100 Gbytes of disk storage. Its peak performance is 2.7 Gflops and it will run Cray Research's UNICOS operating system. It will be connected to the Joint Academic Network, through which access can be provided to higher education institutes.

Together with other computers at the Atlas Centre, the new Cray will have access to very large data storage facilities.

The new machine is likely to attract completely new types of project and it will also enable scientists in this country to tackle some of the large computational tasks which, in the past, could only be dealt with at facilities abroad.

This is the first stage in a renewed programme of investment in national high-performance computing facilities, overseen by the Advisory Board for the Research Councils and managed by SERC's Supercomputing Management Committee.

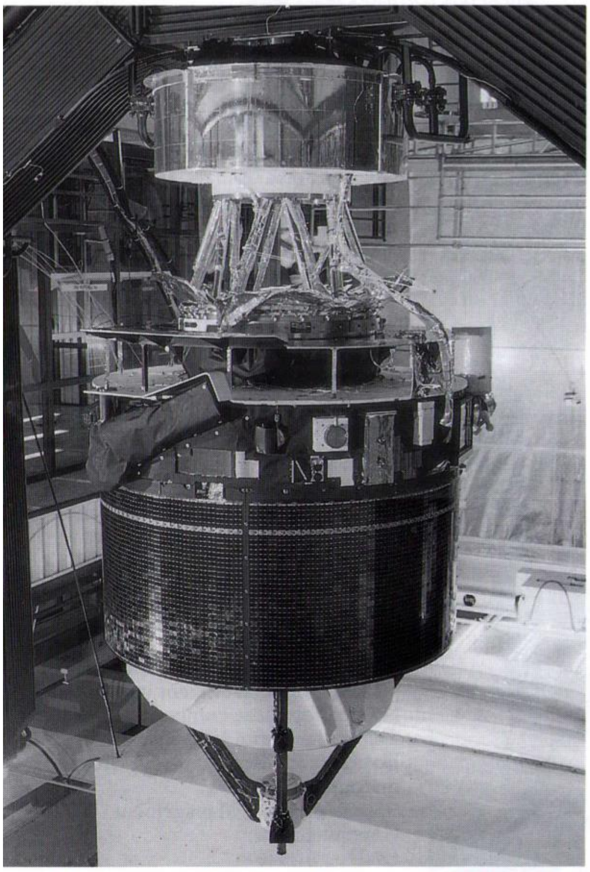
Dr Paul Williams, Director of Rutherford Appleton Laboratory (left) and SERC Chairman Sir Mark Richmond (right) with William Waldegrave during his RAL visit.



JPA results from the Grigg-Skjellerup (GS) encounter showing solar wind velocity (left panel) with sun to left and (right panel) the view from the sun. Deflection and deceleration due to the comet can be seen towards zero. The spacecraft trajectory goes from top to bottom.

Another close call for Giotto

The European Space Agency's Giotto spacecraft surpassed all expectations when it flew past comet Grigg-Skjellerup (GS) on 10 July last year. The working experiments, including those from two teams led by UK groups, returned excellent results on the plasma and dust environment of this relatively old and inactive comet.



The Giotto spacecraft awaits thermal vacuum test in Toulouse. At the top is the antenna and at the bottom are the bumper shield and experiment platform.

The results form an interesting comparison to the comets previously visited by the spacecraft, Giacobini-Zinner (GZ) and Halley, which were respectively a factor 10 and 100 times more active than GS. The mission was extremely cost-effective, at least a factor 20 cheaper than launching a new spacecraft.

In 1986, at comet Halley, Giotto had earned the interplanetary record for the closest man-made object to a comet, at 590km, but it was battered by high-speed dust as it flew by at 69 km/s. This caused a number of problems for the spacecraft and its instruments, including intermittent data for 31 minutes while an impact-induced wobble caused the narrow radio beam to miss Earth. On-board systems damped the wobble out and useful results were gained from many of the instruments for the next 6.5 million km on the outbound leg.

The spacecraft had survived. Also, 90% of the original thruster fuel was available which, with a gravitational kick from the Earth, gave the unexpected possibility of a further cometary encounter.

GS was identified as the most scientifically interesting of a handful of potential targets. This was partly because its orbit has the second shortest period of any known comet, at 5.1 years, an indication that it has been in the inner solar system for a long time.

Controllers at the European Space Operations Centre (ESOC) in Darmstadt, Germany, directed the spacecraft towards Earth with a planned swingby on 2 July 1990, the first by a returning interplanetary spacecraft. The swingby was achieved after a short checkout phase and in between two spacecraft 'hibernations'.

The hibernations lasted 46 and 22 months each. During these spells, most of the spacecraft systems were switched off and Giotto was positioned to optimise its temperature while it orbited the sun, waiting for its alarm call from Earth. As a crucial part of the spacecraft checkout, the instruments were tested to confirm that there were sufficient working to justify a second cometary encounter.

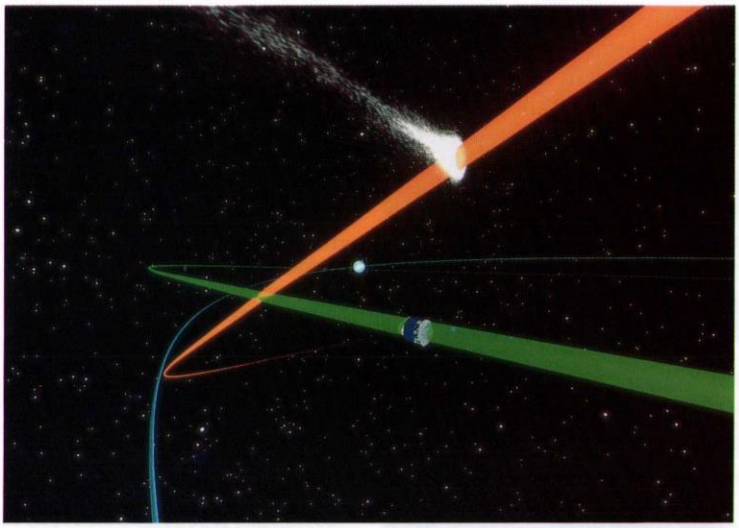
The tests confirmed Giotto's excellent potential for a new encounter. The main topics which could be addressed with the working payload were solar wind-comet plasma interactions and dust. The spacecraft could not photograph the cometary nucleus this time as the camera had been damaged during the encounter at Halley.

The two distinct tails of a comet are caused by plasma and dust. Plasma is the fourth state of matter after solid, liquid and gas. It pervades most of the volume of the universe except relatively cold planets like ours. The Sun's atmosphere is so hot that it emits the 400 km/s solar wind plasma, which blows throughout the solar system.

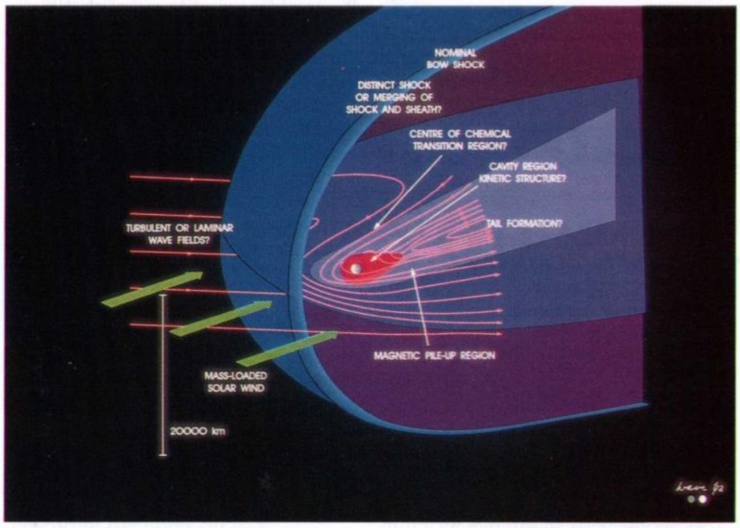
Cometary plasma tails form following the emission of neutral gas when a comet warms as it nears the Sun. This gas then ionises in the solar ultraviolet light at a distance of up to a few million kilometres from the nucleus. The newly created heavy cometary ions (mainly water) are dumped into this fast-flowing solar wind flow (mainly protons).

The way in which these new heavy ions interact with the flow, slowing it down and causing the plasma tail, was the main topic to be studied by the five plasma instruments. The Johnstone Plasma Analyser, provided by a team led from University College London's Mullard Space Science Laboratory, with support from SERC, was designed to measure the solar wind and cometary ions separately and unambiguously. It was a vital tool in probing the interaction at both Halley and GS.

The Halley encounter had provided some expected and some totally unexpected plasma results. As the



Schematic of the GS encounter: Giotto's trajectory is green, the comet's is shown in orange and the Earth's in blue.



Schematic for the comet-solar wind interaction at the GS encounter, showing the bow shock wave in blue and the magnetic cavity in red.

solar wind slowed, a complex bow-shock structure formed which was more obvious at Halley than at the smaller GZ. This was an expected boundary, as was another found by Giotto much closer to the nucleus. Here the magnetic field was completely excluded from and draped around a region of high plasma density.

Yet another boundary was seen in between these two which was unexpected, and notable for the sudden appearance of hot electrons, a change in flow speed and a splitting of the heavy ion population into a low- and high-energy branch. This boundary is still called the 'mystery' boundary as it is not yet understood. For millions of kilometres upstream of the shock it was possible to compare quantitatively the way the ion distribution changed with the amount of energy going into the complicated plasma turbulence – the 'missing link' for the way the cometary plasma tail forms.

At GS, the flyby speed was much slower, at 14 km/s, but the comet was also much smaller, so that we expected no sharp features at all. This was because the heavy ions gyrate in the magnetic field with a radius comparable with the distance between the shocks.

Again, Nature had some surprises because a sharp bow shock was seen. Other features included very narrow heavy ion distributions, seen up to half a million km from the comet, and remarkably large and much more coherent plasma waves upstream of the bow shock than at Halley.

Although the spacecraft did not penetrate the magnetic cavity, the results seem to show a mystery boundary, again with similar features to Halley, so it now becomes even more of a challenge to explain this odd feature. The results show the richness of the space plasma 'laboratory' because the solar wind conditions at the GS encounter made an important plasma wave speed, the Alfven speed, a lot higher than at Halley, allowing an excellent test of theories. The results are now being compared with those from previous comets.

One of the difficulties of the GS encounter was to establish the distance and relative position of closest approach without a camera. It was known that the spacecraft survived again and so did not hit the nucleus. From the orbits, the miss distance is known to an accuracy of only 200km, so all the information from the plasma and dust experiments must now be combined to try and get a consensus.

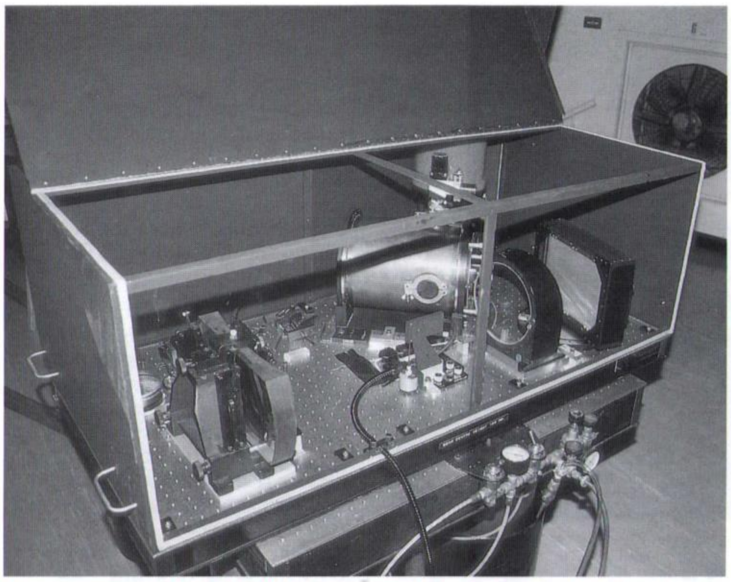
Although the encounter geometry and low dust-production rate meant that only three large dust particles were seen by the University of Kent's dust impact detectors, provided with the support of SERC's Rutherford Appleton Laboratory, the profile of large and small dust particles should help. Preliminary studies show that the miss distance could have been only 120-150 km, so Giotto has achieved another interplanetary record.

What of Giotto's future? The spacecraft is in hibernation again but will return to perform another fast Earth flyby in July 1999. Only an estimated 4kg of fuel remains, probably making a third comet encounter impossible. It would be very interesting to look at the spacecraft to see the battering it has received and even to analyse any cometary material embedded in it – but that will be impossible due to the high speed of the flyby and examination of cometary material will have to wait until ESA's planned Rosetta mission, next century.

But it may be possible to operate Giotto in 1999 to see which systems still work aboard this successful space relic, which could provide useful information on long-term survival of space electronics and sensors.

Other missions are planned to investigate the plasma processes involving injected ions in other contexts, such as the Mars-94 and Cassini (Saturn) missions. There are even Earth-bound experiments where similar processes occur, such as pellet injection and alpha particle production in tokamaks. The lessons from Giotto should help us in interpreting such results.

Dr Andrew Coates
Mullard Space Science Laboratory, University College London



The new spectrograph for FLAIR II, built on an optical table in the dome. Like the telescope, its optics are wide-angle Schmidt-type systems.

Schmidt's flair for spectroscopy

FLAIR II fibres being positioned on the target-field before observing. Each fibre is equipped with a miniature right-angled prism on its input face.

The Schmidt Telescope's FLAIR spectroscopy system proved a tremendous success with astronomers observing the southern sky. Here, Fred Watson and Quentin Parker describe its successor, FLAIR II.

Most people with an interest in astronomy know the 1.2-metre UK Schmidt Telescope in Australia as the source of countless stunning photographs of the southern sky. Formerly an outstation of the Royal Observatory Edinburgh (ROE), and now operated by the Anglo-Australian Observatory (AAO), the telescope was built in 1973 to carry out deep photographic surveys that would complement earlier explorations of the northern hemisphere.

After 20 years, the telescope remains outstandingly successful in its role as a fast, wide-field, photographic camera. It maintains an active programme of improvements, typified by the recent introduction of high-resolution Kodak Tech-Pan emulsion on film, to supplement the more expensive photographic plates. But, in addition to all this, the telescope now has another string to its bow, a mode of operation that was not even remotely envisaged when it was designed and built.

In the early 1980s, following basic work by Fellgett, Angel and others, the possibility of exploiting the huge information-throughput of the Schmidt telescope by means of novel instrumentation was investigated.

In 1985, this work led to new ground being broken with the introduction of a prototype multi-object spectroscopy system, a device allowing detailed spectral analysis of the light from many celestial objects simultaneously. The instrument was known as FLAIR (fibre-linked array-image reformatter), and used low-loss optical fibres to transfer the images of up to 39 selected targets in the telescope's 40 square-degree field to a highly efficient, if somewhat rudimentary, spectrograph in the dome.

Pioneering a configuration that is now being used on much larger telescopes, FLAIR was the first multifibre system in the world to use a remote, floor-mounted spectrograph, and thus reap the benefits of absolute mechanical stability. It was the world's only truly wide-field multifibre spectroscopy system, and its successor, FLAIR II, retains that distinction.

The scientific case for FLAIR rested on its ability to gather, in a very efficient way, the spectra of celestial objects having intermediate brightness (down to 18th magnitude) and a relatively sparse distribution on the sky (one-to-ten objects per square degree). Potential uses included:

- Survey spectroscopy of bright quasars over large areas;
- Large-scale surveys of galaxy redshifts, providing data for studies of three-dimensional structure in the Universe out to 300 megaparsecs (Mpc), or about 10^9 light-years;
- Observations of nearby clusters of galaxies;
- Studies at optical wavelengths of various astrophysically-interesting objects revealed by whole-sky satellite surveys, for example IRAS in the infrared and ROSAT in X-rays;
- Studies of particular classes of object in the Magellanic Clouds and the nucleus of our own Galaxy: planetary nebulae, Wolf-Rayet stars, HII regions, Mira variables, etc.

These programmes are characterised by the need for a very wide field of view to permit simultaneous spectroscopy, but require only a modest aperture. They complement well the types of observations made with multifibre systems on larger, conventional, telescopes, which are more powerful but have much smaller fields of view.

The prototype FLAIR was significantly upgraded in 1988, and from it grew the concept of a fully-engineered, common-user system with capacity for simultaneous observation of about 100 objects.

With SERC funding administered through ROE, and with AAO support, this new, second-generation instrument has now been completed and commissioned. FLAIR II retains many of the basic principles of its predecessor, but is engineered in such a way as to maximise optical efficiency and versatility while minimising as much as possible of the fibre-reconfiguration time between one target field and the next. This has been achieved on a budget of about £100,000 which, together with some small additional manpower costs, is a relatively modest outlay.

FLAIR II hardware

At the heart of FLAIR II is an innovative fibre-positioning technique that is unique to the Schmidt Telescope. Because the telescope's 6.5° x 6.5° field of view is compressed into an area only 356 mm (14 inches) square, the fibres need to be positioned with an accuracy of 10 microns to intercept fully the light from each target object. This is achieved simply by cementing the fibres on to a standard 14-inch-square glass copy-plate of the target field in exact alignment with the selected objects visible on the plate.

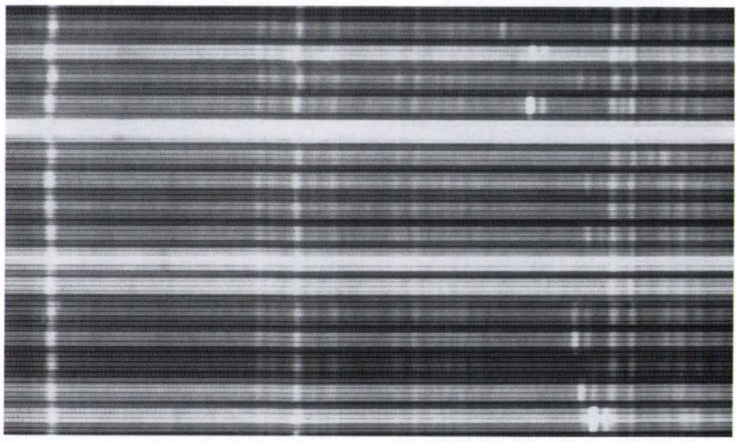
The positioning process takes place in a purpose-built laboratory using a PC-controlled semi-automatic fibre-positioner. With FLAIR II, it is normally a daytime job preceding each night's work and typically takes four to six hours for about 100 fibres. After observing, the fibres can be removed for re-use with another target field.

A special plateholder deforms the "fibred-up" copy plate to the curvature of the telescope's focus and allows it to be loaded into the telescope, just like one of the standard photographic plateholders. Two interchangeable fibre plateholders are currently available and there is a choice of two fibre diameters: 100 microns (corresponding to 6.7 arc seconds on the sky) or 55 microns (3.7 arc sec).

The larger fibres are typically used to observe extended objects such as galaxies and planetary nebulae, while the smaller ones allow observation of faint point-sources – stars and quasars – by minimising the sky-background light admitted with the target object.

Each fibre bundle is about 11 metres long in order to reach from the telescope focus to the spectrograph table. Here, the fibre output ends are arranged in a straight line to form a 20-mm long "slit" for the spectrograph, which is a new and versatile AAO-designed instrument built as part of FLAIR II. The spectrograph's optics are on indefinite loan from the Royal Greenwich Observatory, while the diffraction gratings are shared with other AAO instruments. This means procurement costs have been minimised.

A cryogenic charged-coupled device (CCD) detector with broad spectral sensitivity is used with the spectrograph, and data frames are read out by an electronic camera system under the control of a PC in the comfort of the Schmidt building's common-room. Also here are comprehensive facilities for data reduction, including a Sun Workstation loaded with the IRAF spectral reduction package, under which a FLAIR-specific process has been developed.



A sequence of galaxy spectra obtained simultaneously with FLAIR. Each horizontal band is a galaxy spectrum, and the bright emission-features to the right are staggered by amounts corresponding to each galaxy's redshift.

Observing with FLAIR II

The various components of the new system were phased into service during 1991, gradually replacing the earlier version. The FLAIR II common-user programme started in March 1992 and, since then, more than 4000 observations of quasars, active galactic nuclei, galaxies, stars and planetary nebulae have been made. The system is operated by the AAO and astronomers with suitable observing programmes can apply to the Schmidt time-allocation panels in Britain and Australia. Successful applicants usually visit the telescope to make their observations.

At present, up to seven nights each lunar month are allocated to the system, and each night can be used for one or two fields, with any remaining time reverting to photography. Observations on a single field might consist of half-a-dozen or more 3000-second exposures, depending on the nature and faintness of the target objects. In this time, high signal-to-noise spectra of perhaps 85 objects will be collected, the telescope's modest aperture being compensated for by the long time that it can look at each object.

Thus, at the end of a successful observing run, an astronomer might go away with the spectra of several hundred objects – and they may even be fully reduced.

Many of the programmes carried out with FLAIR II are statistical studies needing data on very large samples. The provision of two plateholders with 236 fibres between them enables the 1.2-metre Schmidt Telescope easily to out-perform 2-metre class instruments for this type of work.

Without doubt, by modern standards of capital expenditure on complicated instruments, the new FLAIR II system has proved an extremely cost-effective option for multi-object spectroscopy.

Dr F G Watson
Royal Observatory Edinburgh

Dr Q A Parker
Anglo-Australian Observatory

Hive of activity: a modern air traffic control system relies on a complex computer program. If this program fails aeroplanes could collide. Increasingly these programs are being specified and designed with the aid of formal methods. Programs are mathematically proved to meet their specifications.

Can theorem proving keep the planes flying?

Alan Bundy is Professor of Automated Reasoning in the Department of Artificial Intelligence at the University of Edinburgh. His Mathematical Reasoning Group is applying mathematics to the development of computer programs. The synthesis, verification and transformation of computer software is done by proving mathematical theorems using an automated theorem prover.

A major technical problem to be overcome is how to guide the search for a proof so that the theorem prover does not become bogged down in the possibilities. To solve this problem, the Edinburgh group has developed proof planning. An automated theorem prover first constructs an outline of the desired proof and then fills in the details of this outline.

Computer programs are playing an increasingly important role in all our lives. When they go wrong the consequences can vary from minor inconvenience to major catastrophe. 'Safety critical' applications of computers range from the control of complex systems such as air traffic control and nuclear power plants to the small embedded computers in medical instruments.

It is impossible to test these programs against the potentially infinite number of situations they may encounter in use, but we cannot afford for them to fail. We must develop a design methodology for programs which gives a high degree of assurance that they will behave correctly.

As they mature, engineering disciplines develop a range of techniques for ensuring the high quality of their products. Mathematics usually plays a major role in these techniques. An example is the use of statics in predicting the stresses and strains in the components of a bridge. As it matures, computer science is taking a similar path. The aim is to provide a quality assurance for computer programs and to minimise the risk of spectacular or dangerous failure.

One family of techniques being developed for - and increasingly used in - program development is called formal methods. This is the use of mathematics to prove that programs have certain properties. A program might be proved to terminate; two programs might be proved to be equivalent; an inefficient program might be transformed into an equivalent, but more efficient, program. Similar techniques are used in the development of electronic circuits.

One barrier to the more widespread use of formal methods is the lack of appropriate mathematical skills among computer programmers and hardware designers. The Edinburgh group is addressing this problem by developing computer aids to assist formal methods users. Automated theorem proving is used to lift some of the burden of proof from the shoulders of the software/hardware developer.

Since current automated theorem-proving technology is not good enough, the group is improving it. In particular, it is looking at ways of automatically guiding the search for a proof. The group is studying the kind of proofs that arise in formal methods to spot common patterns in families of similar proofs. These patterns, or proof plans, are then used to guide future proof attempts.

Viewing program development as mathematics

To use the tools of mathematics to prove properties of computer programs we must have some way of turning programming problems into mathematical problems. Many ways of doing this have been proposed. The most modern, and the simplest to understand, is to view a computer program as a mathematical theory. The lines of program code are interpreted as the axioms of a new branch of mathematics in which the objects of study are computer data structures. In functional programming the programs are relations between data structures. Proving properties of these programs consists of proving theorems in this mathematical theory.

Most types of data structure can take an infinite variety of possible forms. A finite definition of such data structures requires recursion, that is, self reference. The following recursive definition of a list of elements illustrates this.

Base case: The empty list is a list.
Step case: A list with a new element added is a list.

Given a finite list we can always show it is a list in a finite number of steps. We repeatedly apply the step case of the definition and finish by applying the base case.

The specification of a computer program can also be viewed as a mathematical formula. Consider a program for sorting a list of names into alphabetical order. Its specification might be:

The output list is ordered.
The output list is a permutation of the input list.

"Ordered" and "permutation" can both be defined as mathematical relations. The question of whether a particular computer program meets this specification can then be represented as a theorem to be proved in a mathematical theory of lists.

The proofs of theorems about recursive data structures usually calls for mathematical induction. Each data type has its own forms of induction. For instance, one of the induction rules for lists is:

To prove a property for all lists:

Base case: prove it for the empty list;
Step case: assuming it true for an arbitrary list, prove it for that list with a new element added.

This induction rule is modelled directly on the recursive definition of lists.

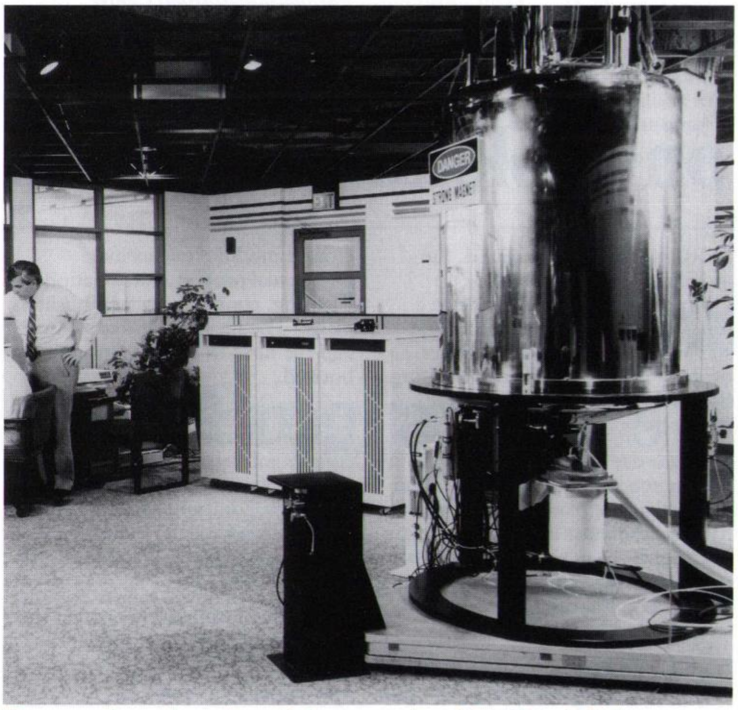
The need for computer aids

Proofs of properties of programs are usually mathematically unsophisticated, but can be long and are usually in non-standard mathematical theories. This poses two problems inhibiting the more widespread use of formal methods. First, most programmers do not have the mathematical background required to formulate and prove the necessary theorems. Secondly, it is easy to make errors during what can be a long and tedious process. One solution to these problems is to provide computer aids for the program developer.

The Edinburgh group has investigated two kinds of such computer aids: systems for helping programmers formulate their needs in mathematical terms and systems for helping programmers prove the resulting theorems. Only the latter kind of system – automated theorem provers – is described here.

Automated theorem proving has its roots in mathematical logic. In logic a mathematical theory can be represented as a collection of axioms and of rules for deriving new theorems from axioms and from old theorems. The formulae can be represented as computer data structures and the rules can be represented as programs which manipulate formulae. Most automated theorem provers apply the rules backwards, reducing the goal to be proved into simpler sub-goals and, finally, into axioms.

The main problem is search. At every step many rules are applicable. Each rule produces an alternative collection of sub-goals. The different permutations define a large search space of alternative proof attempts. Only a very small minority of these attempts will be successful. Some of the unsuccessful branches of this search space may be infinite. A theorem proving program that searches blindly among these alternatives rapidly becomes bogged down. It runs out of storage space and it runs out of time. This phenomenon is called the combinatorial explosion.



Theorem proving can be used to verify the programming of the small, embedded computers used in medical instruments, such as the UNITY 600 Nuclear Magnetic Resonance spectrometer, pictured here at the Varian Applications Laboratory, California.

The solution to the combinatorial explosion is to use heuristics – rules of thumb – to guide the search for a proof along the most promising paths. Most such heuristics are local and shallow. The Edinburgh group has investigated more global heuristics, which rely on a deeper analysis of what is going on in the proof.

What are proof plans?

By analysing a large number of proofs of program properties, the Edinburgh group has discovered common patterns. In particular, they have noticed that most inductive proofs have a common structure. They have captured this common structure in a computational form and used it to guide the search for a proof. As a result, their automated theorem prover seldom searches. Usually, it goes straight to the proof.

Of course, there is a price to be paid for this success; the Edinburgh automated prover cannot find proofs which differ from its stored proof plans. Fortunately, in formal methods proofs, such failures are usually due to only minor divergences from a known proof plan. It is usually possible to give an analysis of the failure which can be used to patch the failed proof attempt and put the prover back on track.

Ways of automating this analysis are being investigated, so it might be used either interactively by a human user or automatically by a proof patching system. The high-level language in which proof plans are described and their failures analysed provides a more comprehensible basis for interaction with a user than the low-level language of logic.

The flavour of the inductive proof plan can be given by describing a small but central part of it, called rippling. Suppose a goal is to be proved from a structurally similar hypothesis. This is the situation in the step case of an inductive proof:

Induction hypothesis: Assume the property true for an arbitrary list
Induction conclusion: Prove the property for that list with a new element added

The induction conclusion is the goal which is to be proved from the, structurally similar, induction

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hypothesis. The aim of rippling is to manipulate the goal formula so that it contains a sub-formula which matches the hypothesis formula. The sub-formula can then be replaced with the formula that is called *true*, considerably simplifying the goal.

Rippling works by a directed rewriting of the goal. Those parts of the goal which differ from the hypothesis are first marked and then moved out of the way. The marked bits are called wave-fronts. The following analogy may help to explain what is going on.

Imagine you are in Scotland standing beside a loch. The surrounding mountains are reflected in the loch. You throw something in the loch. The waves it makes disturb the reflection. The wave-fronts ripple outwards leaving the reflection intact again. The mountains are the hypothesis, the reflection is the goal and the wave-fronts are the bits by which the goal differs from the hypothesis.

Conclusion

With the aid of proof planning a computer system can prove theorems with very little search. This makes it more feasible to apply automated theorem proving to practical problems - in particular, to provide computer assistance for the use of formula methods. This may help make the mathematical development of software and hardware a more practical proposition, which will raise the quality of computer programs and electronic circuits.

The study of proof plans is also of interest in its own right. Proof plans describe the high-level structure of mathematical proofs and how this structure can be unpacked into the low-level details of the individual proof steps.

Human mathematicians may also use proof plans to understand and produce proofs. If so, this would explain such phenomena as differences in mathematical skill; how it is possible to understand a proof at a high-level, but not at a low-level, or vice versa; and the difference between "standard" and "interesting" proof steps. Proof plans enable us to analyse and categorise proofs and make possible a kind of science of reasoning.

Professor Alan Bundy
Edinburgh University

PHOENICS goes parallel

PHOENICS is a leading general-purpose Computational Fluid Dynamics (CFD) package developed by Concentration, Heat & Momentum Ltd (CHAM) and widely used for the simulation of fluid flow, heat transfer, chemical reaction and combustion processes. Parallel computing is a major element in meeting CHAM's objective of making computationally intensive CFD simulations more widely available.

CHAM and Southampton University's Parallel Applications Centre demonstrated a prototype Parallel PHOENICS in public for the first time on the Intel stand at the Supercomputing Europe 93 show, in Utrecht, in February. The prototype is an Intel iPSC/860 version of a generic PHOENICS code for distributed memory parallel computers, being developed in a collaboration supported by the SERC/Department of Trade and Industry Parallel Applications Programme.

Parallel computing involves combining large numbers of low-cost microprocessors to provide cost-effective supercomputing performance. In the the past 20 years there has been a phenomenal growth in the power of computers. Parallel computing technology is widely acknowleged by the major computer companies as being the way to maintain this growth.

The Southampton centre was established in October 1991 at the university's science park at Chilworth. The centre is run like a high-technology company rather than a traditional university research group, with a strong emphasis on professionalism, high-quality work and well-managed projects.

The centre is involved with a number of of major software houses and end users to parallelise industrial and commercial codes.

CHAM and the Southampton centre have established a long-term collaboration which this year will lead to further work on the prototype. The aim is to port PHOENICS to other computer platforms, including workstation clusters and shared-memory multiprocessor systems.

Dr Michael Dickens
Business Development Manager, CHAM

Dr Colin Upstill
Director, Southampton University Parallel Applications Centre

Tips on exploiting research

SERC is sponsoring UnivEd, the industrial liaison arm of the University of Edinburgh, to run a series of courses for academics and staff in university industrial liaison offices. They are entitled Exploiting Research: A Route for Academic Researchers.

The two-day courses are intended to be very much beginners' guides and not to take the place of an MBA or turn all academics into entrepreneurs overnight. They will simply indicate what those who take them need to know to exploit research and where to go to get the information.

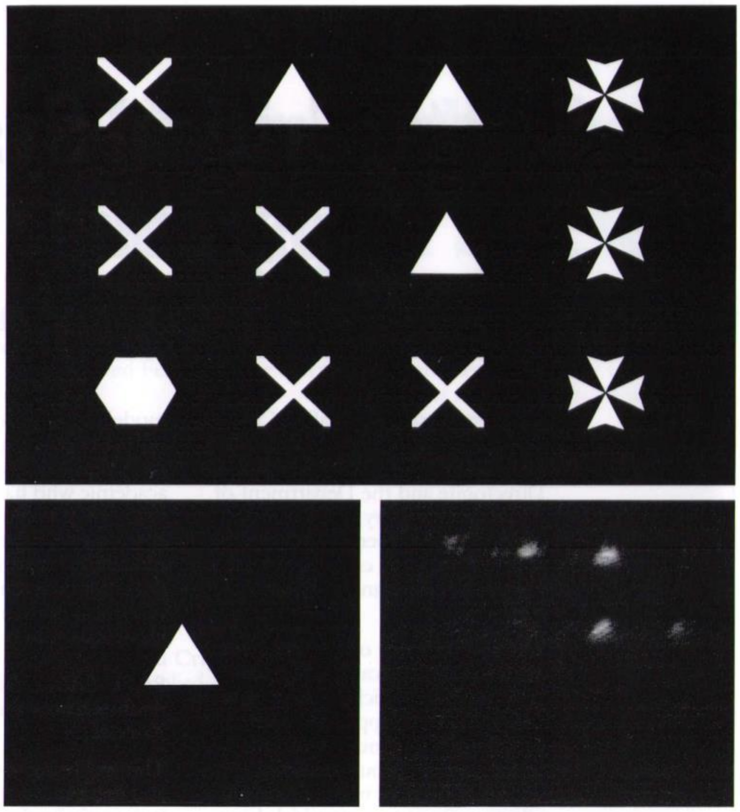
A unique feature of the course will be a hotline to UnivEd, available after the course for anything attendees want to follow up.

Course modules will include intellectual property, negotiation, licensing, company law and business plans. The first course was in April and the next, in May, is already fully booked.

Depending on their success and the feedback from attendees, further courses will take place starting towards the end of the year. Although Edinburgh was the venue for the first two, later courses will probably take place elsewhere in the country.

For further information contact the Industrial Affairs Unit, at Swindon Office, on (0793) 411173 or UnivEd on 031 650 5781.

NIPPY's lightning images



The actual images used for pattern recognition (top) and the output correlation image (bottom). The optical processor has identified the position of triangles in the shape array. This image was captured during a picosecond laser pulse.

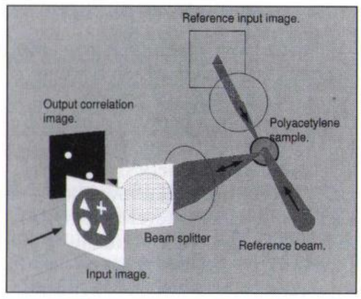
The first SERC/DTI LINK Molecular Electronics project, entitled "Non-linear optical information processing using PFX-derived polyacetylene"(and known as NIPPY), which investigated polyacetylene for use in real-time, parallel optical processing, has been successfully completed.

The project, a collaboration between British Aerospace's Sowerby Research Centre, British Petroleum's Sunbury Research Centre, Manchester University and King's College, London, established the advantages of using nonlinear optical polymers in real-time image processing and provides a further opportunity for the industrial exploitation of of organics.

The programme involved characterisation and optimisation of third-order optical nonlinearities in polyacetylene prepared by the Durham precursor route. The emphasis was on light-induced refractive index changes. The relatively large and rapid nonlinear effects allowed thin films of the material to be used as dynamic holograms in image processing experiments.

A notable achievement was the demonstration of pattern recognition with a possible image resolution of greater than 251 x 251 pixels and a processing speed of one image per picosecond. The recovery time of the material was less than a picosecond, giving potential processing speeds of 10^{16} pixels per second, which is well beyond present electronic processor capability.

To exploit this potential fully, further developments in laser systems and light valve technology are required. But this project has demonstrated the viability of using a nonlinear polymer to help almost instantaneous parallel information processing.



Picosecond image processing using dynamic holography in polyacetylene films. The diagram shows the arrangements of input laser beams and images to the optical processor.

Measuring a Programme's success

Now in the final year of its four-year life, the Technology for Analytical and Physical Measurement (TAPM) LINK Programme looks like meeting its key aim of the transfer of academic innovation into new scientific instrumentation.

The programme, jointly sponsored by SERC, the Department of Trade and Industry and companies, has been responsible for forging many new academic-industrial partnerships. There are currently 25 projects underway, involving 25 departments in 20 higher education institutions (HEIs) in collaboration with 44 companies. Of those companies, 24 are small-to medium-sized enterprises (SMEs).

The programme supports research in chemistry, physics, electronic and electrical engineering, environmental sciences, mathematics and computer science, biological sciences and analytical sciences departments in the 20 HEIs involved. So, its basic goal of supporting research across a broad range of disciplines has been reached.

There is a similar wide range of collaborating industrial partners. Most of the current projects involve three-way collaborations between an academic group, an instrument manufacturer, and an instrumentation user, although flexibility has been retained to allow one-to-one activity where appropriate.

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The multidisciplinary nature of TAPM is most strongly evident in the range of potential applications that the new instrumentation will eventually have. A significant number of projects are developing novel detectors, electronics and software for mass spectroscopy to improve the sensitivity or expand the applications of the technique.

Most of these developments will be used in measuring trace and ultra-trace quantities of various substances in a number of disciplines including, significantly, medicine, the environment and surface analysis. Spectroscopy and image analysis represent another area of significant activity.

Again, developing novel detectors capable of improving the resolution of complex spectra will lead to applications across a wide range of fundamental and applied science. Another significant focus in spectroscopy is developing techniques and instrumentation which allow time-resolved measurements to be carried out.

This will enable researchers to detect the energy transfers which happen during chemical reactions, so contributing to a better understanding of reaction mechanisms and kinetics. The array of spectroscopic techniques and instruments under development in the programme will eventually find application in fields such as oil exploration, food quality, chemistry, biology, plant physiology, pharmacology, engineering, mapping geological strata and flame detection.

The multidisciplinary approach to solving problems in science and engineering research, as encouraged and supported by the TAPM LINK Programme, is important in maintaining the strong scientific base upon which future research in many diverse fields will thrive.

Carrying academic research forward via LINK to the industrial sector will promote significant activity in production through increasingly powerful and sophisticated instrumentation that will find many applications in fundamental research.

Enquiries regarding the TAPM LINK programme can be made to Dr Lyndon Davies, Programme Coordinator, on (0223) 262686, or Mr Larry Atwood, SERC Swindon Office, on (0793) 411000, extension 2110.

Safety Critical Systems Programme gains momentum

The first phase of the Safety Critical Systems Programme, jointly funded by SERC's Information Technology Directorate and the Department of Trade and Industry, (Bulletin Volume 4, Number 9) attracted 18 approved projects covering a wide variety of sectors and software techniques.

The second phase of the programme attracted 60 applications for new projects, from which 17 have now received outline approval. The programme continues to attract interest from various industrial sectors, illustrated in the following selection from projects which have been approved in outline, reflecting the all-pervasive nature of the issue of safe systems.

PRICES – Productivity, Integrity and Capability Enhancement

This involves the Open and City Universities in collaboration with industrial partners from a variety of fields, including Rolls-Royce and Lloyd's Register of Shipping. It is motivated by the desire to build affordably safe systems, and will be examining the productivity and cost-effectiveness of different approaches to system development.

SAFE-DIS – Information System for the Safe Design of Distributed Networks

In SAFE-DIS, Wallingford Software, a small company involved in the modelling of water flow for both water purification and sewage treatment, will work with an academic who has experience of knowledge-based systems. The correctness of the results of modelling is a serious concern. This project is concerned with the validation of the mathematical flow models used in water treatment.

SAFE-SAM – Safe Systems Architectures for Large Mobile Robots

This will bring together engineering and computer science departments to investigate the safety issues relating to robotic JCB excavators. The work has strong support from a number of companies in the construction industry.

RATIFI – Risk Analysis Techniques in Finance and Industry

This involves Birmingham University and Alexander Stenhouse, a major insurance broker, working together to investigate risk management techniques in the financial sector. It will bring the techniques of knowledge-based systems to bear on the reconciliation of multiple views of safety issues.

Catherine Barnes
SERC Swindon Office

Medal winner

Anita Malhotra, of Aberdeen University, has been awarded the 1992 Thomas Henry Huxley Medal by the Zoological Society of London for her thesis "What causes geographic variation?: a case study of *Anolis oculatus*," for which she was funded by SERC.

Correction

In the report 'SERC grant for stellar studies' (Bulletin Vol. 4 No. 12) it was incorrectly stated that the Chairman of Collaborative Computational Project No 7 is Dr Richard Carson. It should have said that the Chairman is Dr David Flower, of Durham University. Apologies to Dr Flower for the mistake.

New Fellows of the Royal Society

Congratulations to the following newly-elected Fellows of the Royal Society:

Professor Frederick Burdekin (Professor of Civil and Structural Engineering, University of Manchester Institute of Science and Technology), former member of the Marine Technology Management, Environment, and Board Management Technology Committees.

Professor David Crighton (Professor of Applied Mathematics, Cambridge University), Chairman of the Materials Commission and member of the Science Board.

Dr Ian Fleming (Reader in Organic Chemistry, Cambridge University), former member of the Organic Chemistry Panel.

Professor Ludwig Fraenkel (Professor of Mathematics, Bath University), former member of the Mathematics Committee.

Dr Richard Friend (Lecturer in Physics, Cambridge University), member of the Electrical Materials Committee and the Molecular Electronics Subcommittee.

Professor Keith Glover (Professor of Engineering, Cambridge University), member of the Control and Instrumentation Subcommittee and former member of the Computing Facilities Committee.

Professor Franz Kahn (Professor of Astronomy, Manchester University), former Astronomy II Committee Chairman and member of the Astronomy, Space and Radio Board.

Professor Angus Macintyre (Professor of Mathematical Logic, Oxford University), former member of the Mathematics Committee.

Professor Colin Pillinger (Professor of Planetary Science, Open University), former member of the Solar System and Ground-Based Programme Committees.

Professor Peter Twin (Professor of Experimental Physics, Liverpool University), Chairman of the Nuclear Structure Committee, member of the Nuclear Physics Board and former member of the Particle Physics and Physics Committees.

Some recent publications from SERC

Unless otherwise stated, all publications are available free of charge from SERC Swindon Office, telephone code 0793 followed by the numbers given below.

SERC's interactions with industry
This report is available from Mrs K B Bartoszewska, on 411342.

SERC Corporate Plan
Copies of SERC's *Corporate Plan* and its *Programme for the next four years* are available from Pam Jones, 411256. Also available from this number is a series of *award scheme leaflets*, which describe awards made by SERC. The series has been revised and extended to cover 11 different schemes.

Biotechnology
Copies of *Final report summaries 1992*, *Current grants 1992* and the *Biobulletin* newsletter, are available from Joe McIlherron, 411310.

Chemistry
Copies of the April 1993 *Chemistry* newsletter are available from Larry Atwood on 411000 ext 2110; *Current grants in chemistry* is available from Dave Turk, 411360; and the *Atmospheric Chemistry* newsletter from Daphne Morris, 411000 ext 2167.

Engineering
Copies of the *Review of SERC Engineering Board education and training programme* are available from Miss Jane Sykes, 411000, ext 2089. Copies of *A review of transportation research and education* are available from Dr Andy Rawlins, on 411353.

Clean Technology
Two reports, *Cities and sustainability* and *Life cycle analysis*, are available from Pam Simms, 411011.

Information Technology
Copies of the *Government strategy for IT*, which sets out the aim, objectives and strategy for the Joint Framework for Information Technology, are available from Liz Strange, 411224

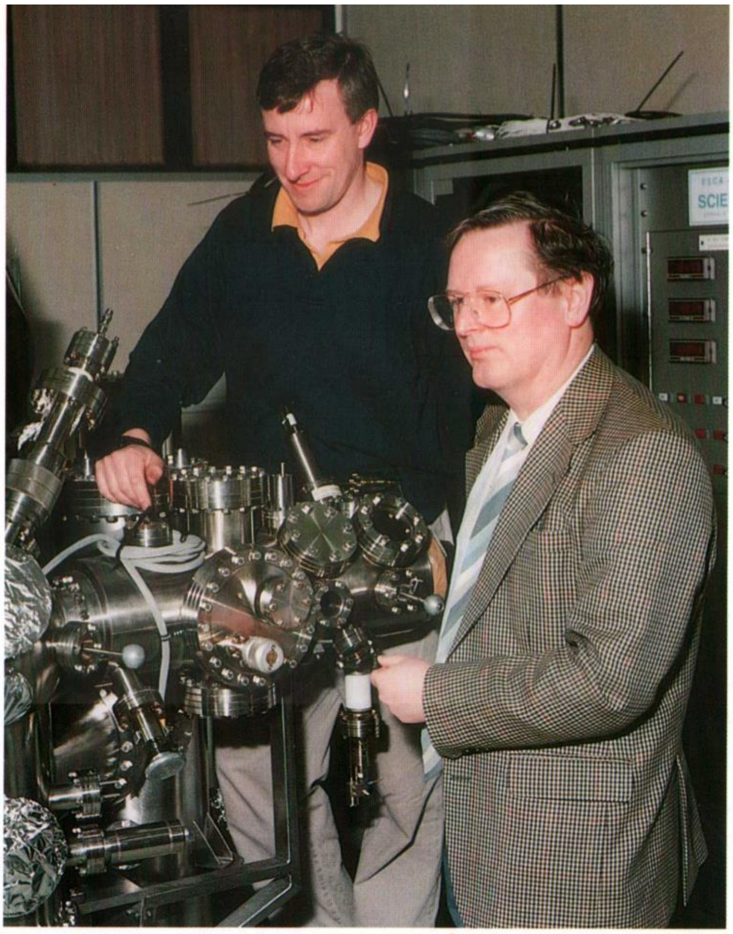
Rutherford Appleton Laboratory
Copies of the following publications are available from the RAL Press and Public Relations Office, on 0235 445789: *RAL Annual Report; Working with industry - RAL Research Services*; *Using wind for clean energy* (a booklet for schools, in association with the British Wind Energy Association); and a set of three leaflets (*Earth, Exploring our Solar System*, and *Investigating the Cosmos*).

OST moves

The Office of Science and Technology moved to new premises in April. Its address is now:

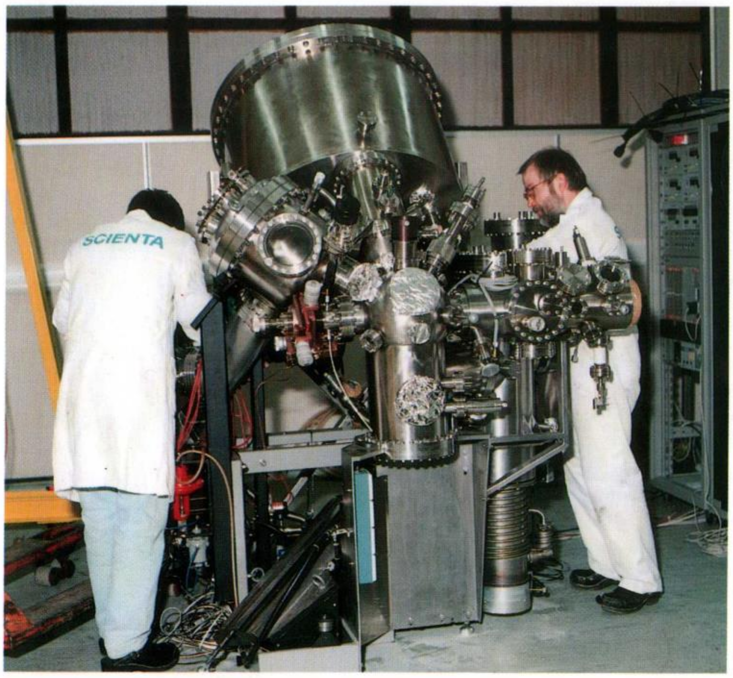
Cabinet Office, Office of Public Service and Science, Office of Science and Technology, Albany House, 84-86 Petty France, London SW1H 9ST; telephone 071 270 1234; fax 071 271 2028.

The information line for the EC Human Capital and Mobility Programme is now 071 271 2112; fax 071 271 2016.



Dr Hywel Price (right), head of RUSTI, and Mr Ron Marl, a member of the RUSTI technical staff, with the ES300.

RUSTI surfaces at Daresbury



The ES300 spectrometer being installed at RUSTI by SCIENTA engineers.

ICI and SERC are joining forces to form a research unit aimed at keeping British companies ahead of the competition in a key market sector.

The Research Unit in Surfaces, Transforms and Interfaces (RUSTI) was established at SERC's Daresbury Laboratory in April and will bring together industrial and academic researchers to develop new processing methods for advanced materials. It will also give academics access to some of the most advanced surface science and engineering equipment in the country.

Head of the unit is Dr Hywel Price, who was Head of Daresbury's Nuclear Structure Facility, which closed recently. Professor David Clark, formerly Director of ICI's Materials Research Centre at Wilton, will assist with the establishment and operation of the new unit and become its Scientific Director.

ICI is transferring an ES300 SCIENTA high-resolution X-ray photoelectron spectrometer to Daresbury. This is the only such spectrometer in the country and one of a very few in the world. The spectrometer bombards samples with X-rays at a single energy, selectively exciting the electrons around certain atoms in the sample. Some of these electrons gain enough energy to escape from their atoms – and electrons emitted from atoms near the sample's surface will escape from it altogether. By analysing the energy of these electrons, researchers are able to study surfaces and interfaces in materials at a molecular level as they are formed. ICI has contracted to use up to 35% of the time available on the SCIENTA spectrometer.

Daresbury's expertise in using ion beams will be a factor in RUSTI's development, as will its close collaboration with the existing research programme on the Synchrotron Radiation Source.

RUSTI will spearhead research into a new generation of advanced materials and will help companies to find the most effective ways of processing new materials to make new products.

It will also help academic researchers investigate the fundamental science that underpins methods of materials processing. And by bringing academic and industrial scientists together, RUSTI will also promote the transfer of research and expertise from the science base to companies.

For more information, contact Dr Price at Daresbury, tel 0925 603307, or Bob Startin-Field, SERC Swindon Office, tel (0793) 411435.

SERC bulletin

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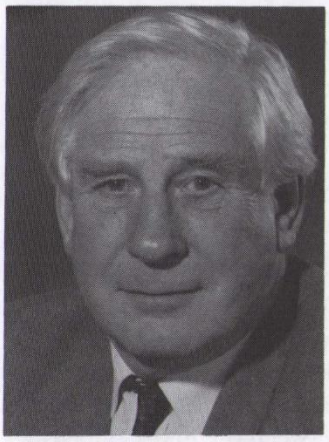
SERC's RESPONSE TO GOVERNMENT WHITE PAPER ON SCIENCE AND TECHNOLOGY

The Government's White Paper on science and technology, entitled *Realising our potential: a strategy for science, engineering and technology*, was published on 26 May, after the Summer edition of *SERC Bulletin* had been printed.

The following is SERC's initial response to the White Paper and was also released on 26 May.

The Science and Engineering Research Council (SERC) is pleased that the White Paper has now been published after a year of debate on the vitally important issue of the Government's approach to Science and Technology. The Council notes with pleasure that the Government considers that the Research Council system has performed well in supporting high quality research. In particular, the Council takes pride in the Government's statement that it wishes to build on the steps already taken by the SERC to develop new approaches to its funding of research and training.

Commenting on the White Paper, the Chairman of the SERC, Sir Mark Richmond, said: "The SERC has pioneered many schemes for encouraging collaborative research with industry, such as Cooperative Awards in Science and Engineering (CASE) and the Teaching Company Scheme, and is now spending £70 million of its budget each year directly on such collaborations. The thrust of the White Paper on exploiting research to enhance industrial competitiveness—embraced in the missions given to Research Councils in the White Paper—builds on this strong base already established by the SERC."



Sir Mark Richmond

In its submission to the Office of Science and Technology during the consultation process, the SERC advocated that clearer missions be set for the Research Councils and welcomes the way this is reflected in the Government's proposals.

The SERC is disappointed, however, that its proposals to form a coherent system by reshaping the Research Councils and the funding of research by Government Departments have not been followed by the Government. If changes are to be made to a system that performs well already, an opportunity has been missed by concentrating the changes on only part of the Research Council arrangements. The increase in the number of Councils from five to six also misses an opportunity to reduce the number of boundaries while still requiring the investment of resources in bringing about the changes.

The SERC is also disappointed that there is no positive indication in the White Paper that the new Councils will have increased resources to enable them to respond to the challenges of their new missions, especially in supporting applied research.

The SERC is nevertheless convinced that the missions given to the new Councils are positive and forward looking, and is committed to the achievement of a successful transition. The new Engineering and Physical Sciences Research Council will, in very large measure, continue the SERC's basic and strategic programmes in general science and engineering. The mission of this new Council corresponds closely to the SERC's current role, stated in its 1993 Corporate Plan, 'to develop capabilities in strategic research related to industrial and social need.' Nearly all of the SERC's current programmes aimed at fulfilling this role will continue under the new Council. This will include support of the SERC's Interdisciplinary Research Centres, the collaborative programmes with the DTI, the training of highly skilled people, and the new Innovative Manufacturing Initiative, launched on 24 May. The SERC expects that universities, under the continuing Dual Support System, will have a central part to play in enabling the new Council to fulfil its mission.

> **'The SERC has pioneered many schemes for encouraging collaborative research with industry . . . . The thrust of the White Paper on exploiting research to enhance industrial competitiveness—embraced in the missions given to Research Councils in the White Paper—builds on this strong base already established by the SERC'**
>
> ***Sir Mark Richmond, Chairman of SERC***

The new Particle Physics and Astronomy Research Council will continue research and training programmes in these fields already supported by the SERC, as part of the SERC's current important role 'to strengthen the UK's capabilities in fundamental research.' The SERC welcomes, and gives strong support to, the commitment made in the White Paper to high quality, basic research as an essential ingredient of the Government's support of science and technology, and the recognition that much basic work in physics and astronomy requires commitment to international collaborations. This new Council will take over responsibility for the SERC's Observatories, now under single management.

Under the new arrangements it seems clear that the SERC's Rutherford Appleton and Daresbury Laboratories will be undertaking work for several of the new Councils. Final decisions for the management of these two establishments will be taken by Government following input from a study, announced in the White Paper, of the detailed allocation of areas of science and technology between the new Councils. The SERC regards it as imperative for effective operation that these two establishments remain under the management of a single Council while undertaking work for several funding agencies.