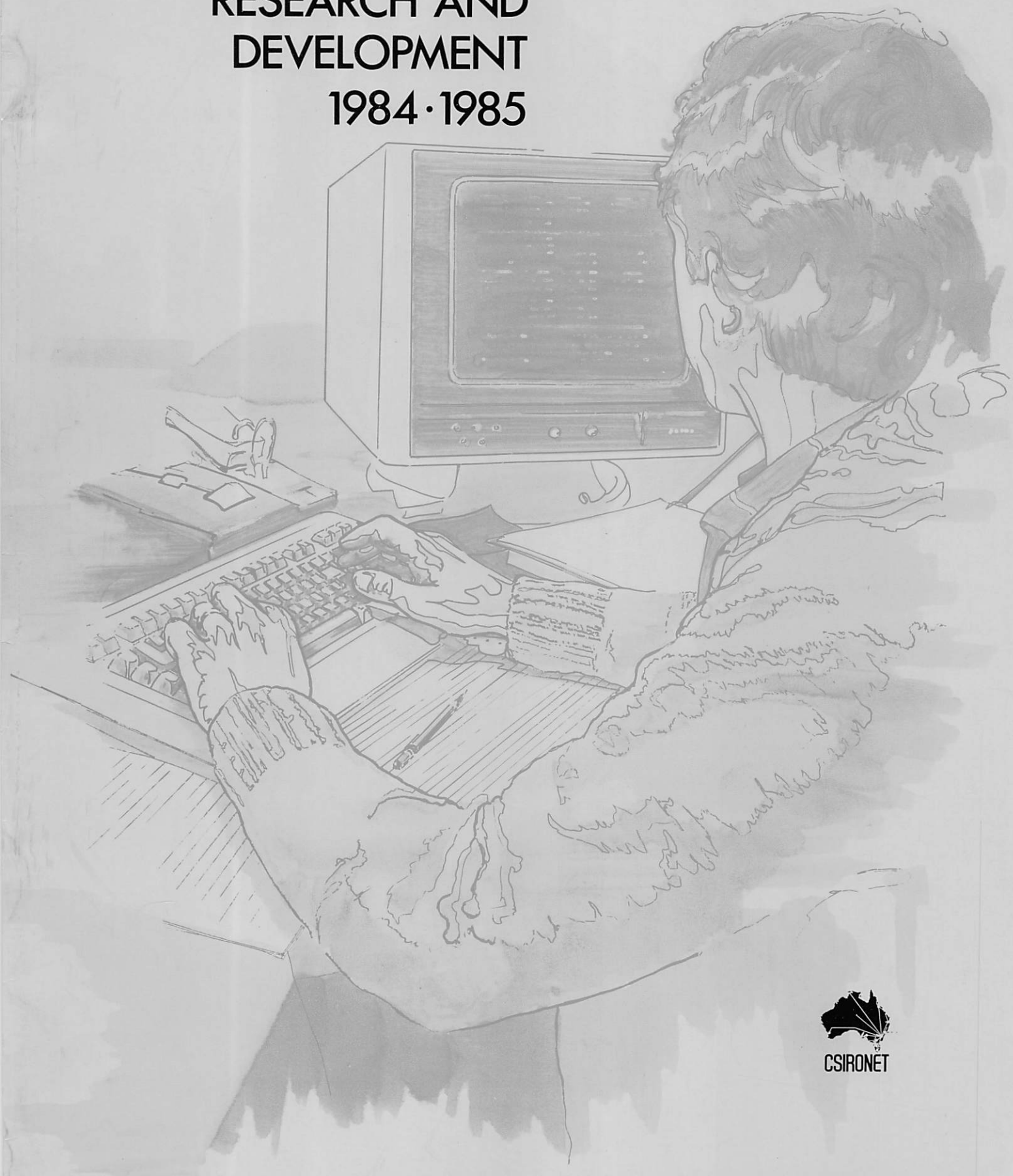
T.S. HOLDEN

AUSTRALIA

CSIRONET RESEARCH AND DEVELOPMENT 1984·1985



CSIRONET

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INTRODUCTION

CSIRONET is an Australia-wide value-added computing service. It provides extensive commercial and scientific computing facilities, and a range of specialised services and peripherals not otherwise available in Australia. Advanced development work is undertaken on projects related to the computing service.

CSIRONET is an autonomous agency, managed by a Board of Management responsible to the Executive of CSIRO. It operates on a full cost recovery basis. The Executive has directed the Board to enhance the commercial role of CSIRONET.

New strategies are being developed to meet the requirements of clients both old and new. Services that provide computing facilities for the non-specialist, as well as advanced facilities for the computing specialist, will continue to be supplied.

History

CSIRONET was established in 1963 as the Computing Research Section of CSIRO. The Section became the Division of Computing Research in August 1967. Following a review of the Division in 1982-83, the computing service and associated developmental activities were placed into a separate agency known as CSIRONET, from 1 January 1985. Research activities not directly related to the computing service form part of the new CSIRO Division of Information Technology.

Management

CSIRONET is no longer part of the Institute of Physical Sciences. The Board of Management is responsible to the Executive through its Chairman. The Board sets CSIRONET's strategic directions, policies and objectives; critically reviews alternative strategies and proposals developed by management; and directs management to pursue specific programs. It also critically reviews and approves specific management proposals made within the context of the Executive's long-term policies. The Board began to meet in August 1984.

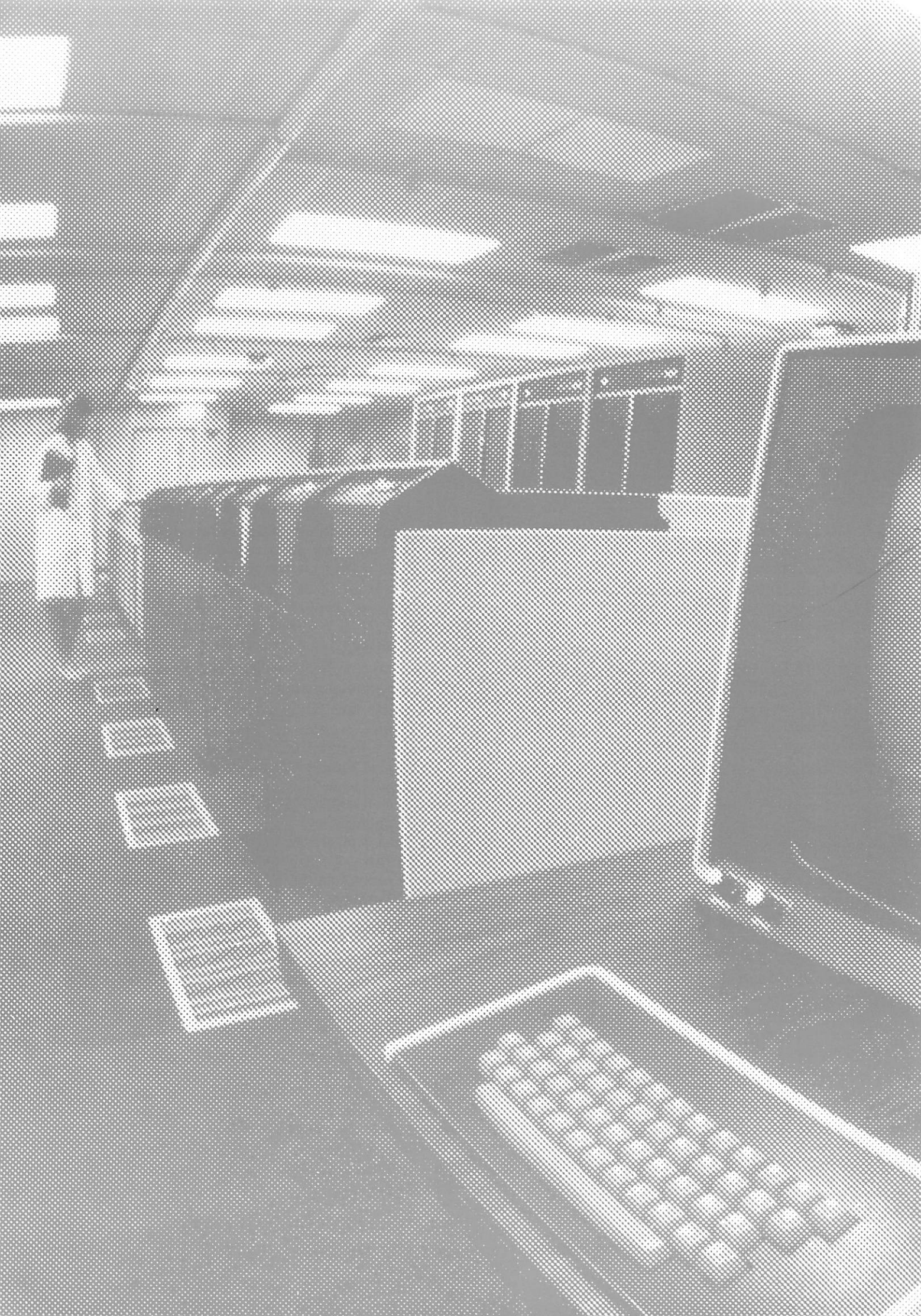
Members of the Board of Management during 1984-1985 were as follows:

- Mr Denys McCullough, Chairman
- Dr Peter Claringbold, Chief Executive
- Dr Barry Brady, Chief, Division of Geomechanics
- Dr Neville Fletcher, Director, Institute of Physical Sciences
- Mr Peter Hanlon, CSIRONET Staff Representative
- Mr Noel Tanzer, Deputy Director-General, Department of Social Security
- Mr Howard Crozier, Secretary, Finance and Administration, CSIRO

The change in the status of CSIRONET has led to a commercial management structure. As well as a Chief Executive, it now has three General Managers (Services, Products and Marketing). A full staff list is given on pages 24-25.

This Report

This Report provides an overview of computing equipment and major development activities in CSIRONET during July 1984-June 1985. Further information may be found in the following publications: *CSIRONET Annual Report 1984-85, Introductory Guide* No 1, 'CSIRONET Services', and *Users Manual* Volume 1, 'Introduction to CSIRONET'.



RESEARCH AND DEVELOPMENT

Research and development work in CSIRONET is in areas supporting the network and services, including computer communications, workstation design, supercomputer applications, typesetting and demand publishing, graphics and image processing, and geographic information systems.

Computer Communications

The functions of the Computer Communications Group are:

- to provide a communications network to enable users of any CSIRONET host service to access that service, regardless of geographical location of the user or host. This includes providing interfaces to hosts, terminals and peripherals.
- to provide support for non-host-specific high-level communications functions on CSIRONET hosts, by specifying architectures for supporting such functions and providing non-host-specific components of systems implementing such functions.
- to produce communications hardware and software products for marketing within and/or external to the CSIRONET environment.
- to provide communications services between user-managed end systems connected to CSIRONET.
- to conduct research in areas associated with computer communications, to contribute to the establishment of international computer communications standards, and to foster the advancement of Australian high technology.
- to provide consulting services in the computer communications field.

Open Systems Interconnection (OSI)

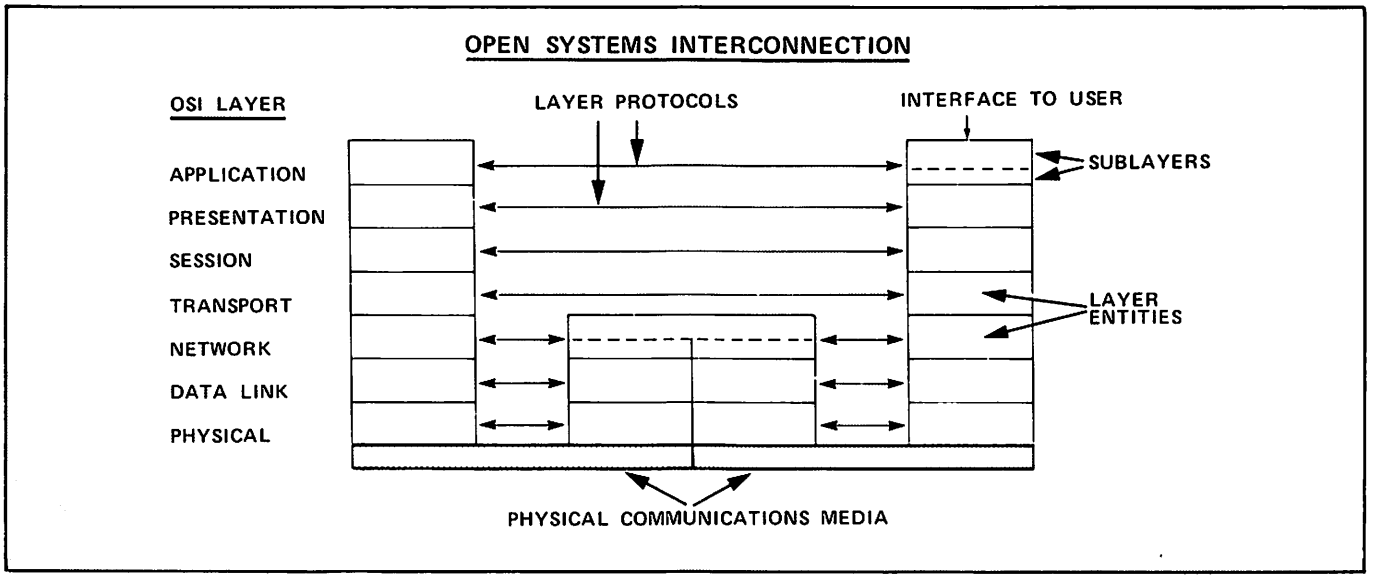
CSIRONET has been involved with the development of national and international standards for information processing, especially in the area of computer communications, for several years. Recent work has concentrated on the Open Systems Interconnection (OSI) standards, and forms part of the CSIRO/Facom Joint Development Project (p. 9).

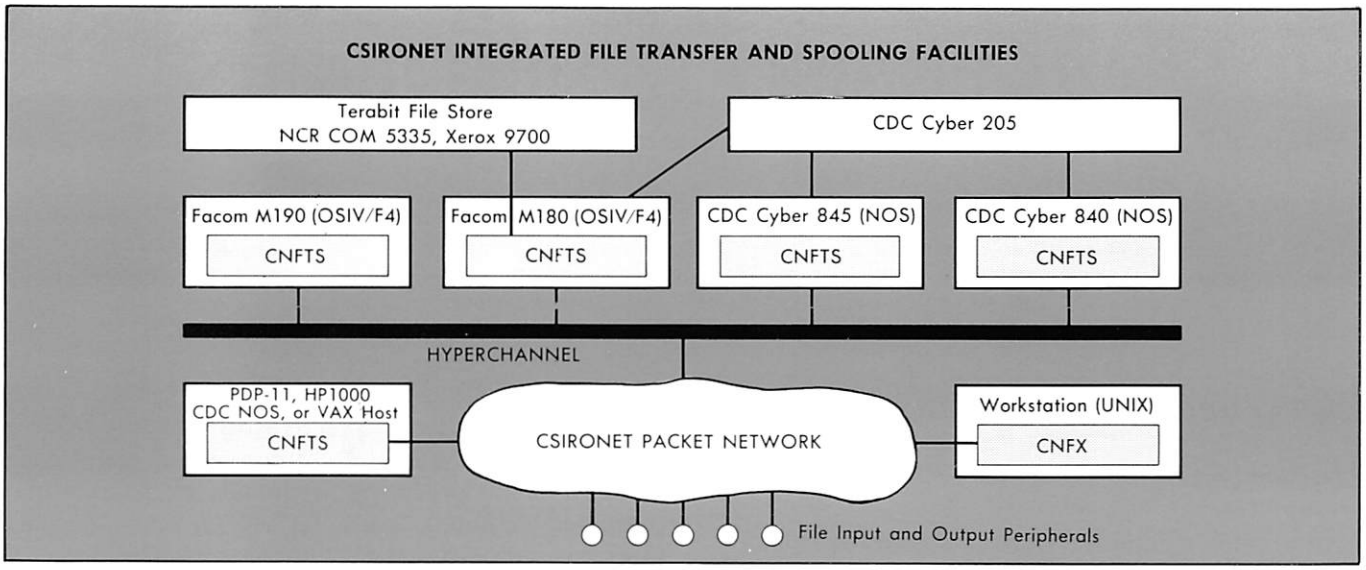
In 1984-85, CSIRONET staff participated in many Standards Association of Australia (SAA) activities on OSI, and represented Australia in International Organization for Standardization (ISO) meetings.

Work on experimental implementations of the OSI standards has continued. An implementation of OSI layers 1 through 4, produced jointly by CSIRONET and Telecom Australia Research Laboratories, was demonstrated communicating via the international packet-switched networks with an independently-produced OSI implementation at the University of Uppsala, Sweden.

Work has also continued in the areas of communication protocol modelling and verification.

A grant from the CSIRO Information Technology Programme has enabled CSIRONET to continue research in these areas during advanced international trials, plus development of automated implementation verification facilities.





CCITT X.25

A major development programme is in progress to implement CCITT X.25 and associated recommendations on CSIRONET. This is being undertaken with a view to:

- minimizing the need to undertake special CSIRONET-interface or gateway development projects;
- maximizing the capability to communicate with external systems, including foreign systems connected directly to CSIRONET and systems accessible via gateways to the public packet-switched services;
- maximizing the marketability of CSIRONET-produced hardware and software systems or components, outside the CSIRONET environment;
- preparing CSIRONET for support of the emerging upper-level OSI standards.

Since July 1984, work has been proceeding on an X.25 DCE implementation designed to run on CSIRONET Micronodes. Code has been written for the Packet level of X.25 and has been extensively tested on a DEC VAX 11/730; Micronode testing is in progress and a X.25 link to Facom OSIV/F4 is planned. This work forms part of the CSIRO/Facom Joint Development Project (see page 9).

New File Transfer and Batch Input/Output Facilities

The CSIRONET File Transfer and Spooling System (CNFTS) is a portable software package which supports file transfer between CSIRONET host computers and spooling between hosts and network peripherals. CNFTS will now run on Facom OSIV/F4, CDC NOS, and Hewlett-Packard 1000 hosts, as well as VAX/VMS and RSX-11M hosts.

The most significant development in 1984-85 was the release, in June 1985, of CNFTS services on the Facom M180 and M190 OSIV/F4 hosts. Services on the Cyber 845 NOS host were in a beta-test stage at the end of June 1985.

The development of the OSIV/F4 version of CNFTS has been part of the CSIRO/Facom Joint Development Project (p. 9). It uses a Hyperchannel connection to communicate between the Facom M180, Facom M190, Cyber 845 and the wide area network. A major extension, incorporating support for co-ordination of multiple CNFTS systems and remote operator interrogation/control facilities, is targeted for completion in July 1985.

The principal services provided by the Facom CNFTS implementations include:

- direct file output from the M180 or M190 to output peripherals on any CSIRONET Micronode or PDP-11 node;
- direct job input to the M180 or M190 from card readers on Micronodes or PDP-11 nodes;
- transfer of files or jobs in either direction between M180 and and M190;
- transfer of files in either direction between M180 or M190 and any CSIRONET VAX/VMS, RSX-11M or HP1000 host.

Services supporting Terabit File Store (TFS) operations for users on any CNFTS host will be provided at a later stage.

For CSIRONET-connected UNIX systems and selected auxiliary computers, a new file transfer package known as CNFX is under development. This will interact with the central CNFTS sytems to provide advanced file transfer facilities. These will include high-performance reliable file transfers to/from central hosts, and a facility whereby files may be output to node peripherals via a central CNFTS system.

CSIRONET Micronode

The CSIRONET Micronode hardware was the result of a joint development project involving CSIRONET and the Australian company Office Automation Pty Ltd. By the end of June 1985, two years after the first Micronodes were deployed to user sites, the 85th machine had been installed.

Micronode software. The range and capability of Micronode software is being continually increased, as follows.

- 3270 Support: two modules of software to allow the support of 3270 BSC cluster controllers and associated terminals across CSIRONET were released on 1 November 1984. The first module runs in a Micronode attached to the host's BSC line. The second module runs in users' Micronodes to control attached 3270 BSC cluster controllers. The two modules of software communicate as necessary to provide a 3270 service, but protect the packet-switched network from 3270 polls.
- NOS Interactive Interface: software has been developed to run in a Micronode to allow interactive access to NOS machines. The software maps between the protocols used by NOS and those in the CSIRONET communications network. It appears as a remote 2550 to the NOS system.

  This software is used in production in two ways:

  (a)Two Micronodes at CSIRONET provide a general interactive service on the Cyber 845. This system is configured to allow up to 50 users simultaneous access to NOS via each Micronode.
  (b)Another Micronode software configuration allows interactive access to NOS machines on users' sites, while also supporting local ASCII interactive terminals and batch output peripherals.

  The software is in use to connect a Cyber 810 at the Department of Primary Industry to CSIRONET.
- Asynchronous Host Interface: software has been developed for Micronodes to provide a simple way of connecting ASCII asynchronous hosts to CSIRONET. The software appears to the host as a number of ASCII terminals connected to multiple serial lines.

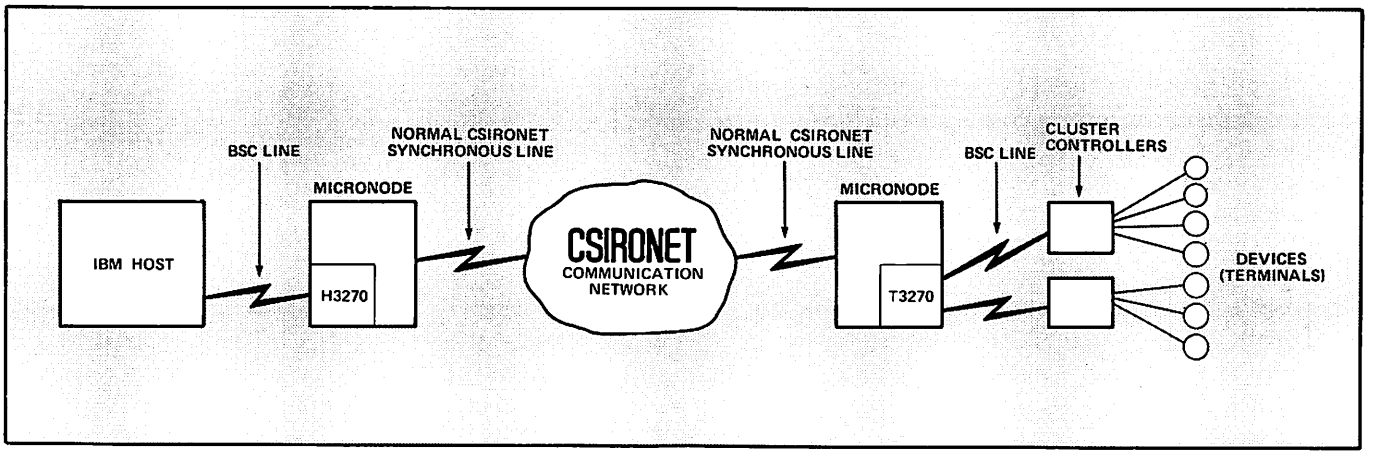
  The following user-owned host machines are connected to the network using this software: an HP3000 at CoCam Computer Services, and an AWA Sequel at the Department of Home Affairs.
- Support for card readers and Canon laser printers has been added to Micronodes.

Micronode Deployment. Of the 85 Micronodes installed in CSIRONET at the end of June 1985, 64 were in user or public access locations, 15 were in use as host connecting or file transfer facilities, and 6 were used for development.

The total numbers were considerably less than expected due to two main events during the year. Early in the period there were severe problems with component and circuit board unreliability.
In addition, CSIRONET was unable to place orders for extra Micronodes until the middle of May. Thus, no new deliveries were effected for some four months. The effect of the ordering difficulty will also be seen in 1985-86. At the end of June there was a backlog of some 50 requests for Micronodes, not including any communications system/host requirements, with new deliveries expected to commence in September-October.

Micronode Reliability. With an installed base of 85 systems, and eight reserved spares, in excess of 1000 machine months have been logged by Micronodes (approximately 720,000 hours). Reported field failures have totalled 28 during 1984-85.
In conjunction with 7 observed failures in 1983-84, this represents a mean time between failure of some 29 months (21,000 hours), which compares very favourably with the original design goal of 24 months.

Software modules connect CSIRONET via micronodes to IBM hosts or 3270 devices.



CSIRONET Micronodes ready for shipment.

Remote monitoring procedures are uncovering a good proportion of problems before users are aware of them, allowing CSIRONET staff to replace the faulty machine before breakdown occurs. 'Hot standby' spare machines are now in most capital cities, so that most user sites can get a replacement machine within 24 hours of a fault report; in practice, replacement takes less than half a working day in most cases. If no 'hot spares' are available, a replacement will be provided within two working days in the worst case.

Improved Environmental Testing Facilities. During the year a need for improved environmental testing facilities for Micronode acceptance and fault investigations became apparent. A specification was issued for environmental test chambers capable of meeting the following requirements: hot cabinet, 0 to 60°C; cold cabinet, –10 to 40°C. Each cabinet was required to house up to four Micronodes, and to have cable and power access arrangements, over-temperature protection and condensation protection.

The improved facilities have been in operation for some months and have proved to be very effective.

CSIRONET Workstation

As a result of the Micronode development, a multi-processor Workstation has been designed and is in prototype development. Special processors are incorporated in the Workstation for file management, input/output processing and computation.

The workstation has been designed to accommodate 15 to 40 users, using the UNIX* operating system. Applications for the Workstation include data entry, office automation, scientific data analysis and database management. Two prototypes are due to be completed by September 1985.

A version of the file transfer system CNFX, being developed by CSIRONET, will be installed on the Workstation, to provide high-level communications access to the CSIRONET computing facilities.

Expressions of interest were recently sought from companies wanting to manufacture and market the product, and attracted over 20 responses. It is anticipated that the Workstation will be offered by at least one company in 1986.

(* Trademark of AT&T Bell Laboratories)

Other Projects

Facsimile Transmission. CSIRONET began a joint development project with 3M in mid-1983 to demonstrate the feasibility of a facsimile service on CSIRONET. During 1984-85, the project proceeded to the point where the connectability of the 3M facsimile unit to CSIRONET was clearly established. Files were moved into CSIRONET host computers and were retrieved efficiently.

A market survey was undertaken to determine the usefulness of the system as a production service and the results were encouraging. A number of necessary follow-on actions were identified to convert the demonstration system to a supportable product.

Fibre Optics System. CSIRONET has now installed its first fibre optic link, connecting Micronode equipment in a temporary building to the main communications centre in Canberra. The fibre optic system was chosen mainly for its superior isolation characteristics and its potential for very high transmission speeds.

Versabus/Hyperchannel System. A previously designed interface to connect a Micronode Versabus system to a parallel Hyperchannel interface has been enhanced and manufactured. The interface will become part of the hardware system supporting remote file transfers from CSIRONET host computers to remote peripherals and hosts. Six such interfaces have now been constructed and are operational.

Voice/Data Integration in Third Generation PABXs. A CSIRO committee was established following a Telecom consultancy report proposing a 'corporate voice network for CSIRO'. The detailed study of the potential for voice/data integration was undertaken by a technical subcommittee, the findings of which are summarised below:

- Voice/data integration is feasible and the immediate level of possible implementation was identified.
- More complex levels of integration presupposed the availability of equipment which was scheduled for release late in 1986.
- Some forms of data integration, particularly with the use of external multiplexers on very high speed lines (2Mbps), may cause significant voice degradation in complex networks.
- The cost-effectiveness of voice/data integration via PABXs, compared to independant data switching, is still to be established.

Hewlett-Packard Connections. CSIRONET, in collaboration with the CSIRO Divisions of Chemical Physics and Protein Chemistry, have developed various software modules to connect HP1000 based systems to CSIRONET. The software modules CNIO/CNIA and CNFTS have been installed in three sites and are fully operational.

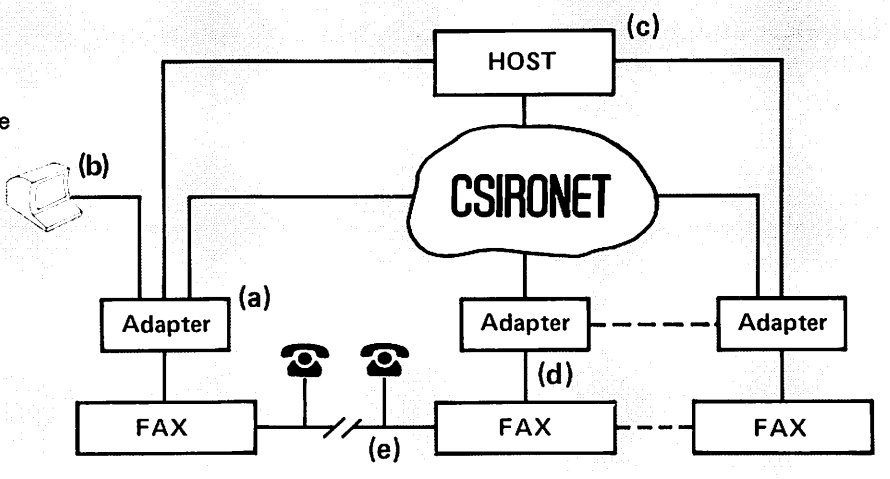
1200 bps Dial-in Facilities. During the year 1200 bps dial-in facilities have been extended to include all CSIRONET public sites. Testing of a possible 2400 bps facility is underway.

Plato Connections. The ability to support a CDC Plato service across the CSIRONET packet-switched network has been successfully demonstrated. This opens the way for the connection of user-owned Plato hosts to the network.

CSIRONET FACSIMILE TRANSMISSION

The diagram shows the test arrangement used.

(a) The adapter positioned between the FAX system and CSIRONET. For the tests FAX data was input using CYBIA and CYJ.
(b) A teminal used to establish the connection.
(c) The CSIRONET spooling host.
(d) The target FAX and adapter connected as device type US.
(e) The conventional use of the FAX via Telecom lines is still available.



Cyber Systems

The Cyber Systems Group maintains and enhances the operating systems and related software on all Control Data machines within CSIRONET. This software includes the so-called Common Products (compilers and utilities supplied by CDC across several systems) and communications software which links the Control Data machines to each other, to 'foreign' systems, and to the wide area network. The Group has considerable interaction with other CSIRONET Groups and Sections, and also with Control Data.

Cyber 205 (VSOS)

The major activity of the year was work on VSOS, the operating system of the Cyber 205, and its related software. The Fortran 77 compiler has given many problems, undoubtedly because the version received with the 205 hardware was an initial release of the product. The most recent version (2.1.6, PSR level 631) has been received and is expected to be installed in July 1985; this version is expected to correct many of the difficulties.

The Remote Host Facility (RHF) was installed in the Cyber 845 when the Cyber 205 was delivered (April 1984), and later in the Facom M180 (April 1985). This software allows either machine to communicate with the 205, and also allows direct communication between the Facom M180 and the Cyber 845. It is important since all Cyber 205 user access must take place via a front-end system.

Cyber 845 (NOS)

Mass storage has been increased, with four disks being used as Reserved File Space (RFS) units, by which users can be given space allocations which are less than a full disk. The RFS scheme is intended to serve the same purpose as 'subsets' under SCOPE, but it has been implemented with much less modification to the basic operating system, and as a consequence has some restrictions.

A TMUS (Temporarily Mounted User Set) service has been introduced, and a Tape Reservation System was made available to users in June 1985.

Facom Systems

The Facom Systems Group is responsible for development and maintenance of operating systems and associated facilities for Facom host computers on CSIRONET. Associated facilities include network mass storage (Terabit File Store) and interfaces to the networks of CSIRONET.

Much of the Group's work is done under the CSIRO/Facom Joint Development Project (p. 9) and involves close liaison with other sections of CSIRONET, and with Fujitsu (Australia).

Facom M180 and M190 (OSIV/F4)

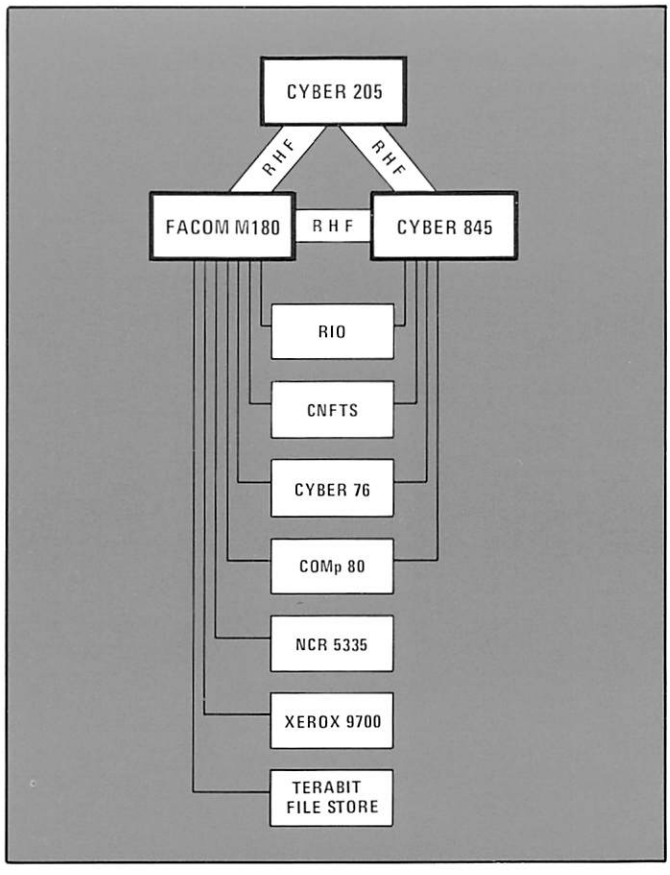
There has been a considerable growth in the OSIV/F4 service during the past year. Large-scale database management applications have been particularly productive. A pronounced preference towards systems based upon ADABAS/NATURAL has led to various studies of system performance, to attempt to optimise terminal response by regulating the demand upon total system resources.

Growth has also been promoted by the support of IBM 3270-compatible controllers and terminals on the CSIRONET Micronode, since November 1984.

Both services were upgraded to the OSIV/F4 MSP operating system in early 1985. The Resource Access Control Facility (RACF) became available on both services in late 1984. RACF administers access to system resources such as data sets, disk and tape volumes, terminals and application programs; such access is dependent on permissions granted by the 'owner' of the resource.

A connection has been established between the Control Data Loosely Coupled Network (which runs the RHF software discussed earlier) and the Facom M180, in conjunction with the Cyber Systems and Computer Communications Groups.

Logical map of the RHF connections on CSIRONET, June 1985.



Participants of the CSIRO/Facom Joint Development Project meeting in Canberra, November 1984.

CSIRO/Facom Joint Development Project

A Joint Development Project on large systems development and communications commenced in April 1979 with Facom Australia Ltd. Research and development carried out under its auspices has varied from primarily research projects, such as the formal description and verification of communications protocols, to product development projects such as the NETEX project.

The Joint Development Project (JDP) is managed by a Joint Advisory Committee which meets twice yearly, alternately in Canberra and Tokyo.

The initial task of the JDP was to incorporate Facom host computers into CSIRONET. Various other developmental projects have been part of the Joint Development Project, and several marketable products have been produced, as follows.

- The Terabit File Store (see pages 10 and 20) became operational in 1983, and has been providing a service since then.
- Four products have been developed by the JDP in conjunction with Virtual Programming Pty Ltd, a small Australian software house, and are being jointly marketed by CSIRONET and Virtual Programming in Australia and overseas.

  The *Programmers Toolkit* is a package of standard general-purpose software to perform basic programming tasks on Facom OSIV/F4 services. The Toolkit greatly increases the productivity of OSIV/F4 systems and applications programmers by making available to them a large collection of commonly-used facilities in an easily usable form. It is an innovative product which provides facilities not otherwise available.

  The *Programmers Apprentice* is a package similar to the Toolkit, but for MVS systems.

  Spoolwtr is a utility to allow automatic routing of OSIV/F4 output to remote cluster devices.

  Boss is a software product providing basic operations on an OSIV/F4 system spool.
- The OSIV/F4 version of CNFTS (see p. 4) is a project of the JDP.
- An OSIV/F4 version of NETEX (a Network Systems Corporation software product which supports Hyperchannel communication between a variety of host computers) has been developed from the MVS implementation in conjunction with NSC.

  It had been planned to use NETEX as the basis for CNFTS on major CSIRONET hosts, but a change in low-lovel NETEX protocol, which led to temporary incompatibility between different NETEX implementations, made this impossible in the required timescale. The CSIRONET CCP protocol is therefore being used instead.
- X.25 development work is in progress (see p. 4).
- Substantial contributions are being made to OSI work (see page 3).
- Work on formal description and verification of standards is being undertaken, in conjunction with Telecom Research Laboratories (see p. 10).

Terabit File Store

The Terabit File Store (TFS), developed as part of the CSIRO/Facom Joint Development Project, has been in production use for about 2 years on the Facom M180 and 15 months on the Cyber 76 and Cyber 845. During that time the load has built up continuously. About 2000 files are now transferred per week, comprising about 1 gigabyte of data.

Against the growing TFS load, there has been a continuing shakedown exercise aimed at making the system robust against a variety of hardware and software failures. A mount time check on tape status was introduced and as a result, an incidence of tape overwriting, caused by operator error, was recovered from completely. There has also been one instance of irretrievable loss of the TFS catalogue itself, the key disk dataset that contains the location of all files within the TFS. This was caused by a disk head crash following a power failure. Recovery was possible since automatic tape backups of the catalogue are taken every few hours. To guard against the remote possibility of loss of the catalogue backups as well as the catalogue itself, a last resort recovery utility is under development.

Recent developments have been in the communications area, concentrating on establishing a direct connection between the Terabit File Store and a Control Data 845 computer via CDC's Loosely Coupled Network (LCN) using the Remote Host Facility (RHF) communications package. This connection will replace the existing Hyperchannel link via the Cyber 76. A basic problem is that of overcoming the incompatibility in format of files saved via the two links, so that existing NOS files saved via the Hyperchannel link will be retrieved via the LCN link.

The TFS interface to RHF will open access to all hosts on the LCN, including the Cyber 205. Access to remote hosts will be via CNFTS, CSIRONET's File Transfer System. A TFS connection to CNFTS is being established.

One of the benefits of RHF is that it will overcome a bottleneck in TFS communication caused by the limited number of simultaneous TFS jobs that can run on the Cyber 76. Another bottleneck is caused by a software limitation that allows only one tape reader to service requests for file retrievals from the four tape drives on the ATL. This limitation is about to be overcome.

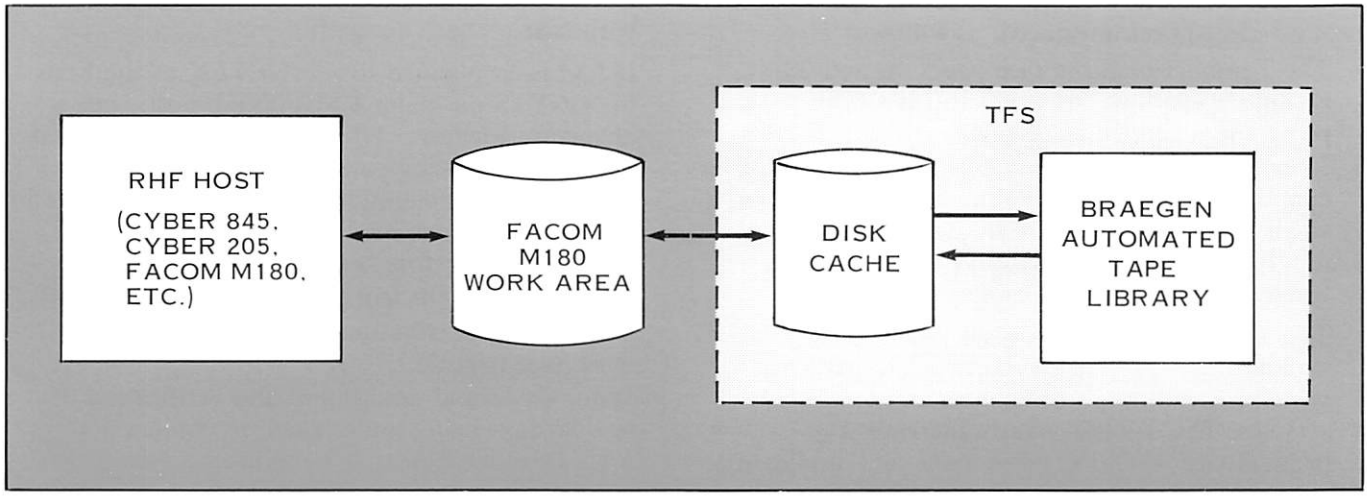
Further improvements in performance will require hardware changes. The TFS with disk cache and ATL is a multi-level file store capable of integrating diverse storage media. Existing levels can be expanded or new ones introduced to suit demand. A new line of development will be a modelling study aimed at assessing optimisation strategies.

Telecom Collaboration

A collaborative agreement operates between CSIRONET and Telecom Research Laboratories, to assist research of common interest, in areas including communications protocol standardisation, communications software methodology, and internetworking techniques. Both organizations are involved in international experiments using implementations of some of the Open Systems Intercommunication protocols.

A project on formal description and verification of standards is being carried out as part of both the Telecom agreement and the CSIRO/Facom Joint Development Project. Numerical Petri Nets have been used to describe Transport Class 0 and Class 2 Protocols. These have then been subject to structured simulations to identify weaknesses or errors in the standards; significant errors have, indeed, been identified and the resulting corrections have been accepted by the international standards community. Formal descriptions are of considerable value to developers of software that conforms to the standards.

Terabit File Store data flows.



Information Display Systems

The Information Display Systems Group is responsible for maintaining and developing image processing, graphics, typesetting and publishing systems on CSIRONET. An Image Systems Laboratory and an Electronic Demand Publishing Service, are available to users (see page 19).

Typesetting and Publishing

A Joint Development Project with the CSIRO Central Information, Library and Editorial Service (CILES) for the use of the TEX technical typesetting system for the typesetting of the Australian Journals of Scientific Research reached the production stage in April 1985, beginning with typesetting of the June 1985 issue of the *Australian Journal of Physics*, and the July 1985 issue of the *Australian Journal of Chemistry*.

A collaborative project with the Australian-owned micrographics company, Microsystems Pty Ltd, has been concerned with the connection of the Xerox 9700 laser printer to the Facom M180 host computer on CSIRONET, and with the design of a communication system to connect other Xerox 9700s in Sydney and Melbourne to CSIRONET. Other work has involved the implementation of typesetting software on CSIRONET hosts, to generate sophisticated publications with graphics and images on the 9700 and other peripherals.

Graphics and Image Processing

Interactive Diagram Design System. CSIRONET and Telecom Research Laboratories are involved in a collaborative research project with International Computers Ltd (Australia). The main aim of this project is to develop specifications for an interactive graphics system to support the use of diagrams in communications system design.

The diagrams of immediate interest are those representing computer and telecommunications systems, which are important to organizations concerned with the design and manufacture of communication systems. The system should also be applicable to other kinds of diagram, used for example in software design (e.g. data charts) and publications (e.g. block diagrams). The prototype system is based on the ICL PERQ, a single-user workstation with a bit-mapped display.

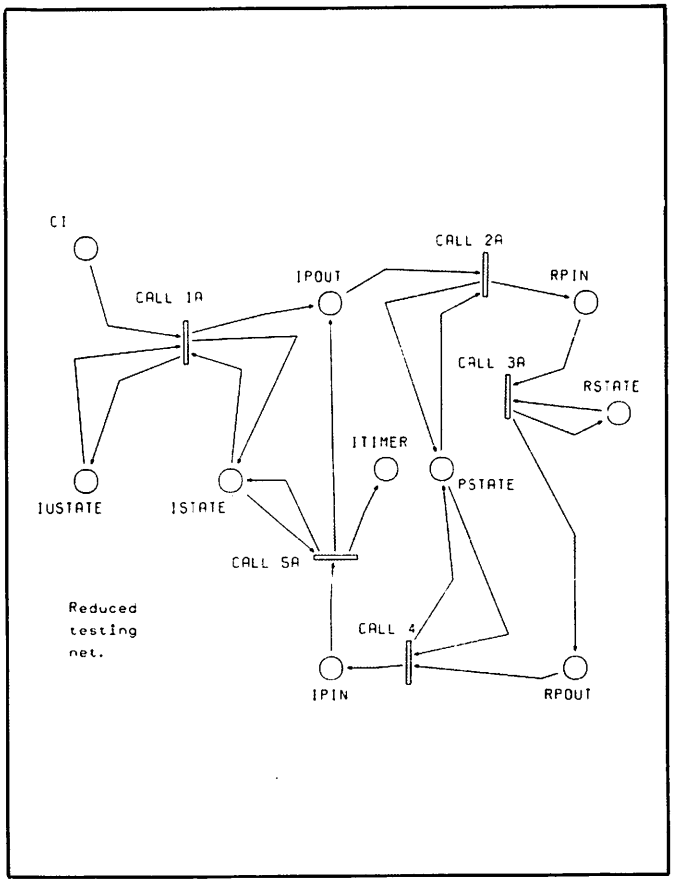
A preliminary system for the design of SDL (System Description Language) diagrams has been developed, and further research is being oriented towards improvements in the user interface and database design.

Interactive Colour Mapping. Under an agreement between CSIRO and Techway Pty Ltd, an interactive colour mapping system is being developed for the presentation of socio-economic and demographic data as coloured thematic maps. The mapping system, called COLOURMAP, includes interactive facilities to quantize the statistical values into classes for display, to select the geographic region of interest, and to control the colours and layout of the displayed map. The software is controlled by responding to a set of menus, so that users can easily operate the system.

Applications for COLOURMAP occur in government and commercial organizations, to assist decision-making processes involving spatial analysis, market research, financial management, and advertising.

COLOURMAP is now in production use at APASCO Pty Ltd (Sydney), and is used to access census and related data via the AP5000 system developed by APASCO. A new system called APASCOMAP is being developed under an agreement with APASCO, to integrate COLOURMAP and AP5000. It will have additional features for site location and territory assignment. A preliminary version of this system was installed at APASCO in June 1985.

This Numerical Petri Net specifies part of the protocol for inter-machine communication, part of the transport layer of the Open Systems Interconnection standard. Diagrams such as this can now be drawn on the ICL PERQ at CSIRONET, and analyzed automatically by Telecom.



The landscape above was made from map elevation data. As a navigational aid the form of the island was rendered by control of saturation and contrast with distance.

Image Processing Software. Several software packages for image processing have been developed under an agreement between CSIRONET and Quentron Digital Systems (a Division of Quentron Optics Pty Ltd). The software was developed primarily for use with raster-image data such as satellite images (Landsat, for example), but can also be used with other images and geographically-referenced (e.g. ecological, geophysical and environmental) data.

The software supports the facilities in the CSIRONET Image Systems Laboratory (see page 19), which can be operated by users in Canberra. Users can also purchase a licence to run the software on their own computer. Up to mid-1985, the software was installed in 10 sites, including two in Finland. The software is under continuing development, and CSIRONET is always interested in joint development projects with user groups on image processing applications.

CSIRONET is transferring image processing software developed within CSIRO to industry and user groups. The collaborative project with Quentron Optics Pty Ltd has existed for four years. Other agreements with Australian companies are being established to interface the software to display systems designed and being manufactured in Australia.

Several short-term collaborative projects have been undertaken in specific application areas of remote sensing (mineral exploration, land management, forestry); these have been described in previous Annual Reports.

Colour Image Display. In an extension of earlier work on colour image transformations, a comprehensive image display approach has been developed on principles drawn from the fields of colour science, human colour perception and computer vision and colour graphics. This approach is based on the premise that image displays should be designed to exploit the normal scene analysing capabilities of the human visual system, and consequently that an image display should be recognisable as a realistic or plausible scene. Individual data variables can then be depicted in terms of the natural descriptors (hue, saturation and lightness) of scene properties. These perceptual colour attributes are separable by the visual system, allowing data variables to be perceived distinctly.

This display approach can be applied to various types of image data, and a computational framework for its implementation has been developed. This framework is based on a 'uniform colour space', defined in terms of the colour response of a standard human observer, and allows the representation of data variables in terms of hue, saturation and lightness. The uniformity of the colour space allows the proportional representation of numerical data by gradations in perceived colour; this is crucial for appreciating the relative sizes of numerical data variations.

The developed display approach not only allows intuitive appreciation of superimposed image data sets (which are difficult to interpret under conventional display methods), but can also substantially improve the presentation of image data sets in general. Applications of the approach and its computational framework include the calibration and modelling of colour display devices, colour representations for statistical and remotely sensed data, colour contrast enhancement techniques for correlated multi-spectral data sets, three-dimensional data display generation (including relief shading and fast perspective and stereoscopic view generation), and techniques for integrating data sets in a single display. Software modules to perform these operations have been incorporated in the Image Processing Software package.

Information Systems

The Information Systems Group is responsible for maintaining and developing database systems and network information systems on CSIRONET.

Network Information Systems

Network information systems are those oriented towards CSIRONET as a whole, as opposed to host-specific systems. These include the Mail System and the Resource Monitoring System, a host-independent system to monitor the status of CSIRONET resources. The latter is under development.

After several months of testing by selected CSIRO Divisions, the Mail System was made available for general use in February 1985. While providing in its initial release only a subset of the planned facilities, it quickly gained acceptance by the CSIRONET user community. Enhanced or additional facilities have been progressively provided.

The Network Information Systems Section is also responsible for the maintenance of the Cyber 76 interactive system CYI (to be discontinued when the Cyber 76 is decommissioned), and for the editing program ED which runs on the Cyber 76 and on the NOS systems.

Database Systems

CSIRONET has been studying for several years the design of geographic information systems (GIS), including database aspects. This research has progressed over 1984-85, with a number of systems implemented and some further theoretical work.

The major collaborative project for geographic databases is CORGIS (Collaborative Reef GIS), in collaboration with the Great Barrier Reef Marine Park Authority. This project commenced in mid-1984 and will run for 3 years. It calls for the implementation of a number of prototype systems addressing selected management and planning tasks of the Authority, with the systems providing an in-depth assessment of the database techniques developed and directions for research and development.

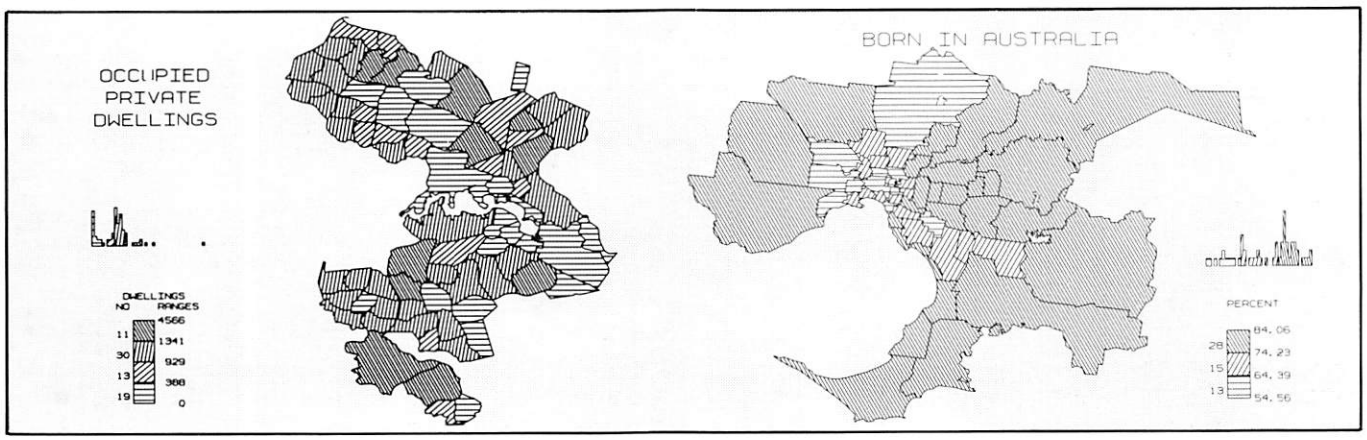
The first study (completed in December 1984) dealt with retrieval of records of Crown of Thorns starfish prevalence within arbitrarily-defined regions, essentially a points-in-polygon problem. The system was implemented on a Britton-Lee IDM500 backend database computer.

A second study, scheduled for completion in mid-1985, is considering the retrieval of data pertinent to arbitrary regions sketched on a display by a user; it extends the first study by using a graphics device for display and input of data and by retrieving from a more complex database.

A second prototype system, also implemented on the IDM500, was a database of the 1981 census data (at a local government authority level of aggregation) and NATMAP boundaries for the local government authorities. This allowed production of coloured maps showing selected demographic variables within a user-specified rectangular area. CSIRONET also provided advice on the implementation of a windowing algorithm to the South Australian Department of Lands and the New South Wales Central Mapping Authority; pilot systems are now under development in those states.

Fundamental studies have centred on development of a stronger understanding of the performance of the windowing algorithm for point sets in order to optimize the performance of the algorithm and to extend the algorithm's applicability to problems of arbitrary dimension. Some simple rules for optimization have been developed and performance has been assessed for range-searching, partial-match and the nearest-neighbour problem. The extension to arbitrary dimensions suggests that the techniques can be usefully applied in databases where a common requirement is to identify records satisfying conditions involving several attributes.

Local Government area maps, from NATMAP boundaries for Canberra and Melbourne, showing 1981 Census data.



Computational Methods

The Computational Methods Section is responsible for the support and development of software for the solution of computational problems. The main focus of its work this past year has been related to use of the Cyber 205.

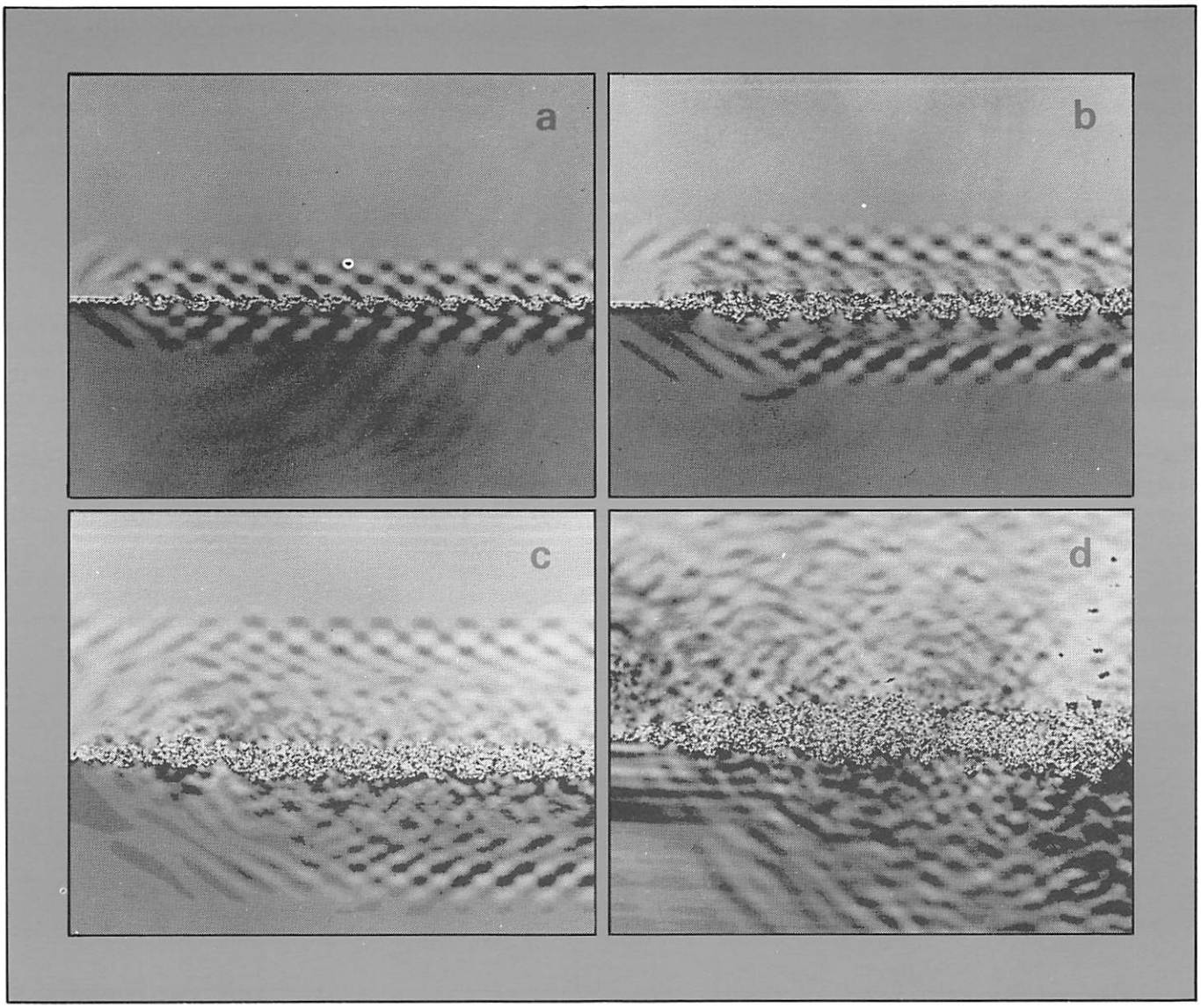
Supercomputer Applications

CSIRONET is involved in several collaborative projects to develop software on the Cyber 205 for a wide range of applications, and continues to actively seek people and organizations wishing to participate in this work. The range of potential applications for the Cyber 205 is diverse, and includes areas in which CSIRONET does not have the requisite expertise. Therefore, in order to fully exploit the capabilities of the machine, CSIRONET is bringing together organizational and individual expertise from diverse sources to jointly develop applications of mutual interest and benefit.

In the past year there has been a significant increase in the use of the Cyber 205. The Computational Methods Section has assisted clients in making use of the maximum power of the machine.

The CSIRO Executive instituted a research grants scheme in 1984, to promote access to the Cyber 205. Grants were awarded competitively on the basis of scientific merit and the relevance of the proposed research to goals of practical importance to Australia. The scheme is administered by the CSIRO Institute of Physical Sciences, and is open to scientists in Australian industry, Commonwealth and State organizations, Australian universities and other tertiary educational institutions, as well as CSIRO.

Illustrated below is a gas dynamic simulation on the Cyber 205. The central speckled zones show the growth of a turbulent layer that arises as a high-speed gas stream (darker area at bottom) passing under a more slowly moving stream (lighter area above), from left to right. The calculations were performed under the CSIRO Computing Grants scheme by G Bicknell and R Gingold, of Mt Stromlo and Siding Spring Observatory, ANU.



EQUIPMENT AND SERVICES

Host Services

Cyber 205 (VSOS)

A Control Data Cyber 205 Series 600 'super-computer' became available for general use on CSIRONET in June 1984.

The Cyber 205 is a very fast vector processing machine, with a performance approaching 400 million floating point operations per second (400 megaflops) in its 32-bit half-precision mode, or 200 megaflops in its 64-bit full precision mode.
It has 2 million 64-bit words (16 megabytes) of main memory, and can be upgraded to offer 8 times the memory size and double the operating speed.

VSOS is the virtual memory operating system for the Cyber 205. It provides efficient access to vector hardware from Fortran, but it requires vectorized algorithms for maximum performance. Languages supported include Fortran; software packages are being acquired or developed. Access to VSOS is through the NOS service on the Cyber 845 or the OSIV/F4 service on the Facom M180.

Suitable applications for the Cyber 205 are in the area of numerically-intensive problems with large requirements for CPU or memory.

Cyber 845 (NOS)*

CSIRONET's Control Data Cyber 180 Model 845 computer system has 2 million 60-bit words of main memory, and can execute 5 million instructions per second.

This service is suitable for general scientific, engineering and commercial applications. It also serves as a front-end access to the Cyber 205.

The Cyber 180 series of computers employs a dual-state architecture that allows two operating systems – NOS and the new NOS/VE – to be executed simultaneously in the same memory and central processing unit. At present, CSIRONET supports only NOS 2, which provides for interactive and batch use, with a single structured command language, a comprehensive on-line help system, and support for full-screen management and editing facilities.

Languages supported include Basic, Cobol, Fortran, and Pascal. Major scientific software packages include the IMSL and NAG subroutine libraries and the GENSTAT, GLIM and SPSS statistical analysis packages. Other software provides simulation, graphics, text processing, and database management.

* A second NOS host, a Cyber 840, was added to the network in August 1985.

Operators station, Cyber computer hall, CSIRONET Canberra.

View of Facom computer hall, CSIRONET Canberra.

Facom M180 and M190* (OSIV/F4)

CSIRONET provides an OSIV/F4 service based on IBM-compatible Facom M190* and M180 systems. The M190 system includes a central processing unit rated at about 4 million instructions per second, with 16 million bytes of main memory, and the M180 system 12 megabytes of real memory and CPU rated at 2.7 million instructions per second. Control Data network adapter equipment has been connected to the Facom M180, allowing it to act as an alternate front-end to the Cyber 205, and to communicate via RHF software with both the Cyber 205 and Cyber 845 systems.

The Facom operating system OSIV/F4 is similar to the IBM MVS operating system, and offers traditional batch and interactive facilities. Languages supported are Fortran, PL/I, Cobol, Pascal and Lisp. Fourth generation products, database management systems, and graphics packages are available.

OSIV/F4 provides services suitable for commercial and administrative applications such as large databases with requirements for simultaneous multi-user access, information storage and retrieval, applications with large memory requirements, general interactive applications, and graphics for commercial and scientific applications.

Facom M150 (VM/CMS)

A Facom M150F host system supports the VM/CMS operating system.† It includes a CPU with 4 million bytes of main memory and a speed of 0.4 million instructions per second.

VM/CMS is a virtual memory operating system which is interactive and user-friendly. It has a powerful and efficient editor and extensive on-line help facilities. Suitable applications for VM/CMS include general purpose interactive computing, data entry and editing; information retrieval; and program development using IBM languages.

Languages supported are APL, Cobol, Fortran, PL/I, Pascal and Basic. Software packages available include text retrieval and econometric analysis.

Cyber 76 (SCOPE)

For twelve years CSIRONET's main computer has been a Control Data Cyber 70 Model 76, but it will be decommissioned in November 1985 in favour of more modern equipment listed above.

CSIRONET Micronode

The CSIRONET Micronode hardware was described in detail in the *1982-83 Division of Computing Research Annual Report.* Micronode software has been developed entirely within CSIRONET; see page 5 for a discussion of recent work.

Micronode hardware is based on the Motorola 68000 CPU and the Motorola Versabus. The main CPU board comprises an 8 Megahertz 68000 16-bit CPU, 256 kbytes of parity-checked memory, 2 Zilog 8030 serial input/output chips, 24 kbytes of ROM, a calendar/lock chip, a timer chip, and an analog to digital converter. All input and output to users' devices connected to the micronode are performed by the serial co-processor board, which comprises another Motorola 68000 8-Megahertz CPU, 128 kbytes of RAM, 48 kbytes of ROM, and 16 Zilog I/O chips providing 32 serial I/O ports.
An optional Western Digital WD2000 encryption chip can be included.

Micronodes are designed to operate in normal office and laboratory environments, in a temperature range of 10 to 50°C. They weigh about 19 kg and are powered from general-purpose power outlets, drawing about 1 amp. Micronodes are designed to have all peripherals connected via RS232C interfaces.

* The M190 CPU was replaced in November 1985 by an M380.

† Until November 1984, this service was provided on a Two Pi V32 minicomputer.

CSIRONET Network

The CSIRONET computing network comprises the host services described previously, interconnected through local area networks and connected to the end user by a wide-area packet-switched network.

Two local area networks are in use on CSIRONET: the Hyperchannel supplied by Network Systems Corporation, and the Loosely Coupled Network supplied by Control Data Corportion. Each has a speed of 50 megabits per second.

The wide-area network comprises telecommunications lines and special-purpose communications processors known as nodes. Since 1971 these nodes have been based on Digital Equipment Corporation's PDP11 minicomputers, but new and replacement nodes since early 1984 are based on the CSIRONET Micronode.

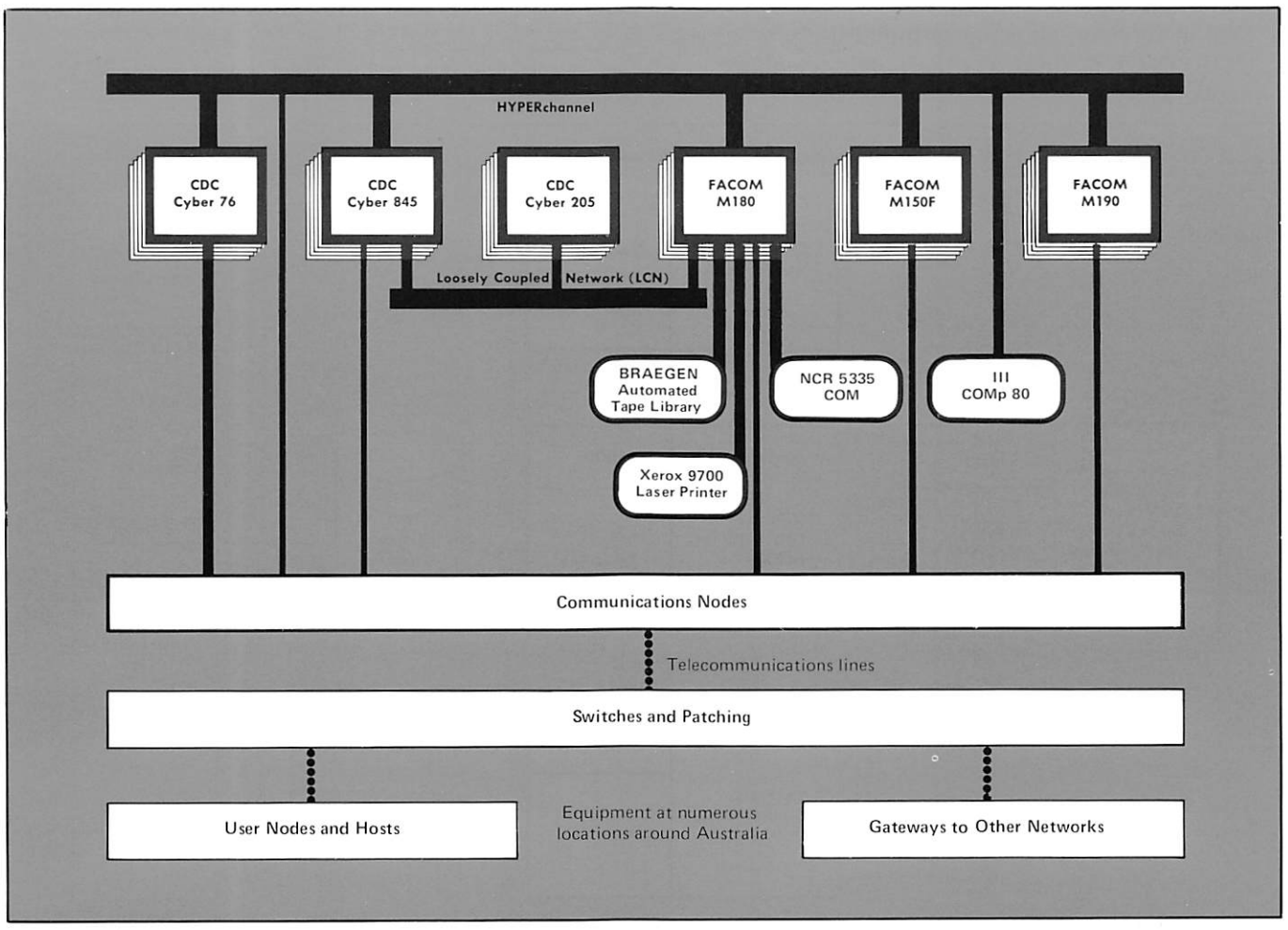
Basic nodes provide the point of connection for interactive terminals, auxiliary computers, and batch input or output devices. Some nodes perform these tasks as well as extra communications tasks.
A communications node is one whose main function is to connect other nodes to high speed communications links or channels.

Network Growth

The total number of user nodes in CSIRONET in mid-1985 was over 150; communications and host-connecting nodes totalled 30. The number of host computer connections and gateways owned by others has continued to increase. There are now 17 CSIRONET-owned and 36 non-CSIRONET-owned host computers and gateways accessible to users, as shown in the table.

	Total	CSIRONET -owned
UNIX connections	14	1
VAX/VMS connections	10	3
PDP11 RSX-11M connections	9	4
Hewlett-Packard connections	3	–
Gateways to other networks	7	–
Control Data hosts	4	3
Facom OSIV/F4 hosts	3	3
VM/CMS hosts	1	1
Mail	2	2
Total	53	17

CSIRONET configuration, June 1985.



Communications Services

CSIRONET provides extensive facilities for transferring information between CSIRONET end systems of many different types, including CSIRONET hosts, private hosts, interactive terminals and batch peripherals on user premises or at public facilities, and terminals or processors on other networks. Communications services include:

- Interactive services, allowing remote interactive terminals to access CSIRONET hosts or other hosts (a major capability is support for IBM 3270-compatible full screen terminals);
- Spooling services, allowing jobs to be input to hosts from remote input peripherals, and output to be automatically despatched to remote printers and other peripherals;
- File transfer services, supporting bulk information transfer between any pair of CSIRONET hosts;
- Electronic mail services;
- Connection services, allowing users to connect private computers to CSIRONET;
- Gateway services, providing access to and from systems on the international packet-switched networks (via OTC's MIDAS) and approved private networks;
- Dial-in services, allowing terminal users to access CSIRONET facilities via the public telephone network;
- Access control services, allowing managers of user groups to control which individual users may access which CSIRONET services.

File Transfer and Spooling Facilities

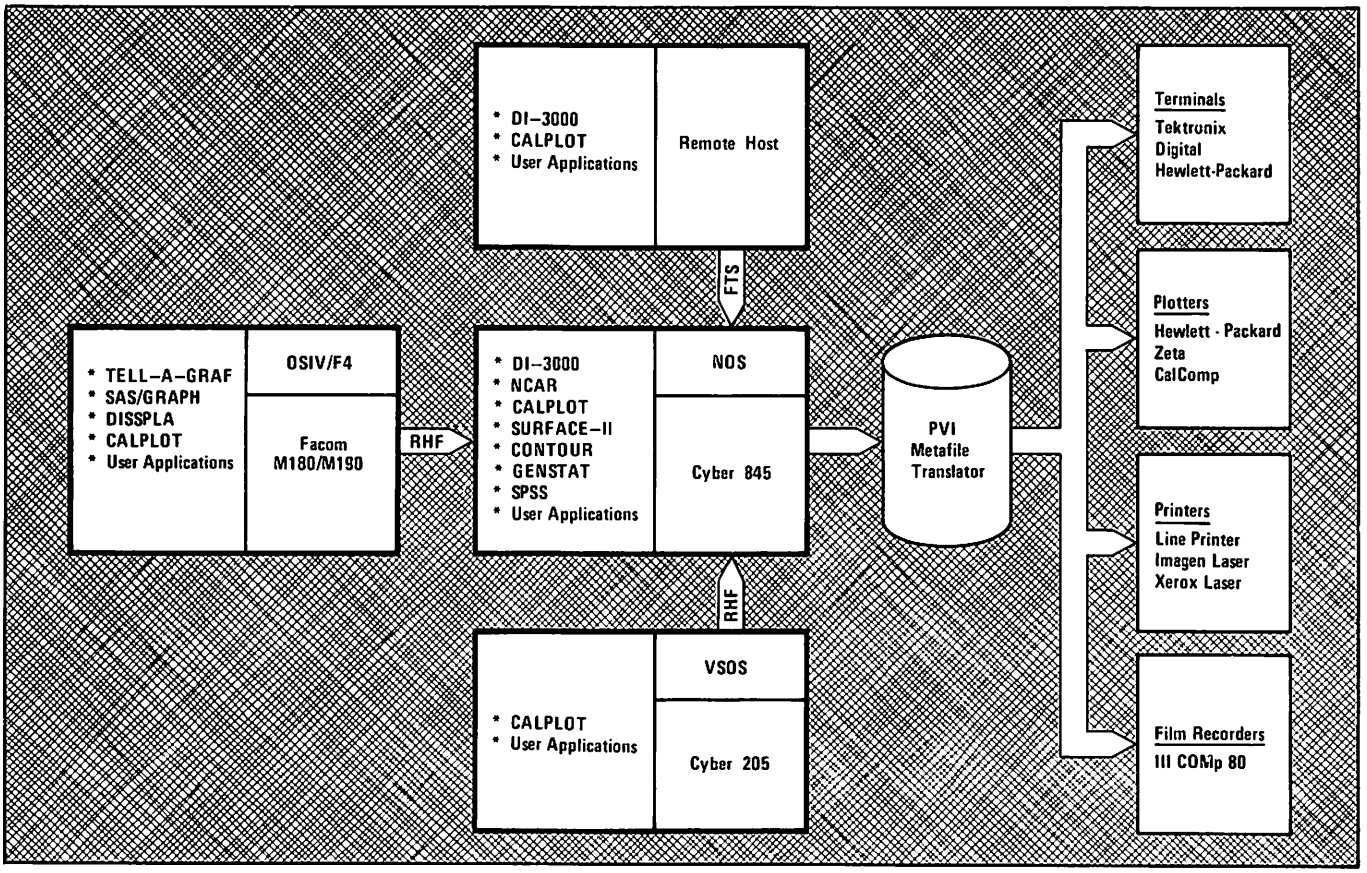
CNFTS is an integrated host-independent file transfer system used in moving files between CSIRONET hosts and between a CSIRONET host and network peripherals. CNFTS is now supported on Control Data NOS, Facom OSIV/F4, DEC VAX/VMS, DEC RSX-11M, and HP1000 hosts. Recent developments are described on page 4.

The Mail System

Electronic mail is an online, interactive system for the creation, delivery, storage and forwarding of messages. It allows CSIRONET users to keep in touch easily with local, interstate, or even overseas colleagues. People in widely scattered organizations, or those who collaborate with people in other organizations, will find the Mail System particularly useful.

The Mail System runs on a Wicat S200 micro-computer, an 8-Megahertz 68000-based system with 1 megabyte of memory. A second, identical system acts as a backup and developmental machine.

An example of spooling services. Generalised access to CSIRONET graphics devices.



Specialised Services and Peripherals

Computer Output to Microfilm

Two Computer Output to Microfilm (COM) units are available: an Information International Inc COMp 80, which has been in service since 1975 and is now used mainly for output of high quality typeset material on a variety of film sizes; and a new NCR 5335 COM, which was brought on line in April 1985 and made available to users in July.

The **III COMp 80** unit is used mainly for:

- output of high quality typeset material on 310mm bromide masters, suitable as camera-ready copy for conventional printing
- microfiche output of high quality typeset material (library catalogues etc)
- microfiche output of line printer listings (this service will be discontinued in November 1985).

It also has facilities for graphics and typesetting on:

- 16mm movie film, used for animated graphics
- 35mm film, an inexpensive proofing medium
- 310mm large format film, for map overlays and overhead projection.

The COMp 80 is connected online to the Cyber 76, but will become an offline batch service in November 1985.

The **NCR 5335 COM** is connected to the Facom M180, but is also accessible from other host services. It provides for automatic production and duplication of microfiche format line printer listings, and will replace the lineprinter microfiche service on the COMp 80, at the end of November 1985.

Laser Printing

There are currently two types of laser printer available on CSIRONET: an Imprint-10 (based on a Canon LBP-10 laser marking engine and an Imagen IMP-10 image processor) and a Xerox 9700-based Electronic Demand Publishing Service.

The **Imprint-10** laser printer is a general purpose device capable of printing high quality characters and graphics on plain sheet paper. It can emulate line printer output (in various page formats using typewriter-like fonts), as well as Tektronix and daisy-wheel terminals.

The quality of Imprint-10 output is similar to that from an ink-jet printer. Applications include documentation (such as CSIRONET Reference Manuals), graphics generated by plot packages, and proofing or final output of typeset material.

Four **Xerox 9700** laser printers are available through CSIRONET, under an agreement with Microsystems Pty Ltd: one each in Canberra and Sydney, and two in Melbourne. Only the Canberra installation is on-line to CSIRONET. The service became accessible through the SCOPE, NOS and OSIV/F4 services in early 1985.

The Xerox 9700 laser printer accepts computer input in several forms: off line tape, on line through CSIRONET, from a wide range of floppy disks, or from a Xerox 860 word processor. The laser printer's own 'front-end' computer converts this input into a page format. Laser beam optics are then used to convert the computer image onto an electrically charged belt from where the actual printing occurs.

The Xerox 9700 prints on ordinary A4 cut sheet paper at a rate of two pages per second – up to 18,000 lines per minute, depending upon data format. A significant feature of the system is its ability to print on a large range of stock. These include a variety of paper weights, coloured stationery, laminated stock, pre-drilled paper, perforated paper, pre-printed letterhead, or acetate (for overhead transparencies).

Ancillary facilities include a Metaform workstation, which produces forms, diagrams and special characters interactively; an Autokon II graphics scanner, which digitises original artwork for processing by Metaform; and a Baber MultiDisc reader, which converts data from a wide variety of floppy disks to a format suitable for CSIRONET. The service provided by Microsystems is thus capable of providing complete, finished publications in a range of styles, at an economically competitive cost, with a production cycle measured in hours.

Image Systems Laboratory

The Image Systems Section provides a consulting service and facilities covering a wide area of digital image processing. The Section is actively engaged in developing image processing packages, and operates an Image Systems Laboratory in Canberra, which is available as a service to users.

A Comtal colour image display system enhances and displays different kinds of imagery to assist interpretation. An attached Matrix camera system allows 35 mm colour slides to be made of displayed imagery, while colour movie sequences can be produced by stop-frame filming directly from the Comtal monitor. A Colorwrite film recorder generates black and white and colour film (and derived products) of special imagery, where high precision and resolution are required.

Image processing software developed by the Section consists of special-purpose modules built on a general image handling package DISIMP (Device-Independent Software for Image Processing). DISIMP is based on a unique framework for representing and manipulating images, and incorporates special techniques for bit manipulation

and for file and device handling. The software runs on PDP-11, VAX-11, and HP-1000 computers.

An interactive module, SLIP (Software for Satellite Image Processing) allows processing of multichannel images, including Landsat and NOAA imagery. SLIP contains utilities for image management, transfer, statistical analysis, geometric and radiometric transformations, Fourier transformation and spatial filtering, and display.

IMAGED (Image-based Analysis of Geographic Data) is a module for the analysis and display of geographically-referenced data. The main task of IMAGED is to generate reports, tables, and maps from the interactive analysis of geographic data represented in an image format. The module is interfaced to other packages for report generation, data modelling and statistical data analysis.

On the Cyber 76 of CSIRONET, DISIMP supports CSIRO-ORSER, an older package for analysing multichannel imagery. With the withdrawal of the Cyber 76 late in 1985, users of this package will transfer to IMAGED/SLIP/DISIMP on the Laboratory PDP-11 or VAX-11 computer.

Terabit File Store

The Terabit File Store (TFS) offers archiving and backup facilities that are often cheaper and more convenient than conventional alternatives such as magnetic tape or off-line disk. At the end of June 1985, it was in use on the Cyber 76, Cyber 845, and Facom M180 hosts.

The TFS is based on a Braegen Automated Tape Library (ATL) housing about 2000 magnetic tapes of up to 150 megabytes each. There are four attached tape drives.

TFS storage is inexpensive because it is tape based, has a high tape utilisation rate, and allows flexible storage allocation. There are no fixed purchase or mounting costs as with conventional tape or off-line disk.

Convenience features include availability, uniform network-wide access, and automatic management facilities. The TFS is available during both attended and unattended hours. Incoming user files are accumulated on a disk cache of 450 megabytes before migrating to tape, as part of a full tape load. Retrievals from tape take 1 to 15 minutes, but a good proportion of retrievals do not involve the ATL since recently stored files are retained on disk as long as possible.

The commands and associated parameters for accessing the TFS are similar on all hosts. Sharing of files between users and between similar hosts (e.g. the CDC hosts) is supported.

The Braegen Automated Tape Library (ATL), CSIRONET Canberra.

COMMITTEES AND LIAISON

CSIRO Computing Committees

The CSIRO Policy Committee on Computing (PCC), at its meeting of 1 March 1985, determined the formal relationships between the three major CSIRO computing-related committees (the PCC, the CSIRONET Board and the Computer Equipment Panel). The present roles of these committees are as follows.

- **Policy Committee on Computing:** 'to advise the Executive on, and of, computing policy issues related to CSIRO';
- **CSIRONET Board of Management:** to run CSIRONET 'as an autonomous unit within CSIRO operating on a full cost-recovery basis with responsibility for the operation and development of a computing network and services for CSIRO and appropriate external users, including the provision of certain scientific computing facilities for CSIRO, and for the conduct of high level development work in support of these responsibilities';
- **Computing Equipment Panel:** 'to consider and advise the Policy Committee on Computing on proposals for the acquisition of computing equipment'. (The Panel may co-opt as necessary expertise to assist in assessing proposals for acquisitions of word processing equipment.)

The Chairman of the CSIRONET Board is responsible to the Executive through that member of the Executive who is Chairman of the Policy Committee on Computing. The Chairman of the CSIRONET Board is responsible for the policies and management of CSIRONET.

The Computing Equipment Panel functions as a sub-committee of the Policy Committee on Computing, applying guidelines determined by the Committee.

CSIRO Telecommunications Committee

CSIRONET has two representatives on the CSIRO Telecommunications Committee. This committee's Terms of Reference include the formulation of a precise definition of the communications network which would most effectively and economically meet CSIRO's requirements, and the preferred arrangements under which such work should be carried out. The Committee held its first meeting on 4 March 1985 and aimed to advise by July 1985 on equipment compatible with the proposed network.

CSIRONET Personnel Advisory Committee

A CSIRONET Personnel Advisory Committee has been established, to advise the Chairman of the CSIRONET Board in approving appointments and promotions in a range of professional classifications. This Committee comprises the Chairman of the Board, the Chief Executive, those Institute Directors or Chiefs of Divisions who are members of the Board, and other Directors or Chiefs to make a total of six members.

Effective 1 July 1985, CSIRONET staff will no longer be subject to the classification procedures and approvals of the CSIRO Institute of Physical Sciences, although they will continue to be subject to criteria which preserve the essential comparability with staff employed elsewhere in CSIRO.

CSIRONET User Groups

CSIRONET User Groups have been established in major centres and other localities with a large enough user population. They replace the Regional Computing Committees (RCCs) formed in the 1970s. The User Groups are intended to continue and expand the role of the RCCs. The main differences are that membership of the User Groups is open to all interested users (instead of being restricted to single representatives from major groups in the area), and that there is a central coordinator in Canberra.

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1. Now in CSIRO Division of Information Technology, Canberra.
2. Now in CSIRO Division of Information Technology, Brisbane.
3. CSIRO Division of Tropical Crops and Pastures, Brisbane.
4. Telecom Research Laboratories, Clayton, Vic.
5. Now in Department of Electrical Engineering, Australian Defence Force Academy, Canberra.
6. University of Arizona, Tucson, Arizona, U.S.A.
7. Former student employee of CSIRONET Brisbane.
8. Dept. Mathematics, Institute of Advanced Studies, Australian National University, Canberra.
9. Department of Mathematics, University of Melbourne.
10. Mathematical Institute, University of St Andrews, Scotland.
11. Facom Australia Ltd.
12. CSIRO Division of Chemical Physics, Clayton, Vic.
13. Department of Geography, State University of NY, Buffalo, USA.
14. Now in CSIRO Division of Forest Research, Canberra.
15. Department of Epidemiology, Commonwealth Institute of Health, Sydney.

STAFF

CSIRONET staff at 30 June 1985 are listed below by Division, Group and Section.
Staff are located in Canberra unless otherwise noted.

OFFICE OF THE CHIEF EXECUTIVE

Chief Executive: P J Claringbold, PhD, FSS, FACS
Senior Adviser: J O'Callaghan, BE, PhD

PRODUCTS DIVISION

General Manager (Acting)*: R J A Dakin, BSc, BE, MEngSc, PhD

COMPUTER COMMUNICATIONS

W S Ford, ME, DipCompSc, PhD, *Leader*

Distributed Systems

I E Pollard, BSc, PhD, *Leader*
M C Butler
W J Ginn, BSc, BE, MSc
K B Townson, BSc, GradDip

Hardware

A J Vezis, BEng, *Leader*
A E Brayshaw, BA
J R Greig, BEng
J M Hennessy
L C Knowles
J C Morrissey
C R Thompson, BEng

Network Architecture (Melbourne)

A C Edington, BSc, *Leader*
G Codsi
T Frencken
T F Hales, BSc, MSc, DIC, DPhil
A J Rawling, BSc
L J Roberts

Packet Networks

J E Paine, *Leader*
J A Gibbons (Sydney), BSc, MSc
J D Hayhurst, BS, MSc
J A Shaw
G C Smith, BAppSc
W B Yong, BEE

* A J Vezis was appointed General Manager (Products) in October 1985.

CYBER SYSTEMS

B J Austin, MSc, PhD, *Leader*
P M Ewens
C M Ey, BSc, PhD, DipCompSci
E H Kinney, BSc
B J McHugh, BSc
M H Paterson, BSc, DipNAAC
R L Ringrose, BSc
D J Seddon, BSc, DipAC

FACOM SYSTEMS

P P Hanlon, BSc, MSc, *Act. Leader*

Information Storage Systems

B R E Lederer, BSc, MEngSc, PhD, *Leader*
A L V Cook, BSc, ARMTC
K R Parker, BSc, PhD

OSIV Systems

K L Robinson, BE, BSc, *Acting Leader*
P P Hanlon, BSc, MSc
V S Nadimpalli, MSc, MPhil
T M Peters
D B Slater, BSc, BE, BA, GradDipCompStud
G G Tonzing, BSc, MSc

VMS Systems

P R Cohen, BA, GradDipCompSt

COMPUTATIONAL METHODS

P F Price, BSc, PhD, *Leader*
R W Brown, BSc
D P Heath, BSc, GradDip

INFORMATION DISPLAY SYSTEMS

D Fraser, BE, PhD, *Leader*

Graphics Systems

L W Simons, MSc, *Leader*
T G Freeman, BSc, PhD
P Garrard, BSc, BE

Image Systems

D Fraser, BE, PhD, *Leader*
P K Robertson, BEng, PostGradDipElEng, MSc
D R Stevenson, BSc, MSc, GradDipCompStud
M A Wilson, BSc

Typesetting Systems

R I McKay, BSc, PhD, *Leader*
G Cardillo, BSc, DipCompSc
S M Green, BA

INFORMATION SYSTEMS

P W Milne, DipElEng, BA, *Acting Leader*

Database Systems

B F Higgisson, BAppSc, GradDipOpRes, *Leader*
D J Abel (Townsville), BSc, DipInfProc, MSc, PhD

Network Information Systems

P W Milne, DipElEng, BA, *Leader*
C J Lokan, BSc, PhD
B V Munter

MARKETING DIVISION

General Manager (Acting)*: G Havas, BA, PhD

MARKETING

G W Bradford, AAMI, *Manager*
K A Doutch

PUBLIC RELATIONS

J H Weber, BSc, MSc, *Acting Manager*
S Paschalidis, *Graphic Designer*

USER SERVICES

I D Munro, BSc, *Manager*

Programming Support (Hobart)

J W Firth, BEc, *Leader*
J M Hudson, BAgrSc, BSc

Applications Support (Brisbane)

D R Ross, BSc, MACS, *Leader*
C M Hulett, BAppSc, AssocDipMusic
K G Shields, BSc, PhD

Documentation

C D Mathers, BSc, PhD, *Leader*
J L Fisher, BSc, GradDipCompStud
A P Howard, BA, GradDipCompStud
A McCulloch
N Seselja

Liaison and Assistance

J K Bubb, BSc, DipEd, *Leader*
J A Cotterill, BA
J S Drabble, BSc, ARACI, GradDipAdmin
R A Hockley
R J Hurle (Darwin), BSc
V G Kane, BE, MTech, PhD
B P McDowall, BSc
K J Muntz (Melbourne), BSc
R G Schwind (Melbourne)
R E Sinclair, BSc, BE

* B D Green was appointed General Manager (Marketing) in August 1985, with G Havas as Assistant General Manager.

SERVICES DIVISION

General Manager: D S Glavonjic

ADMINISTRATIVE SERVICES

M A Smith, BA, *Manager*

Administration

S A Bond
P H Bruce
R J Caldwell
R M Cooper
C F Dent
L Higgins
J M Hilhorst
D A Hilton
T M Hughes
V Jancevski
S B Jones
M E Kennedy
S J Manwaring
L C Pharaoh
S J Smith
P A Springsteen, AssocDipMRA
T Walton
C A Whitby, BA

Library and Information Services

G Watt, ALAA, *Librarian*
M J Lever, LibTechCert
M Ngan, BA

Site Management

C D Gilbert, DipEE, AMIEE, *Site Engineer*
W L Bastion
R G Hooper, Site Manager
D R Zeven

BUSINESS DEVELOPMENT

C Denes, BEc, ACA, LICM, *Manager*

BUSINESS SYSTEMS

E P A Osborn, BAppSc, *Manager*
M T Crofts, BA
S K Grover, BE, MTech(Ind Eng)
M P McKenna, BSc
W H Roberts, BSc, GradDipCompStud

OPERATIONS

P E de Chazal, BE, *Manager*

Operations Management

J A Guggenheimer, BSc, MMaths, *Cyber Operations*
S Iliescu, *Magnetic Media*
G N Pope, BSc, *Facom Operations*
K A Spencer, BAppSc, *Operations Support*

Central Operations

P J Marshall, *Senior Supervisor*
E Barry
M A Belmonte
S Cavazzana
J K Garrett
J Hall
A S Leigh
P B McCarron
S O'Brien
K M Rowell
J Stojanovic
P P Tejeda
S T Wolfendale

Network Operations

T F Forward, *Network Operations Manager*
S C Buckmaster
S G Cornelius (Melbourne)
J E Coughlan (Sydney)
H Doble (Melbourne)
T S Hinton (Brisbane)
M R Keys (Adelaide)
B D Maclaren
D C Mummery (Hobart)
W G Riley (Sydney)
V Small (Townsville)

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