CSIRO DIVISION OF ATMOSPHERIC RESEARCH

COMPUTING PLAN 1986-1991

Computing Advisory Committee

May, 1986

Contents

CHAPTER 1. PREFACE

There has been a rapid growth in the demand for computing power and expertise within this Division over the last decade. A continuation, and even an acceleration, of this trend is inevitable and desirable over the next five years if this Division is to keep in the forefront of fundamental and applied research in our field. We deal with the real world, which is extremely complex, interactive, multi-disciplinary, and non-linear. We must therefore expect that computer models of processes in this real world will become more and more complex and demanding in terms of computing capacity and programming skills.

The growth of computing in the Division is leading to increasing expenditure on hardware, software purchase and development, and on staffing. This gives added importance to forward planning and efficient and professional management.

In response to a request from the Chief, the Computing Advisory Committee has produced a five-year plan for the development of computing facilities and staffing in the Division.

Chapters 2 and 3 provide a technical description of the proposed hardware development and a discussion of policy regarding languages, standards, training and relations with CSIRONET. We believe these to be within our area of competence, and hope that, subject to financial constraints and to new developments which may arise, they can be adopted as non-controversial and necessary for the proper evolution of an essential facility in a Division such as ours.

Chapter 4 deals with organizational arrangements, which are matters far less related to the technical expertise of this committee. Indeed, these are matters on which there should be input, and could well be disagreement from other members of the Division. Our recommendations in this chapter are therefore put forward for discussion and not with any air of finality. Nevertheless, we believe some arrangement on the lines which we have suggested is necessary for the good management of computing resources in the Division. What we have proposed is not radically different from the present arrangements, but would initiate a more formal structure providing a better interface between the Computing Group and the research groups, in the hope that it would improve computing professionalism and service within the Division, and provide a logical path for future growth.

It should be stressed that the computing industry is rapidly developing, with new products and systems coming on the market year by year, and some older systems becoming outmoded. The turnover time for equipment and ideas is rapid. Therefore, the five-year plan should be seen as our best current attempt to plan ahead, and not as some immutable program to be followed automatically. As the time comes for implementation of each new step, the situation should be reassessed in the light of new developments. It is hoped that this report will provide some useful guidance, not only as to immediate steps, but also as to what considerations should guide future decisions.

Finally, I want to record a note of thanks to all members of the Computing Advisory Committee, and their substitutes, for their hard work in drawing this report together over the last few months. It has been a pleasure to work with such an enthusiastic and knowledgeable group.

A. Barrie Pittock, Chair, CAC.

CHAPTER 2. TECHNICAL

2.1 INTRODUCTION

A large fraction of the research output of the Division is directly supported by the Divisional computer facility and CSIRONET. It is therefore extremely important that those working with computers are able to perform the required tasks as quickly and efficiently as possible. Whatever computer systems are acquired, it is imperative that the operational software is reliable, flexible and easy to use. Hardware is only important where it places limitations on software.

It can be anticipated that by 1990 we will be able to purchase personal desktop computers with something like five times the power of a VAX 11/780 for under $5000. These units will incorporate advanced graphics capabilities. It is clear that many of a scientist's computing requirements will be satisfied by this technology. Recently, several manufacturers have announced ranges of mini-super computers with performance to 25% of the Cyber 205 at a fraction of the cost. Similar units are likely to fall below the $100,000 mark over the next few years and their performance is likely to better the Cyber 205.

Given these technology trends we must develop a plan of growth which can accommodate powerful personal workstations and perhaps a mini-super computer. We must incorporate a means of program and file transfer between workstations. We must also provide a large file server unit to store commonly used libraries, perform network maintenance and support a mini-super computer. This is the general framework on which we base the following specific discussions and recommendations.

2.2 NEEDS

The anticipated computing needs of the Division of Atmospheric Research in the next five years fall into a number of areas which can be summarised by the following titles:

- data acquisition
- data processing
- modelling
- computer-aided design
- graphics
- image processing
- office automation
- library automation
- network access

The facilities needed to support the above activities are outlined below.

2.2.1 Data acquisition

Both field and laboratory data acquisition will continue and expand. New data acquisition systems, as needed, should be developed or purchased in consultation with the Electronics Group.

2.2.2 Data processing

This work encompasses data storage, editing, analysing and reporting. The data sets could be derived from field or laboratory experiments, or from models. Good general purpose computing systems with suitable file management facilities are needed for this work. More use is expected to be made of so-called 4th generation systems, such as the Statistical Analysis System (SAS).

2.2.3 Modelling

Research requiring modelling is expected to expand considerably in the next five years. Continuing shared access to a supercomputer is needed to support this work. If the CSIRONET facilities are to be used for this research, then the operational principle of full cost recovery needs to be replaced by a principle of full utilization of computer resources. Continuing rational funding arrangements need to be set up.

2.2.4 Computer-aided design (CAD)

Both the Electronics and Mechanical Group anticipate greater use of CAD. Personal computers and higher-powered workstations will be needed, together with good graphics facilities.

2.2.5 Graphics

Better graphics systems are needed for the efficient analysis of model and experimental data. The Divisional Graphics Section will require graphics workstations for the preparation of display and publication-standard output. There will be an increasing emphasis on interactive graphical systems, although modellers will still need devices such as microfiche or laser printers for the production of large numbers of graphs. The availability of the same graphics packages, such as GKS and NCAR, on a wide range of machines would be advantageous.

2.2.6 Image processing

The CSIDA group has ported its image-processing software to a high-powered workstation. There could be a demand for such workstations in the Division from modellers and others needing higher-powered graphics facilities.

2.2.7 Office automation

The need here includes the traditional "office" activities of registry, filing, accounting, assets registration, typing, printing, correspondence and communication, performed both by "office" staff and by individuals not in the "office" structure, for example, a scientist using a personal computer to enter and edit his or her own correspondence and papers. CSIRO Headquarters should be responsible for choosing and implementing systems for the Divisional Office. Clearly, personal computers will have an expanding role in increasing the productivity of individual workers, but more coordination, compatability and networking is needed. Scientists will need the ability to produce camera-ready copies of scientific papers.

2.2.8 Library automation

Automation of more library activities is planned. Continuing access to Australian and overseas networks will be needed. More library workstations will be needed.

2.2.9 Network access

Both the library staff and individual scientists make use of Australian and overseas communications networks. International collaborative research has been facilitated by access to overseas mail systems via CSIRONET, and the CSIRONET mail system and network is used heavily by the library staff. Administrative data processing continues to need the CSIRONET network.

Access to Australian and overseas networks will be needed, whether provided through CSIRONET or some other means such as AUSTPAC.

2.2.10 Summary

A large range of machines and facilities will be needed to satisfy the Division's needs. The greatest unknown factor in the planning is whether the Division can expect increased access to the CSIRONET Cyber 205 and other CSIRONET facilities at reasonable cost. If not, plans should be made for the acquisition of a mainframe computer.

It would be desirable if the range of machines, from personal computers, through higher-powered workstations, minicomputers and mainframe computers to supercomputers presented the same interface to the user, and could be all linked together.

2.3 SOFTWARE

The selection of computer software is of paramount concern. Hardware is secondary in importance except where it places limits on the generality and performance of the software. Therefore, we shall first examine the choice of software before dealing with possible hardware configurations.

2.3.1 Unix and VMS

In the choices of software there are two realistic paths open to the Division:

1. Digital Equipment Corp. VAX VMS generic operating system.
2. Unix V operating system (Ultrix32 DEC, HP UX, AIX IBM, Pyramid etc.)

VAX VMS and Unix are widely used in the scientific community and both provide an excellent environment for developing and running programs. A large number of application programs and packages are available to run under VMS and Unix. Both operating systems are well supported and have a proven record of reliability (supplier dependent for Unix).

VMS is written in VAX machine code and therefore runs very efficiently, but can run only on VAX processors. DEC, however, offers a good range of VMS compatible VAX processors. Unix is written in the C language, which makes it easy to run on different types of hardware. There is, however, an efficiency penalty paid for this portability and this can be significant if Fortran compilers are written in C. DEC offers Unix as Ultrix32 on the VAX series, and includes both the VMS and Unix Fortran compilers. HP support Unix as HP UX on their 9000 series and Spectrum series computers. HP supply efficient Fortran compilers for both types of processor. IBM offers Unix as AIX on the PC RT with second source Fortran suppliers. Pyramid offers its own RISC Fortran compiler technology. IBM PC MSDOS will be upgraded to Unix in about 18 months. CSIRONET is porting Unix to CSIRONET nodes.

Most Unix systems now support a set of operations defined in the Unix V interface standard. This means that all such systems can communicate, be networked and have identical system calls. C programs and standard Fortran 77 programs are portable.

Unix and VMS are the only operating systems that have achieved wide acceptance within the scientific community and are arguably the best operating systems currently available for general purpose computing.

2.3.2 Comparison with Existing Facilities

Unix and VMS are significantly better operating environments than the present RTE Hewlett Packard systems. They are easier to use, more powerful, better at communications and networking, and are easier to manage than HP RTE systems.

Current Divisional HP systems are dead end products, since HP will not be upgrading them to support Unix as had been expected. HP has opted instead to concentrate its efforts on the new HP Spectrum series machines.

A more detailed comparison of operating systems is given in Appendix A.

On balance Unix is the better choice of operating systems because:

1. It is supported on a range of computers offering program source portability, networking and communications.

2. It offers the potential for software compatibility within the Division and CSIRONET nodes.

3. It does not limit the future choice of hardware to one manufacturer.

The CAC recommends Unix as the most suitable operating system for the Division's future computer systems (R1). This choice is assumed in the following section on hardware configuration. This recommendation does not preclude the use of existing HP systems running RTE and the MicroVAX II running VMS. These systems will continue to be useful for some years. Moreover, the MicroVAX II can be changed at any time to run Unix.

2.4 HARDWARE

2.4.1 Configuration

Discussions with vendors and other Divisions indicate that a distributed system is technically feasible and desirable for the Division. A recommended configuration is shown in Figure 1. The primary node or file server of the network would be a medium size processor comparable to a VAX 8300. This unit interfaces to a large disc storage facility, magnetic tape units, a central printer, and external networks. Intimately connected to the primary node would be a mini-super computer. Other processors, such as PC and graphics workstations, are connected via a LAN (Local Area Network). The majority of user terminals would gain access to the network and distributed peripherals through a data communications exchange.

The LAN offers users fast file transfer, remote spooling of batch jobs and alternative logon access to any other processors in the network. System management and routine backup would be performed from the primary node. Such a network has several advantages over a single central computer:

1. The network can be expanded as required.
2. Individual elements of the network can be easily upgraded with little disruption.
3. With multiple processors on the network no single job can monopolise the system resources.
4. Redundancy in the network allows processing to continue in the event of a failure.

The CAC recommends the establishment of a distributed system in the Division, based on a Local Area Network, initially with a machine comparable to a VAX 8300 as the primary node of the network (R2). The CAC recommends the acquisition of a mini-super computer at a later date (R3).

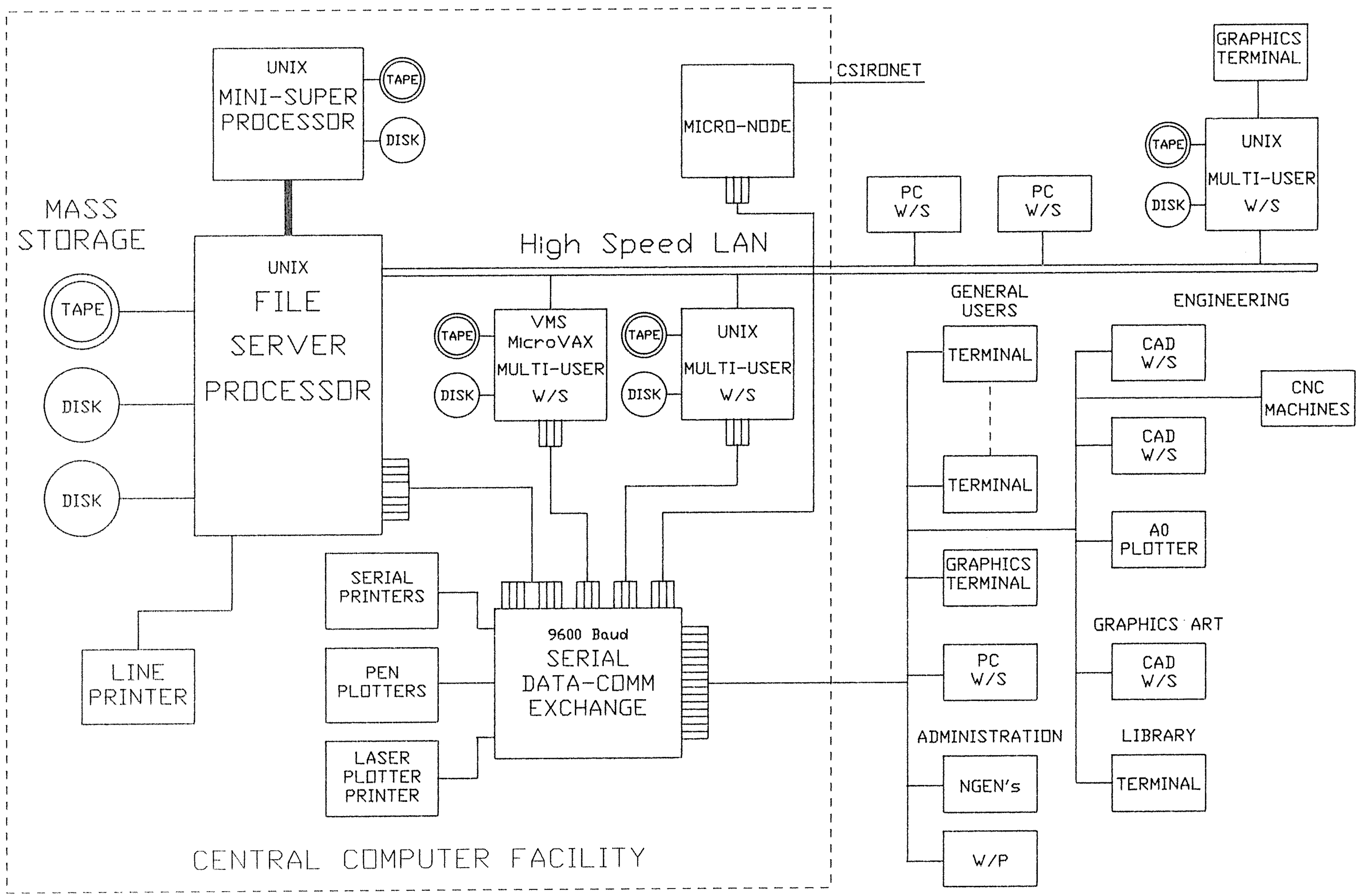

FIGURE 1. DAR LOCAL COMPUTER NETWORK
(recommended future configuration)

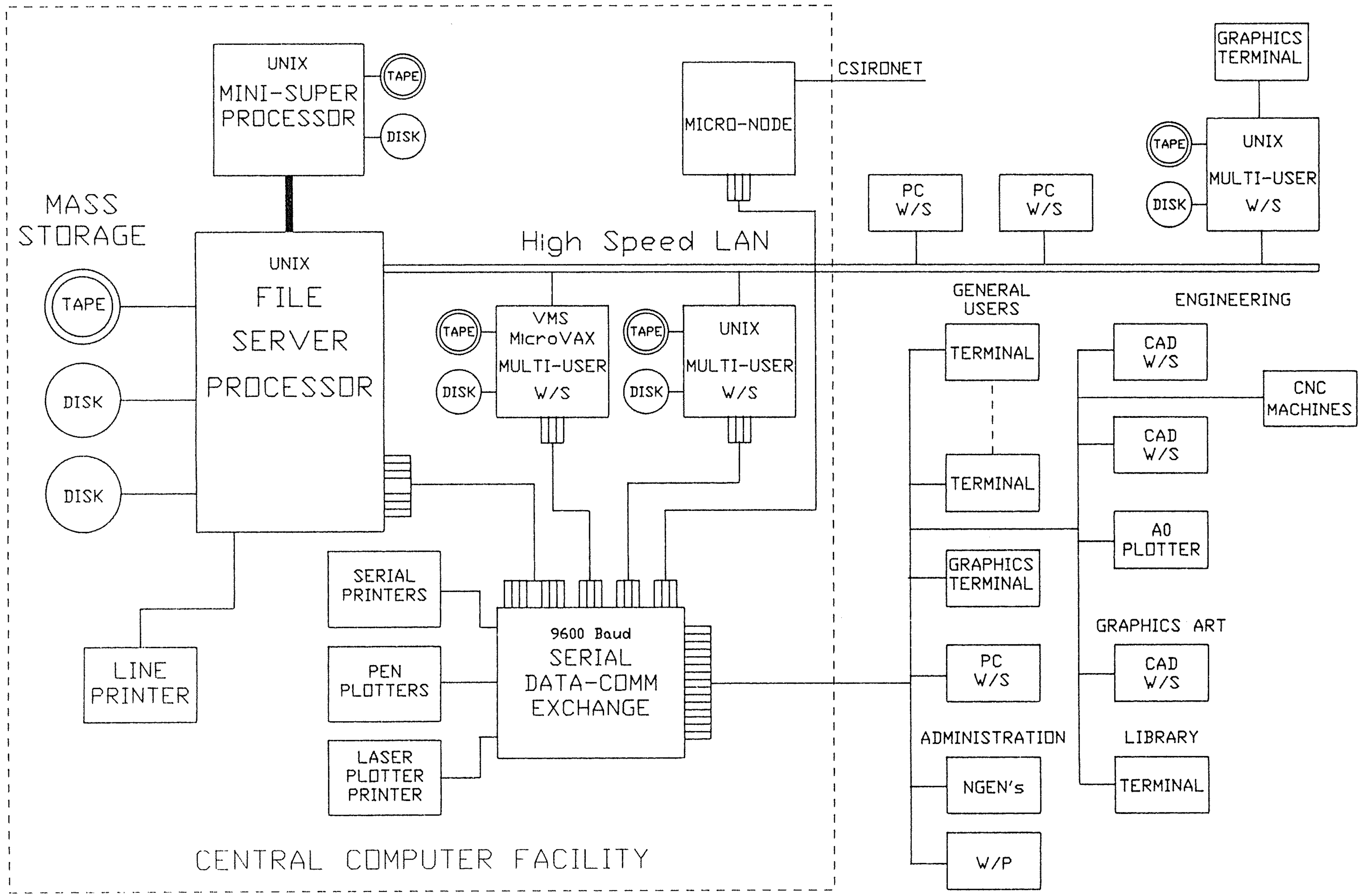

FIGURE 1. DAR LOCAL COMPUTER NETWORK
(recommended future configuration)

2.4.2 Supply

The Digital Equipment Corporation is presently the most appropriate supplier for the major hardware elements including the network. DEC offers a range of processors with proven compilers and full Unix support. Pyramid is also a potential supplier but is a relatively small company with a limited track record. HP have announced the Spectrum series computers but, they are not yet available and so the software is unproven.

A machine of the class of a VAX 8300 would be suitable for the primary node. This acquisition would provide significantly more power than the existing HP network. Mini-super computers are currently available in the range $130K to $500K with performances of 5% to 25% of the Cyber 205. We expect that over the next few years more powerful machines will be available at lower prices. It must be remembered, however, that machines with this type of architecture are best suited for computation intensive tasks and must be used in conjunction with more general purpose systems for program development and data storage.

Because computer technology is advancing rapidly, the supplier of any processors suggested in the network should be decided as close as possible to the time of purchase.

2.4.3 Implementation time-table

Table 2, under section 2.5 Finance, lists the proposed time-table for purchasing major hardware items over the next five years. Refer to Figure 1 for the individual items described.

Major items already purchased this financial year (85/86) are:

- the Serial Data-Communications Exchange ($40,000)
- the AO Plotter ($25,000)
- a specialized data acquisition system by the Small Scale Dynamics group for use in the GFD laboratory ($25,000). This system is independent of the local computer network.

Although Unix is the recommended operating system for the future, the purchase of one DEC MicroVAX II, running VMS, has been approved. This system is to meet the needs of specialized interactive graphics software packages, already in the Division. Nevertheless, if required, it is possible to operate the same system in a Unix environment by purchasing an appropriate copy of DEC Ultrix 32. Tenders for the supply of a system running VMS have been called for, and a purchase order ($50,000) should be issued early next financial year (86/87). It should be stressed that this is a special case, and in no way sets a precedent for further purchases of these specific systems.

Central to the five-year plan is the purchase of a medium size File Server Processor, called the primary node of the network. Such a system would cost about $500,000 and is proposed for 87/88. Because of the long lead time required for a purchase of this magnitude, the case for budget approval would need to be prepared without delay.

Implementation of a high speed (10Mbps) LAN is planned to commence in 86/87, starting with interfaces and cable laying, to provide an interconnection between Personal Desktop Computers. This would be in preparation for later connection to the main File Server Processor in 87/88. Cost of the LAN spread over the first three years would be $35,000, with a further $10,000 p.a. being spent upgrading the RS-232 Data-Communications Exchange system.

For the purpose of medium scale numerical modelling tasks, the purchase of a mini-super computer is planned for 88/89, costing $220,000. An upgrade of the central node to something like a VAX 8800 is scheduled for 89/90, although future decisions about CSIRONET access and funding may change the timing of these purchases.

Provision has been made for the purchase of further super-micro multi-user workstation processors to be connected into the LAN. These purchases have been planned to be spread over the final three years costing a total of $220,000.

Other peripheral equipment purchases listed in the table include a Laser Plotter/Printer and PC workstations, along with various upgrades as needed.

The total capital cost of these proposals over the next five years amounts to just over $2M, which is comparable with five years of current total annual computing expenditure.

2.5 FINANCE

The proposed acquisitions represent a continuing increase in the Division's commitment to computing. At the moment about 6% of the Divisional budget goes towards computing. Within five years this could grow to 10% or more of the total budget. Offsetting these expenditures may be a reduction in real Divisional spending on CSIRONET, but this depends upon CSIRO policy decisions yet to be made. The proposed facility will establish a powerful, flexible network which can grow with the advances in technology to meet the growing demands of the Division's research program.

Divisional computing funding will depend heavily on the means of funding CSIRONET usage, particularly of the Cyber 205. In 1984/85 $83,000 of special funding was provided for Cyber 205 usage, a further $64,000 was provided in the second half of 1985, and $259,000 in grants have been allocated for the current 1986 calendar year. There is some uncertainty surrounding the future of the grants scheme and Cyber 205 funding in general. Any curtailment of Cyber 205 funding or availability would result in a need for a large expenditure by the Division on the local facility to fully support the programs now running, and planned for implementation, on the Cyber 205.

The following tables and graphs outline the financial details of our proposal and the corresponding figures in the past five years. Table 1 outlines the costs of our existing facilities, Table 2 the estimated cost of the proposed expansion, and Table 3 the effective operating costs, past and future, taking depreciation into account. Figures 2 and 3 show these costs in the context of past activities.

In interpreting the following tables, the following points should be borne in mind:

- All the figures for future expenditure shown are 'best estimates' of actual costs at the time to which they apply. Subjective allowance has been made for expected inflation and technological advances in price vs. performance.

- Salary estimates include increases for inflation and for additional staff in coming years. Only computing group staff are included. These estimates allow (tentatively) for one new position in 1986/87, one in 1987/88, one in 1989/90 and two in 1990/91.

- The products mentioned in the plan are intended as 'generic' terms, not as final selections.

- Depreciation figures are based on a three-year write-off period.

- No allowance has been made for the cost of housing the computing facilities; any comprehensive budget would need to do so.

- Multi-user workstations refer to machines of the MicroVAX and IBM-RT genre; desktop workstations refer to PC-compatibles such as the AD-PC or Olivetti.

- It is interesting to note that the increase in spending between 1981 and 1986, although relatively small after discounting inflation, has provided a many-fold increase in our computing power. The proposed plan would mean a continuation of this trend.

Table 1 SUMMARY OF CAPITAL EQUIPMENT PURCHASES 1980-86

	PRE-1980	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
NODE 3 -2112	20000						
DISK 7905	15000						
MT 7970E	15000						
PRTR - TALLY	4000						
TEK 4006	4000						
TERMINALS	32200	9600	8000	14100	32600	10900	
PRTR - DIABLO		4000					
DISK 7925		22000					
PRTR - NODE			12000				
TEK 4014			12000				
DISK 7906				15000			
PLOTTER - 7220				10000			
NODE 2 -2117				55000			
MT 7970E				15000			
DISK 7925				25000			
DISK 7925				25000			
NODE 4 -A600				35000			
DISK 7933				30000			
COMTAL V1/10				90000			
NODE 1 -2117					20000		
DISK 7914					19000		
DISK 7933					24000		
MT 7974					28000		
PRTR - IMPACT					10000		
NODE 6 -A900						70000	
DISK 7933						30000	
MT 7978						35000	
COMTAL V1/10						55000	
MICRONODE						15000	
DESKTOPS						27000	75000
IMAGE W/S						70000	160000
CAD PLOTTER							25000
DATA SWITCH							40000
ANNUAL TOTAL	90200	35600	32000	314100	133600	312900	300000

Table 2 - PROPOSED CAPITAL EQUIPMENT PURCHASES 1986-91

	1986/87	1987/88	1988/89	1989/90	1990/91
MULTI-USER W/S	50000		50000	60000	110000
DATASWITCH EXPN	10000	10000	10000	10000	10000
DESKTOP WORKSTNS	75000	50000	60000	50000	80000
NETWORKING	15000	10000	10000		20000
DATA ACQ	25000				
LASER PRINTER	10000		10000		10000
MICRONODE EXPN	5000				
SUPERMINI (8300)		500000			
UPGRADE (8300-8800)				500000	
MINI-SUPER (FX/8)			220000		
FX/8 UPGRADE					80000
PERIPHERAL UPGRADES	30000		30000		80000
	220000	570000	390000	620000	390000

Table 3 - SUMMARY OF OPERATING EXPENSES, CAPITAL SPENDING, DEPRECIATION & GRANT FUNDS

	PRE-1980	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
SUPPLIES		6000	6000	8000	10000	11000	14000	16000	18000	20000	23000	26000
ELECTRICITY		4000	5000	8000	10000	13000	16000	17000	18000	19000	20000	22000
MAINTENANCE		40800	43000	74500	39000	50100	52200	55000	66000	78000	91000	105000
CSIRONET		110000	104400	118800	140700	243300	200000	200000	200000	200000	200000	200000
TELECOM							3000	5000	6000	7000	8000	9000
SALARIES		106150	112500	125200	132000	142000	156000	190000	235000	260000	300000	400000
TRAVEL		700	200	700	600	6100	1500	2500	3000	3600	4200	5000
TRAINING						1100	1300	1600	2000	2500	3200	4000
TOTAL EXPENSES		267650	271100	335200	332300	466600	444000	487100	548000	590100	649400	771000
CAPITAL SPENDING	90200	35600	32000	314100	133600	312900	300000	220000	570000	390000	620000	390000
DEPRECIATION		41933	52600	127233	159900	253533	248833	277633	363333	393333	526667	466667
EXPENSES+CAPITAL PCHS		303250	303100	649300	465900	779500	744000	707100	1118000	980100	1269400	1161000
EXPENSES+DEPRECIATION		309583	323700	462433	492200	720133	692833	764733	911333	983433	1176067	1237667
205 GRANTS						83000	194000	280000	300000	300000	300000	300000
EXPNS + DEPR + GRANTS		309583	323700	462433	492200	803133	886833	1044733	1211333	1283433	1476067	1537667

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Table 2 - PROPOSED CAPITAL EQUIPMENT PURCHASES 1986-91

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DATA ACQ	25000				
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EXPNS + DEPR + GRANTS		309583	323700	462433	492200	803133	886833	1044733	1211333	1283433	1476067	1537667

Fig.2 TOTAL SPENDING - K$

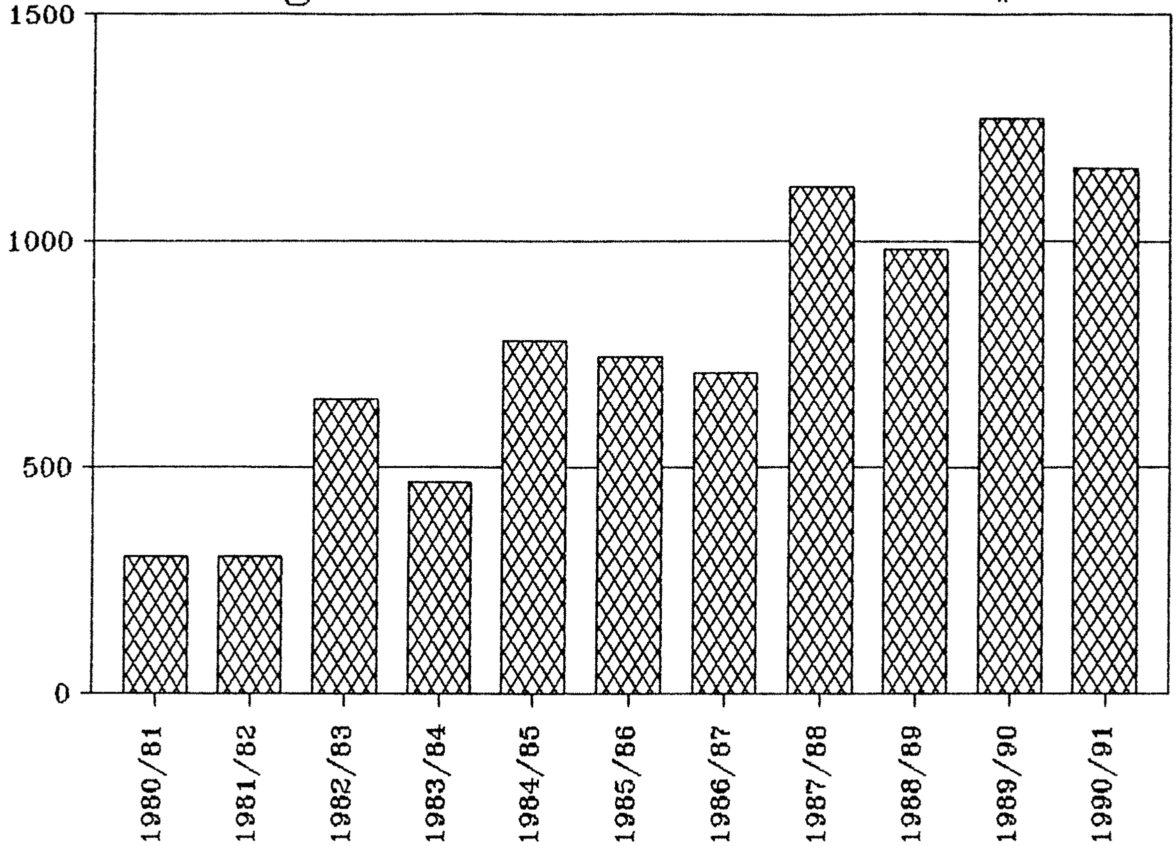
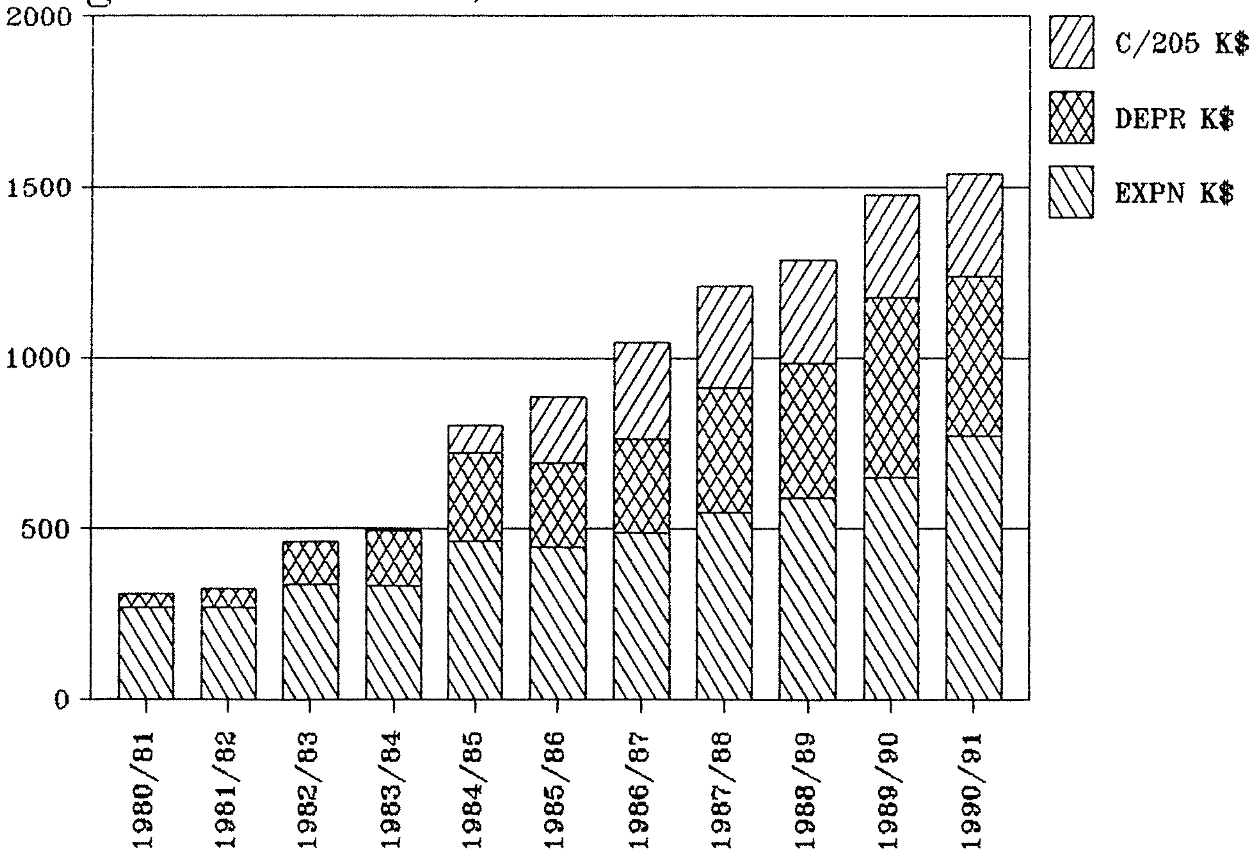


Fig.3 EXPENSES, DEPRECIATION & GRANTS



2.6 CONCLUSION

The provision of good computing facilities is important in ensuring the continuing scientific output of the Division.

In the light of perceived needs and trends in technology a program of moderate expansion of local facilities is recommended. A distributed system with a larger management node and a mini-super computer will meet the likely needs of the Division. The supplier of specific items of hardware must be chosen as close as possible to the time at which the hardware is required.

The system operating software should be Unix. Unix offers a good working environment and an open-ended path for future expansion.

Appendix A

Comparison of Operating Systems

Function	Unix	VMS	RTE A	RTE 6
Multi-user system	good	good	fair	fair
Multi-tasking	good	good	fair	poor
Program size limitations	none	none	some	32K+seg
Virtual memory support	good	good	poor	poor
Hierarchical directories	yes	yes	yes	no
Editors	good	good	poor	poor
Screen editor terminals	any	vt100	HP	HP
Compilers (range)	good	good	fair	fair
Compilers (performance)	good	good	fair	good
Debugging facilities	good	good	fair	fair
Application packages	good	good	poor	poor
Software management	good	fair	poor	poor
Communications	good	good	fair	poor
Networking ability	good	good	poor	poor
System management	good	good	fair	poor
Real time operation	no	good	good	good

Appendix A (contd)

Explanatory Notes for Table

Multi-user environments are provided by all four operating systems and are rated according to the acceptability of the user interface.

Multi-tasking is acceptable under all four and is most easily accessed under Unix. Under VMS it is slightly more difficult to generate additional user tasks. The HP RTE systems come a poor third in this area.

Extremely large programs can be run in Unix and VMS environments; they can occupy almost all of physical memory, and using virtual memory support, they can far exceed the physical memory size. Under RTE A there is a 2Mbyte limit to the data space for physical memory, although larger programs can be run using virtual memory. RTE 6 is very restrictive on program size and special actions are required to load and run large programs.

Unix offers three line editors and two screen editors: 'vi' and 'emacs'. 'vi' is better than the HP screen editor but does not have a good user interface. 'Emacs' has a much better user interface. VMS also offers several editors. Both VMS and Unix offer document formatting facilities and Unix offers type setting options.

A wide range of compilers is available for both Unix and VMS. Unix as Ultrix 32 will run the VMS Fortran compiler as well as the less efficient Unix Fortran compiler. HP RTE systems rely on HP alone for supply.

Appendix A (contd.)

Full symbolic debugging facilities are provided under Unix and VMS. HP RTE systems have a machine code level debugger only.

Large numbers of application packages are available to run under VMS and Unix. Unix packages are often written in C which means they are likely to be very efficient. GKS packages for instance are available for VMS and Unix. Packages have to be ported to run under RTE.

Full software management facilities are provided under Unix. The SCCS system stores differences between versions of a program and can recreate any previous configuration or report differences. MAKE is a system function which selectively recompiles programs and loads them. These features are not fully provided under VMS, and are absent from HP RTE.

Both Unix and VMS are expert at communications and networking. Both can support Ethernet LAN and allow remote job spooling, remote logon and file transfers. The RTE facility DS is inferior.

System management facilities under VMS are highly developed and more screen oriented than those of Unix. Unix does, however, provide a comprehensive set of utilities which allow system performance to be monitored and tuned. RTE 6 is lacking in this area although RTE A is somewhat better.

Appendix A (contd.)

VMS and RTE support real-time operations. That is external experiments can be serviced as required to the detriment of user response and general system functions. Unix is a time sharing system and each task is allocated a time slice according to how long since it last ran. Under Unix, users can only lower the priority of their jobs. HP UX is a real- time Unix and can lockout processes according to a priority scheme.

CHAPTER 3. POLICY

3.1 Standards

The requirements for programming in the Division can be broadly classified into:

(i) scientific programming in the research groups;

(ii) systems programming by the computing group;

(iii) programming of intelligent devices, primarily by the electronics group; and

(iv) a small amount of microcomputer systems development in the research groups.

The need for reliable, maintainable, portable software is of paramount importance to the Division's operations. Reliability of scientific programs is an essential component of scientific integrity - a matter of being sure that a program actually calculates what it is claimed to calculate. The requirements for maintainability must recognise that all but the smallest programs used in the Division will generally have more than one person working on the code during the program's life-cycle, especially when term appointees are involved. The achievement of these aims of reliability, maintainability and portability will, in many cases, require improvements in support software and project management, and additional staff training. The issue of training is addressed in section 3.3 below.

Concerning project management, recommendation 18 of the CSIRO Internal Audit group's review of computing was: 'That CSIRO Divisions, at least for major projects, use an acceptable systems development life-cycle'. By adopting this recommendation, with each group subjecting its major projects to formal evaluation, Divisional staff will gain experience which will also benefit the management of smaller projects and help identify areas in which further staff training is desirable. The precise procedures for project evaluation will need to be developed in an evolutionary fashion as experience with the process is gained. This development should be monitored by the Computer Advisory Committee who may formalise guidelines from time to time.

Recommendations:

- The CSIRO Audit group's recommendation 18, suggesting acceptable systems development life-cycles, should be adopted for large projects (R4).

- The initial planning stage of a system development should include assessment of the possibility of acquiring existing software packages (R5).

- All programming projects should be carried out so as to enhance the maintainability and portability of programs that are produced (R6).

- The computing group should provide information on those constructs of the existing Fortran that degrade portability or upward compatibility (R7).

- The use of any non-standard language features should be confined to critical points of any program and should be fully documented. In the period before Fortran 8x becomes available, this applies particularly to the use of non-standard Fortran to achieve vectorization (R8).

- Improvement of the general programming standards in DAR should be addressed as part of a general training plan (R9).

For examples of specific programming standards, the DCR Software Development Standards Manual should be consulted.

3.2 Languages

Scientific programming is dominated by Fortran, in this Division and everywhere else. Fortran standards are revised on a regular basis, the last revision being Fortran 77 with a proposed Fortran 8x due about 1988.

These revisions have allowed a reduction in the various defects of Fortran. A serious concern for the work of this Division is that Fortran 77 does not include any standards for vector processing. This leads to considerable difficulties since the system used differs from machine to machine and from the initial proposals for Fortran 8x. Thus vectorization should be restricted to those calculations where it will make significant improvements, so that programs remain usable when new machines or new compilers are purchased by DAR or CSIRO, or when transfer of programs to other institutions is required. It is essential that language systems provide facilities for 'instrumenting' programs, in order to identify critical calculations where vectorization or other non-standard facilities may be required.

Fortran was originally designed for numeric calculations in science and engineering and is generally less-suited to non-numeric applications. In particular, the fact that essentially the only languages available for systems programming on the HP machines are Fortran and Assembler is a significant restriction.

In the related areas of programming intelligent devices, C and Pascal are currently being used as appropriate tools. The Turbo-Pascal system is proving particularly suitable for Z-80 applications. For other processors there are problems due to lack of suitable cross-compilers or cross-assemblers.

C is a general purpose programming language which has been closely associated with the Unix operating system. C allows the user to write very efficient portable programs and subroutines. Thus instead of using non-portable machine code to speed up a Fortran program, a C routine can be used which will have similar performance, and be portable to other machines. C provides a means of writing almost at machine code level, but with higher level structures superior to Fortran, and machine independence.

Recommendations:

- High-level languages rather than low-level languages should be used for all computing projects. This includes projects involving systems programming. The availability of suitable high-level languages should be mandatory for all future systems (R10).

- The use of cross-assemblers and cross-compilers for microprocessor systems is highly desirable, and the availability of suitable software tools should be a significant consideration when choosing hardware (R11).

- The use of languages such as Pascal and C should be considered desirable for non-numerical applications (R12).

- Fortran should be the language of choice for numerical applications (R13).

- Compilers should be able (when requested) to flag constructs that depart from the appropriate standard. This applies particularly to Fortran on minicomputers (R14).

- Language systems should provide facilities for obtaining performance information, particularly timing (R15).

3.3 Training and related matters

3.3.1 Introduction

Computer programming is now the most common support work performed in the Division, with about 50 staff members having undertaken some computer programming in recent years.

However, the Division has done little to organise training that is required in order to ensure that the skills of staff keep abreast with the rapid developments and Divisional requirements in the computing field. As far as programming and design skills are concerned, the Division relies on the individuals' knowledge gained during tertiary education and the individuals' ability and willingness to learn on the job. Much of the existing skill base in the Division comes from recent recruitment following the restructuring of the Division. This situation is unlikely to recur and indeed future changes are more likely to strain the Divisional skill base than provide the breathing space that recent changes have given us.

Divisional management procedures and performance counselling should aim to ensure a maintenance of computing skills within the Division. The Divisional training program should be developed along the lines of the CSIRO policy foreshadowed in section 13 of the CSIRO 1984/85 Annual Report.

3.3.2 Staff Management

In order to maintain a Divisional capability to handle increasingly complex software in future years, the level of staff expertise must continue to rise and the Division must plan on meeting its requirements largely with existing staff. Three ways that the necessary developments could be organised are discussed below. These mirror the possible staff arrangements discussed elsewhere in this report.

(i) The section leaders could take responsibility for the professional development of staff in their sections. This is implicitly the present situation, but has been somewhat neglected.

(ii) Programming staff could be transferred to an expanded computing group which would provide oversight and assignment of programmers to projects.

(iii) Programming staff could be made jointly responsible to their research group and the computing group for scientific and computing supervision respectively.

3.3.3 Measures for staff development

All staff involved in programming should have a formal background in computing at tertiary level with additional mathematics as appropriate. No existing staff members should be required to take on new computing duties without this background or retraining, and new staff required for computer programming should have appropriate training.

If the skills of existing staff are to keep pace with developing technology during periods of low recruitment to the Division, then it is essential that staff attend courses outside the Division. Courses relevant to design and program management should be attended by senior staff responsible for computing. A prerequisite for extensive use of external courses is the co-ordination of information on appropriate courses, ideally by the CSIRO Staff Development and Training Unit (SDTU). Unless and until this is possible, the Division should 'go it alone', co-operating with other Victorian Divisions if possible. There are also a number of additional mechanisms that are desirable for disseminating skills within the Division.

(i) Programmers should be encouraged to report on their current work in short seminars similar to the recent ES seminars. Of more value would be reports on new techniques successfully used and talks on new facilities available.

(ii) Programmers should scan the current computing literature. The informal seminar series could be used for critical book reviews and discussion meetings on significant literature such as the 'Programming Pearls' column in Communications of the ACM.

(iii) On an individual level, staff members may enhance their professional development through appropriate professional organisations. We believe that the low membership levels in the Division are symptomatic of a low level of consciousness of the need for professional development in the programming area. (Out of about 50 staff we have an estimated 2 members ACS, 1 member ACM and, perhaps most significantly, no members of the computational mathematics group of the Australian Mathematical Society).

3.3.4 Operational procedures

The prototype introductory note series on CSIRONET usage for DAR users should be expanded to encompass local machines and recommended microcomputers; all local changes to manufacturers' systems should be documented (R16).

Formal management techniques should be introduced for large projects after suitable training. Some of the overly individualistic approaches to project management should be replaced by less egocentric ones. Programmers should work more as teams, critically reviewing the work of the other members of the team and acting as moderators for any proposed changes to production systems. Programming as a team should lead to better software, and improve programmers' skills because of the sharing of techniques and ideas. Programmers should be aware of the considerable savings in purchasing rather than developing software, should be trained to think before coding, and should know where to look for appropriate software or know the appropriate person to contact.

Recommendations

- The Division move as a matter of urgency, to implement management procedures that ensure the continued development of the computing skills of Divisional staff (R17).

- The Division should use external courses as a primary mechanism for upgrading the skill base of its computing staff (R18).
- An information base concerning suitable courses is required. If this can not be provided promptly through the SDTU then the Division should acquire such information through its own resources (R19).
- Procedures for internal skill-sharing be established (R20).
- Internal documentation should be improved (R21).
- Improvements in the programming skill base should be followed up by improved project management (R22).

3.4 Relationship with CSIRONET

This Division has remained a significant user of CSIRONET services while some other Divisions have almost ceased using the CSIRONET host services. In the last two years, the availability of the Cyber 205 (for state-of-the-art modelling) and the ready access to it provided by the Grants Scheme has been the main reason for continued use of CSIRONET. Much of the CSIDA software originally came from CSIRONET. The CSIRONET network itself is used for access to overseas mail systems, and by the Library for data transfers. The CSIRONET mail system is used heavily by the Library and some other users.

Continued use of CSIRONET host services depends on the continued availability of a current supercomputer for modelling work, and on a more rational charging philosophy, based less on the full cost-recovery principle, and more on the full utilisation principle. CSIRONET services appear expensive because they are fully costed, whereas local computing services appear free. There is naturally then a drift away from the use of CSIRONET facilities, and only the Grants Scheme and a need for access to a supercomputer for state-of-the-art modelling work has arrested this drift recently.

It is expected that Library and Administrative processing will make increasing use of services provided on the CSIRONET network and of the network itself. There will always be a need for network access to CSIRO central facilities, and this access will be over CSIRONET's network at least for the next few years.

CSIRONET is developing a general purpose workstation from its micronode, and as this workstation will run the UNIX operating system, and provide simple access to CSIRONET, it might well find its place in any Divisional plan for comprehensive UNIX based facilities.

CSIRONET should be involved in the acquisition of CSIRO-wide licences for software, and the distribution and maintenance of such software over the network.

Recommendation

The Division should make strenuous efforts to get CSIRO to make decisions about future funding of CSIRONET and particularly supercomputer usage. Access to CSIRONET facilities needs to be ensured for some years (R23).

CHAPTER 4. ORGANIZATIONAL ARRANGEMENTS

This section of the report sets out a possible arrangement for the management of the computing facilities within the Division of Atmospheric Research. Basically, there are three choices: a fully centralised computing group; a fully decentralised dispersion of computing facilities amongst the research groups; and a compromise or middle way in which there are centralised facilities and staff, plus facilities and programmers within research groups as appropriate. The two extremes are in effect "straw men" (or whatever the non-sexist term is): the real problem is how to strike a proper balance between the centralised and the dispersed facilities and staffing. The middle option is addressed below, but it might first be useful to briefly examine the pros and cons of either extreme.

A fully centralised facility would involve a central building housing all or most computing hardware, and all programming and hardware support staff, with a leader having considerable authority over the allocation of machine and staff time and budgeting.

Advantages of such centralisation would include greater consistency in hardware and software acquisition and development, including possibly higher standards of programming, and greater "rationalisation" in the bureaucratic sense. It would also mean that greater specialised computing expertise could be available to users. It would provide greater recognition and better career prospects for computer professionals.

Disadvantages of centralisation would include increased bureaucratic frustration as seen from the users' point of view, with less room for user initiatives and adaptations, and less continuity of involvement by particular programmers and computing staff generally in the scientific aspects of particular user groups' problems.

On the other hand, a fully decentralised facility would have the advantage of greater tailoring of computing facilities to the scientific needs of each research group, and possibly easier access to appropriate machines and programming.

The disadvantages of decentralisation would include duplication of facilities, possible lower quality of software products and hardware support, and loss of versatility in adapting to changing research emphasis within and between groups.

4.1 Recommended Organization of Computing Staff

As already foreshadowed in this report, we can look forward in the next five years to a considerable expansion in computing within this Division, comparable with the growth which took place over the last five years. This means that computing will have become a major part of the Division's activities and budget, with a consequent need for higher levels of professional management, staffing, and planning. There is thus an increasing need for a strong nucleus of computer professionals, with a strong interface to the scientific groups. The Computing Group must be seen as highly competent and professional, and also "user friendly".

There are at present some 20 people in the Division whose primary activity is software development and computer systems support, another 7 whose work is mainly computer based, and a further 43 who use computers regularly for scientific, technical or administrative tasks. With a total Computing Group of five persons out of 70 users, there is naturally a strong need for significant computing expertise within the various other groups. Recent experience has shown that the Computing Group, under the present arrangements, has often remained unaware of the problems and needs of the research groups, because of the difficulty of regular communication with such a dispersed user population.

The CAC recommends that the Computing Group should, in the near future, be expanded to consist of at least six professionals with designated responsibilities, plus recognised liaison persons or consultants to each of the research groups and the Administration Group. The five liaison persons or consultants would not necessarily be full-time members of the Computing Group, although this should be considered on a case-by-case basis, with a view to the possible further expansion of the Computing Group (R24).

Options would be for a member of the particular research group, while remaining a member of that group, to be formally designated as the computing liaison person, or for a suitable person to join the Computing Group, either from the research group or from outside as a new appointment, as the designated consultant to the research group. In either case, the intention of the designation would be to afford professional recognition to those persons for their role as computing consultants, thereby fostering expertise and professionalism and offering a better career path and incentive.

In either case, we suggest that such liaison persons or consultants normally be housed within the research groups, but with a regular arrangement whereby they come together with the Computing Group, perhaps one day or half a day per week, to discuss computing problems and to share expertise. This would provide professional stimulus, and help to maintain standards. In considering recommendations for promotion of such liaison persons, both the scientific Group Leader and the Manager of the Computing Group would be involved.

We suggest that the appointment or designation of such liaison people be done with consultation and agreement between the relevant Group Leader and the Manager of the Computing Group, and, in the case of an appointment or designation of an existing staff person from a research group, after staff counselling as appropriate. The question of a replacement position in a research group for a member transferred to the Computing Group should be a matter for negotiation and agreement on a case-by-case basis. It should be clearly understood that the primary duty of such a designated consultant, if a member of the Computing Group, would be to act as a computing consultant to that particular research group, which would therefore have priority use of the consultant's time.

The designation of computing consultants to research groups should not be seen as in any way precluding the continued or additional appointment of computer programmers to individual research groups as appropriate, subject only to the normal limitations on staff positions (R25).

The suggested Computing Group would thus consist of the following:

(1) Manager

(2) Remote Systems Consultant

(3) Local Systems Consultant

(4) Micro-Systems Consultant

(5) Graphics Consultant

(6) Operations Officer

and, either as full members of the Computing Group, seconded to the other groups, or as members of the other groups, designated as computing consultants:

(7) Atmospheric Constituents Consultant

(8) Remote Sensing Consultant

(9) Large-Scale Dynamics Consultant

(10) Small-Scale Dynamics Consultant

(11) Administrative Applications Consultant

Besides its roles in overseeing and managing computing hardware and purchases thereof, as discussed below, and in the development and purchase of software, also discussed below, the Computing Group would have responsibility for organising continuing education in computing for the user groups and be responsible for assisting in the design and implementation of major computing projects.

4.2 Hardware purchasing

Hardware falls into three categories: special purpose, distributed and central.

4.2.1 Special Purpose Hardware

Special purpose hardware would include computing equipment to be dedicated to a single task, such as data acquisition or instrument control, for a single project. In such cases, computing and engineering staff should be consulted for advice on suitability and technical matters; however it would not seem necessary for the facilities groups to make final decisions.

4.2.2 Distributed Hardware

This category would include personal and group workstations, and associated peripheral devices. Computing group and engineering group advice should be sought in such cases.

The need to enforce a degree of compatibility should warrant the continuation of the authority of the central group to oversee such purchases (R26).

The central group would be expected to provide support to the users of such equipment. The Computing Group would also take responsibility for assisting users to link their systems into the Divisional network.

The Computing Advisory Committee ought to be involved in decisions involving major purchases and significant departures from established standards of compatibility (R27).

4.2.3 Central Hardware

Most items in this category would be large purchases. The Computing Group should have primary responsibility for initiation and preparation of purchase plans.

The Computing Advisory Committee should have the power of veto and approve all plans before submission to the Chief for approval of funding (R28).

This is not significantly different from the current situation, but needs to be formalised.

4.2.4 Summary

General purpose computing equipment should be centrally controlled. Divisional standards of compatibility and suitability should be maintained by the Computing Group and Computing Advisory Committee where appropriate.

4.3 Development and purchase of software

4.3.1 Purchase of Software for Distributed Systems

Where software is required by a group or individual for personal or group workstations, the costs are usually relatively low (less than $1000). The group should inform the responsible member of the Computing Group before such purchases, so that if there is general interest, arrangements might be made for multiple licensing with possible splitting of costs. Such consultation would also help avoid unnecessary purchases if similar products are already available in the Division (or elsewhere in CSIRO).

The CAC recommends that the Computing Group maintains a register of software owned by the Division, and our rights to copy and use on multiple systems (R29).

Information on 'Site Licensing' should be sought in consideration of any new package.

4.3.2 Purchase of Software for Central Systems

It is expected that purchases of software for use on the central systems would involve relatively large amounts of money. In such cases, central facilities persons should endeavour to test and assess the quality of the product and its suitability for the Division.

Major purchases of software (above some set value) should be subject to approval of the Computing Advisory Committee (R30).

If such software is to be purchased by and for a single research group, that group would be expected to provide the funds. It is still expected that Computing Group assistance would be sought in deciding on the purchase.

4.3.3 Software Development

If this review results in a stronger central Computing Group, there will be available a pool of experienced people to assist in design and direction of software development. Monitoring of such developments could result in significant improvements in the efficiency of programming effort. Generally useful packages could be designed to handle a wider range of needs - at the design stage where changes are most easily made. Old programs could be adapted to new jobs, making new 'wheels' a less frequent invention. Languages and standards are discussed in more detail in the Policy Section.

CHAPTER 5. Summary

The Computing Advisory Committee has produced a report in response to the Chief's request for a five-year plan for computing in the Division.

Chapter 2 discusses the anticipated needs, preferred operating system, proposed system configuration, costs, and an implementation timetable. Chapter 3 discusses languages and standards, training and the relationship with CSIRONET. Chapter 4 discusses organizational arrangements.

The Committee recommends the building up of a local general-purpose computing facility, running the UNIX operating system, with a large management node comparable to a VAX 8300.

A mini-super computer for numerically intensive tasks would be coupled to the main node. A local area network (LAN) would link most Divisional computing facilities and workstations. The local facility should provide a stable environment for most scientific processing but continuing access to a supercomputer, such as that on CSIRONET, will be needed for state-of-the-art modelling.

The Committee recommends stronger organizational links between a somewhat expanded Computing Group and the Research Groups, to improve the productivity and professional development of the Division's computing staff and to improve the quality of the Division's software.

Summary of Recommendations

The following is a summary of the recommendations:

Technical (2):

R1 The CAC recommends Unix as the most suitable operating system for the Division's future computer systems (2.3.2)

R2 The CAC recommends the establishment of a distributed system in the Division, based on a Local Area Network, initially with a machine comparable to a VAX 8300 as the primary node of the network (2.4.1 and Fig.1)

R3 The CAC recommends the acquisition of a mini-super computer at a later date (2.4.1)

Standards (3.1):

R4 The CSIRO Audit group's recommendation 18, suggesting acceptable systems development life-cycles, should be adopted for large projects.

R5 The initial planning stage of a system development should include assessment of the possibility of acquiring existing software packages.

R6 All programming projects should be carried out so as to enhance the maintainability and portability of programs that are produced.

R7 The computing group should provide information on those constructs of the existing Fortran that degrade portability or upward compatibility.

R8 The use of any non-standard language features should be confined to critical points of any program and should be fully documented. In the period before Fortran 8x becomes available, this applies particularly to the use of non-standard Fortran to achieve vectorization.

R9 Improvement of the general programming standards in DAR should be addressed as part of a general training plan.

Languages (3.2):

R10 High-level languages rather than low-level languages should be used for all computing projects. This includes projects involving systems programming. The availability of suitable high-level languages should be mandatory for all future systems.

R11 The use of cross-assemblers and cross-compilers for microprocessor systems is highly desirable, and the availability of suitable software tools should be a significant consideration when choosing hardware.

R12 The use of languages such as Pascal and C should be considered desirable for non-numerical applications.

R13 Fortran should be the language of choice for numerical applications.

R14 Compilers should be able (when requested) to flag constructs that depart from the appropriate standard. This applies particularly to Fortran on minicomputers.

R15 Language systems should provide facilities for obtaining performance information, particularly timing.

Training (3.3):

R16 The prototype introductory note series on CSIRONET usage for DAR users should be expanded to encompass local machines and recommended microcomputers; all local changes to manufacturers' systems should be documented.

R17 The Division move as a matter of urgency, to implement management procedures that ensure the continued development of the computing skills of Divisional staff.

R18 The Division should use external courses as a primary mechanism for upgrading the skill base of its computing staff.

R19 An information base concerning suitable courses is required. If this can not be provided promptly through the SDTU then the Division should acquire such information through its own resources.

R20 Procedures for internal skill-sharing be established.

R21 Internal documentation should be improved.

R22 Improvements in the programming skill base should be followed up by improved project management.

CSIRONET (3.4):

R23 The Division should make strenuous efforts to get CSIRO to make decisions about future funding of CSIRONET and particularly supercomputer usage. Access to CSIRONET facilities needs to be ensured for some years.

Organization (4.1):

R24 The CAC recommends that the Computing Group should, in the near future, be expanded to consist of at least six professionals with designated responsibilities, plus recognised liaison persons or consultants to each of the research groups and the Administration Group. The five liasion persons or consultants would not necessarily be full-time members of the Computing Group, although this should be considered on a case-by-case basis, with a view to the possible further expansion of the Computing Group.

R25 The designation of computing consultants to research groups should not be seen as in any way precluding the continued or additional appointment of computer programmers to individual research groups as appropriate, subject only to the normal limitations on staff positions.

Distributed Hardware Purchasing (4.2.2):

R26 The need to enforce a degree of compatibility should warrant the continuation of the authority of the central group to oversee such purchases.

R27 The Computing Advisory Committee ought to be involved in decisions involving major purchases and significant departures from established standards of compatibility.

Central Hardware Purchasing (4.2):

R28 The Computing Advisory Committee should have the power of veto, and approve all plans before submission to the Chief for approval of funding.

Purchase of Software for Distributed Systems (4.3.1):

R29 The CAC recommends that the Computing Group maintains a register of software owned by the Division, and our rights to copy and use on multiple systems.

Purchase of Software for Central Systems (4.3.1):

R30 Major purchases of software (above some set value) should be subject to approval of the Computing Advisory Committee.

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