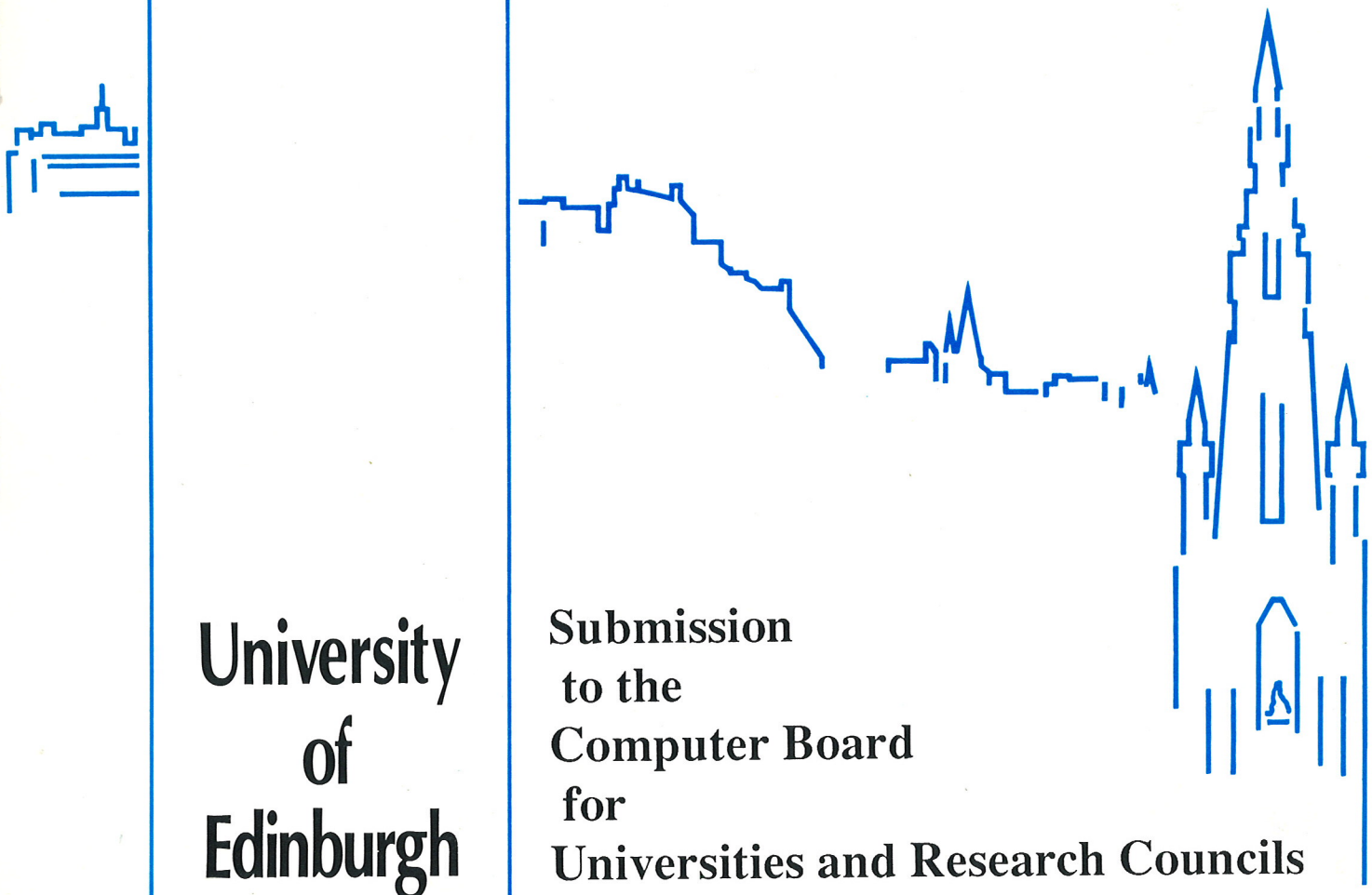
Computing Strategy



University of Edinburgh

Submission
to the
Computer Board
for
Universities and Research Councils

June 1989

Contents

1. Purpose of Paper

This submission by the University of Edinburgh to the Computer Board is a precursor to the allocation of Board funds in 1990 for the replacement of centrally managed systems. Its purpose is to describe current computing activities and to present a strategy for future development on a University-wide basis, along with implementation plans. The equipment needs of the central services from 1990 are assessed and an outline requirement for new systems is provided for the Board to consider. This submission follows a major consultative exercise carried out over the past two years which encompassed every computer user, non-user, faculty and department, and covered academic, research, library and administrative computing.

2. Summary

2.1 Structure

The first 13 sections of this document provide background information on the current state of computing and communications in the University of Edinburgh for academic, administrative and library purposes. Sections 3 and 4 describe the University generally and the relationship of the strategy to the academic plan. An overview of computing at Edinburgh, the relevant committee structure, and descriptions of central and faculty academic computing are given in Sections 5-7. They describe how, over the past 25 years, computing facilities have penetrated into nearly every department and how the use of central timesharing services based on EMAS, Unix and VMS, has continued to grow in parallel with the large growth in distributed computing.

Section 8 covers Computers in Teaching and Research and the trend towards the use of micro laboratories for teaching purposes. Section 9 covers Edinburgh's use of National Centres and Sections 10 and 11 describe the Management Information Service and the Library automation programme. An overview of the support arrangements is given in Section 12. Section 13 describes the Edinburgh communications network including the X.25 Wide Area Network and departmental Local Area Networks.

Section 14 describes the wide ranging consultations which took place prior to the definition of the strategy which is contained in Section 15. A broad implementation plan is given in Section 16 and, finally, Section 17 provides an outline operational requirement for equipment which the University would wish to purchase from the Computer Board 1990 central system replacement funds, to support the basic infrastructure required by the strategy.

Information on the University, computing and communications systems installed, and their usage, is contained in the appendices.

2.2 Strategy

Throughout the planning exercise, consideration was given to the overall information technology requirement of the University. The consultations carried out over a two year period prior to the definition of the strategy were the most extensive ever in Edinburgh. The aim is a more integrated distributed environment, based on a high speed network. This will involve the adoption of standards which will mean the end of the EMAS service and a review of other systems such as the Management Information Service's IBM 4381 and the Library's GEAC 9000. Although by May 1989 there were still some concerns over the planned timescales for the move from EMAS, and on funding, broad agreement had been reached throughout the user community. **The strategy, which the Board is asked to note and approve, will apply to all academic, administrative and library computing and communications.**

The key to the strategy is the installation of a high speed fibre optic trunk network, based on the FDDI standard, interconnecting local area networks based on the ISO 8802/3 Ethernet standard. This is necessary to support the speeds needed for the type of access currently available on local area networks, which will become the expected norm in future on an Edinburgh wide basis. The new network will also support a more intimate integration of distributed local work group facilities with centrally managed services. The existing X.25 network will continue to be supported whilst the new high-speed option is developed.

A more integrated distributed environment will require a greater adherence to standards at all levels and it will be the University's policy to adopt these wherever possible particularly in the areas of operating systems, applications and communications.

As stated earlier, the new strategy includes the demise of the EMAS service and its replacement by distributed and central facilities running standard operating systems. Multi-user systems will in future be based primarily on Unix with support being maintained for VMS. Support for

distributed personal systems will be concentrated on UNIX and OS/2 with DOS and Macintosh PCs being sustained for some time. It will be the University's policy to maintain its support for access to high powered computing facilities through the development of novel architectures. Reviews of administrative and library computing facilities are underway and the new policy will affect their future choice of systems. The central Management Information Service IBM 4381 system is due for replacement in 1991 and the Library's GEAC 9000 in 1993.

The management, support and funding of an integrated, distributed environment will involve major changes and the University's policy will be to rationalise the existing management and support structures. Available funds, from whatever source, will also be coordinated for academic, administrative and library computing and communications.

2.3 Implementation

The implementation of the strategy will be performed over a number of years. Actual timescales will depend on the availability of the required technology, funds and other resources. A project has been established, named "Project Forth" to coordinate the various strands of implementation. Initially, two project teams have been formed to look after the development of the new communications network and the transition from EMAS. These will be major undertakings and a phased implementation plan has been developed. This targets August 1992 as the end-date for the EMAS service which will require a viable central Unix service to be established by the end of the current academic year. **Board agreement is also required on the continuing provision of an EMAS service in parallel with an enhanced central UNIX service whilst the transition is carried out, and the Board is asked to approve this proposal.**

Each department will be assisted to develop a local plan for computing and communications which will allow them to slot into the new environment at an appropriate time.

It is expected that there will be few problems in accommodating the UFC Management and Administrative Computing Initiative's Blueprint within the strategy and the University is due to submit its Migration Strategy for Administrative Computing to the UFC by the end of July. The future of the IBM 4381 will be reviewed over the next year and systems which will be easier to integrate into the new environment will be investigated. The Library's Automation Sub-Committee has already begun its review for the 1990s and will consider alternatives for the system which will replace the GEAC 9000 after 1993.

The network strategy calls for an FDDI backbone serving building or departmental Ethernets through bridges and, although the standard products are unlikely to be available by the summer of 1990, the University is anxious to use FDDI as soon as possible as it offers unique possibilities for tackling the geographical problems of the split Edinburgh campus. A phased plan has been developed which will involve the installation, in Phase 1, of fibre in the three major concentrations of departments, ie. the King's Buildings, George Square and the Old College and spanning the 2.5 mile gap between the main sites.

Under the plan, most departmental Ethernets will be bridged to their local Ethernet spine and the link between the new high-speed network and the X.25 network will be achieved by the use of Ethernet based Pink Book gateways. The transition from Ethernet to an FDDI backbone will proceed when the technology is available.

The IT infrastructure beneath the user services will be managed as a single entity and the different service groups and departments will manage their own various services. Human resources will be more closely allied with the user groups and clusters which will develop, and some redeployments might be necessary as the emphasis increasingly moves from centralised to distributed computing.

A figure of around £18 million is felt to be a realistic estimate of the expenditure required, and at the current average spend of £3 million per annum this is felt to be achievable. Improvements to the current arrangements for the procurement of systems and services such as

hardware maintenance are being actively investigated to help contain the cost of further distribution.

2.4 Operational Requirement

The Computer Board's seven year funds provide the opportunity to give the computing strategy the necessary initial impetus. As this is a time of transition however, the need is for a number of small procurements, spread over several years, rather than a single substantial one. **The University requests the Board's advice on the best way to proceed as there must be some question as to how far the standard procurement procedures are appropriate in this instance.**

2.4.1 Communications

The University will meet the cost of laying cables within buildings and between the King's Buildings and the central area. **The Board is requested to meet at least the initial part of the cost of bridges and other electronic components of the network. In 1990, £300k is requested for links to existing Ethernets, bridges to the KB-Central area link, X.25 gateways, a Network management station, Ethernet repeaters and spine components. In 1991, £185k is needed for FDDI and Megastream bridges and FDDI-X.25 gateways and, in 1992, £65k for more FDDI bridges.**

2.4.2 Central Services

The existing EMAS service needs to be sustained until 1992 to allow for an orderly transfer to other facilities. A modest expansion of the existing VMS service is also required and there is a need for a high power conventional compute server and for a central file archive. The existing Unix service will have to be expanded and it is proposed that this take place in two phases. The need in 1990 is to acquire a substantial stand-alone configuration. By the end of the EMAS service, demand for Unix will have increased and this capacity could be obtained in two ways. The most obvious would be to enhance the existing Unix configuration or to buy a supplementary machine. Alternatively, a Unix service could be developed on an IBM architecture machine running in parallel with EMAS. If this was possible, it would enable the run down of the resources serving EMAS to be matched by an increase in those serving Unix.

The Board is asked to consider the allocation of £350k in 1990 for a machine to sustain the EMAS service until 1992 and to help to provide a Unix service thereafter, £250k for an upgrade to the VMS service and £300k for a new central Unix provision.

In 1991, £100k is requested for a high power compute server, £100k for an upgrade to the IBM architecture machine to support Unix expansion and, in 1992, £150k for a central archive facility.

2.4.3 Centrally Managed Distributed Facilities

The University seeks approval to use part of the Board grant to seed various facilities around the University to encourage the growth of distributed computing. These include seven filestores serving particular faculties or groups of departments and workstation/micro laboratories in Biological Sciences and Arts and in existing public terminal areas. **In 1990, £300k is requested for filestores, £200k for Biological Sciences/Arts workstation/micro laboratories, £100k for public workstation/micro access and £50k for X terminal public access.**

2.4.4 Software

The precise software requirements will depend on circumstances and **all that is proposed is an allocation of £100k, spread over 3 years, to meet such costs.**

3. The University of Edinburgh

Edinburgh is one of the largest universities in Britain, employing around 1500 academic staff and teaching a population of 12,121 students - 8,921 full-time undergraduates and 1636 post-graduates plus 355 part-time undergraduates and 1209 postgraduates. There are in the region of 120 separate academic departments and research units at Edinburgh, organised in 8 faculties, covering nearly all subjects of study. The full-time students in each of these are approximately: Music 66; Divinity 229; Veterinary Medicine 387; Law 690; Medicine 1254; Social Sciences 1986; Arts 2481; Science 3464.

Many of the buildings of Edinburgh University are of architectural and historical interest and they are grouped in 5 main precincts and various other sites across the city *(see Appendix 1)*. The main concentrations are on the King's Buildings site (Science campus) and in the George Square Area (Arts, Social Science, central Medical, Music). The Faculty of Divinity is located in the New College, and the Old College houses the University's central administration, the Management Information Services Unit and the Faculty of Law. Veterinary Medicine is split between the centre of Edinburgh and its Field station at Bush Estate, some 7 miles south, and the Faculty of Medicine has departments located in most of the hospitals spread throughout the city.

Edinburgh is a major international centre for research, and the University has an annual income from external research contracts currently running at over £20 million. Academics in Edinburgh are at the forefront of developments in the study and application of modern languages, micro-electronics, biotechnology, computer-based disciplines and many other subjects. Edinburgh's standing as a research centre is further enhanced by the presence on and around the University precincts of many independently-funded, but linked, national research institutes.

The role of the University, as specified in its academic plan, is to maintain its long-term objective of promoting excellence in teaching and research across a wide range of disciplines. Great importance is attached to the traditional Scottish degree curriculum which emphasises breadth and provides flexibility; the University believes that, while there is a need for graduates trained in specialist subjects to the highest standards, those emerging from the University should not be constrained by the traditional boundaries between disciplines. Breadth in the University also provides opportunities for interaction in teaching and research which is highly beneficial: the University offers, for example, a very wide range of joint honours degrees (some 60-70 such combinations in the Faculties of Arts and Social Sciences alone), and has numerous inter-disciplinary research projects in, for example, molecular biology/biochemistry/chemistry, the Institutes for Advanced Studies in the Humanities, and the Social Sciences Research Centre.

4. Relationship of Strategy to The Academic Plan

The proposed strategy offers the University the basis of an information technology support infrastructure which will assist it to achieve its objectives at a time of constrained funding and reduced staff numbers, by enabling staff and students across disciplines to share widely dispersed teaching and research facilities, data and information, library and administrative resources, more quickly and easily by electronic means.

New computing and communications technologies will allow teaching practices to be enhanced and facilities to be shared between departments at different locations which might be involved in joint degree courses. Computer assisted learning techniques will in some areas compensate for the reduction in numbers of teaching staff. Faster, better access to data and information will allow research, particularly inter-disciplinary projects, to proceed more quickly and effectively across world-wide geographic boundaries and access to the best possible technology will be essential if the University is to remain at the forefront in an increasingly competitive arena.

The strategy also caters for the growing demand for the provision of better, more timely, management information, and allows better use to be made of the existing resources committed to the support of information technology services throughout the University.

5. Computing at The University of Edinburgh

5.1 Overview

The University of Edinburgh recently celebrated the 25th anniversary of the founding of the Computing Laboratory by Professor Michaelson. A few years later, in 1966, the Edinburgh Regional Computing Centre (ERCC) was set up as a result of the Flowers Report. Its successor, the Edinburgh University Computing Service (EUCS) was formed in 1987 from the merger of ERCC and the Centre for Applications Software and Technology (CAST) an organisation which itself had been formed from an off-shoot of ERCC, the Program Library Unit (PLU). Since its beginnings in 1963 computing has penetrated throughout the University to the point where today over 90% of departments make some use of it as a tool for teaching, research or administration.

Edinburgh's initial remit was to concentrate on interactive services, with the convenience of access that implied. It was accepted as a fundamental principle that the use of computers should be as easy and convenient as possible, and that users should not have to become "computer experts". It was also recognised that not all problems could necessarily be solved on a single service and this, and the University's scattered nature, led to the early development of expertise in computer networking, the acceptance of the proposition that all computers should be capable of being connected to a common network, and of the importance of standard protocols. This basic philosophy is continued for the coming decade in the strategy proposed later in this paper.

During the 1970s this philosophy encouraged departments to develop their own computing facilities: these initial developments in distributed computing were based on multi-user mini computers. The continual improvement in the price/performance ratio of these systems, plus the introduction of microcomputers in the late seventies, led to the position today where the distribution of computing systems in Edinburgh is probably greater than in most other comparable institutions in the U.K. There are now in excess of 30 multi-user systems and 2000 micro computers in addition to centrally managed facilities which are accessible from over 1600 network connections in Edinburgh *(see Appendix 2)*.

The use of computing by departments led to areas of special expertise including, for example, parallel computing, which the Department of Physics saw as a useful tool for their development of computing in physics research and which is now of wider interest within the University and externally. Similarly, Edinburgh's molecular biologists developed expertise in biocomputing which led to the establishment of the Biocomputing Research Unit; the Department of Geography is renowned for its work in Geographic Information Systems; the Edinburgh Computer Aided Architectural Design (EdCAAD) research unit is a leader in its field, and there are many other areas where the use of computing in research work has led to a special expertise in applied computing.

In the early 1980s, those departments carrying out research into the various aspects of computing itself were grouped into the School of Information Technology. This was formed to promote academic co-operation in this field and is a federation of departments which crosses faculty boundaries. It includes the Departments of Computer Science, Electrical Engineering and Artificial Intelligence, all of whom are recognised world-wide as leaders in their fields. In addition, they have used computers as tools for their research and their use has normally been in advance of the rest of the University which has benefited generally from their expertise. Also forming part of the School of I.T. are the Artificial Intelligence Applications Institute and the Centre for Speech Technology Research, both of which are actively researching into areas of computing which will be of wider interest in coming years to University and external computing.

5.2 Central Service Organisations

The provision of centrally managed computing services is split between the Computing Service and the Management Information Services Unit. A further major central service, the University Library, uses both its own computing facilities and the centrally managed services to enhance its services to the University.

With the increasing use of computers in library automation and administration, the computing activities of these three organisations are increasingly overlapping and the computing strategy and organisational changes proposed later in this paper attempt to integrate these independent units into a University-wide Information Technology support environment.

The Computing Service manages and supports central academic facilities which include, in addition to VMS and Unix multi-user services, the Edinburgh Multi-Access System (EMAS), which has been the major central service for over fifteen years. EUCS also supports the University-wide communications network (EDNET) and provides technical advice and support to departments, not only on central facilities and the communications network, but also on the procurement and use of computing systems in general. Facilities management is also undertaken on behalf of departments; for example the School of Information Technology's multi-user Gould system and the parallel processing systems in conjunction with the Department of Physics.

The focal point for administrative computing in the University is Management Information Services which originally serviced the needs of the Secretary's and Finance Offices. In recent years, its support has extended to Faculty Offices and other administrative units throughout the University.

The University Library has undertaken a major automation programme with the aims of providing responsive, professional, efficient and cost-effective bibliographic and reader services; computing has also been introduced into the library's internal administration and management.

5.3 Computing Policy Committee

The principal committee concerned with computing in the University of Edinburgh is the Computing Policy Committee (CPC). This has a membership representing all parts of the University, and its remit covers all computing, including library and administrative computing. It has no official executive authority but it is a standing committee of the University Court and its views therefore carry considerable weight. It meets at least once a term and it provides advice to the University Court through the Planning and Resources Committee, and to Senatus Academicus through Educational Policy Committee (on policy implementation and operations). This is shown diagrammatically in *Appendix 3*.

A number of sub-committees report to the Computing Policy Committee, the most important of which is the Convener's Sub-Committee, which comprises the conveners of the other sub-committees, the Director of the Computing Service and the University's Director of Finance. This committee meets once a month and deals directly with urgent matters and a number of minor ones. Its main function is to identify emerging issues for the main committee to consider and, since 1987, the membership of this committee has been expanded to guide the planning exercise which has resulted in this document.

Other sub-committees include the Users' Committee, consisting (as far as is possible) of a representative set of users in all fields of computing, and the Computing Equipment Panel which meets periodically to comment on the technical adequacy of proposals to purchase computing equipment including software. The latter's main function is to provide expert advice and to try to avoid unnecessary incompatibility with other equipment and standards in use elsewhere in the University.

The coordination of academic, administrative and library computing is the function of the Computing Policy Committee, and it is assisted in this by a technical coordination group,

consisting of the Directors of the Computing Service and Management Information Services, and the University Librarian.

There are also numerous ad hoc groups including a number of special interest groups concerned with a particular aspect of computing, for example parallel processing, graphics, statistics, VMS, Unix, IBM PC, Apple Macintosh etc. which are represented on the Users Committee.

6. Central Academic Computing Facilities

6.1 Introduction

The main central computing facilities for academic purposes are located within the Computing Service. These are based on 3 major timesharing systems: the EMAS service running on a NAS EX/40 machine; a VMS service running on a DEC VAX 8530; and Unix services running on hardware from Gould and Sequent. Specialised supercomputing facilities are also supported on a Meiko Supercomputer and two AMT Distributed Array Processors.

(The current configurations of these central academic systems are shown diagrammatically in Appendix 4, plus usage statistics and details of package availability.)

6.2 EMAS Service

The EMAS service has been running on the NAS system since the middle of 1988, having replaced the Amdahl 470 series equipment which in turn replaced the ICL 2900 machines as a result of the mid-term Computer Board Review. EMAS has been the main provider of large scale, general purpose computing in the University of Edinburgh for over fifteen years and it is not surprising, therefore, that its use is widespread in all of the main departmental groupings and faculties. The strengths of the service continue to be its exceptionally effective use of system resources, which enables it to sustain high levels of simultaneous user activity with good response characteristics, and its comprehensive user file backup and archive facilities. Despite the growth in distributed and departmental computing, the demand for the EMAS service has remained high with new undergraduate courses replacing those which have moved to departmental or faculty funded micro laboratories.

Overall, EMAS provides the major proportion of the service delivered to centrally supported time-shared users. It supports peak simultaneous user loads of over 200 from an accredited population of 6500 users. Over 4000 interactive sessions are supported per day in peak term-time conditions with 1100 individual users active in a day. In addition some 400-500 batch jobs are processed each day. The central long-term archive continues to grow and now comprises half a million files amounting to 80 gigabytes of data; this is held currently on 3500 magnetic tapes. The major growth area since the University's last report to the Computer Board, however, has been in network-related services: some 2200 mail messages are delivered to EMAS users daily, requiring 1600 transfers with other hosts; in all, 2000 file transfers are performed daily involving 30 megabytes of data; device spooling accounts for the dispatch of 2200 documents per day to 120 remote printers totalling 50 megabytes of data. The "Edinburgh" mail service, which centrally co-ordinates mail for other Edinburgh University hosts and provides remote directory management facilities, is also hosted on EMAS. In addition, most of the University's centrally delivered applications package service is provided on this service, with statistical and graphical work predominating along with general documentation production.

6.3 Central VMS Service

Using University funds, the central VMS service was introduced six years ago as a complementary service to EMAS to provide more ready access to a wide range of commercial package software. This is still the main role of the VMS service and the user base has been gradually widening. In 1986/87 most of the cpu power went into university research projects, but more recently there has been a significant increase in its use for undergraduate courses.

The service is based on a VAX 8530 configuration which lacks the cpu power to satisfy peak demand, but an even greater problem has been the shortage of file space to satisfy the requirements of database and data library services. It is hoped that the imminent introduction of a file archive service will improve matters, but more space will still be needed.

The VAX is at present the principal machine for the provision of database and data manipulation software. ORACLE is provided on VMS alone and the UWGCG "Wisconsin" databases, of special interest to molecular biologists, are also mounted. The VAX is often the first choice for the provision of commercially available software: examples of "VMS-unique" provisions are LUSAS, PAFEC, SAS and REDUCE, and packages such as SIR, SPSS-X and SAS are also heavily used, particularly by social scientists.

6.4 Central Unix Services

The Computing Service currently provides a central Unix service on both a Gould NP1 and a Sequent Symmetry. Both of these systems are being evaluated prior to a major investment on one of them from University funds. The proposed configuration will provide at least 14 Mips of performance and have 5 Gigabytes of disc space.

A 10 Mips Gould PN9080, running Unix version 4.3 BSD, is managed on behalf of the School of Information Technology. 10% of this system is also dedicated to general University access. It supports a total user population of some 1300 users, running up to 80 simultaneously. It is mainly used for undergraduate teaching and 88% of the cpu power went to this in 1987/88.

6.5 Specialised High Power Computing Facilities

The specialised computing facilities currently include a very large Meiko Computing Surface, two AMT Distributed Array Processors (DAPs), and a vector processing capability attached to a conventional mini-super computer, the Gould NP1.

Software support for the Meiko machine is provided by two distinct operating system options; the M^2VCS system and the more conventional Unix operating system. Work is progressing at Edinburgh on the development of a Unix based service and the associated communications facilities.

The potential importance of computing systems with high performance based on massive parallelism was recognised in the Forty Report on Advanced Research Computing (June 1985) and Edinburgh has been at the forefront of these developments.

The Edinburgh Concurrent Supercomputer (ECS) Project, in collaboration with Meiko Limited, has received Computer Board, DTI and SERC support to a total of £1.4 million to date. A second phase proposal is currently under consideration by the funding bodies. There is also an industrial affiliation scheme associated with the project which has attracted, in cash or kind, an investment of some £430k from industry.

The exploitation of these facilities does of course require new programs to be written or existing ones adapted, and there is a need for high power conventional processing power. This is at present met locally on the EMAS NAS machine but the numerically demanding work often exceeds the capabilities of this general purpose computer.

7. Faculty Computing

7.1 Introduction

Throughout the eight faculties in the University of Edinburgh the penetration of computing varies considerably, with the main concentration being within the Faculty of Science. The Faculty of Social Sciences is probably the next most intensive user with Medicine being an area where the application of computing has for many years been concentrated in a few specialised pockets but has recently been applied more generally. The Faculties of Veterinary Medicine, Law, Arts, Divinity and Music are increasingly seeing benefits to be gained from the introduction of new technology but are hampered by various factors particularly the lack of funds and support resource which are increasingly proving to be inhibiting factors in all the other faculties as well.

Although there is a wide diversity of systems installed in departments throughout the University, a reasonable degree of consistency is now being achieved. Departmental multi-user systems are primarily Unix based but a few use VMS. High powered workstations are almost entirely Unix based with the vast majority running on SUN hardware. The extreme diversity in microcomputers which bedevilled the management and support of computing in the first half of the 1980s has now to a large extent been overcome, with the bulk of systems procured now being based on either DOS based IBM PCs and clones or the Apple Macintosh. Even this reduced level of inconsistency, however, has its problems, particularly in network integration.

In recent years, very few multi-user departmental systems have been purchased. The "user friendly" attractions of workstations and PCs plus the ability to buy a few more each year, has pushed most users in this direction. This pattern may change if multi-user systems can be made more attractive by the introduction of windowing terminals and the problem of the costs involved in maintaining and supporting personal systems can be overcome. *(Details of systems installed in departments are contained in Appendix 2)*

7.2 Faculty of Science

Science is the biggest user of computing in the University and is the largest user of the central EMAS and VMS services, with most departments making some use. Whilst there will be a major move towards more distributed computing in this faculty in the coming years, if funding permits, there will be a continuing need for powerful centrally managed facilities. In some departments, nearly all computing has been concentrated on EMAS for many years and the transfer to alternative solutions will be a major undertaking.

Several Science departments, including Molecular Biology, Civil Engineering, Physics, Genetics, Forestry and Natural Resources and Zoology, are also major users of the central VMS service and wish to continue to use it and expect enhancements to be carried out to cope with their growing demands. The biological scientists and others make considerable use of the Wisconsin DNA sequencing package which is currently VMS specific. In addition to a heavy involvement in parallel computing, the Department of Physics has departmental facilities based primarily on VMS though a Unix teaching facility is being set up, and is the largest user of the EMAS service.

Those departments which carry out research into aspects of computing, such as Computer Science, Electrical Engineering and Artificial Intelligence, are primarily Unix based. They already have advanced installations of Ethernet local area networks supporting local filestores and many workstations in addition to several Unix multi-user mini systems from a variety of manufacturers: some VMS systems are also installed. Very high speed networking will be essential for many departments in the Faculty of Science, but particularly for those in the School of Information Technology.

The other engineering departments (Chemical, Mechanical and Civil) have until recently concentrated most of their work on EMAS but this has now been complemented by a major SUN workstation LAN facility. Within the School of Agriculture, some staff make use of central

EMAS and VMS services but their local facilities, which have to satisfy the dual requirements of both the University School and the Department of Agriculture and Fisheries' College of Agriculture, are based primarily on VMS. Personal computers of varying types are used throughout the faculty with departments such as Chemical Engineering and Chemistry using them for real-time data capture whilst others such as Forestry and Natural Resources and Geology have adopted them for teaching.

7.3 Faculty of Social Sciences

The computing community within the Faculty of Social Sciences is diverse, with major use being made of personal computers, central EMAS and VMS services and departmental multi-user minis and high powered workstations. Some departments concentrate on the IBM PC (or compatible) environment, particularly the departments of Business Studies, Accounting and Business Methods and Economics as this is the standard in industry and commerce. The Department of Economics also has a VMS system. The three departments are currently preparing to interconnect equipment on a LAN. Within the Social Studies grouping and several other departments, the Apple Macintosh is the preferred desk-top solution.

The Department of Architecture and the Edinburgh Computer Aided Architectural Design (EdCAAD) research unit have been long standing users of Unix and have a well established local area network with SUN workstations and a multi-user mini. The department has also recently adopted Apple Macintoshes for some teaching purposes. The Department of Geography has a departmental VMS system which supports work on geographic information systems, their choice of VMS being influenced by the many shared projects with external organisations, and commercial software package availability.

Major users of central services in this faculty have been the Departments of Economic and Social History, Sociology and Psychology and the Centre for Educational Sociology (CES). Economic and Social History have been long standing users of EMAS and have accumulated large amounts of data which will require long term storage, and CES have been major users of the central VMS service for the commercial packages which are essential for their survey work.

Whilst much of the computing of this Faculty will be carried out in future on personal systems, there will be a substantial continuing need for centrally managed facilities, particularly for statistical and database packages and long term archive.

7.4 Faculty of Arts

Within the Faculty of Arts, computing technology has now developed to the stage where it can be a useful tool for most departments but there are complex requirements, such as multi-lingual text processing in languages such as Chinese and Japanese, which will require much more mature technology than is available at a reasonable price today.

Some departments use the central EMAS service for word processing, statistical analysis, text analysis etc., and over the past few years nearly all have introduced micro computers (mainly IBM PC and Macintosh) in small numbers, often one shared between two departments and often shared between academic and secretarial staff. Plans are currently in hand for shared micro laboratories for teaching and research purposes, this being seen as the only economic way of providing the type of modern facilities required in the Faculty of Arts to a wide number of staff. This in itself is unlikely to satisfy a fast growing demand in an area which has not traditionally been a major computer user (apart from the Department of Linguistics which has been heavily involved in advanced computing since the early 1970s and has close links with departments in the School of Information Technology).

7.5 Faculty of Divinity

At present, around half the members of staff in the Faculty of Divinity make use of computers, both personal computers and the central EMAS service. They see the bulk of their future needs being met on distributed systems. The heaviest use is in multi-lingual word processing for writing articles, books and theses but work is also carried out in text searching and analysis. The use of computers is now crucial for research work in certain areas of Divinity and the demands are complex often involving the requirement for Greek, Hebrew, Arabic and English on the same page of output.

In common with other small faculties, Divinity's main problem has been a lack of adequate funding to meet their growing computing needs. They are also affected by their location which is detached from the main concentrations of University accommodation and the historic nature of their building, both of which make communications charges higher and public facilities less accessible.

7.6 Faculty of Law

The Faculty of Law has made good progress in computing over the past few years. A decision was taken some time ago that a distributed environment was the correct solution to their computing requirements and a plan was developed for a phased implementation which would take several years to come to fruition. Each secretary has a personal computer with a network connection on the desk and systems are being distributed to staff as fast as funds will allow. They are dependent on DOS based PCs and want to be sure that their investment strategy will be effective for a considerable number of years.

A faculty wide local area network is currently being installed, based on Ethernet, to link all the PCs and support a local filestore. An imminent growth area is the setting up and management of a Scots Law Database which may require the installation of a powerful multi-user system with large amounts of disc storage. This system will be integrated into their LAN.

7.7 Faculty of Medicine

The Faculty of Medicine, including the School of Dentistry, consists of a large number of departments at several sites spread throughout Edinburgh, some on University premises, some in Health Board accommodation. There are widely differing backgrounds in computing usage throughout the Faculty and a further complication is the need for interaction with the local Health Board. Any close integration of University and NHS facilities via network links does of course raise major security issues. Spread as it is over several hospitals in Edinburgh, the maintenance and improvement of communications links is very important to this faculty. Apart from the need in most departments for access to central services for electronic mail and statistical packages, there is some requirement for high speed links to the parallel processing facilities in the Computing Service.

Although most of the computing within the faculty is based on distributed systems, mainly personal computers (IBM PC and BBC micros), there are several groups who make heavy use of EMAS for statistical package work and there is a long term need for access to such facilities particularly for teaching large numbers of students. There is also a substantial VMS facility within Medical Physics and Medical Engineering and a Unix one in the Medical Statistics Unit (part of the Department of Community Medicine). The analysis of images is seen as a growth area and Computer Assisted Learning (CAL) is likely to be very useful in some areas of Medicine. The existing use of the Wisconsin DNA sequencing package is also likely to grow considerably. A recent development has been the installation of a new shared microcomputing laboratory within the Erskine Medical Library.

7.8 Faculty of Music

The Faculty of Music is a small faculty and historically has had little involvement in computing. In recent years, however, a powerful SUN workstation has been acquired which is connected to the network. Around this system, an electronic music studio has been developed which involves sophisticated real-time computing techniques and sound synthesis and generates large amounts of data. This Faculty also intends to make use of personal computers for staff and student manuscript production.

7.9 Faculty of Veterinary Medicine

The Faculty of Veterinary Medicine in Edinburgh recently underwent some internal reorganisation and is now subject to the uncertainties relating to the UFC recommendations on the future of the Veterinary Schools. This might involve relocations within their existing accommodation, and increases in the number of staff and students in Edinburgh. This makes future planning very difficult at present.

Veterinary Medicine has been a user of computing since the early 1970s in areas such as real-time data capture, statistical analysis and database systems. In addition to some use of personal computers, they have made substantial use of central systems, initially developing databases on EMAS which were subsequently transferred to Oracle on the VMS service. They are also involved in DNA sequencing with the Department of Molecular Biology. Consideration is currently being given to a microcomputer laboratory for teaching and research purposes.

8. Computers in Teaching and Research

8.1 Teaching

Computers are used widely throughout the university for the preparation of teaching material such as slides and lecture notes, and the growth in student use of word processing for essays and the like is expected to continue and accelerate over the next few years. There are varying opinions around the University on the benefits of computer aided learning, particularly as the work involved in developing CAL systems is a disincentive to many. Excellent progress has already been made, however, in many subject areas (assisted by the Computer Board Computers in Teaching Initiative) and it is generally felt that CAL will make a major impact over the next ten years, particularly in language-based studies and medicine.

The trend recently has been an increase in the use of microcomputer teaching laboratories which has resulted in a levelling off of the use of central and departmental multi-user systems. Although cheaper and easier to manage, these do not at present offer the user interface available on microcomputers and workstations which is so attractive to students, particularly in non-science disciplines, and which reduces considerably the initial learning time for both staff and students. Such laboratory facilities are already installed in a number of areas including the School of Information Technology, Social Sciences, Forestry and Natural Resources, Earth Sciences and Medicine, and a public laboratory has also been centrally funded and supported. The normal practice now is for several departments to share a teaching laboratory, including the initial start-up and running costs, and some central funds have been made available in these instances to assist with the communications aspects. Plans are in hand for new facilities in the Faculties of Arts and Veterinary Medicine.

The general opinion around the university is that the current provision of laboratory teaching facilities is modest for a university the size of Edinburgh and more emphasis must be placed on them in future.

Support is provided by the User Support Teams in the Computing Service, the Teaching, Learning and Assessment (TLA) Centre, and by individual departments, and consideration is now being given by the Computing Policy Committee and the Teaching Learning and Assessment Committee on how best to improve this support and increase the provision of facilities for computers in teaching.

8.2 Research

There is no clear distinction between computing equipment used for teaching and that used for research, except in the case of certain equipment funded through research grants. Even in the case of micro laboratories set up specifically for teaching, the laboratories are open to all comers when not booked for particular classes and are used by postgraduates and staff. A survey could be conducted to gather estimates of the scale of use of equipment for the two purposes but the result would be somewhat subjective and it has not been attempted for the purpose of this document. Other sections however, particularly that on Faculty Computing (Section 7) do indicate certain important areas of research in which computers are used.

9. National Centres

In recent years, Edinburgh has made relatively little use of the National Centres, probably due to the local provision of high powered parallel processors (initially ICL DAPs and now the Meiko Computing Surface and AMT DAPs). The ULCC Cray is used by the Department of Chemistry in a Class 1 peer-reviewed project, whilst the ULCC Amdahl (CMS) is used by Social Sciences. Meteorology and Chemistry make use of the MCC Amdahl VP and CMS services and use is also made of CERN and Daresbury by Edinburgh Physicists. The University Library contributes to the CURL database held at MCC.

The future scale of use of National Centres is not clear, but is likely to be small and restricted to the use of very specialised software rather than merely the use of a very powerful machine. Machines offering a significant fraction of the power of a Cray are beginning to appear at prices within the range of individual universities, with the opportunity for graphical connections which could not be supported over JANET. The relevance and cost effectiveness of National Centres as a source of pure computing power must therefore be in serious question.

10. Administrative Computing

The focal point for administrative computing in the University is Management Information Services (MIS) which originally serviced the needs simply of the Secretary's and Finance Offices. In recent years its support has extended to Faculty Offices and most recently to departmental administration. The services offered by MIS include finance systems, student records, personnel and payroll, estates and buildings, office systems and end user support.

The bulk of the computer based data managed by MIS is held on an IBM system (model 4381 running VM/SP, CMS and VSE). This has resulted in a dependence on the use of 3270 full screen working on which most of the main MIS applications rely. Although coping reasonably with current loads, the expected increase in end user access and major new applications will require increased processor power and file space in the near future. MIS and EUCS are currently working on interim improvements to access to the IBM from EDNET, and a pilot project is being undertaken in an administrative office which will provide experience in applying local work group/LAN technology in an administrative environment.

The UFC Management and Administrative Computing initiative currently under way will significantly influence the provision of administrative services by MIS. Although the emphasis of the Initiative will be on portable software solutions, it remains to be seen to what extent these can be made available on IBM hardware. The growing need for access to administrative data by academic departments, and for better integration of the communications infrastructure, will require a careful assessment of whether a move away from IBM systems should be made.

11. Library Automation

The University Library offers services on eight major sites and a number of smaller locations and a networked environment is essential to its operations. It presently offers an online public access catalogue (OPAC) and automated borrowing facilities using a GEAC machine which is a host on the University network. The Library is currently engaged in the transition from the GEAC 8000 (installed in 1983) to a GEAC 9000 system and expects to have extended its operations to book and serials acquisition, budgetary control and management information on this system within a year. The Library looks to full compatibility with the University network by the mid 1990s and is committed to the adoption of OSI protocols as they emerge.

The Library service depends not only on the GEAC system but on the Computing Service mainframe for its networked information service, including a second copy of the catalogue and the union list of serials in Edinburgh and the other seven Scottish university libraries. The Library uses the Janet and PSS gateways for access to the British Library for inter-library loans, to other library catalogues, and to commercial and other database providers for on-line information retrieval. It is developing (on behalf of SALBIN, the Scottish Academic Libraries Bibliographic Information Network) a user-friendly micro-based interface for reader access to a wide variety of library databases on Janet. This is at the evaluation stage and has been funded by the UFC.

The Library is increasing its use of micro-based packages and is rapidly expanding its provision of data on CD-ROM. It is about to experiment with document image processing of non-copyright materials.

The construction of its bibliographic database is likely to continue to occupy much of the Library's attention for some years to come. Its retroconversion programme (costing about £2M over 8 years) is one of the most comprehensive in the UK. At present the public file contains about 350,000 records. The Library expects to need to mount about one million records over the next decade and to have to provide for up to 400 simultaneous users. All bibliographic data are compiled to international standards and are fully portable. The map database will include graphic information using the Cartonet software developed by the Department of Geography.

The Library contributes to and derives records from the CURL database held at MCC. It also co-operates with the EUCS Data Library team in the provision of full-text databases and other data library services, and envisages a rapid increase in demand for database services in general.

12. Support

Support for computing is provided in various ways within the University. The Computing Service provides support to academic and research users and the Management Information Services Unit supports the central administration and over 50 other related units. The University Library supports its own central services, distributed libraries and assists departments to make use of local and external information systems. Many departments also have their own dedicated computing support staff and the numbers involved in all of these areas are included in *Appendix 5*.

During 1987 the Computing Service made major changes to its support arrangements. Instead of a central advisory service, teams of staff were allocated to the support of groups of departments around the University in broadly related areas and these new arrangements have been very well received. It is felt that more resource will have to be dedicated to this type of user support in future to cope with the growing number of non-scientific users.

The Training Unit in the Computing Service offers a series of courses for staff and post-graduate students covering a wide range of subjects. In recent years more emphasis has been placed on courses for personal computer users such as introductions to spreadsheets, DOS, Apple Macintosh etc. whilst the traditional mainframe and programming courses have been maintained at the same level. Some courses have been modularised and plans are in hand to procure and, if necessary, produce videos on some topics to allow users to engage in self teaching.

The Computing Service initiates, and is involved in, negotiations with manufacturers and suppliers on behalf of the University for the procurement of hardware, software and services such as hardware maintenance. Purchases of hardware and software are currently in excess of £1 million per annum and the maintenance contracts negotiated and administered on behalf of the University are valued at approximately £500k. Users are also able to buy consumables from EUCS and annual sales are currently in the region of £100k.

"Shop fronts" have been established to assist users with their procurements in specialised areas. The Micro and Graphics shops work closely with the User Support Teams and offer a platform to suppliers who might wish to demonstrate their products. Consideration is now being given to the establishment of a Unix shop to support the continued growth of distributed Unix facilities encouraged by the University's strategy.

13. Communications

13.1 Introduction

The main University campus network carries mainly academic and research traffic to the central and departmental services. It also supports some administrative and library computing although, to support IBM and GEAC specific facilities, both these organisations have at present substantial dedicated networks which it is intended will be supplanted by the main University network as part of the new strategy. The network has been built up using Computer Board and University funds and is shown in *Appendix 6*.

The Computing Service is responsible for the design, development and maintenance of networking facilities throughout the University and departmental networks are expected, wherever possible, to conform to University policy which is consistent with the Joint Network Team's policies.

13.2 Wide Area Networking

Since the commencement of the X.25 network in 1983, it has been a consistent policy to ensure a very high degree of interconnection between all the varying operating systems in use in the University of Edinburgh and to facilitate connection with other Universities via JANET, to other academic networks via gateways on JANET, and to the rest of the world via the gateway to the public packet switched services PSS and IPSS.

The Wide Area Network comprises seven X.25 packet switches, supporting nearly 200 synchronous ports running at speeds up to 156 kbit/s. The equipment attached to the packet switches comprises some 103 PADs supporting over 1600 asynchronous terminals and micros, 25 departmental minis including the Library and Administrative machines, EUCS mainframes, supercomputers, and five network support and management machines.

The network carries some 14 million data packets per day in term time with a total data content of some 980 million bytes per day. The peak rate per hour that has been observed on a single switch is 375,000 data packets (an average of 104 packets/s).

The rate of growth of the network has been fairly steady at about 20% per annum but over the past year, the pattern of growth has changed. Firstly, there has been a dramatic change in the desired speed of attachment to the network and with modern terminals or micros now capable of either 19.2 kbit/s or 38.4 kbit/s, a maximum attachment speed of 9.6 kbit/s has limited ease of access. The new generation of PADs being installed, however, can support either 19.2 kbit/s or 38.4 kbit/s at extra cost and this has required them to be connected to the network at a high speed which has had a knock-on effect to hosts to maintain a balance. Concomitant with the increase in line speeds, there have been changes in the user traffic on the network, e.g. more bulk file transfer. Also, with the advent of Local Area Networks, there is now a requirement to support the higher throughput demands imposed by LAN to WAN gateways and/or to transport data between LANs over the X.25 network.

The overall effect of these changes is that instead of a typical synchronous line being run at 9.6 kbit/s, the average new connection speed is 48 kbit/s. Although the new generation of packet switches are capable of supporting these speeds, attention will need to be paid to the speed of the inter-site links.

The existing network has served the University well for a number of years and will continue to do so but the growth of local area networks and new developments in computing, however, will require the very much higher speed network that is proposed in the strategy.

13.3 Local Area Networking

About 14 local area networks are installed in departments supporting high-powered workstations, multi-user minis and fileservers. The current local area networking policy of the University is based on the ISO 8802/3 CSMA/CD Ethernet standard with systems running the Joint Network Team approved software protocols ("Pink Book"). The emphasis is on standard hardware and software packages, although the hardware policy recognises that many other protocols can, and sometimes need to be, run over the Ethernet hardware.

Over the past year, the University has successfully sought funds from the Computer Board to implement an ISO 8802/3 spine network, initially to serve the King's Buildings campus. Plans are in hand to implement a similar spine in the central area and these form part of the strategy proposed later in this paper.

In practice, the University is attempting to link departmental Ethernets to a backbone spine. This procedure is software independent, although the Computing Service hosts will support Pink Book access. It is also to some degree hardware independent in that any ISO LAN should be able to attach to the backbone network.

13.4 Personal Computer Networking

There are a few local area networks installed to support personal computing on DOS and Apple Macintosh systems and these are based on a recently defined policy which recommends network software supplied by 3 COM running over Ethernet. These networks are gatewayed to the wide area network using the Rainbow product which was produced locally on behalf of the Joint Network Team. Where there are concentrations of Macintoshes, Apple proprietary networks are installed. Given the volatility of the market, the PC networking strategy is under constant review.

14. Strategy Development and Level of Consultation

As a precursor to the allocation of Computer Board funds in 1990, the University's Computing Policy Committee (CPC) commenced, in the latter half of 1987, the widest consultation exercise on computing ever carried out within the University of Edinburgh in order to arrive at an agreed corporate computing and communications strategy for the next decade. The investigations were carried out by a small planning team which was formed within the Computing Service. Its remit was to review the computing requirements of users and to report back to an enlarged Convener's Sub-Committee of the CPC which coopted representatives from the user community, the University Library, Management Information Services, the Computing Service and the main Policy Committee.

The consultations sought opinions from users in a number of ways: Heads of Departments provided statements of departmental computing strategies; meetings with over 100 departments were held by the Planning Group; surveys were carried out of past and expected future expenditure on computing, of all currently installed computing equipment, and of the views on computing of all members of staff and post-graduate students.

In addition to the above internal consultations, discussions were held with other universities including Cambridge, Oxford, Kent, Liverpool and Newcastle; account was taken of recommendations from Computer Board reports such as the Nelson Report on Computer Facilities for Teaching and the Forty Report on Facilities for Advanced Research Computing; an analysis of current market and technological trends was carried out; manufacturers previews were attended and initial informal discussions were held with representatives of the Board.

This initial stage in the planning exercise produced four reports to the Convener's Sub Committee including a draft strategy and an action plan for implementing it, which became the foundation for future debate amongst the user community. The basic recommendation of the strategy was that the University should continue (and if possible, accelerate) its evolution from the main delivery of computing power through central time-sharing services such as EMAS towards a much more distributed form of computing increasingly based locally in user clusters, and in particular placing processing power on users' desks. Any residual central time-sharing service required should be based primarily on the Unix operating system for compatibility with the personal workstations but VMS would continued to be supported. Feedback was received on each of these reports in a number of ways including written comments from Faculties, Heads of Departments and individual users, and comments from an open meeting organised by the Edinburgh Computer Users Committee. Guidance and comments were sought from University management committees.

The outcome from this first stage was broad agreement on the basic strategy, but some concerns over the timescales proposed for the move away from EMAS and on how the move to a more distributed environment could be funded.

Two additional project teams were established at the end of 1988 to carry out further discussions with departments on the evolving strategy and to consider the action plan in more detail. In particular, they were concerned with the planning and implementation of the communications infrastructure necessary to support effective distributed computing, and the planning and coordination of the overall action plan with particular emphasis on implementing a smooth transition from EMAS. Their consultations during the first quarter of 1989 produced further written comments from Faculties, Heads of Departments and individual users, comments from over 40 meetings with departments and user groupings, and a report on the consultations.

This report again found broad agreement with the strategy and clarified continuing concerns on how the new arrangements would be funded and on the proposed timescales for a move away from EMAS. A need for a larger provision of continuing time-sharing services than had been suggested during the earlier phases of the exercise was also identified. Several recommendations

were produced on how the new environment could be funded, how a smooth transition from EMAS could be achieved, and how the timescales for the implementation of the strategy might be revised. The report also contained recommendations on what should be procured from the Computer Board funds in 1990 to provide the basic infrastructure.

15. Strategy for Future Development

15.1 Aim and Objectives

The aim is to provide an environment in which teaching and research can derive the maximum advantage from the use of Information Technology, in a situation where financial and other resources are severely constrained. The objective is to install a university-wide infrastructure for information transfer and storage which will be able to expand and evolve in response to the increasing demand for network provision in the coming decade. The strategy therefore defines a target computing environment to be achieved by stages during the 1990s, and lays down a number of standards to be followed in the selection of equipment and software. The standards are intended to provide an adequate range of facilities while limiting acquisition and support costs and ensuring interconnectability.

The use of computers in teaching will continue to grow and progress in computer-based learning applications must be made in order to ensure that, within the limits of available resources, new demands and new opportunities may be seized. The demand from students for service and facilities beyond the standard teaching provision is also expected to increase. Such provision implies not only an open access to facilities but extension of the available training in basic computing skills.

A particular objective of the strategy is the integration of administrative and library computing into the overall environment. In administration the intention is to provide a secure, efficient, high quality, university-wide, management information service. In the case of the Library, the primary objective is to offer all staff and students easy on-line access to high quality collections, data and information services, in Edinburgh and elsewhere and to enable Library staff to work with maximum efficiency.

15.2 University Wide Computing Policy

To meet the objectives stated above, major changes in emphasis, both technical and organisational, will be required throughout the computing environment in Edinburgh. The requirements specified by users, which were outlined in the report "Computing in the University of Edinburgh" dated 30th June 1988, dictate a move towards a different environment based primarily on desk-top personal workstations complemented by, and better integrated with, central, faculty and departmental multi-user services. These offer compute power and applications packages which cannot be cost-effectively satisfied on personal systems. Overall, users should be presented with a complete campus computing environment which appears to them as one integrated tool. The University's policy therefore, will be to place emphasis on the University-wide support of integrated distributed systems for academic, research, administrative and library computing.

15.3 Applications Software Policy

In the past, any computing strategy might have revolved around a discussion of operating systems. Whilst the choice of operating systems will remain important, the key to the success of the strategy will be applications portability and accessibility, i.e. the ability to run similar applications across a range of systems from a variety of suppliers whilst offering a common interface to the end user. In a multi-vendor environment, such as exists in Edinburgh, the need, beyond the obvious physical connections between different systems is for applications that make transparent use of these systems and connections.

The necessity of shielding users from the complexities of each operating system has been recognised by the definition of a number of standards. The emphasis now is on defining a common computing environment for applications and users, regardless of the hardware and operating system in use.

The University's policy will be to adopt relevant standards (e.g. POSIX) in this area as they evolve and preferentially to procure systems and applications software which conform to them.

15.4 Communications Policy

15.4.1 High Speed Networking Policy

Computing facilities are already widely distributed in Edinburgh with departmental systems outweighing the central provision in terms of capital cost and power. These are however individual facilities connected via a slow-speed wide area network which was designed primarily for linking distributed terminals to central processing systems, i.e. a "terminal/computer" approach. A move towards a more distributed processing environment operating on a "client/server" basis will require a fast, reliable, secure data network as a precondition to successful implementation and the University's policy will be to install and support a high speed network, which is easily accessible throughout the University. The installation of such a network will permit the major change in emphasis to take place and it will support the integrated information technology environment which will offer the teaching, research and administrative tools which users desire. This network will be installed alongside the existing X.25 wide area network which will be sustained until such time as all users have connections to the new network. It will be necessary therefore to provide gateway facilities from the X.25 network to the high speed network for several years.

15.4.2 Main Trunk Networking Policy

The main trunk network, access to which should be available from all the major concentrations of University accommodation, should be capable of supporting data transmission speeds of at least 100 Mbit/s and should be based on fibre optic cable, laid in ducts which will also be capable of supporting non-data services if required, and offers an investment which will last the University into the next century. On this section of the network it will be the University's policy to adopt the FDDI (Fibre Data Distributed Interface) standard, which nearly all the major manufacturers have announced their intention to support, as soon as that standard has been finalised and products are available.

15.4.3 Departmental Networking Policy

The University's policy for departmental networking will be based on medium speed ISO 8802/3 Ethernet standard local area networks (LANs) which can be bridged to the main FDDI trunk network to allow local work groups access to shared facilities on the Edinburgh network and elsewhere.

15.4.4 Network Software Policy

The software protocols used for data transmission in the open systems environment will conform wherever possible to the Open Systems Interconnect (OSI) standards as they evolve. In the short and medium term however, the interim protocol sets (coloured books) as approved by the Computer Board, will be used whilst the ISO protocols are developed and implemented fully.

15.5 Distributed Systems Policy

15.5.1 Local Work Group Policy

The key difference between today's personal computers (PCs) and workstations is that the latter normally have an integrated network attachment, both hardware and software, offering peer to peer communication and a multi-tasking operating system. Technological developments are now offering these facilities to PC users and there is convergence between the two. The price/performance of these systems will continue to improve and the level of facilities will become increasingly sophisticated, yet easier to use, as further improvements in the man/machine interface are achieved.

The current trend in Edinburgh, where local work groups have developed around clusters of workstations, fileservers and departmental multi-user systems interconnected by a medium speed, Ethernet, local area network, gatewayed to the wide area network, will continue and accelerate.

The University's policy will be to foster the provision and support of local work group computing based around local area networks which are connected to either the backbone or wide area network.

15.5.2 Personal Systems Policy

Personal systems currently installed can roughly be separated into three groups; the high powered Unix based scientific workstations; DOS and OS/2 based personal computers, and others based on proprietary operating systems, eg. Apple Macintosh, BBC micros etc. At least until 1993, this situation is unlikely to change. Each of these environments offers facilities which cannot yet be met on the others. Over the next five years however, Unix and (probably) OS/2 are expected increasingly to dominate the marketplace but DOS and others such as the Apple Macintosh will continue to have a strong base.

The University's policy will therefore be based primarily on the UNIX and OS/2 operating systems with support for DOS and Apple Macintosh personal systems being sustained until such time as Unix and OS/2 offer cost effective alternatives at the lower end of the range. Communication and higher level applications standards will be used to integrate these communities with other "non-standard" products which will continue to exist to satisfy specific requirements.

15.5.3 Multi-User Systems Policy

Whilst the local workgroup will be the main "unit" of user computing, complementary university-wide (or faculty or departmental) multi-user services will be required for a number of purposes eg. electronic mail, long term file storage, corporate databases, data libraries, large scale scientific computing, information services etc. These services will also include some timesharing provision for the foreseeable future as this is likely to remain the only cost-effective way of providing access to computing facilities for the less well off departments. It is possible that the recent availability of windowing terminals to the X windows standard may offer a method of providing timesharing users with an environment similar to what is available on personal systems within a local workgroup, thus making remote services more attractive.

Within the various computing communities around the University, services are currently supported on a range of multi-user interactive timesharing systems, with Unix and VMS being the dominant environments. Many are also supported on the central EMAS service and, within Management Information Services and the University Library, alternative solutions have been adopted based on IBM's and GEAC's proprietary systems.

If standards are adopted to enable applications portability and improve accessibility, and given that it will be possible to access these systems from across a very high speed network, a far greater level of integration between multi-user systems and personal systems will be feasible than is the case at present.

To assist with the process of developing a campus wide integrated environment and to minimise the support requirement, the University's policy will be to rationalise the number of supported operating systems in use and to concentrate on centralised services based on Unix and VMS with the main emphasis being placed on Unix. Other solutions will only be adopted when it is not cost effective to satisfy the requirement on one of the preferred solutions. Communication and higher level application standards will be used to integrate specialised systems into the main environment.

This policy will of course mean the demise of the existing EMAS service. Whilst recognising the value and importance of this service to its users in Edinburgh, and taking into consideration the amount of work involved in effecting a transfer to alternative solutions, it will be the University's policy to target the summer of 1992 as the termination date for the EMAS service.

15.5.4 High Power Computing Policy

Powerful computer facilities based on novel architectures, most notably parallel processing, will be required for the solution of particular research problems. These facilities are used by a narrow community at the moment, but it is evident that in the 1990s the use of these techniques will become more widespread. The University is a leader in the use of novel computer architectures to provide very high power computing and, although external funding is likely to be required for capital expenditure on the scale that may be necessary, it will be the University's policy to make every effort to ensure that this position is not lost.

Novel architectures, however, at present demand the reprogramming of problems and there is a need for high power conventional computing facilities which can run the mass of standard software. It will be the University's policy to attempt to meet this need. Suitable relatively inexpensive machines are beginning to appear on the market and these should enable the University to continue to provide a level of computing power adequate for most of its research workers locally with National Centres providing capacity for very specialised requirements.

15.6 Support Policy

Although the demand for computing facilities will grow over the next 10 years, support staffing levels will be constrained. The University's policy will be to co-ordinate the activities of all central, faculty and departmental computing support staff to ensure that maximum benefit is gained from the limited resources. The main emphasis will be placed on the provision of support to the end user in applying the technology to assist with the primary teaching, research and administrative functions.

15.7 Management and Control Policy

The provision of a university-wide integrated computing environment will demand a more coherent overall computing management structure than exists at present. The University's policy will be to rationalise wherever possible the existing committee and senior management structures involved in the academic and research, administrative and library computing infrastructure to ensure the procurement and development of an integrated environment. The management of the infrastructure will in future be handled by a single management group whilst the delivery of the user-level library, administrative or academic and research applications will remain the responsibility of each service organisation.

15.8 Funding Policy

Funding for computing within the University is derived from a number of sources. UFC funds only account for approximately 40% of the capital expenditure. Political factors also influence the distribution of funds which creates imbalances in the provision of facilities. The University's policy will be to adopt mechanisms which will permit funds, from whatever source, to be combined to support as far as is possible access to modern facilities in all areas of the University.

A particular issue here is the effective application of funds across academic, administrative and library computing to ensure a coordinated policy and the best use of capital and resources of all kinds.

15.9 Security Policy

It is accepted that security is more of a problem in a distributed environment than on conventional mainframe services. The University's policy will be to implement and encourage security features wherever possible to minimise the risk, with particular emphasis being placed on administrative systems integrated into the network.

15.10 Implementation Policy

The strategy could not be implemented in a single phase because financial considerations will require a phased plan of expenditure, and all the technological developments necessary to support a fully distributed environment are not yet available. The University intends therefore to adopt an evolutionary implementation which moves computing in the University in the required direction as quickly as possible whilst taking into consideration the availability of funds and other resources. Preserving the many years of investment in the current system and protecting users from the worst effects of any changes will also be major factors which will influence the implementation.

15.11 Policy Coverage

The above computing policies will be adopted for the support of university-wide, central and departmental, academic and research, administrative and library services.

15.12 Review Policy

In view of the rapid changes which occur in technology, funding and other areas, the strategy and its implementation will be reviewed regularly.

16. Implementation

16.1 Introduction

The implementation of the new strategy will require major undertakings in a number of areas. To coordinate the management of the various strands of technical development involved, a project has been established which has been named "Project Forth". Initially, two project teams have been established to look into the main areas which will affect the development of the new environment, namely the planning and installation of the new communications network and the transition of EMAS users to alternative solutions. More teams will be established as the need arises.

The transition from the current situation to the new environment will be performed in phases over a number of years. Actual timescales will be dependent on the availability of the required technology, funds and other resources.

16.2 EMAS Transition

The major effect of the new strategy on central academic services will be the transfer of users from EMAS to alternative solutions. The following is the broad action plan proposed for implementing the transition, the initial steps of which are already underway.

- Produce detailed departmental transition programmes	April-June 1989
- Establish a viable central Unix base	April-June 1989
- Train and equip EUCS for support of new strategy	April-June 1989
- Run prototype transitional training courses	May 1989
- Provide Unix and transitional EMAS documentation	1989 May-September
- Provide essential applications software on central Unix service	May-December 1989
- Provide transitional software aids	May-December 1989
- Begin departmental programme for Unix awareness	August 1989
- Begin phase 1 of EMAS transition for users requiring long-term use of central Unix or VMS services	September 1989
- Begin phase 2 of EMAS transition for users moving to local faculty or departmental facilities	August 1990
- Begin phase 3 of EMAS transition for users with difficult technical or strategic problems in moving from EMAS	October 1991- target end date August 1992

16.3 Distributed Systems

Much of the planning for the implementation of the strategy at faculty and departmental level will be done as part of the EMAS transition and network planning exercises. The Computing Service will assist each department to develop a local plan which will allow them to slot into the new environment at an appropriate time. Some initial information has already been collected by the two project teams during their round of meetings with departments in the first quarter of 1989, and departments will also be assisted by the User Support Teams as part of their normal daily duties. The Computing Equipment Panel will ensure that, wherever possible, annual procurement requests are consistent with the overall strategy.

16.4 Administrative Computing

The main objective for Management Information Services is to provide secure, university wide services to help provide an efficient administrative structure in support of the University's primary teaching and research functions.

The University's Management Information Services Committee has confirmed the importance of the compatible development of administrative computing with that for academic and Library purposes, and recognises that this will mean establishing local work groups in certain areas alongside the central administrative system. The national Initiative in Management and Administrative Computing is, however, expected to determine the future direction of core administrative applications in universities. The Initiative's Blueprint caters for the information needs of both central and departmental administration, but does not constrain the balance between central and local systems of where data is held and processed. Thus it is expected that there will be few problems in accommodating the Blueprint within the University's distributed computing strategy.

The University is due to submit its Migration Strategy for Administrative Computing to the UFC by the end of July. At this early stage in its preparation, the priorities for new core applications are expected to be Personnel/Payroll and Physical Resources. Both Personnel and Physical Resources are likely to be relational database developments on suitable hardware, with appropriate arrangements being made to replace the existing Payroll system at the same time.

The IBM 4381 system will be reviewed over the next year with the intention of replacing or upgrading it in 1991 and alternative systems are being investigated which might support the applications software currently being run on the IBM but which will be easier to integrate into the proposed new environment. Consideration is also being given to the possibility of running administrative applications on the same central system as academic and research users, subject of course to suitable enhancement from University funds to cope with the increased load, the Board's consent, and a guaranteed secure environment being achievable. Such an arrangement might allow savings to be made in technical support and running costs, which would have to outweigh the substantial effort involved in implementing such a development. Also, as stated earlier, a pilot project is being undertaken in an administrative office which will provide experience in applying local work group/LAN technology in an administrative environment.

16.5 Library Automation

The University Library fully endorses the strategy and together with the Automation Sub-Committee of the Library Committee has already begun to consider the specification of objectives and requirements for Library automation in the 1990s. This will include the criteria for choice of system to succeed the present GEAC 9000 after 1993. Staff of the Computing Service and Management Information Services are members of this committee which will help to ensure that the automation plan is consistent with the University's computing policy. The committee is particularly concerned with the need to control support and running costs as well as the costs of purchase, and will consider the possibility of specialist library systems being mounted on the same hardware as academic and administrative systems in the University. Full integration into the new high speed network will also be a priority for any new systems to eliminate the current need for a separate dedicated Library network.

16.6 High Speed Network

The key to the success of the overall strategy will be the early installation of the new high speed network which is shown diagrammatically in *Appendix 7*. The data network project team will develop the overall plan and assist departments with their local plans, providing costings, suggested implementation timescales and installation support.

The networking strategy calls for an FDDI backbone serving departmental or building Ethernets through bridges. It is clear that standard FDDI to Ethernet bridge products are unlikely to

be available by the summer of 1990 at a price which would enable all existing Ethernets to be connected, particularly as the FDDI specification is not yet complete. While it would be possible to implement a backbone with one of the interim high speed products now on the market, the University would be very reluctant to do so, even with the promise of an upgrade to FDDI. There is sufficient doubt at present over the ability of these interim products to be upgraded that it would be better to wait for products which comply with the relevant ISO specifications. The University is, however, anxious to use FDDI as soon as is possible as it offers unique possibilities for tackling the geographical problems of the split Edinburgh campus.

The existing 14 Ethernet systems are clustered in three areas, the King's Buildings, George Square, and in the vicinity of Old College. The King's Buildings campus is nearly 2.5 miles from the central area of the University and it is the intention to use FDDI to span that gap. The first step in the network implementation is, therefore, to lay fibre between the three areas: the University is fortunate in having the requisite Oftel licence. In order to cover the distance between the two main sites, it may be necessary to invest in single-mode fibre and single mode FDDI attachments. Edinburgh would expect to be one of the first universities to use this technology and would be happy to report on its experiences to the Computer Board, via the Joint Network Team, for dissemination elsewhere. It should be noted, however, that single mode technology will be more expensive than multi-mode. The laying of fibre between the main sites will involve a major financial investment by the University; the budgetary estimate is £350,000, the majority of which will be in digging up the roads. It will therefore be imperative to utilise the fibre as soon as possible. There is already an embryonic Ethernet spine at the King's Buildings, and it is intended to create another Ethernet spine, split over each of the other sites, and use the FDDI as a backbone to link the spines together. In this way, it is intended to implement an FDDI service as soon as products to the ISO standard are available, whilst minimising the initial investment in FDDI bridges as only two will be required. Thus the early purchase of these bridges can bring an immediate benefit to the University, by linking the three sites at speeds much greater than has been possible before. If, as seems increasingly likely, FDDI products are not available in 1990, it is the intention to link the two spines using Ethernet bridges over the installed fibre and move to FDDI when required and possible.

Under this plan, most departmental Ethernets will be bridged to their local Ethernet spine. It is expected, however, that within a reasonable time the cost of bridging to FDDI will become roughly the equivalent of the cost of bridging to Ethernet. At this point, those departments which can use the higher speeds will be moved to the FDDI, while those with lower speed requirements can continue to use the Ethernet spines. By that time bridges are expected to be required within departments and thus the spine bridges could be reused elsewhere. A small number of Ethernets are currently used solely for PC networking, and they will continue to be linked to the X.25 network via Rainbow gateways until they require expansion.

The topology of the network on each site, and the number of fibres laid to each building, will be designed so that the change over from Ethernet to FDDI will be a case of changing the bridge and not the wiring. It will also be designed in such a way that the FDDI ring can be extended to any building in the future. Remote buildings will use Kilostream or Megastream bridges to link into the main backbone.

In the short term, the link between the new high-speed network and the X.25 network will be achieved by the use of Ethernet based Pink Book gateways. It is expected that direct FDDI to X.25 gateways will be a requirement for the academic community as a whole, and the University would expect to purchase at least one such gateway as soon as it became available.

16.7 Management, Control and Support

In order for the University to derive the maximum benefit from the significant investment about to be made in the various aspects of IT, including application of the Computer Board

replacement funds, it is clearly necessary for the University to ensure that all related expenditure is harmonised as far as possible. By this means, the University can ensure that all such expenditure will contribute towards the achievement of the strategic objectives outlined, and be consistent with that strategy.

The major IT related service groups, ie. the University Library, the Management Information Services Unit and the Computing Service, all subscribe to the view that the future of such services should be compatible with the network, and indeed exploit the facilities of networking to the greatest possible extent. It is intended that the IT infrastructure beneath the level of user services should, therefore, be managed as a single entity allowing the different service groups and of course departments and faculties to manage their various services on the distributed basis described and recommended in the strategy.

In line with the distributed nature of the infrastructure, the human resources for support will eventually need to be associated more closely with the user groups and clusters which will develop. What will emerge will be a management and control system which allows local line management of applications and direct user services, supported in significant clusters by dedicated support staff, but with the overall and career management of the staff concerned managed functionally at the University level. This approach will allow the user services to be responsive on a day-to-day basis to the needs of users whilst ensuring that the resources provided work within the broad University strategy for the development and provision of IT service as a whole.

It is unlikely that it will be possible to increase the number of support staff in line with the growing demand from new and existing users, particularly in a more distributed environment. It will therefore be essential to make best use of existing resources and some redeployments may be necessary as the emphasis increasingly moves from centralised to distributed computing.

The current user support arrangements within the Computing Service, involving teams of staff dedicated to the support of groups of departments in broadly related areas, has proved to be an effective method of using limited resources to cover as wide a community as possible. It still allows a reasonable degree of intimacy with applications and users in specific areas. The intention is therefore to enhance further these teams, possibly by the addition of staff to provide operational assistance to user clusters for tasks such as local file server management and backup.

The rationalisation of the number of differing systems installed throughout the University will also permit a wider, more effective, technical support to be provided through a better integration of the skills of existing central and departmental computing support staff.

It is also expected that the growing experience of computing amongst the user community, assisted by improvements which are planned in training and documentation, will allow users to become increasingly self-sufficient in many areas and that their need for professional support will become less frequent though more specialised.

16.8 Funding

As indicated earlier, the principal concern expressed by faculties and departments has been whether or not the strategy can be afforded. This is a natural concern, especially at a time when the University has serious financial problems, but the evidence of recent years suggests it can.

It is only possible to make a rough estimate of the total cost of implementing the strategy, since much will depend on the extent to which users will continue to rely on multi-user systems or, if they elect for workstations or micros, what the mix of these will be. A figure of around £18 million, however, seems realistic and this level of expenditure would be attainable over a six year period at the current rate of spending on computing equipment, which is averaging around £3 million a year *(see Appendix 8)*. More than half of this money comes from research grants but such equipment still forms part of the computing facilities available to staff and research students.

There are two particular problems which face the University. The provision of the backbone part of the network is felt to be part of the University's infrastructure and hence not

directly chargeable to departmental funds. A sum of £350k has already been allocated and will provide the funds for expenditure in 1989/90 of £255k to start work on the network. Thereafter, some form of top-slicing totalling about £900k over the three years 1990-1993, is being contemplated, but the precise mechanism for this has still to be decided.

The other problem concerns the distribution of capital funds. Although the typical rate of expenditure on computing equipment is sufficient if it is directed towards the implementation of the strategy, the funds concerned are not distributed to faculties in the proportions which would enable them all to implement the strategy at the same rate. Some degree of priority will have to be established for the basic provision but pressure of demand will determine the pace of implementation during the planned period. This will clearly present problems which will have to be resolved.

A projection of capital and recurrent expenditure during the period up to 1993 is given in *Appendix 8c*.

The recurrent costs of equipment, and to a lesser extent software, are a problem for many departments, but there is scope for more cost effective University-wide maintenance arrangements than exist at present, and these are being actively investigated. There is no evidence, however, that there is a significant amount of equipment around the University which is sitting idle because it has gone wrong and there is no money to fix it, and it must therefore be concluded that in practice departments are finding ways of keeping equipment operational.

17. Operational Requirement

17.1 Introduction

The Computer Board's seven year funds provide the opportunity to give the computing strategy the necessary initial impetus. This is, however, a time of transition and the need is for a number of relatively small procurements, spread over several years, rather than a single substantial one. There must therefore be some question as to how far the standard procurement procedures are appropriate in this instance and the University will require the Board's advice on the best way to proceed.

The requirements can be split into four groups. These are detailed below together with a rough estimate of the likely cost of each requirement. The total estimated cost is £2.55 million. This is probably rather more than the current capital guideline (the University has not been told exactly what this is but a rough estimate can be made by working back from the recurrent grant) but one of the advantages of the RFI procedure is that it will enable the University to refine its estimates and if necessary adjust its priorities. It is also assumed that expenditure deferred will be inflated according to the usual formula.

17.2 Communications

Adequate networking is the key to the effective integration of computing and related services throughout the University. The existing X.25 network has been of tremendous benefit and will continue to give good service for many years. There is a need however for much higher speeds than a wide area network could hope to provide and, as has been noted earlier, the University proposes to install a fibre optic network running initially at 100 Mbit/s using FDDI standards, but capable of much higher speeds in the future. This will act as a backbone to which departmental and other LANs, and various servers, will be connected.

The major cost consists in the laying of cables, particularly within buildings and between the King's Buildings and the central area of the University. This cost will be borne by the University; the Board is requested to meet at least the initial parts of the cost of bridges and other electronic components of the network. University expenditure will be phased over several years and it is proposed that the Board's should also be phased, though over a shorter period. This is partly because there is no point in putting in a bridge until there is a LAN full of equipment to use it, partly because the FDDI standards will not be complete for some time, and partly because the later the procurement can be left the lower the costs will be. It will be necessary in 1990 to install Ethernet bridges to enable existing Ethernets to interconnect.

The proposed phasing of expenditure from the Computer Board grant is:

1990	Bridge existing Ethernets to KB-Central Area link X.25 Gateways Megastream bridge Network management station Repeaters (Ethernet) George Square/Old College Ethernet spine components	£300k
1991	FDDI bridges, Megastream bridges and FDDI-X25 gateways	£185k
1992	FDDI Bridges	£ 65k

This requirement clearly does not lend itself to procurement from a single supplier and it is proposed that the JNT should be consulted when the time comes to place orders.

17.3 Central Services

The need is to sustain the existing EMAS service until 1992 to allow for an orderly transfer to other facilities, either central or local, and to expand the VMS and Unix services. Only a modest expansion of the VMS service is proposed, to meet the needs of those users dependent on packages which can only run on that service (which includes users of Oracle - the Unix service has recently obtained INGRES but this has not, at the time of writing, attracted any substantial use). There is also a need for a high power conventional compute server (number cruncher) and for a central file archive.

The EMAS service can be sustained either by the extension of the lease of the existing NAS EX/40 or by its purchase, or the purchase of another IBM XA type machine. Enhancement of the VMS service will involve the replacement of the existing processor and the addition of more disc space. It is possible that this might best be achieved by combining the requirement with that arising in a faculty, where the acquisition of a large multi-processor VMS machine is being contemplated but where existing funds are insufficient. In that case, the estimate below may be higher than will actually be required. Either way it seems unlikely that anyone other than DEC would be able to meet the requirement and single tender action may be necessary.

Expansion of the central Unix service is proposed to take place in two phases. The need in 1990 is to acquire a substantial stand-alone configuration capable of supporting about 150 simultaneous users. By 1992, the closure of the EMAS service will have increased demand for Unix and more capacity will be needed. There are two ways in which this capacity might be obtained. The obvious way is to enhance the existing Unix configuration or to buy a supplementary machine. An alternative is to develop a Unix service on the IBM type machine, running in parallel with EMAS. This would of course be dependent on a suitable version of Unix being available for the IBM type machine which would be capable of supporting a heavy interactive load, but, if possible, it would enable the run down of EMAS to be matched by an increase in the Unix service, which would be very convenient for users and might well be cheaper. Such a strategy would of course require the IBM type machine to be purchased rather than leased, and would require front-ends and possibly some other enhancements to be purchased. In 1992, further enhancements to meet an exclusively Unix load would be needed but would almost certainly be cheaper than alternatives. It might be noted in passing, however, that any disc expansion on the IBM type machine would most easily and cheaply be achieved by the purchase of second hand drives to expand the existing partial storage, rather than by complete replacement. This has obvious implications for the procurement process. The cost estimates assume the gradual conversion of the IBM architecture machine to provide a Unix service.

A central archiving service has long been provided as part of the EMAS service. The need in the 1990s is to replace this by a general purpose archive for remote as well as central systems, using suitable media so that retrieval of a file does not require manual action (unlike the EMAS archive which uses magnetic tapes). The bulk of the cost of the facility will be in storage devices; the requirement could be satisfied on a standard machine or as part of some other service but this may not have much effect on costs. It might be possible to use the facility to back up data on remote systems as an insurance against loss but that would depend on a number of factors and could not be predicted at this stage.

The need for a powerful conventional number cruncher might be satisfied by one of the other services but the increasing tendency to use multiprocessor architectures means that single stream power is not very impressive on many of the machines suitable for those services. There appear to be several very powerful machines available at relatively modest cost, and used in conjunction with other local facilities would be much more effective than an off-campus server. The estimated costs are:

1990	Machine to sustain EMAS service until 1992 (and provide Unix service thereafter)	£350k
	VMS service upgrade	£250k
	New central Unix Provision	£300k
1991	High power compute server	£100k
	Upgrade to "EMAS" machine to support UNIX	£100k
1992	Central archive facility	£150k

The University has recently acquired a Sequent Symmetry on trial to provide a central service and it may be that some Unix provision could be deferred from 1990 until 1991.

17.4 Centrally Managed Distributed Facilities

Part of the Board grant will be used to seed various facilities around the University to encourage the growth of distributed computing in those areas, e.g. up to seven filestores, serving particular faculties or groups of departments; workstation/micro laboratories in Biological Sciences and Arts; and workstations and X terminals in existing public terminal areas. It is also intended to set up a small pool of workstations and micros for loan to departments to enable them to explore the potentials for their own subjects.

The expenditure is assumed to take place in 1990 but, especially for filestores, it would be possible for at least part of the purchase to be deferred until the relevant faculty or group of departments has secured the funding for its part of the facility.

1990	Filestores	£300k
	Arts and Biological Science micro/workstation laboratories	£200k
	Workstations/micros for public access	£100k
	X terminals for public access	£ 50k

17.5 Software

The setting up of new services is bound to require the purchase of various software applications packages. The precise requirements will depend on circumstances and all that is proposed at present is the allocation of £100K from the Board grant to meet such costs. The expenditure would probably occur as follows:

1990	£ 50k
1991	£ 30k
1992	£ 20k

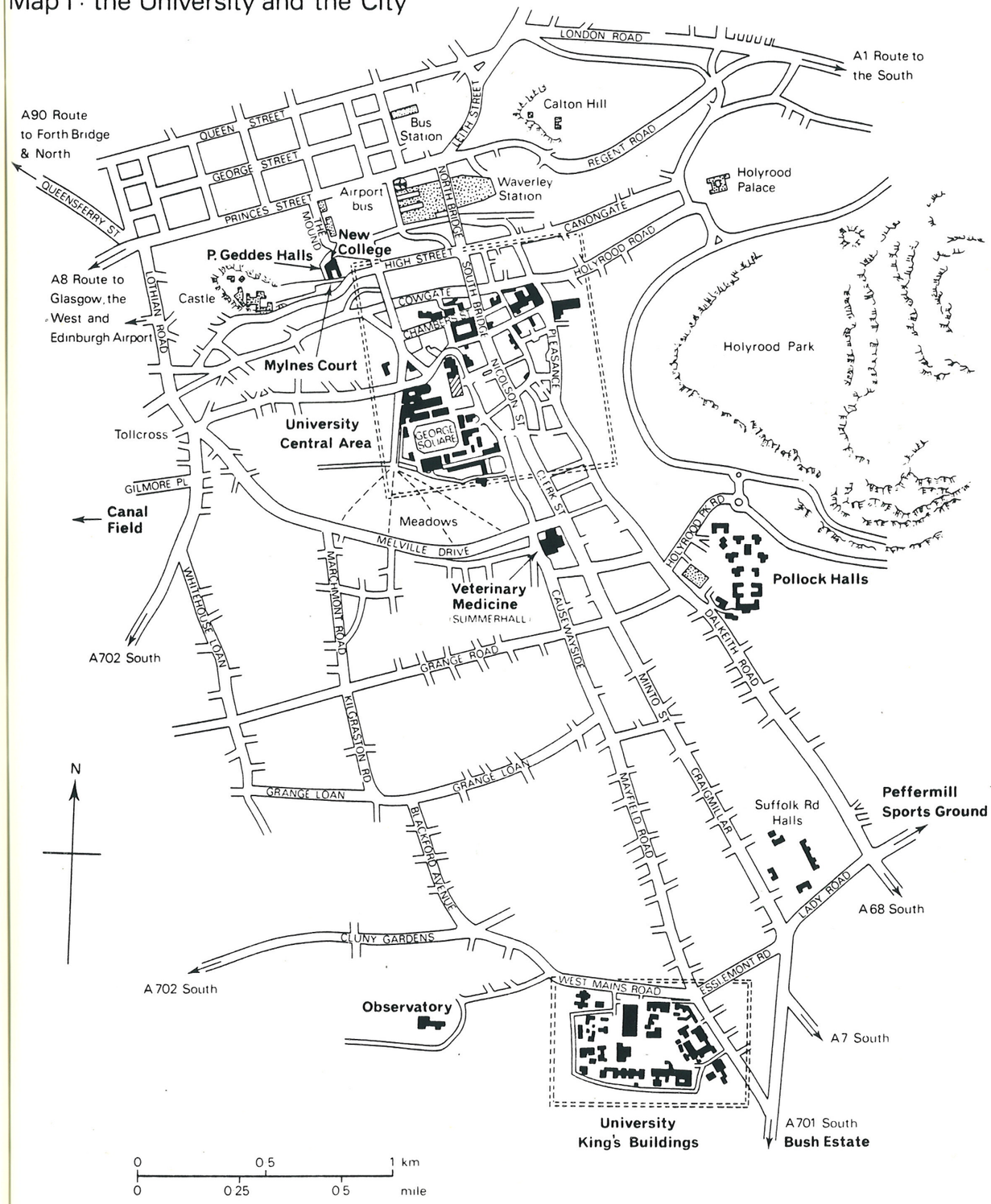
18. Appendices

18. Appendices

1. Map of The University of Edinburgh

THE UNIVERSITY OF EDINBURGH

Map 1 : the University and the City



Drawn and printed by the Cartographic Unit Department of Geography

2. Departmental Computing

Installed Microcomputers in January 1988

	IBM PC/PS2	DCS Clone	Other Clone	BBC Micro	Sirius/ Apricot	Apple MAC	Atari	Other	Total
Phys.Science	26	9	19	85	14	39	2	46	240
Biol.Science	22	64	7	82	26	23	3	20	247
Engin.Science	6	3	5	28	3	2	1	52	100
Soc.Science	77	36	16	16	26	28	11	16	226
Medicine	58	59	38	132	38	25	3	73	426
Law	6	4	0	5	4	0	0	1	20
Divinity	1	2	0	1	2	0	0	1	7
Arts	5	5	6	7	23	6	1	2	55
Vet.Medicine	14	7	11	18	2	0	0	16	68
Music	0	0	0	0	0	0	1	0	1
EUCS	48	8	0	64	56	40	8	17	233
MIS & Admin	79	0	7	0	32	2	0	1	121
Library	4	9	0	3	0	1	0	8	25
Total	338	206	109	441	226	166	30	253	1769

*** Note EUCS figures include Public Areas and AT Microlab**
Physical Science includes AIAI, Arts includes CSTR

Appendix 2a

VMS

Departments with DEC VMS Computer Systems

Agriculture
Biochemistry
Computer Science
Economics
Edinburgh University Computing Service
Electrical Engineering
Geography
Linguistics
Medical Physics
Meteorology
Physics

VMS based Computing Facilities

1	VAX 8530
1	VAX 8350
1	VAX 11/780
4	VAX 11/750
10	MicroVAX 2
1	MicroVAX 3000
3	VAX station 2000

UNIX

Departments with UNIX Computer Systems

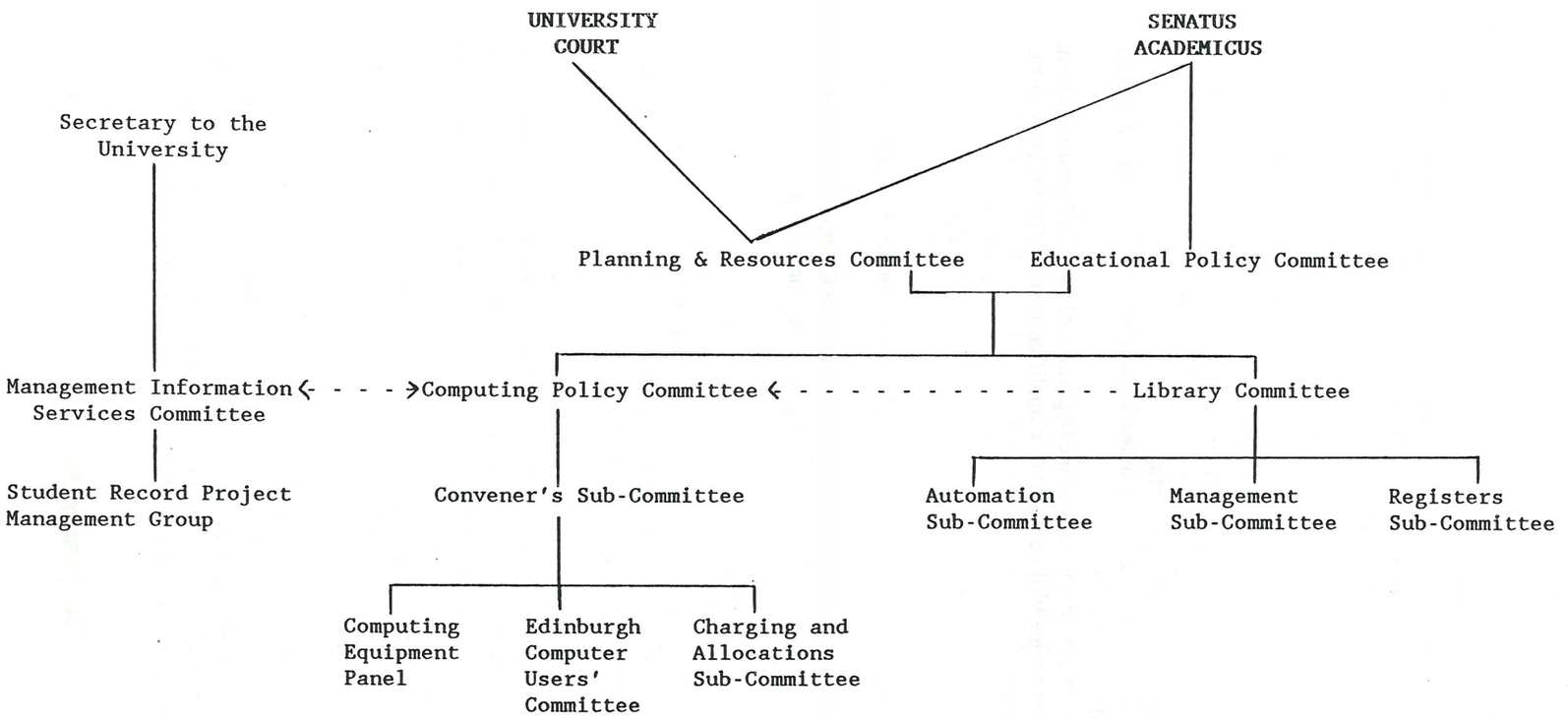
Architecture
Artificial Intelligence
Artificial Intelligence Applications Institute
Centre for Speech Technology Research
Chemical Engineering
Chemistry
Civil Engineering
Cognitive Science
Computer Science
Edinburgh University Computing Service
Education
Electrical Engineering
Linguistics
Mathematics
Mechanical Engineering
Medical Statistics
Meteorology
Music
Physics

UNIX based Computing Facilities

>250	SUN Workstations
<30	HP workstations
1	Gould 9080
1	Gould PN6031
1	Gould NP1
2	Sequent Symmetry
6	VAX 11/750
3	Systime 8750
1	GEC 63
1	Pyramid 98XE
2	Orion
3	PDP11
3	Masscomp
5	IBM 6150

Appendix 2b

3. Committee Structure



EXTRACT FROM THE UNIVERSITY OF EDINBURGH COMMITTEE STRUCTURE FAMILY TREE

Appendix 3

Committee Remits

1. Computing Policy Committee

a. The membership of the Computing Policy Committee shall be determined by the University Court on the recommendation of the Educational Policy Committee.

b. The Computing Policy Committee will be responsible for advising the Educational Policy Committee and the Court and where appropriate the Treasury and Research Council Users, on:
   i) Matters of Computing policy for the University as a whole;
   ii) The general policy, operation and development of the Computing Service; and
   iii) The Edinburgh interest in the Regional Computing Organisation.

c. The Committee will have in particular the responsibility of allocating resources among categories of user of the Computing Service and of recommending the allocation of financial responsibility among interested parties.

d. The Computing Policy Committee will report at least annually to the Educational Policy Committee and the University Court.

e. The Committee will be appointed annually at the beginning of each University session.

f. The secretary to the Committee will be a suitably qualified member of the staff of the Secretary to the University.

Sub-Committees

1.1 Convener's Sub-Committee

To advise the Computing Policy Committee on all aspects of its business and, in particular:

(a) to examine and comment on the budget and accounts of the Computing Service;

(b) to comment on the financial effects of staffing and expenditure policies on the Computing Service; and

(c) to make recommendations on capital expenditure

1.2 Charging and Allocation Sub-Committee

To make recommendations to the Computing Policy Committee on the charges to be made for the services organised and run by the Computing Service and on the allocation of the facilities of the Computing Service among departments, research councils and other users.

1.3 Computing Equipment Panel

To assess technically, on behalf of the Computing Policy Committee, plans and proposals for the acquisition of computing equipment, to ensure that the equipment proposed is suitable, economical and compatible with the computing environment in the University.

1.4 Computer Users' Committee

To act as an advisory body to the management of the Computing Service and as a channel of communication between the users of computing and the Computing Policy Committee; to appoint 4 members to serve on the Computing Policy Committee.

1.5 Computing Staff Assessment Panel

To make recommendations to the Staff Committee on accelerated increments and promotions of academically related staff, or promotions of staff to the academically related scales, for computing staff in the Computing Service, academic departments and the administrative Data Processing Unit; and to make recommendations to the Computing Policy Committee or, where appropriate, Staff Committee on staffing policy.

2. Senatus Academicus

The Senatus Academicus, subject to the powers of the Court, regulates and superintends the teaching and discipline of the University (1889 Act, Section 7), and promotes research (1966 Act, Section 8).

It consists of the Principal, the Professors, not less than one third of that number of Readers and Lecturers elected by the Readers and Lecturers of the University, a number of elected members of research staff and University Demonstrators and certain other ex-officio members together with 13 student associate members.

The Senatus usually meets twice in each term.

3. Planning and Resources Committee

Taking into account the University's financial position (on which the Committee will be advised by the Finance Committee), and such other guidance as may be provided from time to time by the University Court and the Senatus, to exercise overall responsibility for the direction and integration of the University's financial, academic and physical planning; after taking account of representations and recommendations from other appropriate committees and University officers, and in particular from Educational Policy Committee in relation to the academic sector of the budget and from the Estates and Buildings Committee in relation to matters within the remit of that Committee, to agree plans and determine budgets (the holders of which will be accountable to the Committee) for the principal heads of expenditure, including those for individual Faculties and academic services; and to monitor the effects of its decisions; to monitor, and update as appropriate, in collaboration with Educational Policy Committee, the University's Institutional Plan; and to report to the Court and Senatus.

4. Educational Policy Committee

(a) To act as a preliminary forum for discussion of matters of academic policy which are to be considered by the Senatus;

(b) To have overall responsibility for the allocation of resources to the academic sector of the University budget, subject to the Court and to ratification by the Senatus;

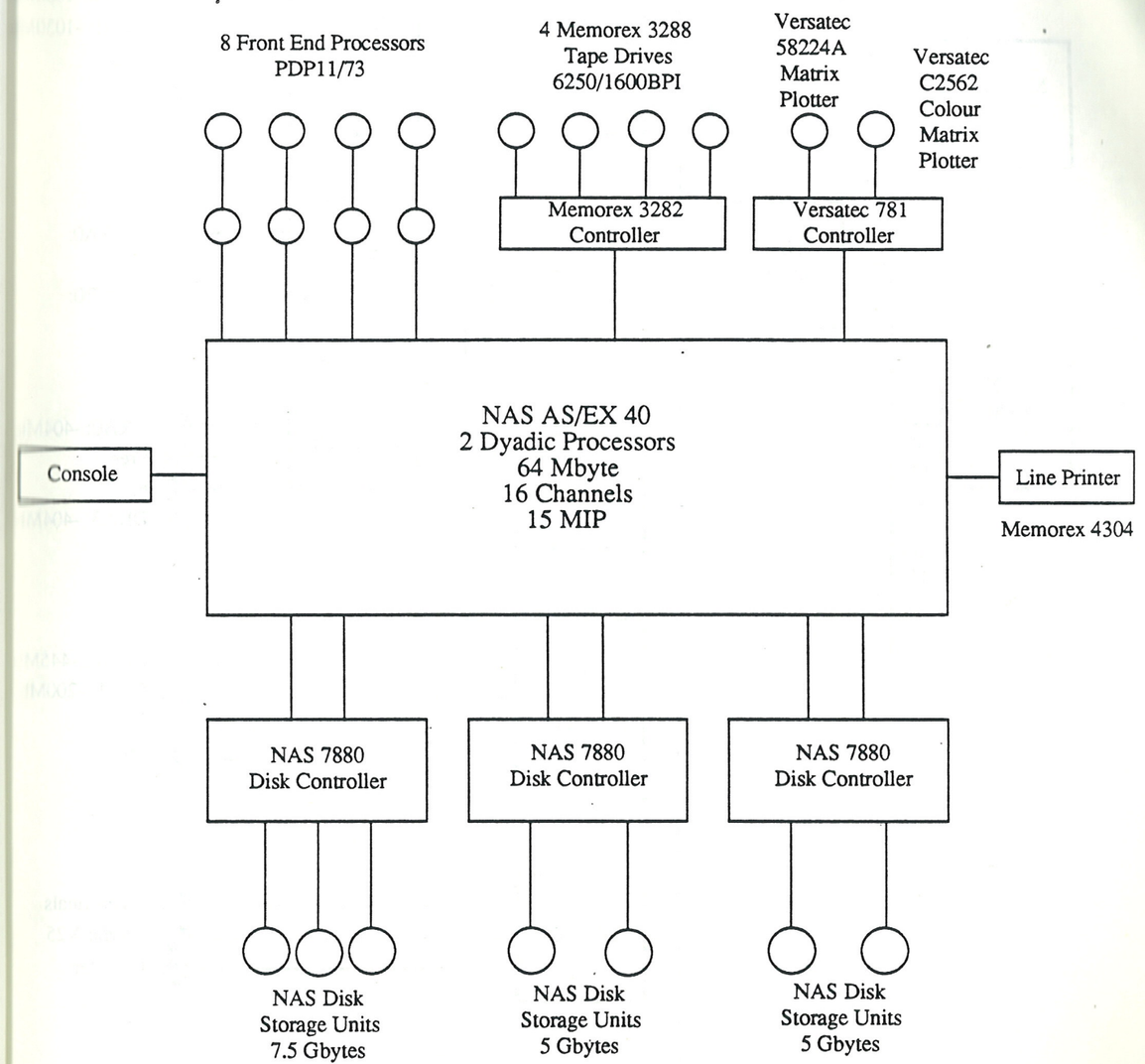
(c) to receive in the first instance the reports of certain other Senatus Committees;

(d) to fulfil specified executive and advisory functions, and deal with such other matters as may be remitted to it by the Senatus.

The Committee has three Groups or Sub-Committees viz: Academic Group, Planning Group, and Principal and Dean's Group, which report to the main Committee.

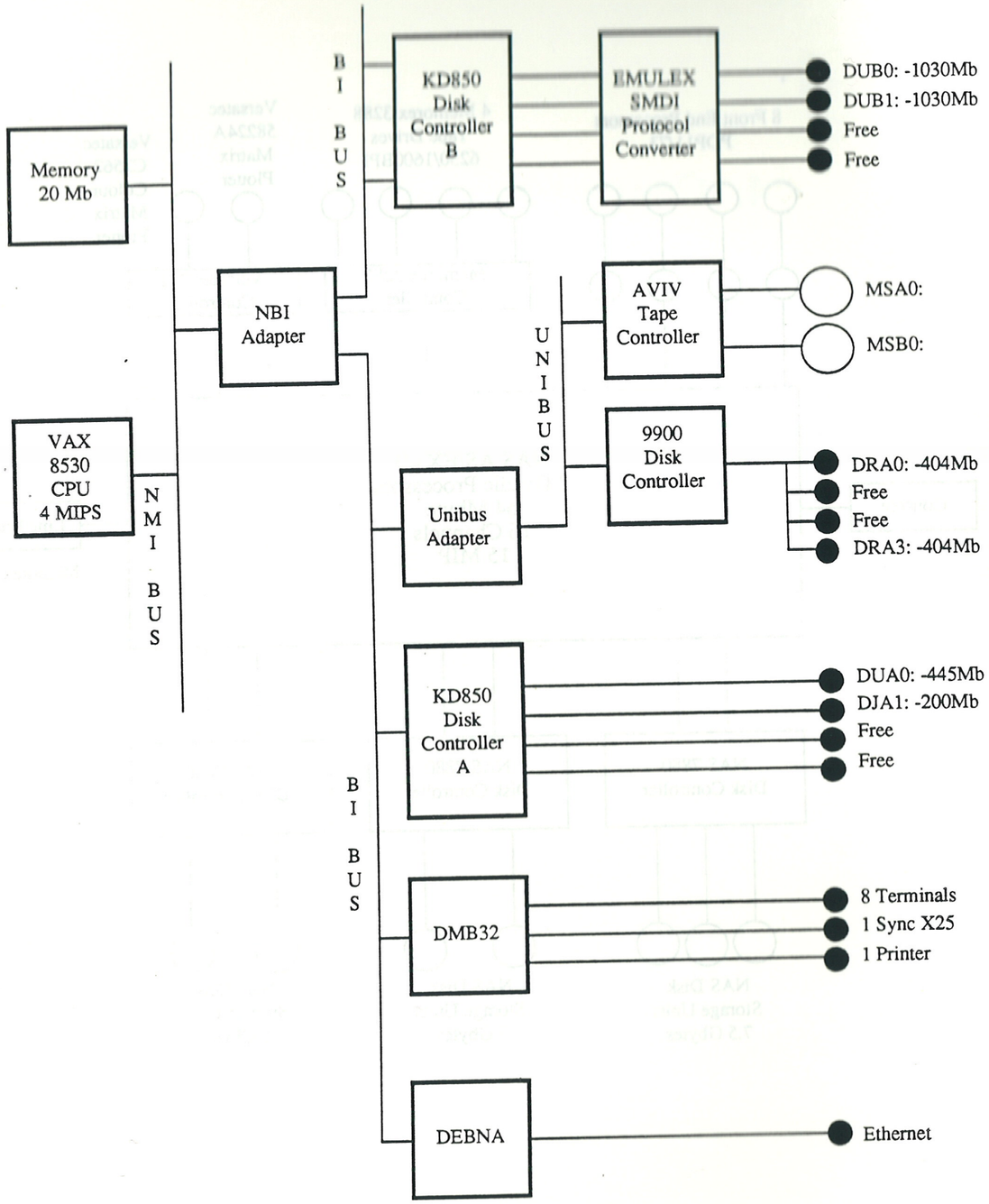
4. Central Academic Services

National Advanced Systems EX/40



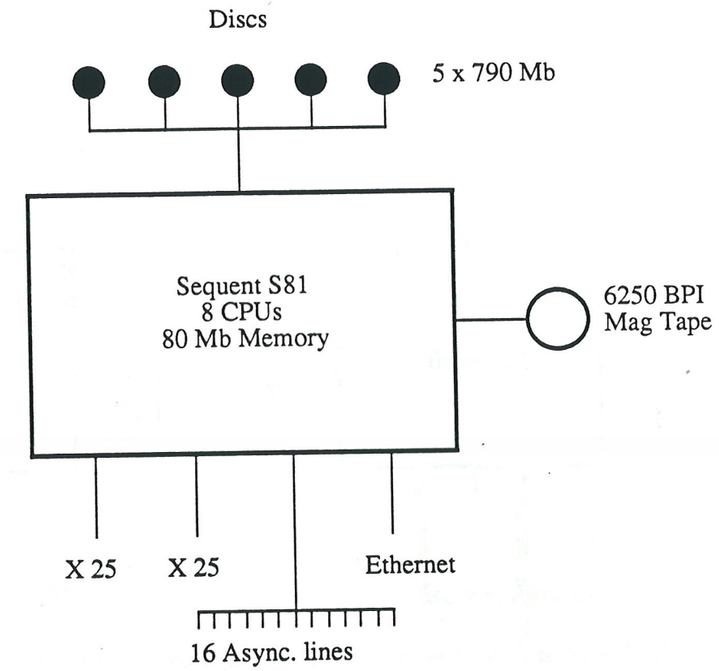
Appendix 4a/1

VAX 8530 Configuration



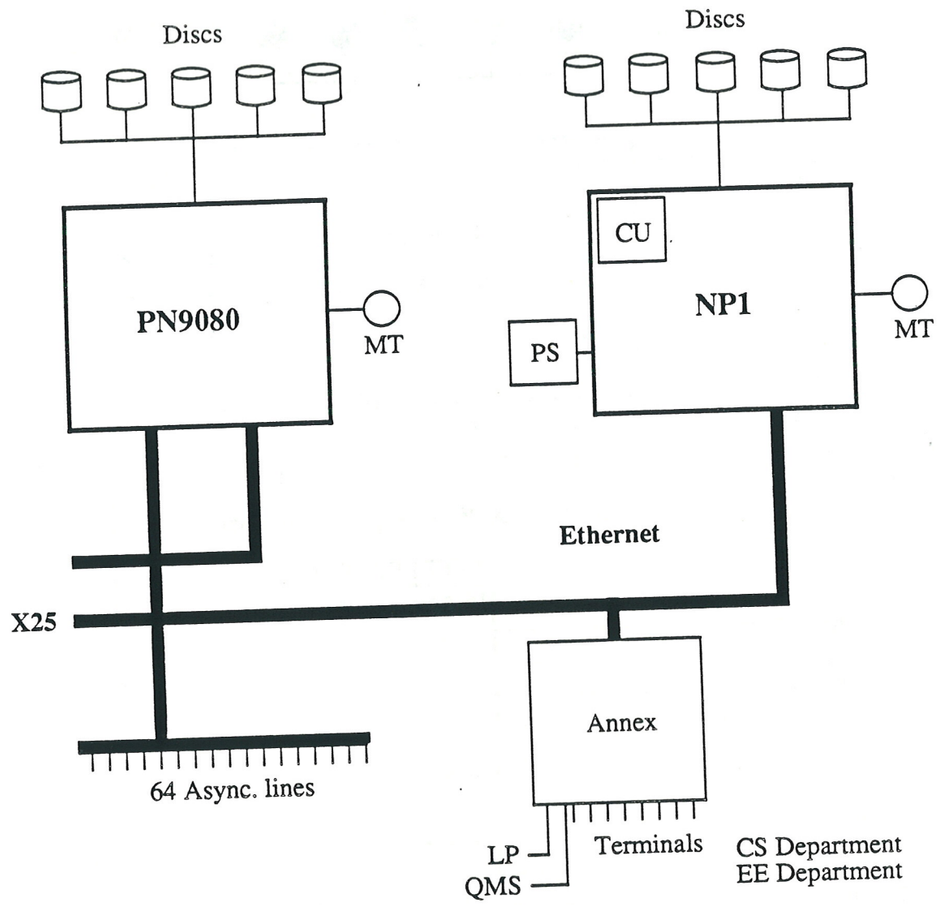
Appendix 4a/2

Sequent Symmetry S81



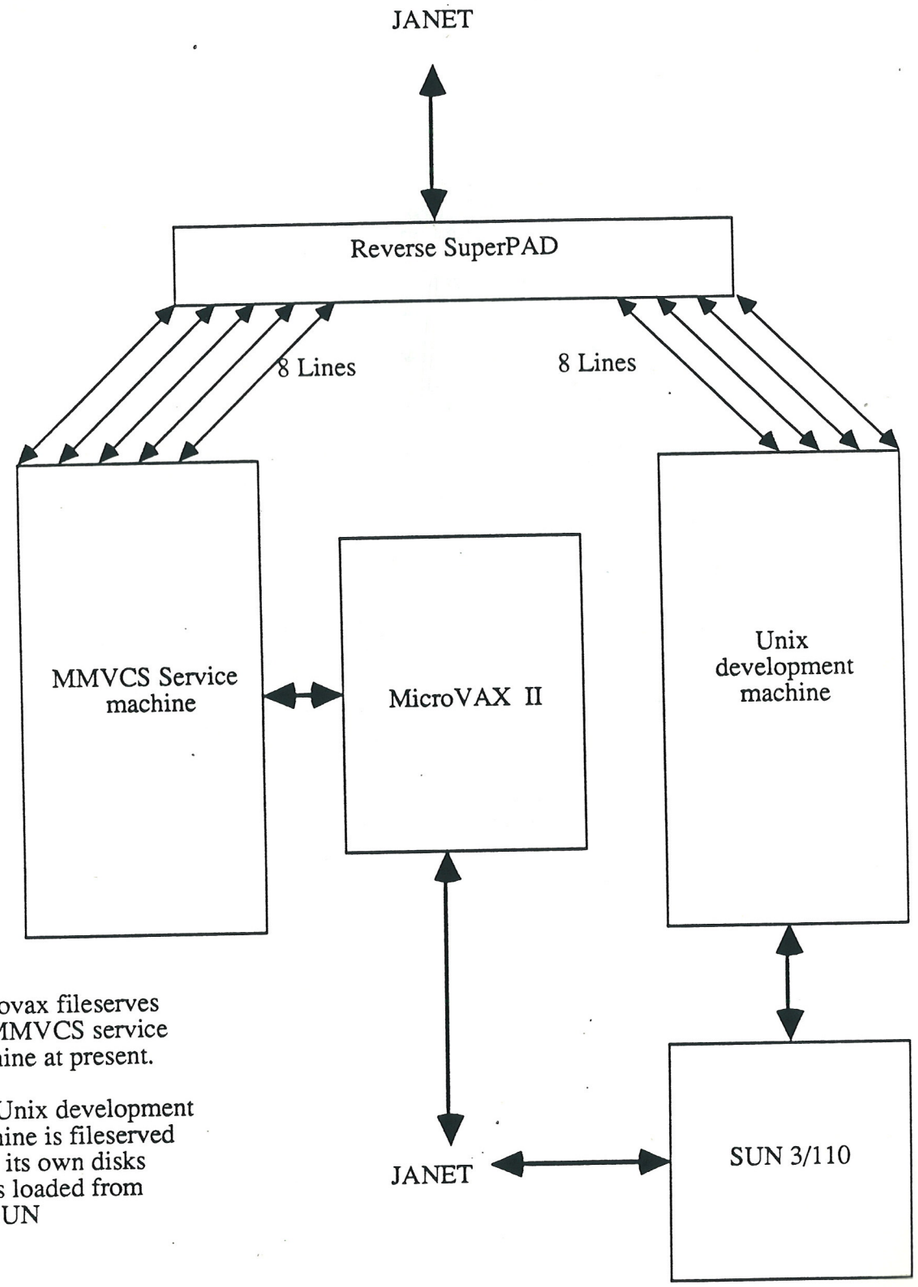
Appendix 4a/3

Gould Systems



Appendix 4a/4

Edinburgh Concurrent Supercomputer Hardware and Communications

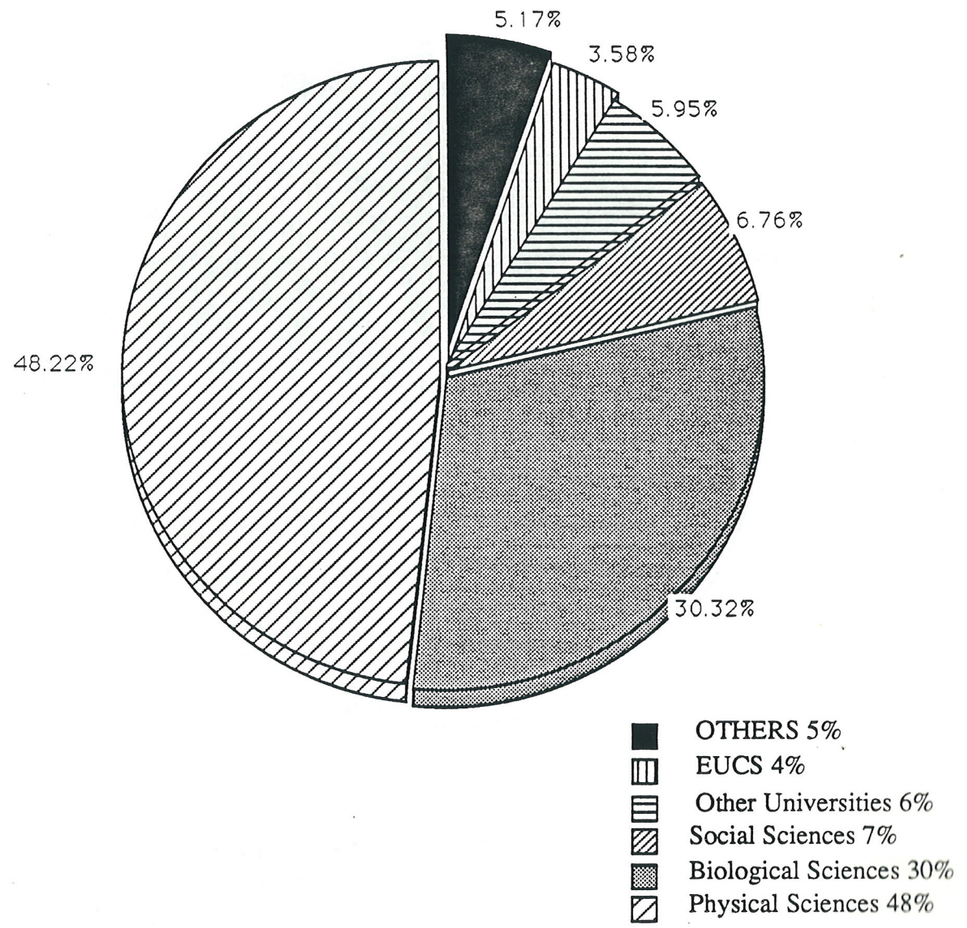


Microvax fileserves the MMVCS service machine at present.

The Unix development machine is fileserved from its own disks but is loaded from the SUN

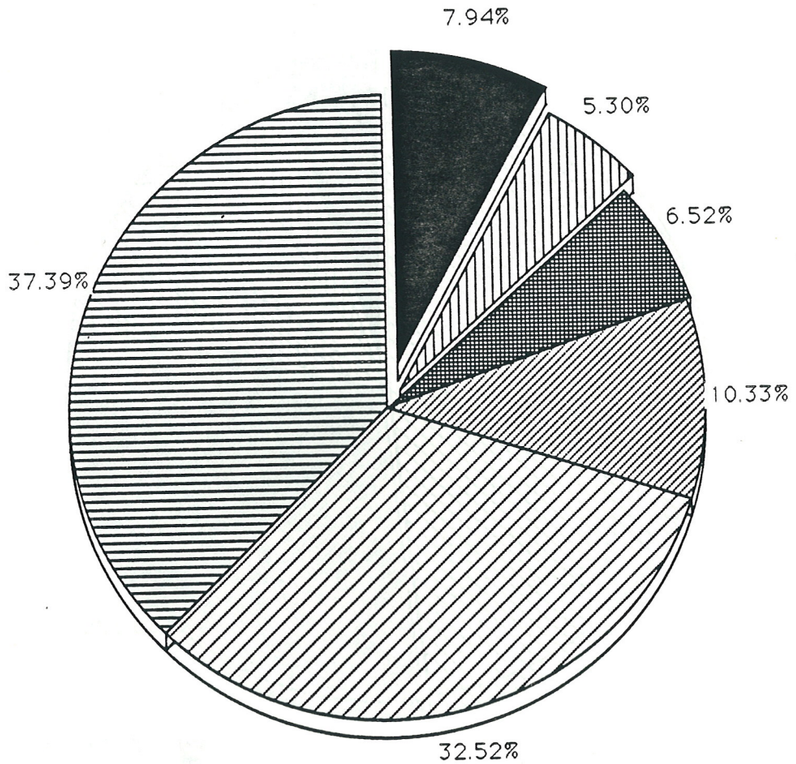
Appendix 4a/5

Utilisation of NAS EX/40 EMAS Service 1987-88



Appendix 4b/1

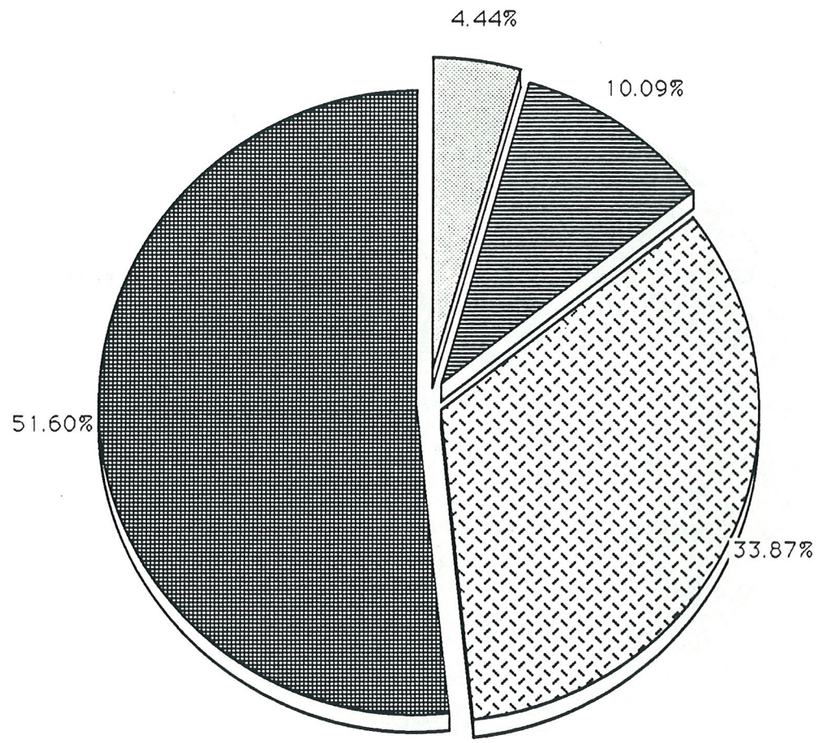
Utilisation of VAX 8530 VMS Service
1987-88



- OTHERS 8%
- EUCS 5%
- Biological Sciences 7%
- Social Sciences 10%
- Physical Sciences 33%
- Engineering Sciences 37%

Appendix 4b/2

Registered Users NAS EX/40 EMAS Service
March 1989

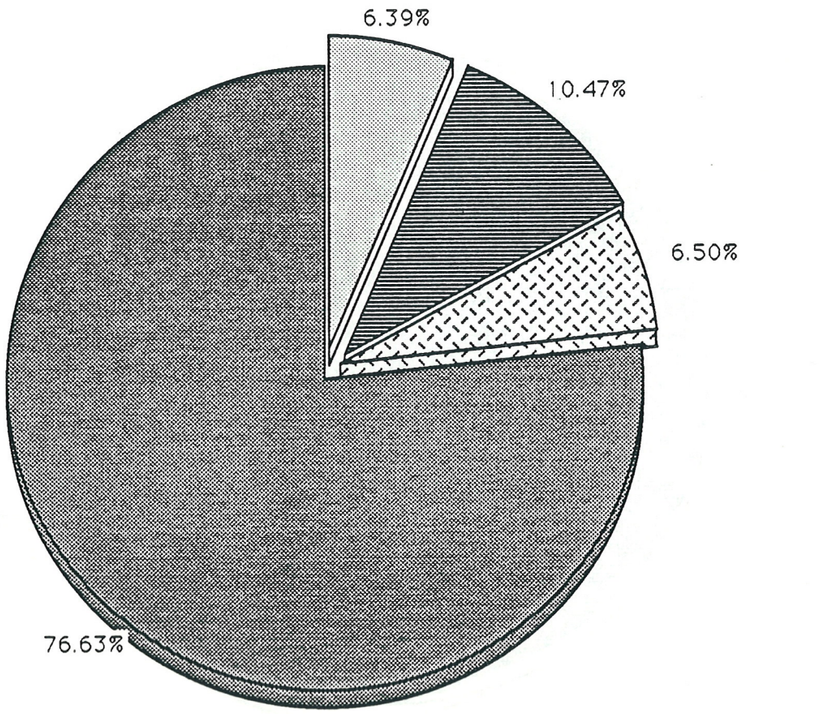


- Research Councils 4%
- Other 10%
- Undergraduate 34%
- University Research 52%

Total number of Users: 6669

Appendix 4c/1

Registered Users VAX 8530 VMS Service
March 1989

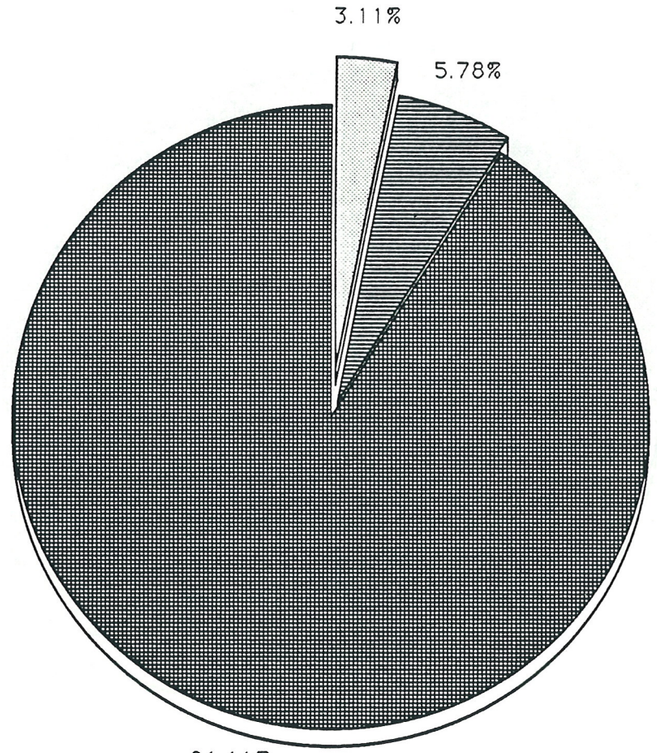


- Research Councils 6%
- Other 10%
- Undergraduate 7%
- University Research 77%

Total number of Users: 907

Appendix 4c/2

Registered Users Gould NP1 UNIX Service
March 1989

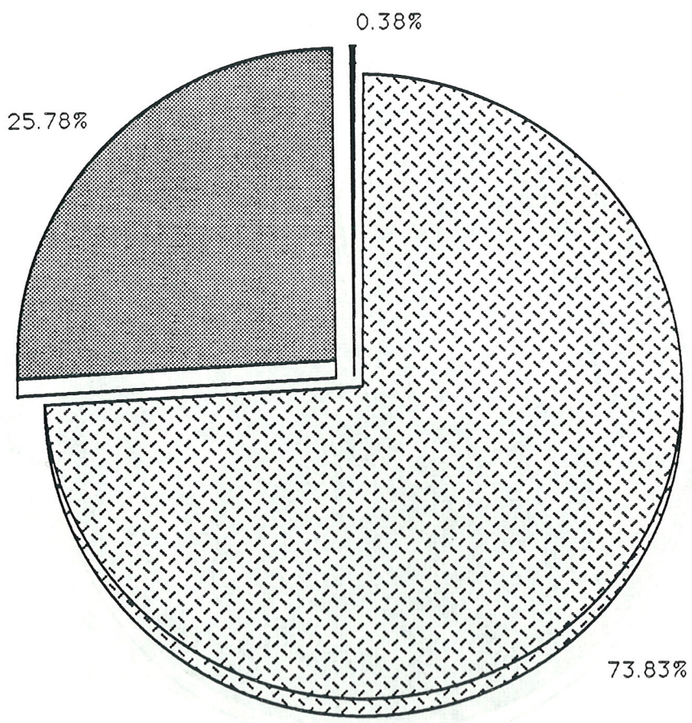


- OTHERS 3%
- Other 6%
- University Research 91%

Total number of Users: 225

Appendix 4c/3

Registered Users
School of IT Gould PN 9080 UNIX Service
March 1989

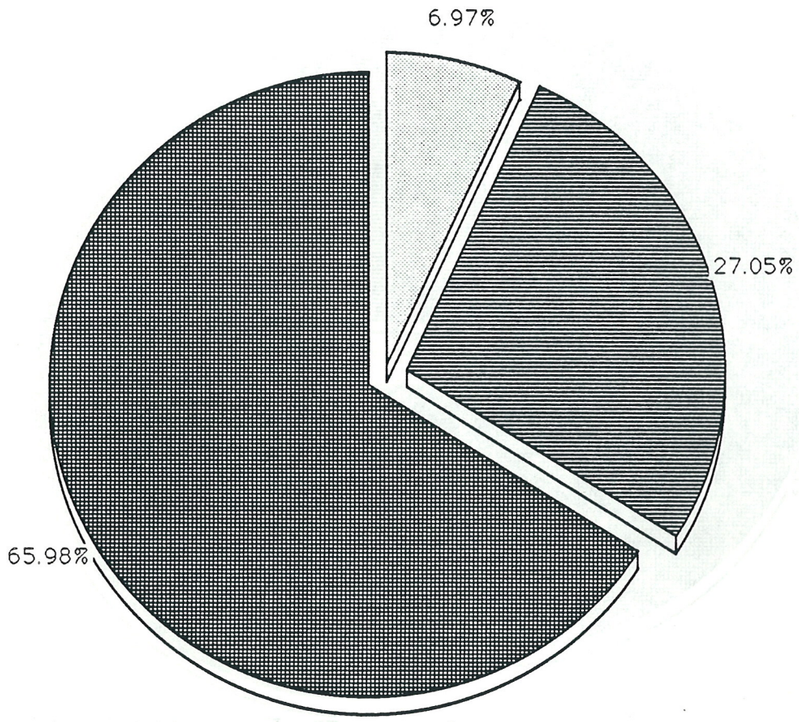


- OTHERS 0%
- Undergraduate 74%
- University Research 26%

Total number of Users: 1307

Appendix 4c/4

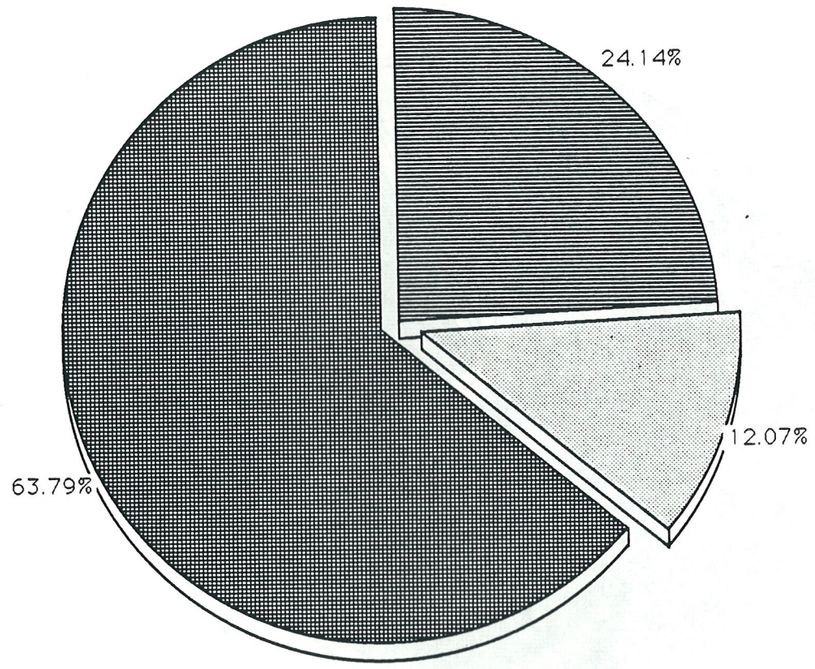
Discrete User Communities NAS EX/40 EMAS Service
March 1989



- External Agencies 27%
- Research Councils 7%
- University Departments 66%

Appendix 4d/1

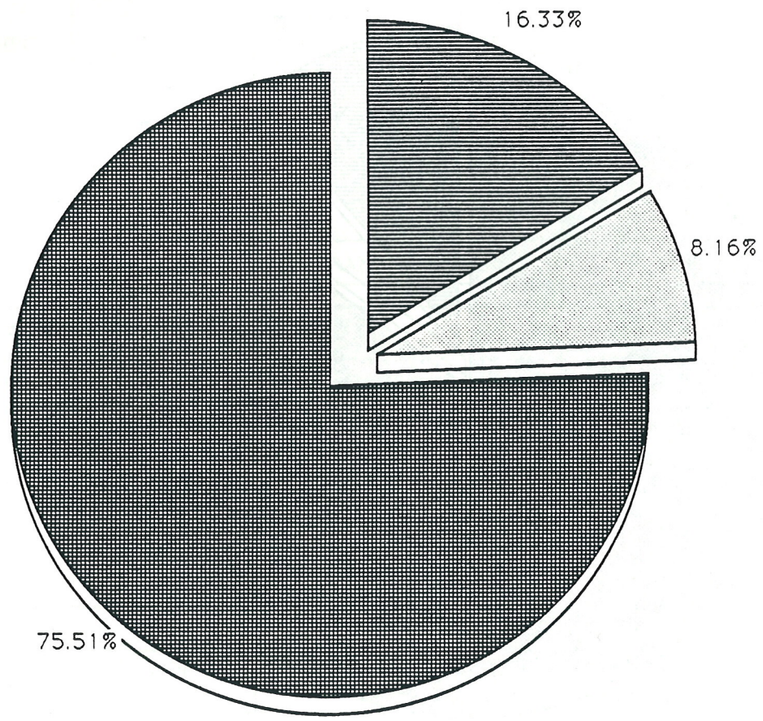
Discrete User Communities VAX 8530 VMS Service
March 1989



External Agencies 24%
Research Councils 12%
University Departments 64%

Appendix 4d/2

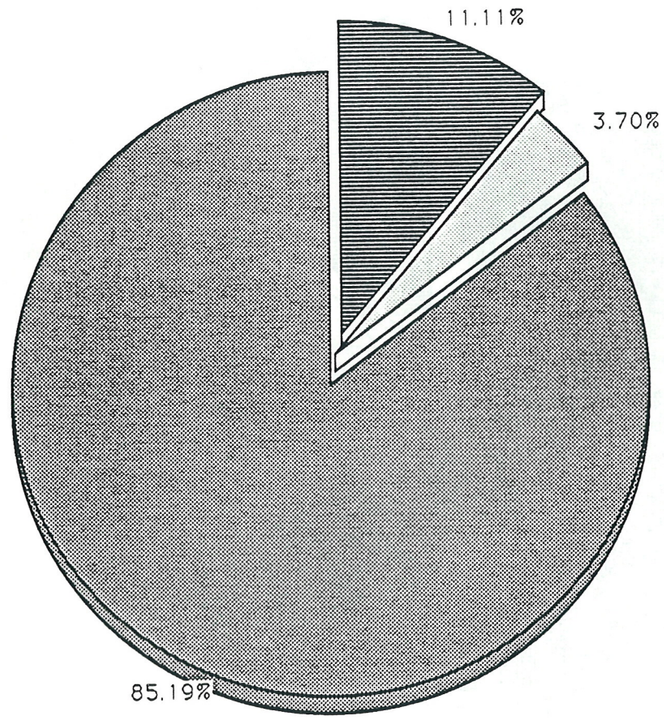
Discrete User Communities Gould NP1 UNIX Service
March 1989



External Agencies 16%
Research Councils 8%
University Departments 76%

Appendix 4d/3

Discrete User Communities Gould PN 9080 UNIX Service
March 1989



- External Agencies 11%
- Research Councils 4%
- University Departments 85%

Appendix 4d/4

Package Availability

March 1989

NAS EX/40 EMAS Service

Packages

AGRILIST	AGRSPSSX	ASPEX	BLISS	BMDP	CAMAPED
CAMAPGB1	CAMAPGB2	CAMFRAME	CAMGRID	CATALOG	CENSUS
CLUSTAN	CONCORD	DATAC	DATALIB	DECRYPT	DRAWPICTURE
DSIGNX	EASYGRAPH	EDEX	ENCRYPT	FACSIMILE	FAMULUS
GAZ	GAZF	GENSTAT	GIMMS	GINO	GKS
GLIM	GPCP	HIERF	INGRID	ISCOL	LAYOUT
LASERCHEC	LIMDEP	MAXLIKE	MDSX	MINISQ	MINITAB
MINOS	MLP	NAG	NAGGRAPHICS	NAGHELP	NOTICE
POSTSEND	PRESEND	SASPAC	SCRIBE	SCSS	SGPCP
SHAZAM	SIR	SPIDER	SPSSGRAPH	SPSSX	SUPERCARP
SYMAP	SYMTRAN	SYMVU	TSA	TSP	UMAPIT
UNIRAS	VARCL				

Languages

BASIC	C	FORTRAN	IMP	PASCAL	SIMULA

VAX 8530 VMS

Packages

BASIS	DRAWPICTURE	EDWIN	ELIOPOULOS	GENSTAT	GIMMS
GKS	LAYOUT	LIMDEP	LUSAS	MINOS	NAG
NAGGRAPHICS	(NAGHELP)	ORACLE	PAFEC	PHOENICS	REDUCE
RGSP	SAAM	SAS	SASGRAPH	SCA	SCICONIC
SCRIBE	SIR	SPIDER	SPSSGRAPH	SPSSX	STADEN
TOOLPACK	UNIRAS				
UWGCG					

Languages

C SIMULA	FORTRAN	IMP77	MODULA	PASCAL	PROLOG

GOULD NP1 UNIX SERVICE

Packages

INGRES TEX	MINITAB TRANSCRIPT	NAG	SPICE	SPSSX	STAT

Languages

C COMMON PASCAL	C++ ML	COMMON C	COMMON LISP	COMMON FORTRAN	

SEQUENT SYMMETRY UNIX SERVICE

Packages

INGRES STAT	(MINITAB) TEX	NAG TRANSCRIPT	S (UNIRAS)	SPICE	SPSSX

Languages

BASIC PROLOG	C	C++	F77	ML	PASCAL

Appendix 4e/1

Package Use
August 1987-July 1988

NAS EX/40 EMAS Service

Name of package	Total cost	No of runs
SPSSX	169152	52846
BMDP	46000	14740
GENSTAT	32194	23570
GPCP	29462	3512
MINITAB	28885	29651
SIR	10533	1767
GLIM	3019	2728
CATALOG	2910	5901
SCSS	2490	1627
SASPAC	2224	1690
SIMULA	2154	335
GIMMS	2072	1662
SHAZAM	1553	1434
SYMVU	953	1814
TSP	867	1068
SPSSGRAPH	522	403
MLP	346	364
FACSIMILE	333	308
LIMDEP	277	352
CLUSTAN	265	546

VAX 8530 VMS Service

Name of package	Total cost	No of runs
LUSAS	119632	809
SIR	34274	13087
SAS	9494	3493
ORACLE	7138	5266
SPSSX	2824	5811
PAFEC	1407	1150
REDUCE	615	718
POSTER	52	169
LIMDEP	26	42
GIMMS	5	30
RGSP	0	7

Appendix 4e/2

Top User Departments
of Central EMAS and VMS Services
1987-88 (Notional £s)

	EMAS		VAX VMS	
1.	Physics	3135615	Civil Engineering	181810
2.	Animal Genetics	3059813	Physics	88555
3.	Mathematics	846104	Geology	46928
4.	Chemistry	834785	Educational Sociology	40887
5.	Glasgow Statistics	592791	Geophysics	17407
6.	Educational Sociology	483061	Molecular Biology	10705
7.	Geophysics	375868	Animal Genetics	6579
8.	Meteorology	317508	Forestry & N.R.	6457
9.	Forestry & N.R.	136858	Biochemistry	4758
10.	Statistics	113426	Economics	4395
11.	Economics	86514	Botany	4391
12.	Agriculture	70558	Business Studies	3642
13.	Mechanical Engineering	57372	Statistics	3245
14.	Geology	54113	Animal Physiology & Gen Res	3167
15.	Library	51913	Astra Clinical Research Unit	3074
16.	Medical Statistics Unit	51894	Small Animal Clinic	2970
17.	Chemical Engineering	49422	Vet. Pathology	2298
18.	Computer Science	49205	Vet. Clinical Studies	2177
19.	Molecular Biology	45498	Conservative Dentistry	2152
20.	Psychology	41746	Computer Science	1188

Appendix 4f

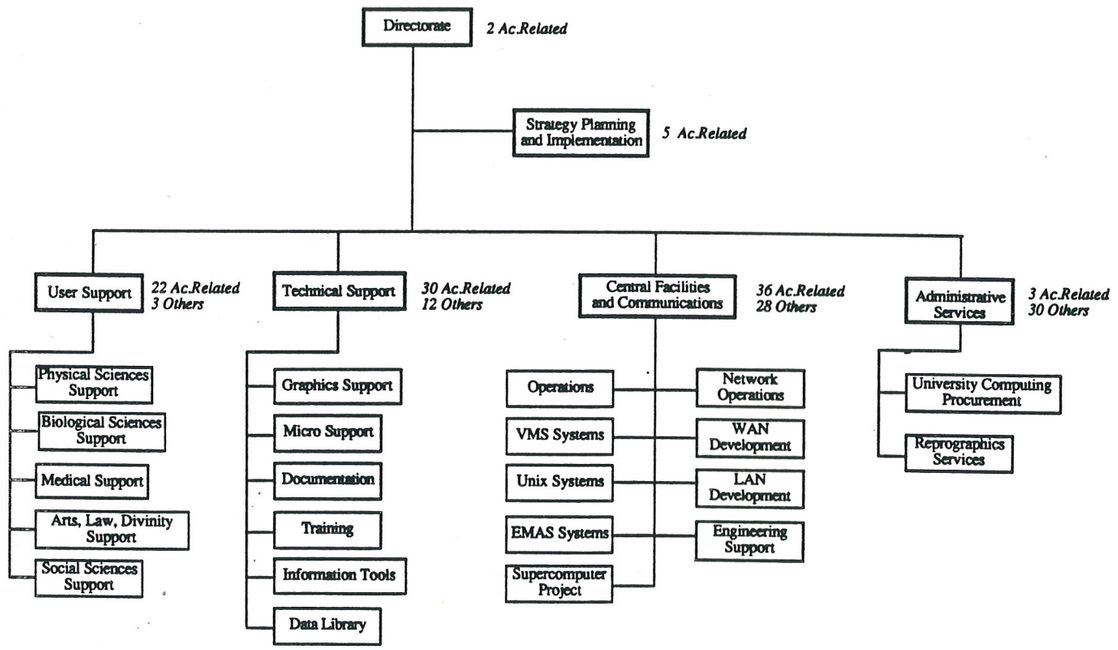
5. Computing Staff

Computing Staff

Academically Related	AD Computing Officers	~ 180 incl. AIAI
	AS Computing Officers	

Others	CD 26 (FTE)
	Clerical, Operations and Technical (~100)

EUCS Organisational Structure and Staffing Levels



Appendix 5

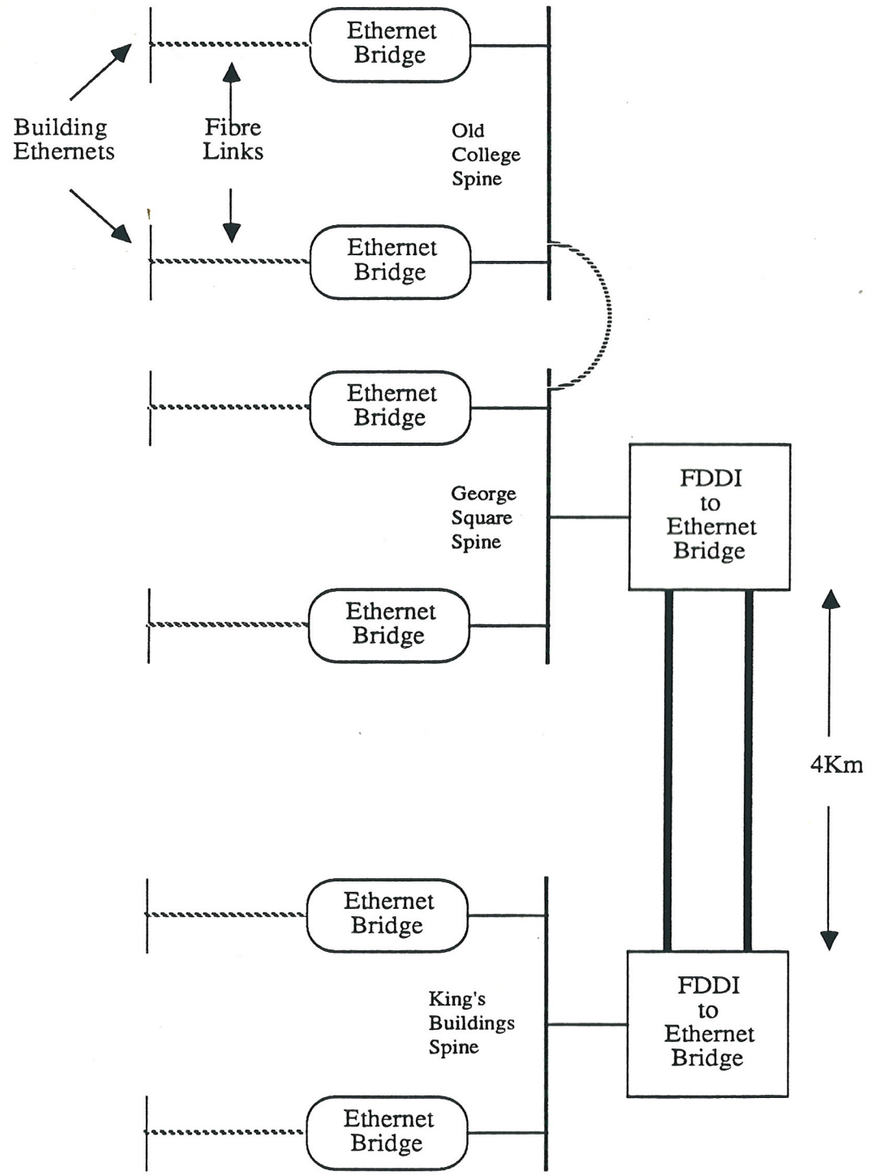
6. Existing Communications Network


Joint Academic NETwork
EDINBURGH UNIVERSITY COMPUTING SERVICE
Communications Network-EDNET
Ednet Supports 1989 (1988)
Host Systems 39 (37)
Synchronous Connections 245 (232)
Asynchronous Connections 2717 (2525)
(C)PSE- (Campus) Packet Switches
Network Host Systems
Other Systems
PADs (Camtec or Netcomm)
Workstations (W/S)
Ethernet
Cluster
B. Gilmore April 1989
To/From British Telecom's PSS/IPSS Network
PSS/IPSS Gateway Torch XXX
British Geological Survey
Royal Observatory VAX 11/780 VMS
Institute of Terrestrial Ecol.
Bush Estate
Banchory
St.Andrew's Univ. CPSE
Stirling Univ.CPSE
Heriot Watt Univ.CPSE
Aberdeen Univ. CPSE
Glasgow Univ.CPSE
Strathclyde Univ.CPSE
Dundee Univ. CPSE
Rutherford JANET PSE
UMRCC JPSE
Edinburgh Janet PSE
Daresbury JPSE
Newcastle CPSE
Paisley College VAX 11/750 VMS
Kelvin Lab VAX 11/780 VMS
Ed.Physics
S.C.R.I. Invergowrie
Medical Sch.
Sch. of Ag. VAX 750 VMS
Inst.of Animal Phys. and Gen.Res.
Prime 750 550
Scottish Agricultural Statistical Service Prime 550
Royal Edinburgh Hospital
High School Yards
Pollock Halls
Science Faculty Office
Science Faculty
Forestry & Nat.Resources
Engineering
Chemistry
ERTE PDP 11/44
EUCS KB PADs
Computer Science
Genetics
Zoology
Geology
Bush Estate
ESCA APAD
Scottish Ins.of Ag.Eng
Macaulay Land Use Research Institute
SCRI Pentlandfield
Vet Field Station
Forestry Commission N.R.S.
Telepac
W. of Scotland Coll. of Agric.
TelePAC
GEC 4190
KING'S BUILDINGS
TelePAC
VAX 8530 VMS
MicroVax VMS
MEIKO supercomp.
Physics
Physics VAX 11/750 VMS
Mechanical Engineering
SUN W/S
VAX 11/750 UNIX
Bridge T/S
SARI
Systime / UNIX
HP9000 UNIX
VAX 11/750 UNIX
SUN W/S
Integrated Sys. Ed. Microfabrication
Electrical Engineering
Micro VAXs VMS
VAX 780
SUN 3/260 UNIX
Orion UNIX
Pyramid 90XC U.
A.P. M/Cs
SUN W/S
Depart. of Computer Science
Gould NP1 Unix
Sequent Unix
NAS EX40 EMAS
PDP11/40
PDP11/10
Slow Devices
Network Info. Torch
IT School PN9080 Unix
Spider Ether G/W
Spider PAD
SUN W/S UNIX
EUCS KB Spine
VAX 11/780
MRC Clin.& Pop. Cytogenetics Unit
Systime 8750
New College
Erskine Medical
Western General Hosp
CEOS
Law
A.I.
ESCA
Darwin
Genetics
Engineering
Zoology
Geology
JCMB
KB
CTVM
VFS
RDVS
EDINBURGH UNIVERSITY LIBRARY
GEAC 9000 & 8000
Main Library
Erskine Library
Royal Dick Vet School
Biochemistry Vax 11/750 VMS
Western General Hospital
Medical Faculty
Economics MicroVAX VMS
Business Studies,B.P.
Social Science Faculty
Research Centre for Social Sc.
Psychology Acorn Econet
Centre for Educational Soc.
Archaeology
Old College
MIS IBM 4381 VM/CMS
N. Buc. Pl.
Appleton Tower CAMTEC PADs
VAX 11/750 UNIX
Artificial Int. Forresthill
SUN W/S UNIX
EUCS Library
3Com F/S
PCs & Macs
Rainbow G/W
TelePAC
GEC 4190
APPLETON TOWER
TelePAC
VAX 11/750 VMS
Geography
(DECNET)
MicroVAX VMS
Computer Science A.T.
A.T. Microlab
Gould PN9080 UNIX
Edinburgh Portable Compilers
Gould PN9080 UNIX
Linguistics Vax 11/750 VMS
Centre for Cognitive Science
VAX 11/750 UNIX
Xerox Wkstns.
SUN W/S UNIX
TelePAC
Gould PN6031 UNIX
AIAI SUN
ALICE
Symbolics 3670
HP320 UNIX
ICL 3930 VME (ALICE)
Sys. 8750 UNIX
C.S.T.R. VAX 11/750 UNIX
Xerox W/S
Whitechapel
SUN F/S
SUN W/S UNIX
SUN W/S UNIX
XEROX W/S & F/S.
Masscomp
Artificial Intelligence Applic. Inst.
Artificial Inteligence, 80,South Bridge
Centre for Speech Tech. Res.

Appendix 6

7. Proposed Backbone Network

Proposed Backbone Network Schematic



Appendix 7

8. Computing Expenditure

University of Edinburgh

Computing Expenditure

		Social Sc.	Science	Medicine	Law	Divinity	Arts	Vets	Music	MIS/Admin	Library	ALL
1983-84	Capital Exp.	162,829	1,182,493	66,954	3,000	-	24,825	3,269	-	144,000	61,500	1,648,870
	Maintenance	11,779	118,586	47,715	-	830	16,540	90	-	63,000	-	258,540
	Consumables	3,670	6,050	15,600	-	-	1,814	200	-	21,000	16,700	65,034
	TOTAL	178,278	1,307,129	130,269	3,000	830	43,179	3559	-	228,000	78,200	1,972,444
1984-85	Capital Exp.	74,846	1,181,802	105,211	27,000	800	567,086	13,030	-	207,000	46,000	2,222,775
	Maintenance	17,732	176,253	53,933	-	714	28,663	-	-	82,000	38,200	397,495
	Consumables	5,772	15,652	17,844	-	-	8,226	200	-	30,000	12,300	89,994
	TOTAL	98,350	1,373,707	176,988	27,000	1,514	603,975	13,230	-	319,000	96,500	2,710,264
1985-86	Capital Exp.	106,564	2,050,176	110,313	13,500	5,134	231,957	17,788	-	210,000	28,800	2,774,232
	Maintenance	24,329	229,243	68,454	-	775	61,668	540	-	105,000	58,500	548,509
	Consumables	7,591	22,018	22,339	-	-	7,910	50	-	41,000	16,700	117,608
	TOTAL	138,484	2,301,437	201,106	13,500	5,909	301,535	18,378	-	356,000	104,000	3,440,349
1986-87	Capital Exp.	176,839	2,796,138	209,511	11,000	6,421	387,447	2,888	-	207,500	278,200	4,075,944
	Maintenance	44,776	382,721	89,584	2,500	800	89,643	150	-	116,000	88,000	814,174
	Consumables	10,416	29,828	28,803	-	-	8,940	1,200	-	47,000	15,600	141,787
	TOTAL	232,031	3,208,687	327,898	13,500	7,221	486,030	4,238	-	370,500	381,800	5,031,905
1987-88	Capital Exp.	115,776	3,123,501	127,175	21,000	7,000	123,416	5,670	39,000	240,000	179,200	3,981,738
	Maintenance	79,113	612,152	103,081	3,500	9,900	95,071	800	8600	131,000	114,000	1,157,217
	Consumables	11,589	40,110	26,565	-	-	9,301	2,100	-	55,000	-	144,665
	TOTAL	206,478	3,775,763	256,821	24,500	16,900	227,788	8,570	47,600	426,000	293,200	5,283,620

Appendix 8a

Computer Board Grants to the University of Edinburgh Since the 1980 Review

Capital		
GEC packet switches	£112,002	*
Amdahl installation (mid term enhancement)	718,743	
Computers in teaching	42,000	
Pilot X25 switch (Telepac)	27,284	*
MicroVAX for Meiko Computing Surface (first)	60,000	
Meiko Computing Surface	250,000	
High Speed network	87,681	*
AMT DAP (Molecular Biology)	110,000	
X25 Network enhancements	41,000	*

Note: Not included are grants associated with the Regional Service

*Denotes networking grant

Recurrent		
		Minor Facilities Grants
1980/81	£530,574	
81/82	619,665	
82/83	641,530	
83/84	671.004	39,000
84/85	731,000	39,000
85/86	831,111	51,500
86/87	851,664	32,500
87,88	497,225	37,700
89/90	571,738	38,400

Note: The total recurrent grant includes, where appropriate, regional service costs and is regardless of where it was distributed within the University.

Appendix 8b

Expenditure Projections

Capital Projection

		1989/90	1990/91	1991/92	1992/93
Network	University	255k	320k	359k	359k
	Computer Board		310k	186k	65k
		255k	630k	545k	424k
Facilities	University		2980k	2980k	2980k
	Computer Board		1600k	230k	170k
			4580k	3210k	3150k

Although no figure is given for University expenditure on facilities in 1989/90 there will be the normal expenditure on computing equipment and much of it will contribute to the implementation of the strategy.

Computer Board Recurrent Grant

The application of the Board's current formula would lead to the following grants, ignoring any inflationary increases:

1990/91	£267k
1991/92	£340k
1992/93	£373k
1993/94 etc.	£373k

The present grant (stripping out special grants) is about £313k - less than what is projected because of the low capital value of the secondhand Amdahl computers on which it was based. The phasing of the capital grant expenditure might require some existing equipment to be retained temporarily. That would obviously affect the size of recurrent grant that was needed in 1990/91, but it seems unlikely that the total would exceed the present £313k. Any requirements would of course become clear as the implementation plan was decided in detail this summer during the RFI discussions.

Appendix 8c