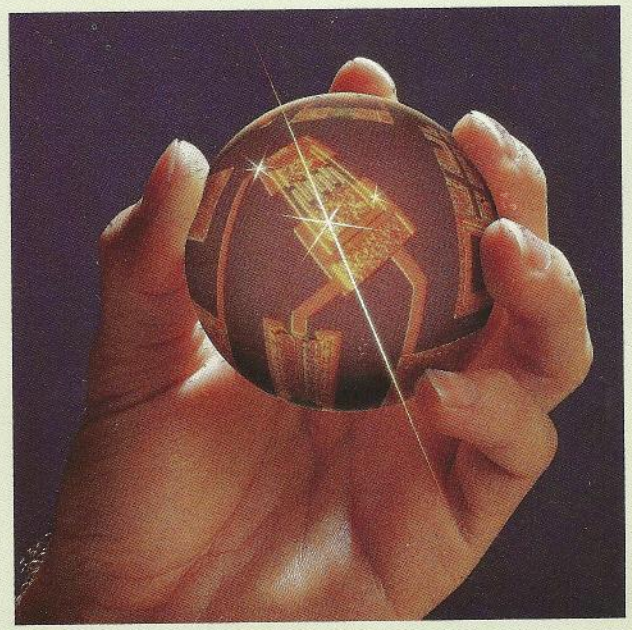
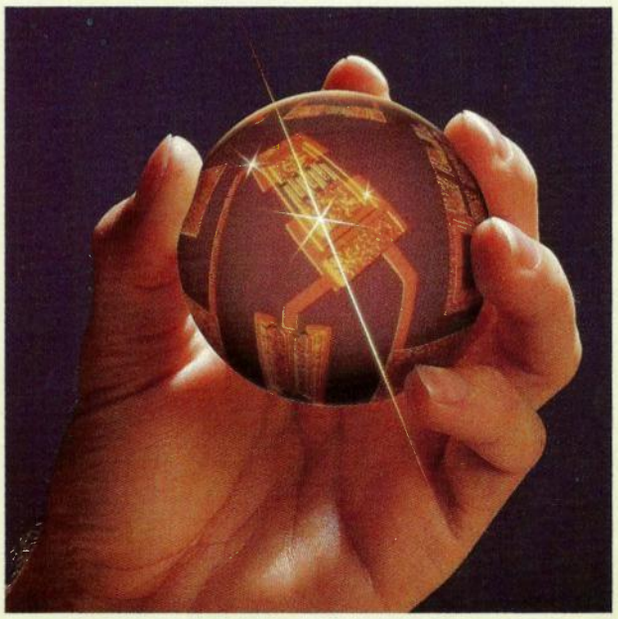
REVIEW OF ACTIVITIES 1988



TELECOM RESEARCH LABORATORIES



C O V E R

The cover is a combination of elements symbolising the advance of Man and Technology into the Future.

The background, with the freedom of movement of its feathery pattern and use of various colours,represents the increasingly complex future enviroment of the "Information Age", in which telecommunications will play a vital role.

The photograph, central in this environment, depicts Man (the hand) holding and example of modern Technology (an opto-electronic device) as he faces the challenge of this Future, using science for the creation and development of ideas and products of technology in the interests of Australian telecommunications.

F O R E W O R D

Telecommunications services are an important part of the expanding and developing information sector. They share a foundation with computer-based services in their common rapidly advancing technologies. Both types of service are converging towards an interactive future, in which rapid technological innovation will find its expression in community demand for more complex and diverse services.

In Australia as in most countries, telecommunications services are vital to national economic and social well-being. Telecommunications in Australia is a multi-billion dollar business and the public networks operated by Telecom Australia are a multi-billion dollar national asset.

As the major provider of national telecommunications services, Telecom Australia recognises that it must competently manage rapidly changing technologies as one important facet of its responsibilities to develop the Australian public telecommunications network infrastructure and provide effective telecommunications services to the people of Australia in an efficient and economic manner. Telecom regards as imperative its need to remain well informed on the potential of new technologies — to determine how, where and when they should be applied in the future development and operation of the network infrastructure or in the provision of new or existing services.

To maintain an independent competence to evaluate new telecommunications technologies and techniques and thereby to evaluate and determine new customer services and network systems, Telecom Australia has its own Research Laboratories. More formally known as the Telecom Research Laboratories, they are the largest Australian centre dedicated to R&D in telecommunications.

This publication outlines the role of the Laboratories in the context of the Telecom Australia organisation and the wider Australian telecommunications environment. It also contains representative descriptions of current projects and activities to illustrate how the Laboratories fulfil their role.

I am sure that you, the reader, will find it both interesting and informative.

R. K. McKinnon

R.K. McKINNON
Chief General Manager

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Telecom Research Laboratories

RESEARCH EXCELLENCE

FOR

TELECOM'S SUCCESS

MISSION STATEMENT

To provide Telecom with technological
and scientific leadership, knowledge and
expertise so that it can be the best
provider of telecommunications
and information services

THE TELECOM RESEARCH LABORATORIES

THE LABORATORIES' MISSION

The mission of the Laboratories is to provide Telecom Australia with technological and scientific leadership, knowledge and expertise so that it can be the best provider of telecommunications and information services.

The mission is being achieved through six major thrusts:

- provision of strategic advice and expert consultancy
- value adding to Telecom Australia's products and services
- cost reduction of Telecom Australia's equipment, systems and networks
- technical support of Telecom Australia's existing plant and equipment
- transfer of technology to other parts of Telecom Australia
- increase of ownership in Telecom's products through system and component design.

A SHARED RESOURCE UNIT OF TELECOM AUSTRALIA

The Telecom Research Laboratories are a Shared Resource Unit within the Telecom Australia organisation, responsible for performing Telecom Australia's research needs. The Laboratories conduct a Research Programme derived from a corporately endorsed Business Plan, which is approved by the Chief General Manager. The services of the Laboratories are available to other organisational units of Telecom Australia.

The processes leading to the annual formulation of the Business Plan consider corporate priorities and needs for the performance of R&D projects and related activities - in terms of the required "deliverables" and the resources needed to ensure their timely delivery. These processes require that specific projects are either funded by a particular "client" unit in Telecom Australia or on a corporate basis.

Deliverables include:

- the conduct of the Research Programme in accordance with the approved Business Plan
- the operation of Corporate Facilities (Industrial Property, Library, and Time and Frequency Standards)
- the management of and participation in Corporate External R&D Programmes on behalf of Telecom Australia.

ROLE OF THE LABORATORIES

The Research Programme

Through the performance of research, development and related activities, the Laboratories provide a strategic resource which is the key to Telecom Australia's technological leadership. The Laboratories:

- provide technological advice regarding the application of new and existing technologies to ensure that Telecom Australia has technological leadership, the most value-effective services and a highly reliable network
- collaborate with industry to ensure systems and equipment are cost effective and highly reliable
- collaborate with universities to ensure that future graduates will have appropriate skills
- participate in the development of technical standards to ensure that they suit Telecom Australia's requirements to greatest advantage
- operate, at a level of excellence, corporate facilities.

In providing technological advice regarding the application of new or existing technologies, the Laboratories strive to:

- provide strategic advice concerning opportunities for exploiting potential new technologies and new generic services
- transfer technology to other parts of Telecom Australia, industry and academia
- support existing network technologies to enhance reliability, reduce operational costs and improve performance
- increase ownership in Telecom Australia's products, both at system concept levels and through specialised device design.

Participation in the development of national and international standards relating to telecommunications is considered a key element of the role of the Laboratories. In this role, the Laboratories provide delegates to represent Telecom Australia's and Australian interests in national and international fora, able to debate technical issues from a position of in-depth expertise and to influence the development of standards which are in harmony with Australia's telecommunications needs. These fora are also a source of strategic information regarding future trends in service provision and system development. In this role, the Laboratories are able to advise Telecom Australia on the current status of

technical standards and the probable directions of evolving standards, assisting Telecom Australia to apply standards in a timely manner and with assurance as regards their credibility and viability. This work often leads the Laboratories to develop tools to optimise the application of new standards by Telecom Australia.

Corporate Facilities

As an adjunct to the performance of the Research Programme, the Laboratories manage and provide several specialised Corporate Facilities for the whole of Telecom Australia. They are:

- an Information Service, providing up to date scientific and briefing services
- Telecom Australia's Technical Reference Standards for Time Interval and Frequency, with accuracy traceable to national/ international standards
- Intellectual Property Consultancy, including the management of Telecom Australia's intellectual property portfolio.

Corporate External R&D Programmes

The Laboratories are also responsible for the management and conduct of Corporate External R&D Programmes on behalf of Telecom Australia. These include:

- the management of a portfolio of industry and university research contracts. This programme, presently budgeted at about $2.3M, complements the intramural Research Programme and seeks to encourage appropriate research in industry and universities. It is currently being expanded in scope to include development of Centres of Expertise in higher education bodies.
- participation in the activities of the Australian Telecommunications and Electronics Research Board (ATERB), including representation on the ATERB Board. ATERB is a cooperative institution funded by Telecom, OTC, CSIRO and the Department of Defence, making grants to academia to foster research in the telecommunications and electronic sciences.
- representation of Telecom in various scientific and academic bodies.

MANAGEMENT OF THE LABORATORIES

The Business Plan is the corner stone of the management of the Research Laboratories. It provides the vehicle for determining which projects will be included in the annual Research Programme and what resources will be allocated for their performance. It also provides a basis for Branches of the Laboratories to derive more detailed Work Programmes and for the monitoring of project progress and associated resource expenditures.

The Business Plan is reviewed and re-formulated annually. Specific research projects must be endorsed and notionally funded either by specific "clients" among the Business and Operational Divisions of Telecom Australia or by the Corporate Centre.

The formal annual consultation processes leading to the endorsement and approval of the Business Plan ensure that:

- the Research Programme derived from the Business Plan is cost-effectively related to corporate needs for research outputs
- a balance is struck between shorter term projects relating to client needs and longer term projects necessary to maintain the ongoing viability and skill base of the Laboratories
- accountability for technology and information transfer is a clear responsibility of the Laboratories
- the Laboratories maintain an up-to-date technical skill base which can be rapidly re-deployed to meet sudden emergent and strategic needs.

FOCUS PROJECTS

The Business Plan and the derived Research Programme are formulated in terms of Focus Projects encompassing:

- about 30 major R&D projects, each comprising a number of separately identifiable smaller projects generally grouped in terms of their applicability to Telecom Australia's business and operational activities
- the Corporate Facilities provided by the Laboratories for Telecom Australia
- the Corporate External R&D Programmes managed by the Research Laboratories on behalf of Telecom Australia.

The Programme also encompasses internal and external overhead activities, necessary to the performance of the Focus Projects.

TIERS OF ACTIVITY

Although the Research Programme is determined and listed on a project basis, each project may cover a span of activities. These activities can be considered in four major tiers, each depending on the support of the tiers below it.

The highest tier is concerned with "networks and services" and is most closely related to the essence of Telecom Australia's business and revenue earning capabilities. It encompasses activities such as service delivery, network structures, network management and network serviceability. These activities support Telecom's business-related activities and are directed mainly towards corporate strategic and forward planning operations.

The second tier is concerned with the "system-level elements" from which networks and services are derived, such as transmission, switching, signalling and control systems, and including service definition and reliability at the system level. These activities support the planning, building and operation of Telecom's networks.

The next tier supports those above by activities at the "component and technology" level. In some cases, where the results apply to only one particular system, they may be grouped with and carried out in conjunction with system-level activities. These activities support Telecom's field operations and the industry which supplies equipment to Telecom. There is heavy emphasis on activities such as component reliability, advanced components, energy technology, signal processing and human factors at this level.

The lowest tier is that closest to fundamental R&D, comprising "strategic studies" of new materials, communications needs, traffic theory, etc. These studies constitute the scientific base of other Laboratories' activities and establish Telecom's scientific and intellectual credibility and authority with industry, academia and government. There is considerable interaction with academia at this level, with support given to and received from related activities in other institutions.

RESOURCES

During 1987/88, the Laboratories employed approximately 500 staff. Of the total staff, approximately 230 have professional qualifications in engineering or the applied sciences and 10 in the social and information sciences. A further 190 technical staff supported the professional staff, with administration performed by remaining staff.

The annual operating costs of the Laboratories total approximately $40 million. Of this total, about half is expended on salaries and salary-related costs. Capital expenditures, primarily on laboratory test equipment and facilities, amount to about 17%, and the remaining 33% covers operating expenditures on consumable materials, incidental items (including R&D contracts), and buildings and building services. Laboratory test equipment items number about 15 000, with a depreciated value of approximately $19 million.

Customer-related Projects
- Electronic Data Interchange and Message Handling
- Electronic Directory Systems
- Value-Added Services (VAS) Delivery
- Geo-Informational Research
- Secure Communications
- Voice Interactive Access and Control of VAS
- Artificial Intelligence

Network-related Projects
- Broadband ISDN
- Data Network Evolution
- ISDN and Common Channel Signalling
- Network Traffic Management
- Teletraffic Engineering
- Intelligent Network Services & Systems
- Protocol Engineering
- Inter-exchange Network Evolution
- Mobile Communications Systems
- Optical Customer Access Network
- Satellite Networks
- Wireless Office Systems
- Metropolitan Area Networks and Customer Access Management
- Caldermeade Antenna Range

Reliability-related Projects
- Electromagnetic Compatibility of Information Technology Equipment
- Bioelectromagnetic Hazards
- Reliability of Plant
- Cable Technology
- Scientific Consultancy

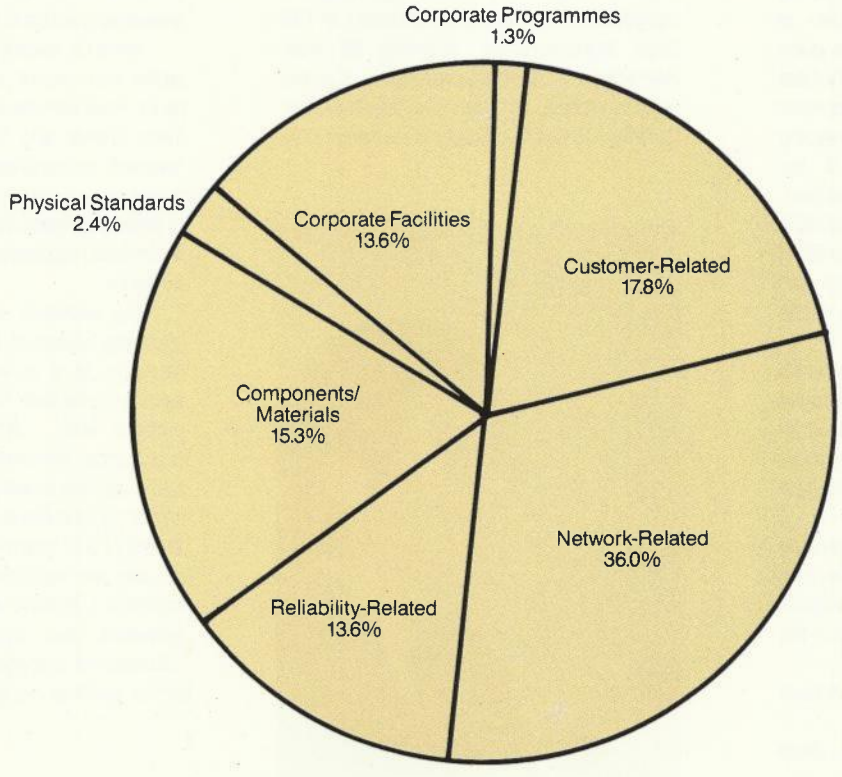
Components/Materials-related Projects
- Mid-infrared Optoelectronics
- Energy Conversion and Storage Systems
- Broadband Optoelectronics
- New Communication Fibres
- Material Processing Technology

Physical Standards
- Standards of Electrical and Optical Quantities

Corporate Facilities
- Information Resources (Library)
- Standards of Time and Frequency
- Intellectual Property

Corporate Programmes
- ATERB
- Industrial/University Contracts
- Sundry Contributions to Outside Organisations

Table of Focus Projects comprising the Research Programme.



Disposition of Laboratories' resources (in total $ terms) against Focus Projects.

SEMINAR: "FUTURE NETWORKS FOR SERVICE FLEXIBILITY"

As a special initiative towards more effective transfer of information on a broad range of future trends from the Laboratories to a wide group of decision-makers in Telecom, the Research Laboratories held a two-day seminar entitled "Future Networks for Service Flexibility" at the Menzies at Rialto Convention Centre in Melbourne, on 8-9 October 1987.

The seminar was presented to an audience comprising only Telecom Australia staff, allowing frank information exchange in a Telecom-specific context. Over its 2-day agenda, the seminar speakers gave a comprehensive outline of foreseeable technological developments and their likely impact on future service issues, customer access networks, the evolution of the "Intelligent Network", new switching architectures and network management.

Arrangements for the seminar were shared by representatives of an organising committee chaired by Peter Gerrand, General Manager, Switched Networks Research, who conceived the idea of the seminar. The committee drew upon the assistance of a number of Laboratories' Branches and was also given valuable support by John Costa, Principal Engineer heading the Engineer Development Section, Headquarters Network Engineering Department, and representatives of the Victorian Network Engineering Department. The latter representatives gave valuable insights into the information requirements of the prospective wide Telecom audience and thus helped to ensure the relevance of the seminar programme.

The seminar was opened by Telecom's Managing Director, Mel Ward, who supported the concept of the seminar and indicated an increasing need for Telecom staff to seek more and better ways to keep up with technological advances in telecommunications.

The two-day programme had the common format of two sessions each day, each devoted to a specific theme, followed by a discussion session led by selected speakers later in the afternoon. The themes covered:

- Service Issues and the Customer Access Network
- Technologies for the Longer Term Intelligent Network
- New Network Architectures - Design and Traffic Management
- Longer Term Trends and Influences.

In addition to the formal conference sessions, members of the Telecom audience, drawn from all Australian states, were able to mix informally with the seminar speakers and one another over morning and afternoon teas, luncheons and a special seminar dinner. These events provided further opportunities for technical and social discourse and making and renewing acquaintances.

A special feature of the seminar dinner was the presentation by some of the more musical Laboratories' staff (with friends) of a potted piece of Gilbert and Sullivan, with lyrics updated to bear satirically upon the current restructuring activity pervading the Telecom organisation and political issues such as privatisation and deregulation, which were topics of current public debate. This bubbly entertainment was followed, not without co-incidence, by a more serious treatment of many of the same topics by Telecom's Chief General Manager, Bob McKinnon, in an after-dinner address.

In terms of reaching a wide Telecom audience, the seminar was a resounding success, with every State Administration represented. The audience consisted of 136 State representatives, including 50 from interstate, 78 HQ/Corporate Centre representatives, and three from the Corporate Customer Division (officially in existence only 6 days before the seminar). The audience mainly comprised representatives of middle and senior management from Telecom's engineering and commercial areas, especially Account Managers and Chief Engineers, but also included other staff, ranging in level from junior engineers to senior managers. This diversity was satisfying to the organisers, but a challenge for the presenters.

The presentations ranged in style and content to match the wide ranging background of the audience - from philosophy to science, management to high technology, informative to entertaining.

The presentation by the guest speaker and only non-Telecom person attending, Dr. Sadahiko Kano, Executive Manager, Network Technology Laboratory, NTT, Japan, was a very interesting highlight in the seminar programme. His contribution, entitled "Possible Evolutionary Paths for Telecommunications Networks - Ideas from Japan", and his comments as a member of the subsequent discussion panel were most informative, and the organisers and audience were impressed by the candour with which he answered questions and offered comments.

While Dr. Kano's talk could be considered as the "main course", certainly the presentation by Dr. Fred Symons on "The Impact of Longer Term Trends and Developments" was the "dessert" to complete the menu. While his points were poignant, his highly humorous use of yesteryear material (with pertinent subtitles in his slides) was extremely well received by the audience.

The audience response was the most gratifying aspect of the seminar. Audience response to a survey conducted after the seminar indicated that it had achieved its purpose well. While there were some constructive comments that were noted for future use, the audience judged the seminar to be not only the equal in quality of presentation to that of any international seminar but most relevant and valuable in terms of its subject matter to a Telecom audience. Certainly, the response was such as to encourage Laboratories' management to plan for another similar seminar in the near future.

Left:
Dr. Sadahiko Kano, keynote speaker at the seminar on "Future Networks for Service Flexibility".

RADIO STATION VNG CEASES TRANSMISSION

On 1 October 1987, VNG, the radio station broadcasting the Standard Frequency and Time Signal Service ceased transmission. Located at Lyndhurst in Victoria, this station had provided precise radio time signals for use in surveying, geophysical and seismic activities and a wide range of Australian scientific and industrial operations for over 23 years. From its beginning, the accuracy of the frequency and time signals was a responsibility of Telecom Australia's (earlier, the Postmaster-General's Department) Research Laboratories.

In the early 1960s, a demand for an Australian broadcast time signal service arose from a number of sources because the available service at that time was not able to meet user needs. The most pressing needs were those of the highly mobile surveying, geophysical and seismic communities, often pursued in the remote parts of Australia. The time signal transmissions then available on CCIR bands were of little use to these communities in their field operations because of the confusion caused by the transmission of several time signals from different sources on a single carrier frequency. Furthermore, since the stations broadcasting the CCIR signals were located overseas, signal reception was poor in a number of Australian locations. These considerations led to the establishment of VNG, an Australian-based station providing a continuous high frequency service on exclusive frequencies.

For many years prior to the 1960s, the Postmaster General's (PMG) Department had been active in the generation and distribution by landline of standard frequency and time signals. This activity was relevant to its then responsibilities for telecommunications and radio broadcasting service operations, including radio frequency spectrum management. After consultation with other interested Departments, it was therefore decided that the PMG's Department should develop and operate the VNG Service.

The Service was developed in two stages. At 0815 hours EST (2215 hours UT) on 21 September 1964, the PMG's Department inaugurated a time signal broadcast service from station VNG, Lyndhurst. This was an interim service operating on two frequencies simultaneously in the high frequency (HF) band. For technical reasons, Lyndhurst was considered to be the most appropriate site for the transmitters. The time signals were generated by auxiliary equipment attached to the Speaking Clock at Melbourne's City West Exchange and relayed over about 30 km to Lyndhurst by programme line. On 22 December 1969, a new service with improved accuracy, increased time-of-day information and stabilised carrier frequencies was introduced. The frequency and time signal generating equipment was designed by the Research Laboratories and installed at Lyndhurst. A control signal sent via landline from the Research Laboratories' time and frequency standard in Melbourne was used to lock the quartz oscillators.

Following the establishment of the VNG time and frequency service, its use by the surveying, geophysical and seismic communities increased markedly. Other uses included radiocommunication measurements, broadcasting, civil engineering, mining, marine navigation, power generation, equipment calibration, radio and optical astronomy, and aerospace manufacturing and operations. Users of the service were distributed throughout the government, private and academic sectors of Australia. Since VNG was only one of two standard frequency and time signal broadcast stations in the Southern Hemisphere, there were many other users located in South East Asia and Oceania.

In September 1986, the Australian Broadcasting Commission gave notice that it intended to close down its inland broadcasting service transmitters at Lyndhurst. This decision meant that the VNG transmitter would become the only operating transmitter at the Lyndhurst site after 1987, imposing an urgent need for its re-location at another site. Since Telecom Australia's role and responsibilities for radio broadcasting and spectrum management had been divested in the 1975 re-structuring of the PMG's Department into a number of Government organisations, Telecom announced that it proposed to discontinue the VNG service in 1987 and unsuccessfully tried to interest other potential operators to continue to provide the VNG service.

Following these discussions, which also considered alternative means, now available, of providing replacement services, Telecom terminated its VNG Standard Frequency and Time Signal Service at 0000 hours UT on 1 October 1987.

Left:
Transmitting antenna at radio station VNG, Lyndhurst.

TELECOM EDUCATIONAL FELLOWSHIP WINNERS, 1987

Each year, Telecom Australia, through the Research Laboratories, assists a select number of outstanding undergraduate students to complete the final year of a course of tertiary study leading to a Bachelor Degree in a telecommunications-oriented field of engineering or science at an Australian University or Institute of Technology. The scheme is called the Telecom Australia Educational Fellowship Scheme and it is intended to encourage promising undergraduates to consider a career in telecommunications whilst lending them positive financial assistance to complete their studies. The scheme also seeks to demonstrate Telecom's desire to inject an awareness of telecommunications topics into the processes of tertiary course development, so that Australian centres of higher education will continue to develop capable telecommunications engineers and scientists in the future.

The Educational Fellowship Scheme supplements Telecom's support of postgraduate research on telecommunications topics in Australian centres of higher education through its R&D contract programme and its active support of the R&D grants scheme operated by the Australian Telecommunications and Electronics Research Board.

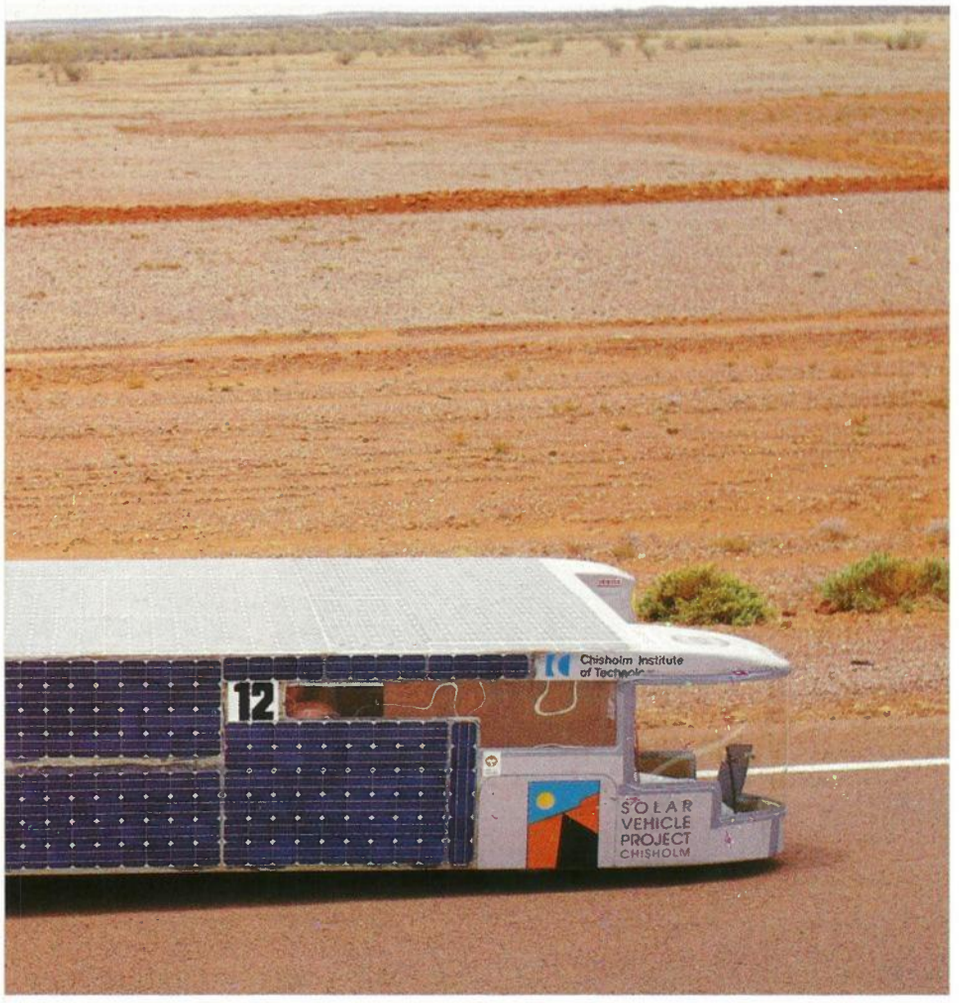
Eight Fellowships were awarded by Telecom in October 1987. The recipients were:

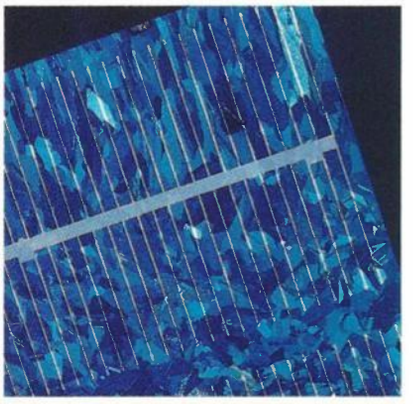
- Nigel Aylott, completing his science/ engineering degree at Monash University in 1988
- Lynette Cross, completing her computer science degree at LaTrobe University
- Katharine Fisher, completing her engineering degree at Monash University
- Andrew Jenkins, completing a science degree at Sydney University
- Jan Kautsky, completing an engineering degree at Adelaide University
- Daniel Kirkham, completing his science degree at the University of Tasmania
- Barry Kitson, completing a science degree at Queensland University
- Andrew Reilly, completing a science/ engineering degree at Queensland University.

"Winners of Telecom Educational Fellowships would have the opportunity to contribute to the discoveries, the innovations and the technologies being developed for telecommunications in the 1990s and beyond", Telecom's Chief General Manager, Mr. Bob McKinnon, told the three Victorian Fellowship winners at a presentation function at Telecom's Research Laboratories in October 1987. He said that Telecom's selection processes had demonstrated that the the 1987 Fellowship winners have outstanding ability and Telecom was delighted to assist them with their studies, in the expectation that they will go on to rewarding and challenging professional careers and contribute to the future prosperity of the nation.

The Fellows subsequently joined the staff of the Laboratories from December 1987 to February 1988, where they undertook a variety of R&D projects. At the conclusion of this period of employment in the university vacation, it seemed that they had found the experience both interesting and rewarding. For its part, Telecom wishes the Fellows success in their studies and hopes that they are stimulated to seek careers in Australian telecommunications.

Right:
Pictured at the presentation of Telecom Fellowships to the Victorian winners at the Research Laboratories, from left: Research Executive General Manager, Harry Wragge, Lynette Cross, Katharine Fisher, Nigel Aylott and Chief General Manager, Bob McKinnon.





SOLAR POWERED CAR RACE

During 1987, the Research Laboratories supported the entry by the Chisholm Institute of Technology (CIT) in the World Solar Challenge car race. The Laboratories provided advice and technical assistance to the CIT project to design its solar powered car, specifically on topics such as solar cell performance, complementary design of battery power systems and electronic control of the car's hybrid power system. The race was held in November 1987, starting at Darwin and finishing in Adelaide. It was over a distance of 3026 km through the centre of Australia. The CIT entry finished sixth in the field of 25 competing cars, with the sophisticated General Motor's "Sunraycer" car winning the race with an average speed of 67 kmph.

The race rules dictated a maximum area for the solar panels on the car, from which the Laboratories modelled the solar performance of various aerodynamic car shapes devised by CIT. A catamaran shape for the car was finally selected, with solar panels on the flat roof and two sides. Experience gained in system design for Telecom's remote area power supplies enabled the Laboratories to predict the daily energy input from the solar panels as the car travelled south along the Stuart Highway.

The specially constructed solar panels for the car were obtained from the Hozan Corporation, a Japanese company. The solar panels had a thin plastic film on the front surface instead of glass, providing a reduction in weight of 100 kg. Thorough electrical and environmental testing of the panels was undertaken at the Laboratories. In an unusual adaptation of the hail-stone impact test normally used in the laboratory to simulate and evaluate damage to Telecom's solar cell modules, an indication was obtained of the extent of potential stone damage to the solar panels caused by passing vehicles.

A Dunlop Pulsar lead-acid battery was selected for use in the race because of its small size and weight and its rugged construction. The Laboratories tested the battery's life under the harsh electrical conditions which it would endure in the race. The test results showed that a reduction in capacity would occur over the expected small number of charge/discharge cycles, and the battery was dimensioned to allow for this.

The solar panels and two drive motors were electrically connected to the battery by switchmode power electronics equipment. Microprocessor control of the equipment used an optimisation algorithm to match the power components electrically under varying conditions of solar insolation, battery state of charge and car speed. The Laboratories also provided expertise to CIT for the design of high efficiency power conversion and interference suppression techniques.

Although not in the line of normal activities, the Laboratories' support of CIT's entry in the World Solar Challenge race provided a refreshing interlude for Laboratories' staff to demonstrate their expertise to their CIT colleagues. It also provided an opportunity to evaluate new materials, devices and novel design concepts under harsh conditions, as well as to participate in an interesting and unique "extra-curricular adventure" with its inbuilt challenge.

Centre:
The CIT solar-powered entrant in the World Solar Challenge car race 1987.
(Photograph by courtesy of Chisholm Institute of Technology)

Above:
Solar panel detail.

HONOURS FOR RESEARCH LABORATORIES' STAFF

During 1987, several members of the Laboratories' staff received honours from professional and learned institutions in recognition of their professional contributions and dedication to telecommunications.

• Harry Wragge, Executive General Manager of the Laboratories, was invested in October 1987 as a Fellow of the Australian Academy of Technological Sciences.

The citation to the fellowship mentioned Harry's "distinguished contributions to telecommunications, especially in the development of the experimental digital telephone exchange which was in the vanguard of world developments" and his "leadership within Telecom's Research Laboratories".

• Peter Gerrand, General Manager, Switched Networks Research Branch, was named a Fellow of the Institution of Engineers, Australia.

The award was made in recognition of Peter's high achievements and level of leadership and responsibility over a long period for important engineering decisions and research programmes in the field of telecommunications switching. In making the award, the Institution noted that the fellowship approval process involves selection by peers, confirming Peter's eminence and high standing in the engineering profession.

• Alan Gibbs, General Manager, Transmission Networks and Standards Branch, was nominated "Engineer of the Year" in 1987 by the Institution of Radio and Electronics Engineers, Australia, of which he is a senior member.

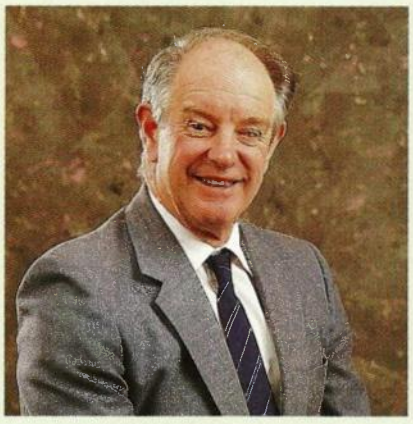
Alan joined the Laboratories in 1961 and has worked primarily in the field of transmission systems research. His pioneering contributions in the field of digital transmission systems laid a foundation to their introduction in Telecom's network in the 1970s. More recently, Alan has led research projects in the fields of optical fibre transmission systems for trunk and local access networks and mobile radio and satellite transmission systems. A highlight of Alan's career was his participation in the NASA voice-data network for Project Apollo, which first put man on the moon.

In addition, several other members of the Laboratories' staff were selected for special overseas assignments.

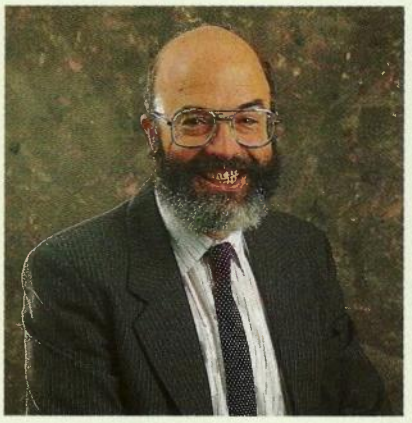
• Tony Bundrock, a senior engineer in the Laboratories' Transmission Networks and Standards Branch, was nominated by Telecom and accepted by the International Telecommunications Union to undertake a two-part mission in New Delhi, India, as a senior ITU expert advising on satellite communications systems.

Tony completed the first part of his mission in the latter half of 1987, working with research staff of the Telecommunications Research Centre in New Delhi on investigations of new techniques for satellite communications. Tony will undertake the second part of his ITU mission in another year or so.

• Tom Stephens, Principal Engineer, Transmission Networks and Standards Branch, and Bryan McGlade, Senior Engineer, Customer Services and Systems Branch, were awarded fellowships by the Rockwell International Corporation (USA), enabling them to undertake research as Visiting Scientists at Rockwell's Research Laboratories in the USA for a period of about 12 months, commencing on 1 July, 1988. Tom will research advanced coherent modulation and detection techniques with potential application in future optical fibre transmission systems, under the direction of Rockwell's Mr. Paul Hartman. Bryan will investigate technologies relevant to the future introduction of broadband services in the business and residential sectors, under the direction of Rockwell's Dr. Neven Karlovac.



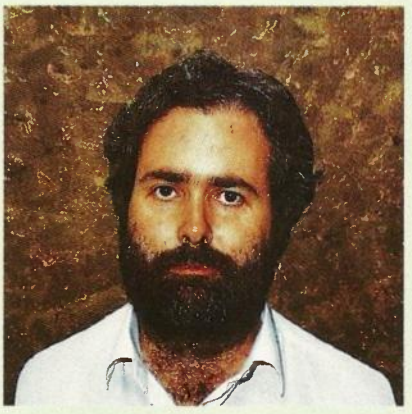
Harry S. Wragge, BEE, MEngSc, FTS, FIEAust



Peter H. Gerrand, BE, MEngSc, FIEAust

Alan J. Gibbs, BE, ME, PhD, SMIEEE, SMIREE

A.J.(Tony) Bundrock, BE



Tom D. Stephens, BE, MEngSc, MIEEE

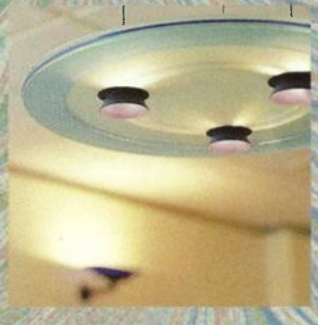
Bryan J. McGlade, BE






Buildings 1,3 & 4
Loading Bay 2






A SELECTIVE REVIEW OF CURRENT ACTIVITIES

In the fulfilment of their mission, the Laboratories engage in a number of research investigations and developmental projects in the engineering and scientific fields. This work is chosen for its relevance to Telecom Australia's customer services and network systems, and it comprises a wide variety of specific topics pertinent to the present technical standard and future technical advance of these services and networks.

It is not possible to report, even briefly, on all Laboratories' projects in this Review. As a consequence, the activities outlined in the following pages have been selected to give an overall picture of the type and breadth of work undertaken and of the degree to which the Laboratories are keeping abreast of world developments in telecommunications science and technology. A more comprehensive list of current projects is issued in the "Research Quarterly", a publication made available to selected bodies with more specific interest in the work of the Laboratories.

The normal method of publishing the detailed results of a research project is through a Research Laboratories Report or a Branch Paper, prepared when an investigation has reached a conclusion or a conclusive stage. These publications are the vehicles by which the results of the work are conveyed to the "client" and other interested Divisions of Telecom Australia, and in many cases, to other telecommunications agencies, industry and research bodies, both local and overseas.

Conclusions resulting from research studies are, on appropriate occasions, documented as contributions to the deliberations of national and international bodies concerned with technical standards relating to telecommunications. The staff of the Laboratories also contribute to Australian and overseas technical journals and present papers to learned societies.

An indication of the scope of these various publications of the outputs of the Laboratories can be gained from the lists given in the last section of this Review of Activities.

INFORMATION FLOW ANALYSIS IN THE HEALTH SECTOR

Information flow analysis grew out of early research into the human communications aspects of how new communication needs arise in society, how technological innovations appear to fill those needs, and how social change both results from technological innovation and precedes new needs. Information flow analysts utilise this circular relationship between social change and new technologies to predict new needs before they become fully obvious, by understanding the functions which old technologies serve. Clearly, information flow analysis can be useful in the determination of the needs of a particular group of customers for telecommunications services which enhance the efficiency of information flow within the group. Combined with appropriate geographic information, the outputs of such analyses can benefit long range planning of telecommunications network infrastructures.

In order to develop an understanding of how technological innovations can be adopted effectively in new customer services, the Research Laboratories are applying information flow analysis techniques to identify and analyse information flows in the Australian health care sector. The study is being pursued in close collaboration with Telecom's Business Divisions and representatives of health care organisations and practitioners.

The health care sector was chosen as the subject area of this research project because:

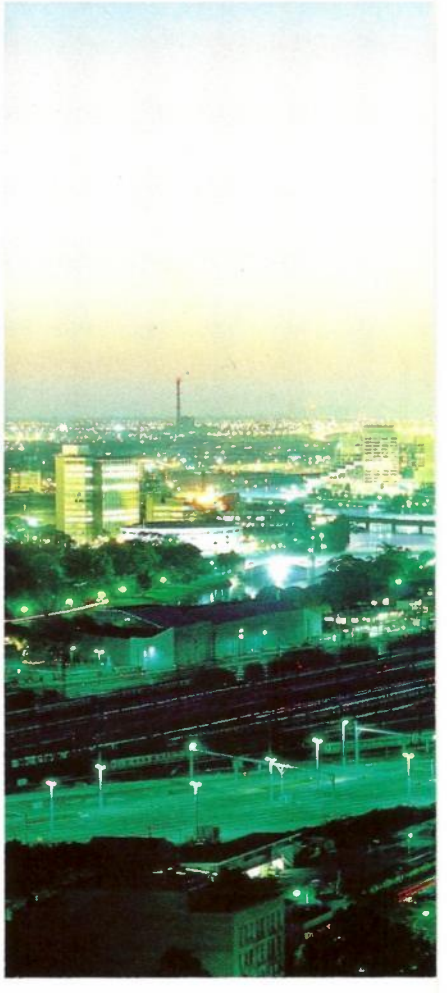
- it provided a suitably challenging and relevant research site, comprising a large and diverse group of Telecom's customers which is distributed geographically across Australia and reliant on effective communications to provide essential community health services
- non-Telecom participants in the study could derive short term benefits by obtaining a better understanding of their own communications environment
- Telecom could derive hands-on experience with this research technique, at the same time gaining insights into the communications needs of an important customer sector.

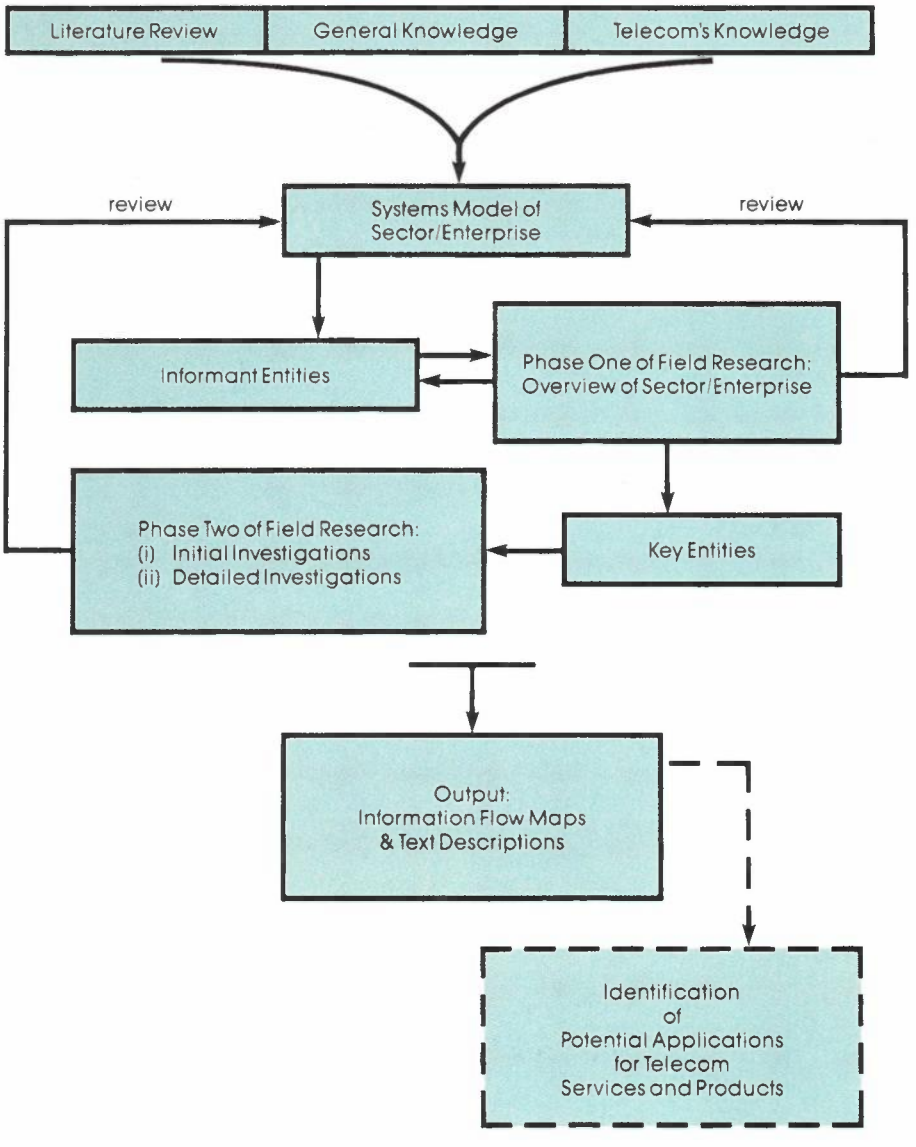
In the study, Laboratories' staff with special expertise in human communications are systematically mapping information flows related to the diverse health care functions performed by hospitals, medical practices, laboratories, government and privately operated health services, health insurance companies, etc. Information flow patterns within these organisations are being mapped, in addition to those across the sector as a whole. The mapping process

is the essential preliminary step to gather data for subsequent characterisation of information flows in relation to functions to be performed.

By analysing these functions, the Laboratories' researchers are able to identify the information necessary to carry them out. Information flow maps are then generated. These maps disclose whether or not the information needed to perform some function is flowing to where it is required and help to identify any information gaps which can hinder the performance of the function. Ultimately, this approach to the study of information flows is expected to yield useful insights into how they might be facilitated or improved in the future development or application of telecommunications services.

In the pursuit of the study, the Laboratories' information flow study team has been able to catalyse improved communications between Telecom's commercial representatives and their customers. They have been able to promote increased awareness of available telecommunications services relevant to improving information handling, on one hand, at private medical practitioner level, and on another, at the level of large organisations operating medical record storage and handling systems. Working in conjunction with Telecom's commercial account managers, the Laboratories' staff have thus been able to demonstrate Telecom's competence to meet customer requirements in an increasingly competitive Australian telecommunications environment.

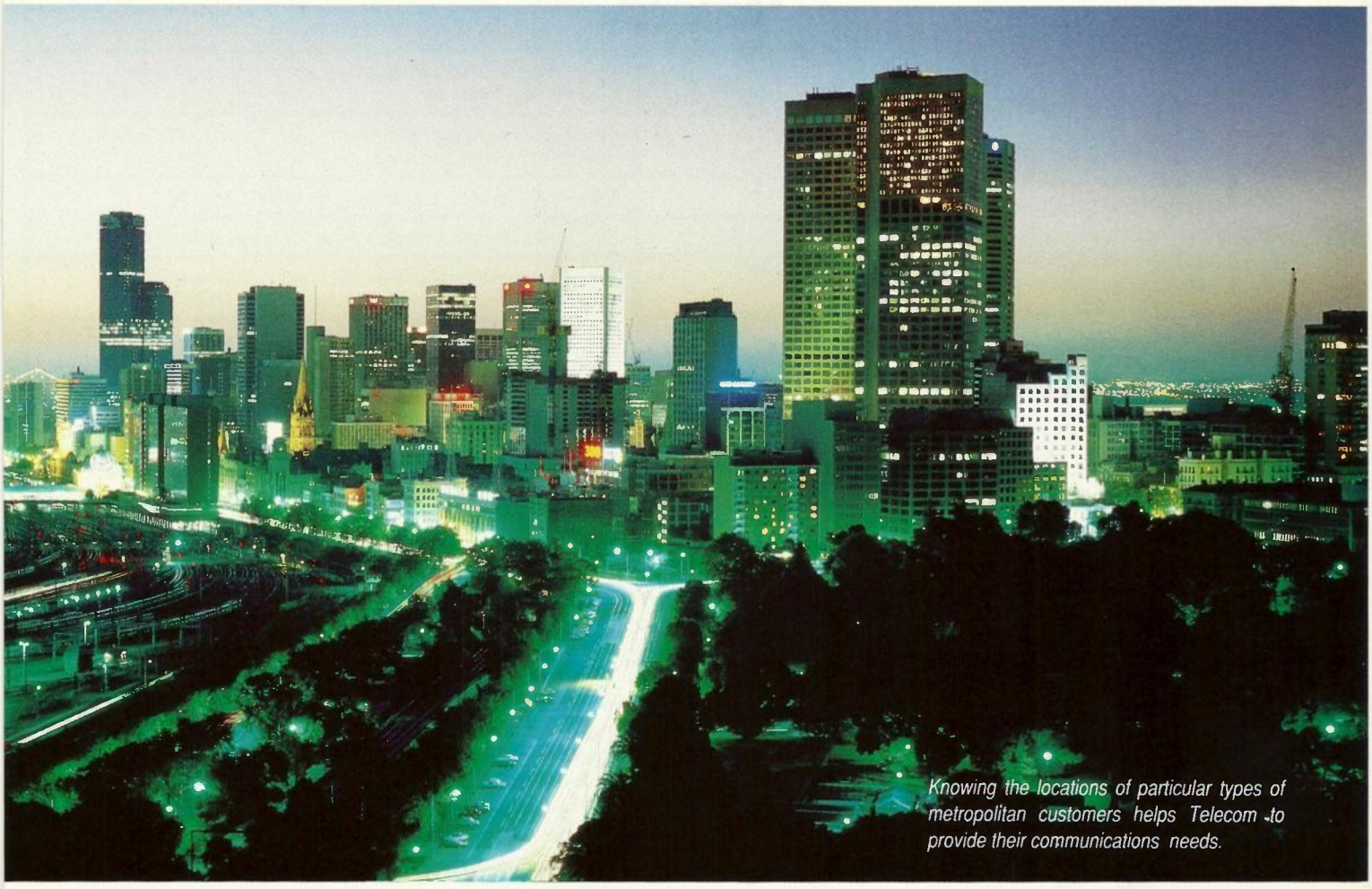




Flow chart depicting the information flow analysis method.

In exchange for the participation of the health sector representatives in the study, the Laboratories' staff have also been able to provide them with insights into ways in which state-of-the-art communications technology might be adapted to health service applications. In return, the Laboratories' staff have enjoyed otherwise inaccessible freedom to observe the actual functioning of the health sector, and have received expert guidance from practitioners in comprehending essential health care functions, ranging from basic medical treatment to health insurance rebate messaging and storage systems.

In the course of the study, the research staff are also testing the applicability of the information flow analysis approach as a portable research method, suitable for future study of other customer sectors, private business organisations or any other type of information-dependent activity.

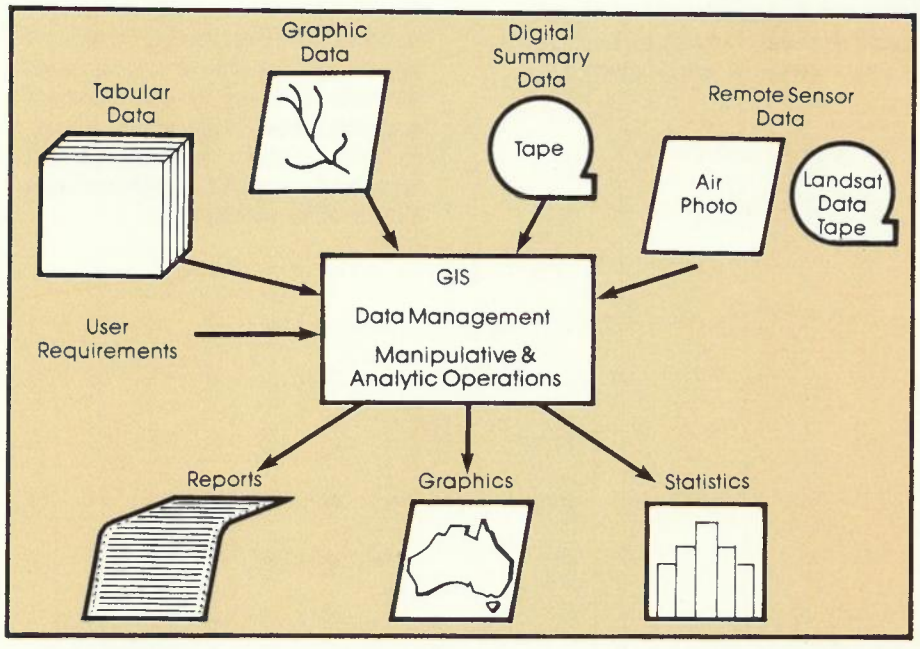


Knowing the locations of particular types of metropolitan customers helps Telecom to provide their communications needs.

UTILISING GEOGRAPHIC INFORMATION

"Geographic information" is information which can be related to specific locations on the Earth. It covers an enormous range, including descriptions of infrastructure such as buildings, cables and other services, patterns of land use, distribution of natural resources and socio-economic data such as the patterns of wealth, employment, housing and business groupings.

Much of Telecom Australia's activity depends on geographic information, on knowing where things are and understanding how they relate to each other. Many aspects of decision making - for management, planning and investment - depend on it. For example, Telecom uses geographic information on the location of particular groups of customers (such as business or residential) to direct services, to determine the most appropriate sites for new telephone exchanges, to determine charging boundaries and to anticipate likely service uptake and potential demand.



Schematic outline of a Geographic Information System (GIS)

Large sums of money can be spent collecting geographic information, but using it to its full potential is difficult. For example, linking together separately collected pieces of information relating to the same location is sometimes impossible because of the different way location is described. In addition, the large amount of information required even for simple problems, such as estimating the number of customers within a particular exchange area, often makes manual analysis tedious and error prone. More complex problems, such as predicting the effect of ISDN technology on future patterns of telecommunications usage, might require modelling alternatives. This sort of operation, which is often an essential part of the decision making process, requires the use of sophisticated computer systems.

In the light of the preceding discussion, it is important that Telecom develops effective means of handling geographic information, encompassing its collection, processing, storage, retrieval and analysis. The application of computer-based Geographic Information Systems (GIS) provides potentially powerful tools to integrate these functions and represent the locational character of geographical information effectively. The use of such database technology can lead to better management of resources, business planning and satisfaction of customer needs.

The Laboratories are undertaking a demonstration GIS project to illustrate the potential applications and benefits of geographic information technology. With this end in mind, the Laboratories' project has the specific objectives of applying the technology to a real operational activity, developing a prototype system structure for a Telecom GISand testing new methods for collecting information about existing and potential customer demand. The project involves collaboration between the Laboratories' research staff, potential GIS users, system suppliers, data suppliers and academics.

During the past year, a number of steps to establish an operational GIS have been successfully completed. Much of this ground work concerned the establishment of a geographic referencing system and data systems for customer and other attributes. These systems comprise the major architectural elements of the GIS. Current work concerns the application of computer-based information technology for data operations, comprising retrieval, transformation, storage, searching, analysis, recombination and modelling. Examples of these eight operations are given in the adjoining table.

OPERATION	EXAMPLE
RETRIEVAL	Obtaining information about a customer at a particular address (e.g. revenue).
TRANSFORMATION	Relating telephone prefixes to an exchange (e.g. all types of PABX by exchange).
STORAGE	Entering field survey information by individual properties.
SEARCHING	Listing all customers with more than 15 lines by exchange.
ANALYSIS	Testing correlation between location of Viatel users and grouping of certain socio-economic characteristics.
MEASUREMENT	Establishing relationships between exchange size and type and concentration of population/customer type.
RECOMBINATION	Analysing distribution of call revenue and number of exchange lines per customer by exchange.
MODELLING	Regression modelling of revenue by exchange versus income distribution and land use.

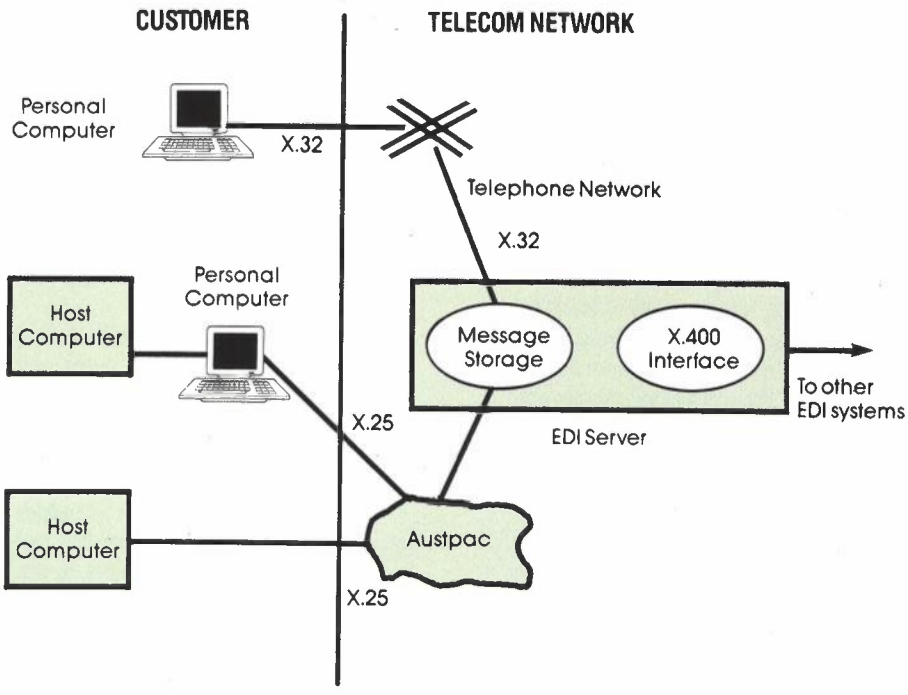
Examples of the eight data operations performed by a Geographic Information System.

ENHANCEMENT OF THE TELECOM TRADELINK SERVICE

Recently, Telecom Australia established a new business-oriented Tradelink service which provides a network vehicle enabling business customers to adopt Electronic Data Interchange (EDI) techniques for the exchange of information relevant to a variety of business transactions between their computers and those of their business partners engaging in such transactions. The information characteristically comprises that contained in documents such as orders, invoices, delivery dockets and remittances. The use of EDI avoids the inefficiencies and potential for clerical error which occur with paper-based transactions, arising from the need for information to be re-keyed a number of times in the course of each transaction. When associated with computer-based "just-in-time" inventory control, businesses using EDI over Telecom's Tradelink service can increase their productivity and improve their customer response times.

Although Telecom's Tradelink service for EDI is still in an early stage of development, it is a value added service which will be of major importance in the future.

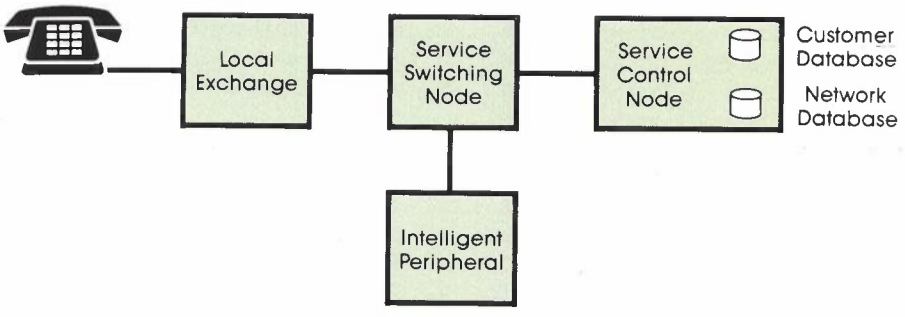
While Telecom's initial Tradelink service for EDI uses currently available networks, the Laboratories are examining the design of a software system which could provide for migration of the Tradelink service to one based on the Open System Interconnection (OSI) international standards. This would overcome a number of limitations of the initial service, including interconnectivity and addressing



Schematic architecture of an EDI service based on OSI standards.

issues, and introduce new customer-requested features such as improved security. Further, while an EDI network can be built using proprietary protocols, there are significant user benefits to be gained by using internationally standardised interconnection protocols, such as X.25 and X.400, to increase connectivity and thus the value of the EDI service to the customer.

With the above considerations in mind, staff of the Research Laboratories, who have a high level of expertise in the relevant CCITT OSI standards, have been working with staff of Telecom's Corporate Customer Division, who are responsible for the Tradelink service, to develop a new EDI network architecture. This architecture, based on the latest X.400 standards, is intended to serve the needs of Telecom's customers into the next decade. Laboratories' staff have also assisted the Corporate Customer Division in the marketing of Tradelink services by providing timely advice and information about EDI and X.400 technology.



Simplified architecture of an intelligent network.

A MODEL FOR VOICE SERVICES IN AN INTELLIGENT NETWORK ENVIRONMENT

The intelligent network concept is a means whereby enhancements of present telecommunications networks and services may be introduced in an economic and generally non-disruptive fashion. The central components of the architecture of an intelligent network are the service switching node and the service control node. The former provides the basic switching functions of the intelligent network, and the latter maintains and provides information relating to individual customers, the communications network and specific services.

Within the above framework, the intelligent peripheral is a component which can be used to provide additional service capability. A range of value added voice services can be provided by one such intelligent peripheral. These enhanced services would make use of speech input and output technology to interface interactively with the service user.

The Laboratories are investigating an architecture of such an intelligent terminal, a schematic outline of which is shown in the adjoining diagram.

The communications processor in this model provides the means whereby the intelligent peripheral can communicate with the intelligent service switching and control nodes as well as with other remote service nodes, and indeed also with the service user. By using a telephone, service users can access enhanced services which invoke this

intelligent peripheral via the local exchange and service switching node, under the control of the service control node. Communications from the user to such a service could be either via the usual dual tone multi-frequency (DTMF) signals from the telephone keypad or via spoken commands. The intelligent peripheral could guide the user by issuing spoken prompts.

The command translation function is responsible for accepting user input, either as DTMF tones or as spoken commands, and decoding it appropriately. It must also generate the appropriate spoken prompts, as requested by the applications processor. The speech input/output database incorporates "speech templates" necessary for the recognition of speech input as well as the encoded speech prompt vocabulary. The applications processor guides the user/service interaction, requesting and recording appropriate information from the service user, and also retrieving information (eg, "electronic mail"), possibly from remote service nodes, to be output to the user. Such information may require the use of text-to-speech synthesis techniques.

This model, which incorporates speech input/output technology, could provide a wide range of computer-based interactive services with ready access via telephone. Such services could range from simple information retrieval to more complex business transactions such as order entry applications. The range is limited only by the capability of the applications processor depicted in the model.

ELECTRONIC SECURITY PROCEDURES FOR COMPUTER COMMUNICATIONS

The Laboratories are currently developing experimental hardware and software to demonstrate the feasibility and utility of cryptographically based authentication procedures for computer communications systems. These procedures rely on the use of "public key" cryptography to identify the source and integrity of messages (by way of a mode known as the "digital signature" mechanism) and on the existence of trusted organisations (called "Certification Authorities") to ensure the integrity of publicly available user data.

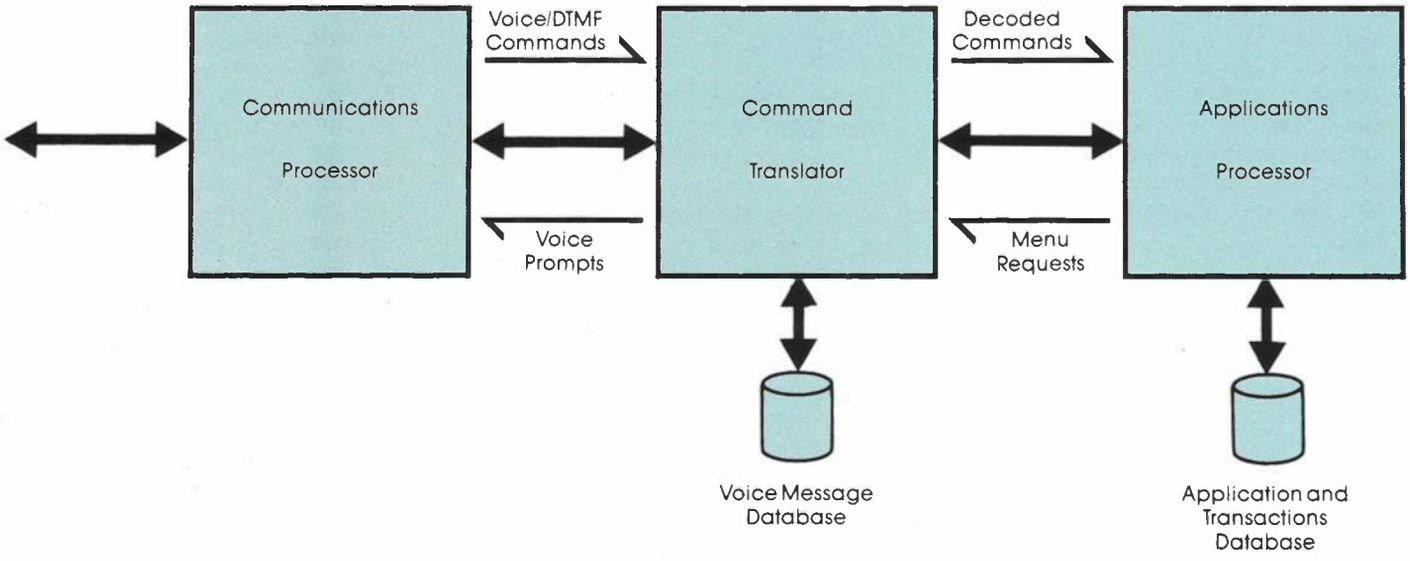
Public key cryptosystems rely on the use of two different keys. Either key can be used to transform (ie, encrypt) text or data into a form that is unintelligible, while the other can be used to transform the encrypted message back (ie, decrypt it) to its original form. The unique feature of these cryptosystems is that it is not feasible to compute one key given the other. Consequently, one of the keys can be made publicly available, for example, by publishing it in a newspaper or in a paper-based or electronic directory system. For this reason, it is known as a "public key", while the corresponding unpublished key is known as a "secret key".

A digital signature is produced when a message sender uses its unique secret key to encrypt a message, or a short summary derived from it, and then appends it to the message prior to its transmission. This allows receivers of the message to check the validity of the signature, and therefore the source and integrity of the message, using only publicly available key data.

The role of a Certification Authority is to ensure by way of the digital signature mechanism that customer/user data (in the form of "certificates") cannot be altered without the alteration being easily detected. Its functions have been developed in the Laboratories to conform as closely as possible to those described in the current CCITT Study Group VII, Draft Recommendation X.509 (The Directory - Authentication Framework) and include:

- a hardware implementation of the "Rivest, Shamir and Adleman" (RSA) public key algorithm
- the generation of large multi-precision prime numbers, since primes of about 77 digits are currently required for RSA use
- the generation of RSA public and secret key pairs for users who cannot create their own keys, whereby the secret parameters used to create the keys are destroyed after creation
- the creation of "certificates" which include the user's "distinguished name", public key and the period for which the certificate is valid (certificates are lodged in a directory and may be checked by anyone knowing the public key of the Certification Authority), and
- the ability to create "certificates" for user-created public keys and associated data, as well as public keys and other data created on behalf of the user.

The knowledge gained from this Laboratories' project is providing Telecom Australia with both hands-on experience and software tools potentially applicable in future developments of a broad range of new as well as enhanced computer-based communications services featuring electronic security.



Detailed architecture of an intelligent peripheral providing voice value added services.

IMPROVED MODELS FOR SPEECH

Speech is the most natural mode of communication for humans and speech signal processing is thus an active area of research undertaken by telecommunications organisations worldwide. Computer techniques for speech recognition and synthesis have the potential to make a dramatic impact upon the range and cost of enhanced services offered to customers.

The ease with which we communicate by the spoken word belies the difficulties associated with man-machine speech communication. Significant developments in man-machine speech communication are likely to result from improvements in speech models, together with the incorporation of probabilistic and knowledge-based systems for handling higher level functions. The ultimate goal of free, speaker-independent discourse with a machine is still some distance away. However, there are aspects of the more general problem which are realisable in the foreseeable future.

Work is in progress within the Laboratories to develop an improved speech model which overcomes a number of limitations existing in the more commonly used approaches. The improved model utilises a novel time-varying Auto-Regressive Moving Average (ARMA) model excited by various multi-pulse strategies. The model parameters allow the accurate tracking of highly non-stationary segments of speech which are of important perceptual significance, whilst still efficiently representing the more stationary segments. Multi-pulse excitation is recognised as a superior excitation for conventional models and is being extended in the current Laboratories' work to time-varying models.

The work is being applied, in the first instance, to high natural quality text-to-speech synthesis. In this approach, the speech is taken as a concatenation of suitably chosen speech segments (such as demi-syllables) obtained from human speech, as opposed to synthesis-by-rule systems which rely on a complex system of rules for obtaining model parameters.

Although synthesis-by-rule systems can be highly intelligible when sufficiently complex, they fail to produce natural sounding speech. Furthermore, a major change in speaker qualities involves major rule modification.

The development of semi-automatic procedures for demi-syllable extraction will enable the concatenation approach to realise a major accent change without significant rule modification. The speech segment concatenation approach reduces rule complexity at the expense of additional computer memory, required for storing demi-syllable templates. The main model requirements are:

- efficiency of model representation
- computational efficiency in performing synthesis calculations
- time scale and pitch modification for control of prosody
- ability of the model parameters to perform smooth segment transitions efficiently.

It is expected that this approach to text-to-speech synthesis can also be applied to the task of speaker-independent limited-vocabulary speech recognition. The future adoption of such speech recognition and synthesis techniques could add a new dimension to the user-friendly control of a wide range of value added services such as voice store-and-forward services as well as services providing general access to databases such as those of electronic directory services.

DATABASE SUPPORT FOR AN ELECTRONIC DIRECTORY SYSTEM

The potential growth and diversity of valued added telecommunications services has produced a need for fast, convenient access to up-to-date directory information about service users. The evolution of the integrated services digital network (ISDN) will ultimately provide all customers with a single access link to the network for a range of voice, data, text and image services. Connections between differing types of customer terminal equipment will be established by complex signalling and structured rules (protocols) to provide particular services. This future scenario requires that more complex directory information about the customer and his services/terminal facilities is available and applied in a user-friendly automated way to establish service connections. These requirements can best be met by the use of computer databases of directory information in association with automated processes for accessing particular information to provide appropriate service connections.

Such electronic directory systems are of current research interest to telecommunications administrations worldwide, including Telecom Australia. Reflecting the need for the orderly development of these directory systems to provide global connectivity, telecommunications administrations and industry have participated in the activities of the International Telegraph and Telephone Consultative Committee (CCITT) and the International Standards Organisation (ISO) in the development of the X.500 Series of international standards for Electronic Directory Systems.

These standards define a global system of "Directory System Agents" (DSA) controlled by different organisations and a hierarchical naming convention to uniquely identify the entries in the directory. Apart from the global scope of an electronic directory system based on the X.500 Series standards, there are several features which distinguish an X.500 system implementation from existing directory systems. For example:

- uniform access can be provided to a single source of directory information for a variety of telecommunication services;
- search requests can be based on any characteristic of the stored entries; the directory is not limited to search by name (as in Telecom's current paper-based "white pages") or search by business type (as in the "yellow pages"), and undesirable searches, such as for

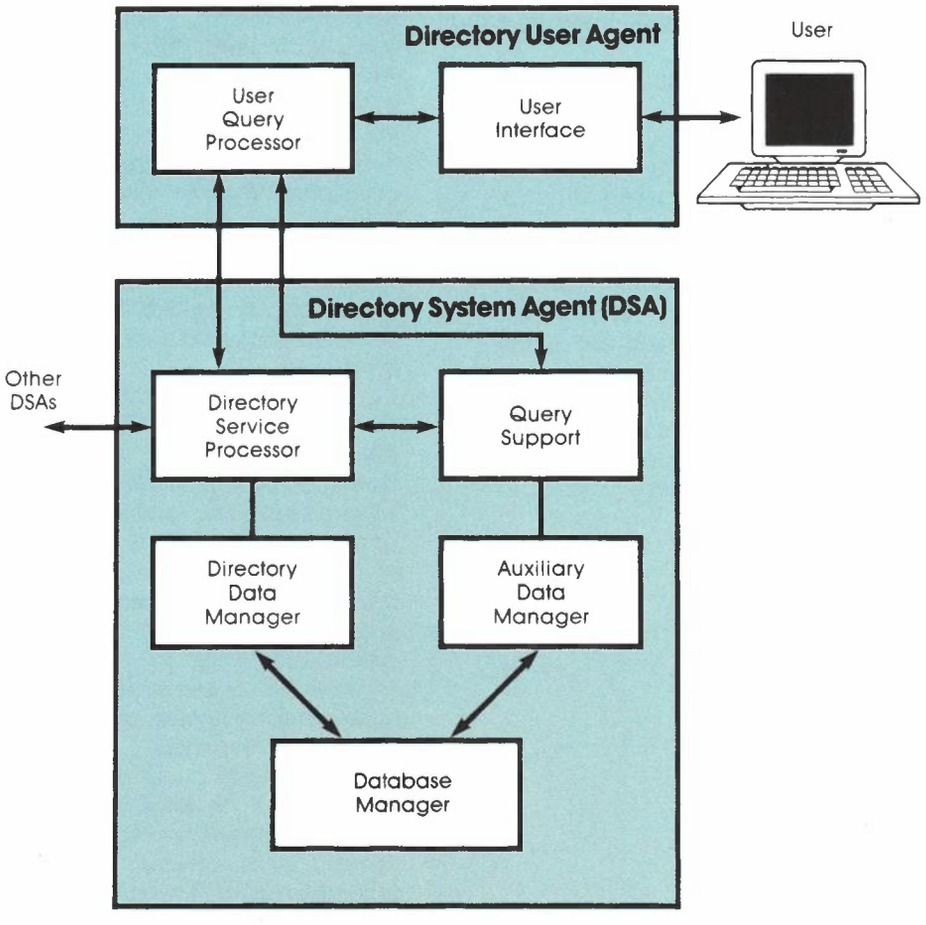
entries based on telephone numbers, can be disabled;

- through standardised access protocols, directory users can have direct access to the directory from their own desk-top computers, and a powerful access control mechanism can enable directory providers to control that user access and to allow directory users to add useful information to their own entries.

The Laboratories have a continuing strong involvement in the development of the X.500 Series standards, which are largely concerned with the global interworking of DSAs. In support of this involvement, the Laboratories are studying the issues involved in implementing an individual DSA. The areas which have been and are being studied concern:

- the internal storage of the directory data and indexes over that data to support both the naming hierarchy and efficient directory access, where the naming hierarchy is only conceptual and implementors of the standards are not actually constrained to store entries hierarchically
- the relative costs of various algorithms for entry searching in the directory
- the provision of useful features that are allowed but not standardised in the X.500 Series standards, such as spelling correction of user input and phonetic and other approximate matching in directory search requests
- the functional decomposition of a DSA to produce an internal organisation which minimises the communication overheads between components and maximises throughput of user requests.

This work will assist Telecom to implement electronic directory systems in the evolution of an Australian ISDN which enables users of future Australian telecommunications services to access other users worldwide.



Functional model of an electronic directory system.

MANAGING LARGE SCALE DISTRIBUTED DATABASES

The increasing capabilities of available computing and communications technologies are creating opportunities for Telecom to offer a variety of new information-based services over its public networks. Many of these services involve distributing the stored information across large numbers of co-operating computers. These services are dependent on an underlying distributed database (DDB) technology that provides the mechanisms for organising and accessing the stored data. DDBs are likely to find application in a variety of value-added telecommunications services, such as on-line directories and public access databases. DDBs may also be employed internally within Telecom to assist in the management of its network resources.

The distribution of data across very large numbers (eg, thousands) of computers is well beyond the capabilities of any commercially available DDB software package. In large systems, problems arise in the design of the system's internal data directory. Since a data directory provides each computer with knowledge of what data exists and where it resides in the network, directory maintenance becomes problematic when the number of computers and the number of directory updates arising per second reaches a critical threshold. This threshold occurs where the volume of update message traffic exceeds the delivery capacity of the communications network linking the computers. The volume of directory information may also impose a storage burden on smaller capacity sites.

Solutions to these problems must be found if the potential of large scale DDBs is to be realised. The Laboratories have therefore developed a novel DDB architecture that permits arbitrarily large numbers of sites to be interconnected in a manner that is significantly more flexible than that available with any previously existing or considered alternative. The architecture defines a new class of Partially Informed Distributed Databases (PIDDBs) in which each computer has limited, rather than complete, knowledge of the data and other computers comprising the system. No other information about the remainder of the network, or even of its existence, is directly available to any computer. Partitioning the directory in this way enables it to be distributed without burdening either the storage resources of the individual computers or the communications links connecting them.

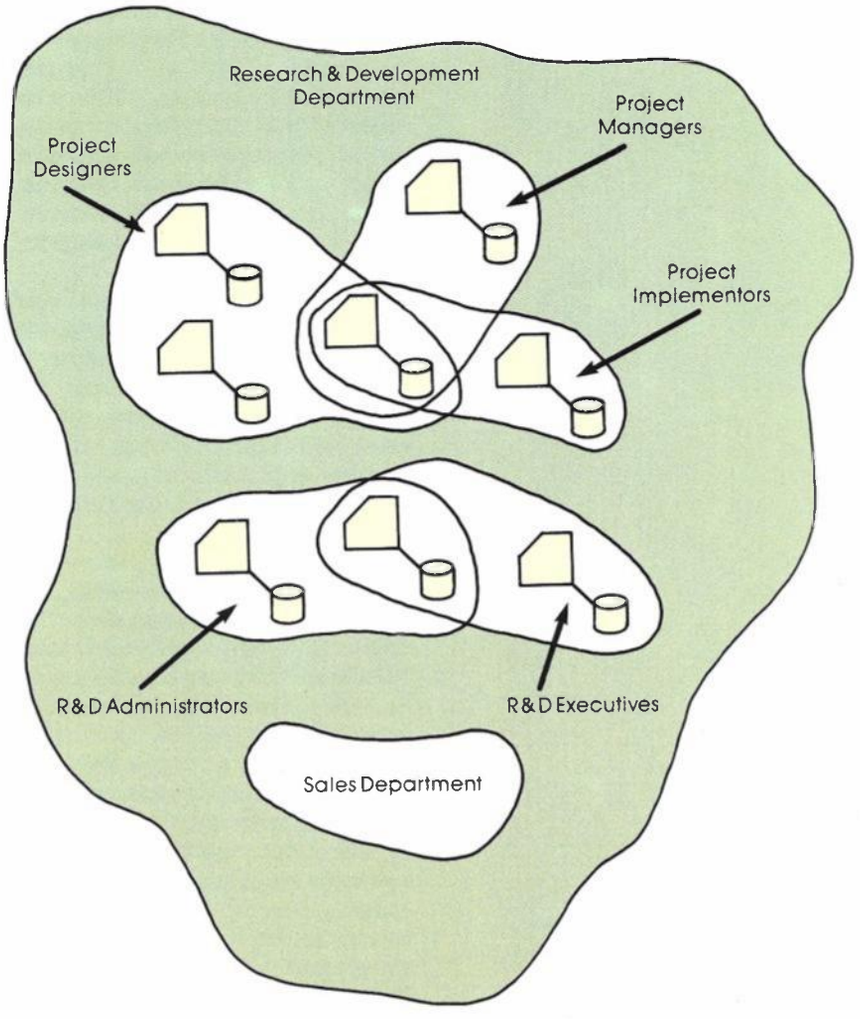
The PIDDB class was developed by proposing two models:

- a "topological" model that logically clusters computers into "aggregates" that can be named and hence identified, thereby effectively reducing the scale of the network perceived by each computer
- a "knowledge" model that defines each computer's view of the visible topological aggregates and of the data available within those aggregates.

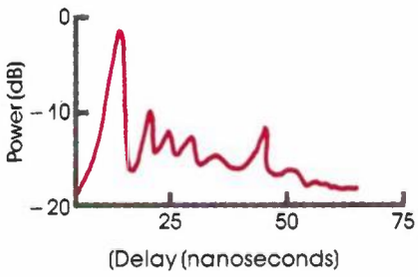
The PIDDB models enable the development of a variety of information-based and transaction-oriented systems. One example, concerned with modelling the information flows that arise within the Research and Development Department of an enterprise, is illustrated in the adjoining diagram. Each computer possesses a local database of the documents and other information pertinent to the work role of a particular user (ie, each computer is a personal workstation). The PIDDB topology clusters together those computers that are expected to access one another's data frequently. These aggregates are defined on a logical rather than a physical basis, and hence the sites comprising the system may be widely distributed geographically. Such systems are likely to rely on public networks to interconnect the constituent computers.

The illustrated topology groups the set of designers collaborating on a particular project into a common aggregate. Each computer would possess detailed knowledge of the other members of that aggregate and of the data (eg, documents) possessed by those computers. The project managers and implementors would be similarly grouped. Generating aggregates in this way may result in some sets overlapping and in some sets of aggregates remaining disjointed. The models accommodate this by defining different types of aggregate descriptions corresponding to the differing levels of required knowledge. All computers within the R&D Department would, for example, have access to a description of that department, so that a project designer could readily discover the location of a file possessed by an executive if required. The Sales Department is represented at a high level of abstraction (ie, by name alone) within the R&D Department, so that data stored there could be located when accessed, albeit infrequently.

The plausibility of the PIDDB models has been investigated in the Laboratories by exploring the ramifications of partial information availability. Detailed specifications of the operational procedures required to locate data and to distribute updates were developed. Despite each site's partial information and the resultant complexity of the knowledge model, the PIDDB models have been shown to be sufficiently powerful to enable the distributed operations of the system to be described by a series of simple deterministic algorithms. These procedures demonstrate that the PIDDB framework is indeed viable and well suited to the management of very large distributed databases. The algorithms and data structures have been developed in sufficient detail to develop an operational system.



Modelling the information flows within an enterprise: the PIDDB topology groups together those computers that frequently access one another's data.



Typical delay spread profile of a radio path in a wire-less office environment.

RADIO TRANSMISSION INSIDE OFFICE BUILDINGS

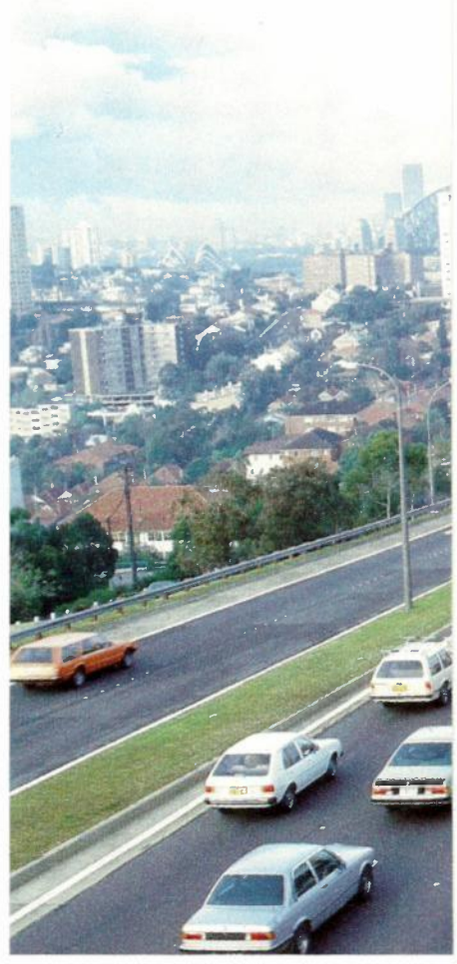
The high costs of installing and modifying cabling in office buildings to interconnect localised office communications systems and computers and to provide access to public switched telecommunications networks has prompted research interest in the "wire-less office" alternative. Instead of requiring individual fixed wiring to each communications or computer system, the wire-less office would use digital radio transmission techniques to provide flexible interconnection facilities. Telephones, computer terminals, etc. would use radio transmission to communicate to conveniently located wall or ceiling mounted base stations which, in turn, are interconnected by a cabled backbone local area network (LAN). In turn, the LAN is connected via an appropriate gateway to the public network.

The Laboratories have been studying factors which might influence the adoption and specification of wire-less distribution systems by Telecom Australia. Important considerations are the practical limits on the range and data rates that can be achieved in the wire-less office due to the radio propagation characteristics of office buildings. These limits to radio propagation have been investigated using two different but complementary techniques.

The first approach used a swept carrier transmitter and a frequency tracking receiver to estimate the effective frequency response of the radio path between the two devices. The average of this frequency response gives an estimate of the expected path loss and so the maximum range, while the shape of the response can indirectly indicate the limit to transmission bit rate.

A further indication of indoor radio transmission capability was determined using a second experimental system which could directly measure the radio path's delay spread. The delay spread can be directly related to the maximum possible data bit rate. This system uses radar-like radio frequency pulses, with the carrier swept over a 100 MHz band. An average of the received signal directly gives the signal's delay spread and strength.

The results obtained from these experiments indicate that such wire-less office systems are feasible if transmission bit rates are less than 2 Mbit/s and transmission ranges are restricted to approximately 20 metres. This suggests that the wire-less office of the 1990s will use multiple radio signals, each carrying 2 Mbit/s data streams, which will carry voice, data and photo-videotex services between terminals and the base stations.



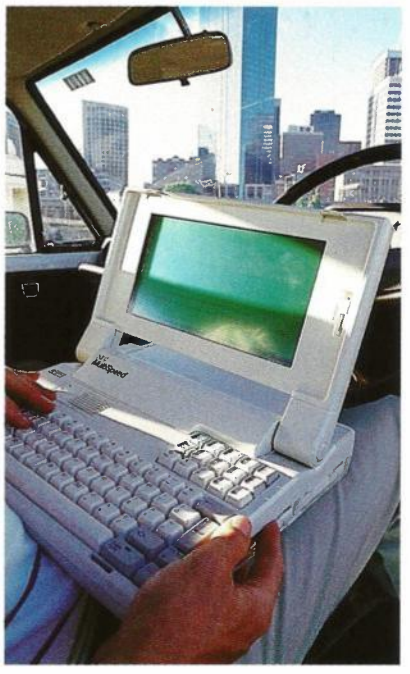
DIGITAL SERVICES USING MOBILE TELEPHONES

Telecom Australia's Cellular Mobile Telephone Service is a rapidly expanding service, much in demand by customers whose business keeps them on the move. Many of these customers would like to have this service enhanced to provide capabilities additional to voice communications, for instance, allowing them mobile access to computer-based digital services over Telecom's Austpac packet switching network, the Viatel videotex service, the Keylink electronic mail service or Datel analogue data transmission services. Customers who would benefit from such enhancements include transport and delivery companies, travelling sales representatives, real estate agents, newspaper reporters, customs agents and many more.

The Laboratories have been investigating economic and expedient means of enhancing the Cellular Mobile Telephone Service to provide effective digital communications services by applying digital/analogue techniques and portable "laptop" computers at the mobile station.

Centre:
Cellular mobile telephones help customers with businesses that keep them on the move.

Far Right:
With available error correcting modems, digital data services can be successfully accessed over cellular mobile telephony systems.



Although it is possible to connect a portable computer to Telecom's Datel service via an ordinary modem operating into the baseband voice channel of a mobile telephone transceiver, the resultant digital transmission quality is often poor and inadequate for effective data communications. Satisfactory transmission performance is achieved only in areas where radio signals are strong. Improved performance occurs if the user is stationary in a good radio signal area. When such conditions are not met, very high error rates are likely to be experienced, with rates of one bit error in 100 bits not uncommon.

To overcome this limitation, some form of error-correction is necessary, with user-access involving the use of a laptop computer connected to a special modem and thence into the mobile telephone transceiver. Tests of purpose-built error-correcting modems capable of withstanding such bad error rates from the radio channel have been tested by the Laboratories. They were found to perform sufficiently well to provide a 1200 bit/s error-corrected capability over the geographic area in which radio conditions enable intelligible speech calls to be made satisfactorily over the mobile telephones.

The Laboratories are currently assisting in a Telecom trial of a technique to integrate such a service into the current network with minimal modifications to the network.

SIMULATION OF DIGITAL CELLULAR MOBILE RADIO SYSTEMS

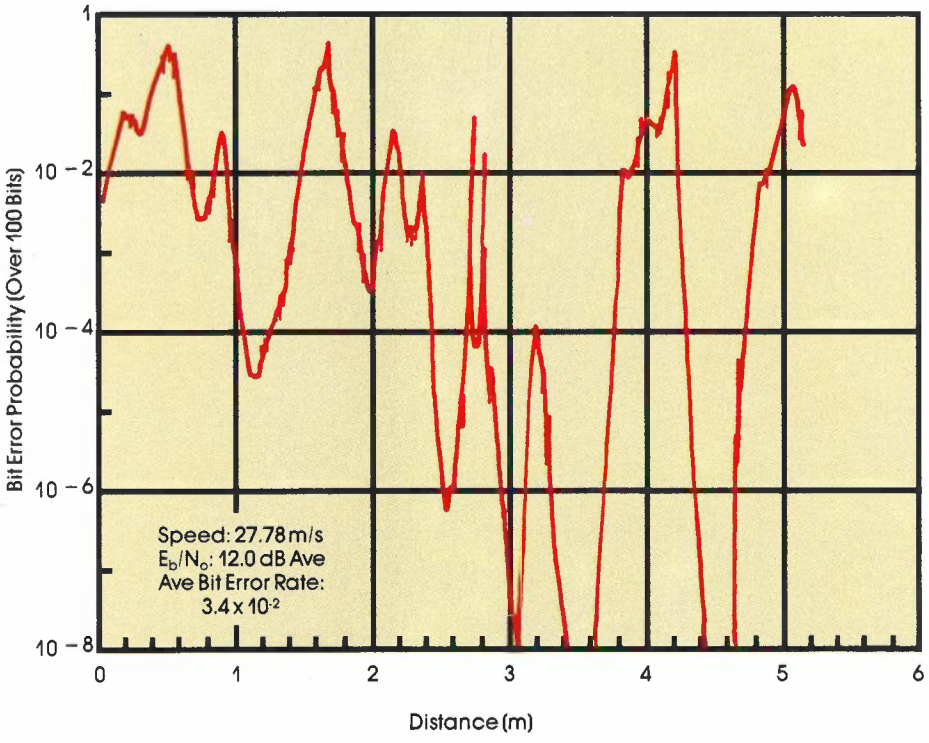
Telecom Australia's current Cellular Mobile Telephone Service, which employs narrow band analogue frequency modulation techniques, is a very popular service, experiencing high customer demand for connection. The available capacity of the current generation systems is expected to be filled within only two or three years. As a result, Telecom is undertaking research investigations and planning studies, preparatory to installing next-generation systems in the early 1990s.

Current developments for next-generation cellular mobile radio systems are based on the use of digital modulation and time division multiple access techniques with bit rates of about 200 to 300 kbit/s, giving rise to relatively wideband transmissions. Reflections and scattering from buildings and other features of the terrain result in propagation of the radio waves along multiple paths, which in turn produces spread (or dispersion) of the signal in time due to the different signal delays associated with the various paths. The highly dispersive multipath propagation encountered in urban and suburban environments is manifest as space-selective and frequency-selective fading.

When considering wideband propagation, the major problem faced is no longer that of flat Rayleigh (or space-selective) fading which is associated with narrowband systems. It is rather that of time delay spread or signal dispersion which results in frequency-selective fading. In digital transmission systems, frequency-selective fading becomes apparent as intersymbol interference, which severely degrades the digital transmission and determines performance limits for digital mobile radio systems.

In the Laboratories, the development of a wideband multipath simulator, based upon a statistical model derived from experimental data, has been undertaken. Such a simulator offers an attractive and viable method to determine the relative performance of different system alternatives for a wideband digital transmission system in the mobile environment.

Studies of the performance of wideband digital transmission over mobile channels are also being pursued via computer simulations. The simulations provide analyses of the probability of bit error for a given channel and average signal-to-noise ratio as the mobile



Variation of bit error probability over a 5 m distance travelled by a mobile receiver in a typical urban mid-block location.

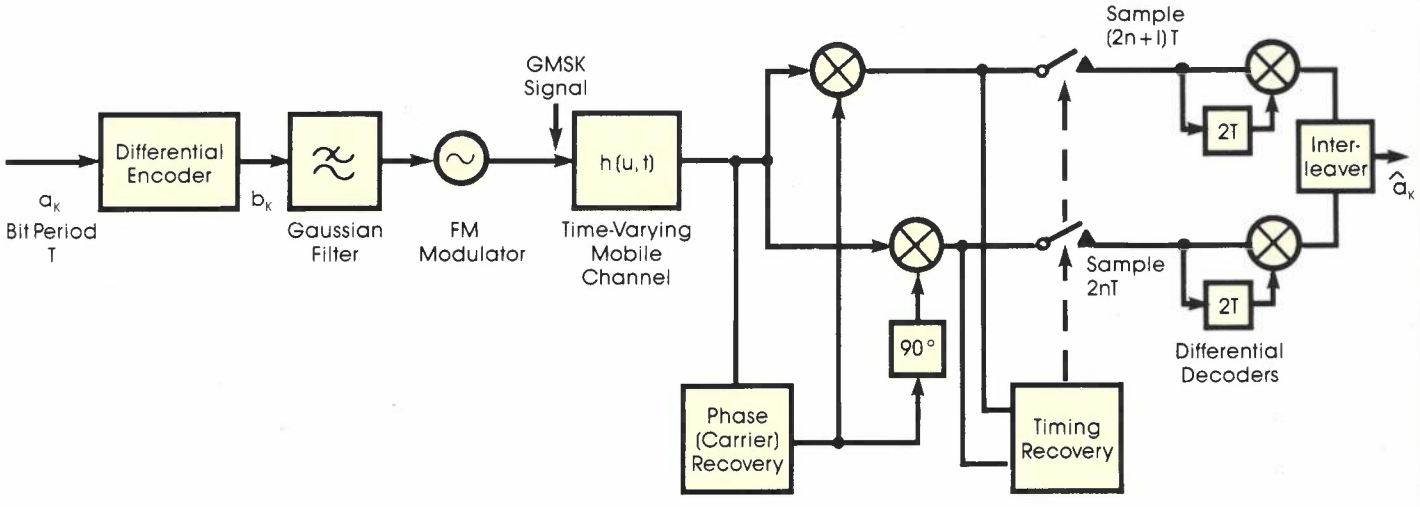
transceiver moves through its environment. The performance of six modulation schemes are being studied, namely, the coherent and differential forms of each of:

- binary phase shift keying
- quaternary phase shift keying
- Gaussian minimum shift keying.

The studies seek to determine the robustness of the modulation schemes, irreducible error rate characteristics, and effects of speed, phase offset and timing offset, as well as to characterise the wideband mobile channels. Other outputs from the simulations include eye diagrams, constellations, vector diagrams, channel impulse response and frequency response, and signal spectrum.

The studies have indicated wide variation in bit error rate due to rapid changes in channel response as the mobile station travels along its path. Errors occur in bursts and the average bit error rate is high.

The Laboratories' studies into the performance of wideband digital transmission over mobile channels are being continued, to include studies of system parameters such as channel coding, diversity and adaptive equalisation. The Laboratories-developed simulator provides an extremely useful tool for studying transmission over mobile channels and for evaluating system alternatives. It will assist in the development of design parameters for Telecom's next-generation cellular mobile systems.



Schematic outline of a transmission system employing Gaussian Minimum Shift Keying (GMSK) modulation.

TRAFFIC ENGINEERING OF CELLULAR MOBILE RADIO SYSTEMS

The realisation of Telecom's plans to introduce digital cellular mobile radio systems within the next five years will result in more efficient use of the available bandwidth and therefore provide greater traffic capacity, as well as lower cost terminals and the ability to carry ISDN services. Future system evolution is in the direction of decreased cell sizes and increased use of hand-held portable telephones, to provide a more personal service. The foreseen system is one of small cells with cell diameters of the order of several hundred metres, a so-called "microcellular" system.

It is important for Telecom's planning purposes to be able to evaluate the traffic performance of these new systems, which have significantly different operating characteristics from the existing telephone network. To this end, the Laboratories have undertaken studies of the traffic engineering aspects of digital microcellular radio systems.

In considerations of the traffic handling capabilities of a digital microcellular network, one of the major issues is that of dynamic channel assignment. Current cellular communication systems use fixed channel assignment, where particular radio channels are assigned permanently to particular base stations. With dynamic channel assignment, channels can be assigned to base stations on demand, as they are required by real-time traffic loads. This results in higher traffic capacity, but at the expense of higher equipment and control costs. In a microcellular system with its great proliferation in the number of cells, it is very difficult to define the cell boundaries in a precise manner. The variable radio propagation characteristics over such short distances leads to very fuzzy cell boundaries, and some form of dynamic channel assignment is likely to be necessary in order to plan and manage such a system effectively.

Within the general framework of dynamic channel allocation, two further major traffic engineering issues arise from the requirements to carry ISDN traffic and to adjust to moving users.

ISDN services require a bandwidth greater than that needed for a single telephone call. Their provision over microcellular systems requires some sophisticated channel allocation policies in order to achieve a reasonable traffic performance. The Laboratories have explored this question, and it was concluded that, while a fixed channel allocation policy could not adequately handle such traffic, dynamic channel allocation could provide good performance.

User mobility is, by definition, an integral feature of a cellular mobile communications system. However, this ability to move between cells, which is very attractive from the user's point of view, produces very volatile traffic patterns which result in difficulty in planning the mobile network. One important feature of dynamic channel assignment is that it can adapt itself automatically to these volatile traffic parameters. Laboratories' studies of this aspect have concluded that dynamic channel assignment displays a much lower sensitivity to traffic variation than does fixed channel assignment, as well as the ability to carry a higher basic level of traffic.

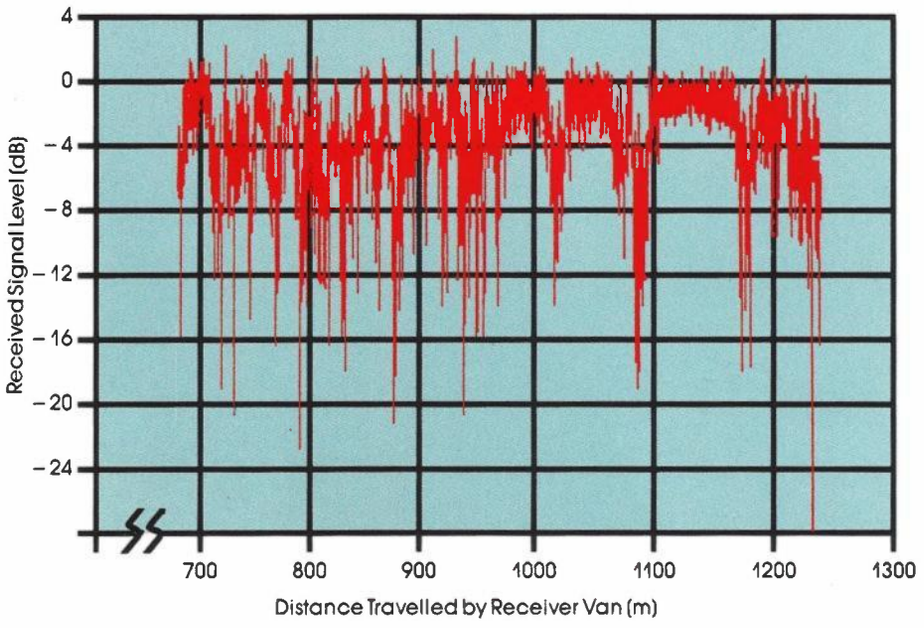
The Laboratories are furthering their studies of the traffic engineering aspects of digital cellular mobile radio systems to develop strategies and rules for the dimensioning of Telecom's next generation mobile radio communications network.

Above:
Personal portable telephones are a product of recent technology developments.

LAND-MOBILE SATELLITE SYSTEM PROPAGATION STUDIES USING A HELICOPTER

In 1986, the Laboratories began a series of studies into the technical and economic viability of providing satellite-based land-mobile communications services to the more geographically remote areas of Australia. As the properties of radio propagation from a moving vehicle to a geostationary satellite were largely unmeasured and unknown for the Australian outback environment, equipment was devised to measure and characterise these propagation effects.

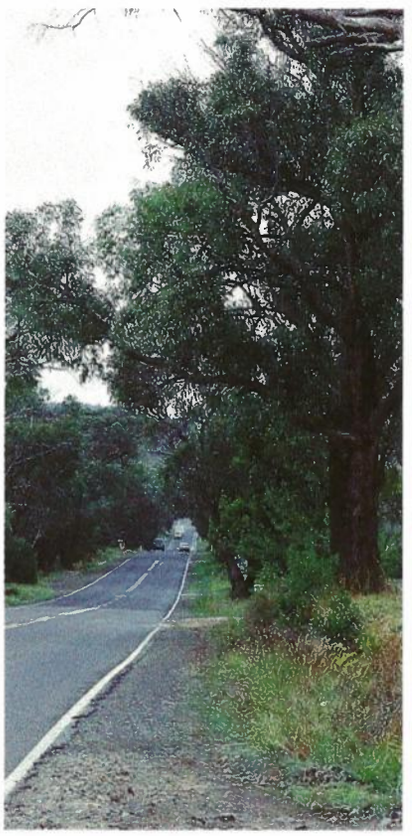
In the absence of a satellite with the appropriate frequency allocations for these mobile communications studies, a helicopter was used to carry three transmitters whose signals, at frequencies of 893 MHz, 1550 MHz and 2660 MHz, were recorded by a ground mobile vehicle fitted with appropriate receivers and a data logger. This helicopter/mobile van pair has been used to make simulated earth-to-space radio propagation studies along Victorian roads having sparse, medium and dense roadside foliage, collectively considered representative of Australian remote areas. To



Simulated mobile earth-to-space propagation results

Legend for diagram:
:Receiver Van Road Speed - 50 kmph
:Helicopter travelling at same speed as van and on parallel path, at fixed relative elevation and distance.

Below:
Roadside view of eucalyptus foliage.



date, ten flights (including equipment test flights) have been conducted, each of approximately three hours duration.

The results of these radio propagation measurements, in the form of data on magnetic tapes, are being used in the Laboratories to generate statistical models of the earth-to-space propagation for the frequencies of interest. Results to date have shown that serious fading can occur at depths which will have a significant impact on receiver design for a land-mobile satellite system (LMSS). For example, a single stringybark eucalyptus tree of average height can briefly attenuate the signal more than 20 dB. Measurements along 1.6 km of road lined with trees of medium density show that a margin of 6 dB must be allowed to receive satisfactory signals for at least 90% of the time.

The propagation models are constantly being upgraded as new data becomes available. The models describe such parameters as depth, duration and frequency of signal fading. They will be used in a microcomputer-controlled laboratory-based satellite simulator, currently under construction in the Laboratories, to establish LMSS channel characteristics experimentally.

Once able to simulate accurately the earth-to-space propagation conditions experienced in various remote Australian geographic areas in the laboratory, Telecom will be in a position to evaluate and undertake performance comparisons of new and state-of-the-art satellite communications equipment under well controlled and highly repeatable laboratory-based conditions. This, in turn, will enable Telecom to study the economic and technical feasibility of a land-mobile satellite system based on an understanding of the capabilities and limitations of current and future LMSS-related technologies.

A HELICOPTER ANTENNA MOUNT FOR LAND MOBILE/SATELLITE PROPAGATION STUDIES

For the Laboratories' simulation of earth-to-space radio propagation conditions using the previously mentioned helicopter/mobile vehicle combination, special equipment mounting arrangements were devised and developed. The stringent requirements for the mounting of the antennas to the undercarriage of the helicopter presented a particular design challenge.

The mobile van was extensively modified to incorporate computerised receiving equipment weighing 260 kg and to provide quick and easy access to all equipment by the operator. All modifications to the vehicle complied with the standards of the Victorian Government Road Traffic Authority.

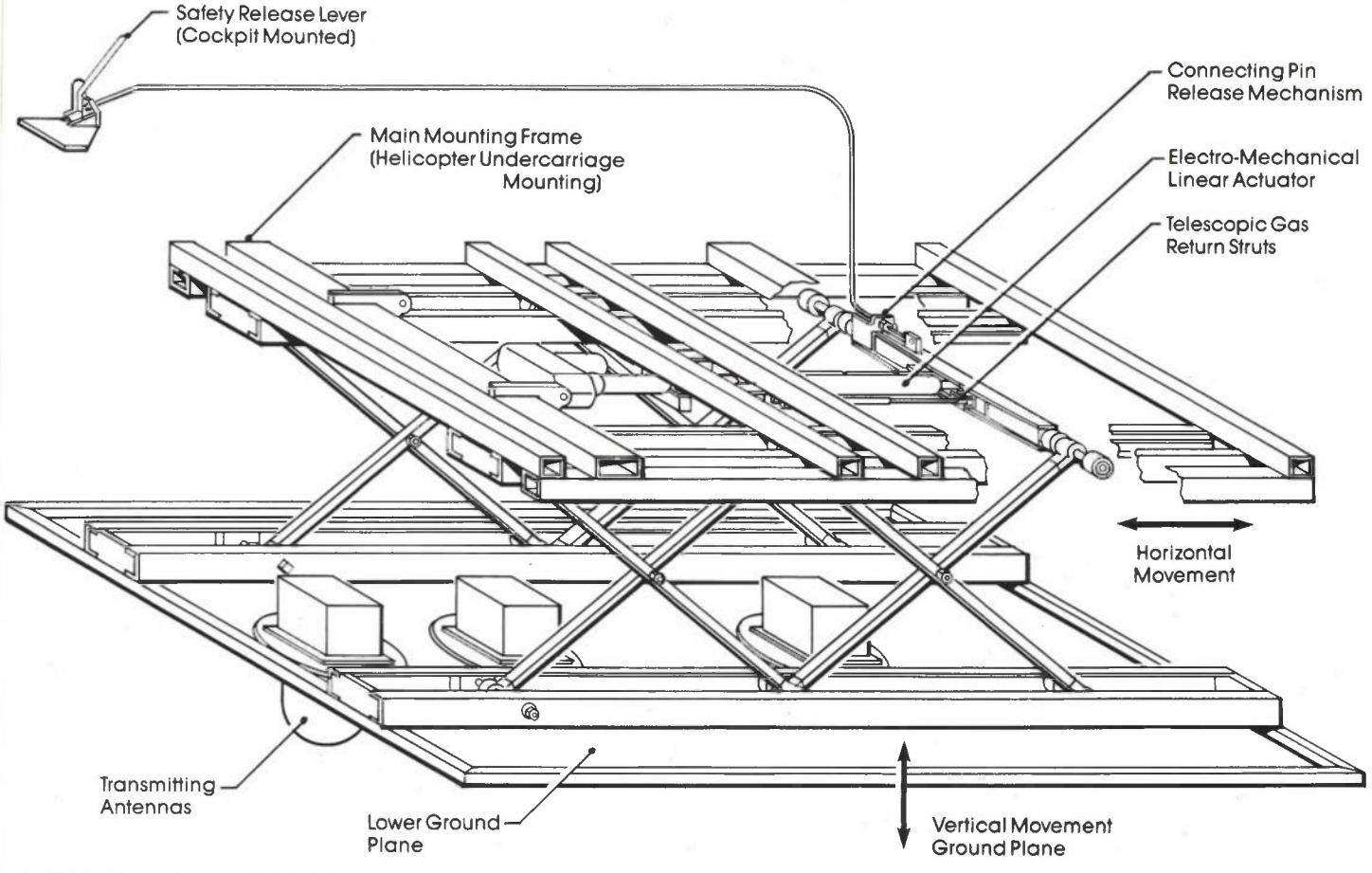
An antenna mount was designed and constructed to enable three transmitting antennas to be mounted to the undercarriage of the helicopter. To satisfy electrical and operational aviation requirements, the design incorporated the following features:

- minimal deflection and vibration of the antenna ground plane under flight conditions
- provision of a means to allow the ground plane to be positioned below the level of the helicopter's landing skids during testing to reduce distortion of antenna radiation patterns, and to retract the ground plane to allow safe landing of the helicopter after test flights
- a fully automated electro-mechanical drive system
- a quick and easy means of attaching/detaching the antenna mount to and from the helicopter
- ability to withstand the following loading conditions under operational use with antennas mounted:
  - vertical :2.0G
  - sideways : 1.5G
  - fore and aft : 2.0G
- failsafe design to ensure safe landing in adverse circumstances by providing the operator with an easy manual means of retracting the ground plane quickly, should the electro-mechanical drive fail.

The helicopter antenna mount comprised the following sub-assemblies:

- a main mounting frame attaching to the

Below:
The antenna mount beneath the helicopter.



The Laboratories-designed helicopter antenna mount.

helicopter undercarriage

- a lower ground plane
- a ground plane adjusting mechanism
- a remote safety release device.

The main mounting frame was a welded structure made from standard aluminium sections. It incorporated a guide system for the adjusting mechanism and a mounting frame for both a linear electro-mechanical actuator and telescopic gas return struts. This frame was securely attached to the helicopter undercarriage by three high tensile bolts acting in shear.

The 2.0 m x 1.2 m lower ground plane provided a flat surface to which the transmitting antennas were mounted. It comprised a rigid chassis supporting both the guide system for the adjusting mechanism and a 2 mm thick aluminium sheet acting as the ground plane. The chassis structure was designed to keep deflection/vibration limits to acceptable levels during flight. The ground plane was attached to the chassis with a special aluminium adhesive, this approach ensuring a distortion free radiation pattern compared with conventional fastening techniques.

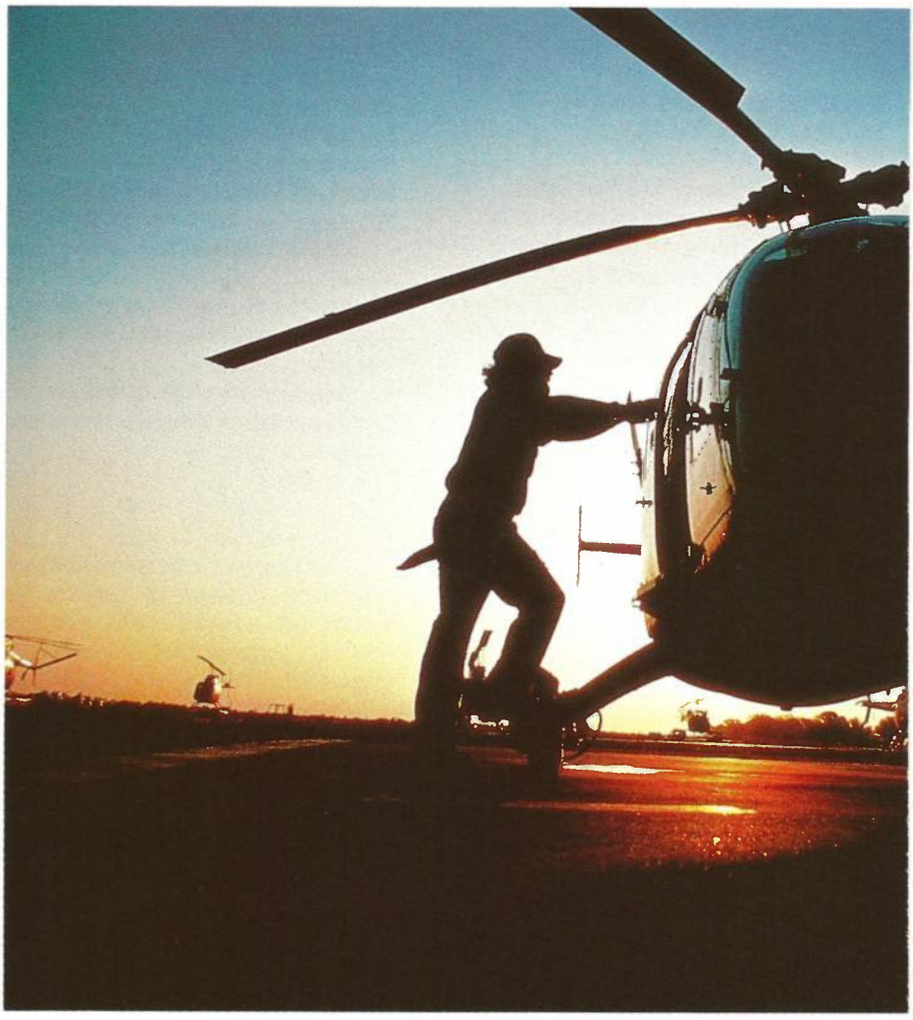
Positional adjustment of the ground plane was achieved by employing a scissors-type mechanism, providing the advantages that:

- the centre of gravity of the whole system remains on the same vertical axis irrespective to the ground plane position, and
- the mechanical advantage gained greatly reduces the load on the linear actuator and the gas telescopic struts.

At the scissor ends, PTFE wheels with ball bearing hubs enable horizontal movement and the transfer of axial and thrust loads from the ground plane to the main mounting frame.

The actuating force required to raise and lower the ground plane was provided by an electro-mechanical linear drive. This type of drive operates under a wide range of environmental conditions, employs a smooth action, is maintenance-free and does not cause radio frequency interference.

The failsafe design requirement was addressed by incorporating a safety release mechanism. Manually operated, it was located in the helicopter cockpit. The components which actually retract the ground plane under an emergency situation are two telescopic gas return struts. These units are compressed when the ground plane is in the extended position. Their stored energy is released when the pilot operates the manual safety release lever, which disengages the connecting pin between the linear actuator and the scissors mechanism. This action returns the ground plane to the upper or parked position. This design concept eliminated the need for costly secondary drives, is maintenance-free and provides an instantaneous response.



Centre:
A helicopter provided a pragmatic means of simulating a satellite.

Following the detailed design phase in the Laboratories, the antenna mount was fabricated in Telecom's Victorian Workshops. It was then subjected to stringent testing at the Laboratories, under the supervision of a consultant aviation engineer and the Federal Government Department of Aviation. The successful conclusion of these tests demonstrated that the antenna mount would be safe in operational service.

The antenna mount has since been employed to equip the helicopter for the test programme simulating, measuring and characterising propagation effects which might be encountered in future satellite-based land-mobile communications systems.

A DATA NETWORK DESIGN TOOL

Telecom Australia offers a number of different data communications services to meet the variety of needs of the Australian community. These services include the Austpac packet switching network services, the Digital Data Service providing data transmission services over dedicated lines, and Datel services connecting computers and terminals via modems over the analogue switched telephone network. As each of these services has different and complex tariffing structures and technical design principles, Telecom Australia's sales staff must develop and maintain significant technical skills just to answer basic questions from prospective customers, such as "What specific service can you provide for me and how much will it cost?".

To help these sales staff respond rapidly to prospective customer queries, the Laboratories are developing a software package for operation on IBM-compatible personal computers. The package is called "The Data Network Design Tool" and it is being

developed by means of a modular approach in two stages.

The first stage comprises the development of a number of stand-alone "Network Design Modules". Each module will contain all of the necessary tariffing and design principles required to design a data network using a specific Telecom data service. The modules will aim to determine the best network design for the particular customer using that data service, and the resulting network design will be presented as either a quotation for implementing such a design (as a detailed list of costs) or as a service order (as a detailed list of equipment).

The second stage of development will be to integrate the individual Network Design Modules into a single package, to allow the best network design to be selected from the range of Telecom's data services options. The customer's network requirements will be interactively specified using a Network Configuration Module. These requirements will then be translated into a network specification which is used by the Network Design Modules to create individual networks. The resulting network designs will be evaluated by the Configuration Module, and the best design, or combination of designs, will be presented as either a service quotation or as a service order.

It is intended that the stand-alone modules will be made available to Telecom's sales staff as they are successively developed and field tested. To date, a Network Design Module for Telecom's Digital Data Service (DDS) has been completed. Written in PROLOG, the module utilises artificial intelligence techniques in the process for designing DDS networks. Additional Network Design Modules for Telecom's Austpac and ISDN services are under development, and proposals for a QPSX design module are under consideration.

MINDER - A TELEPHONE NETWORK DESIGN TOOL

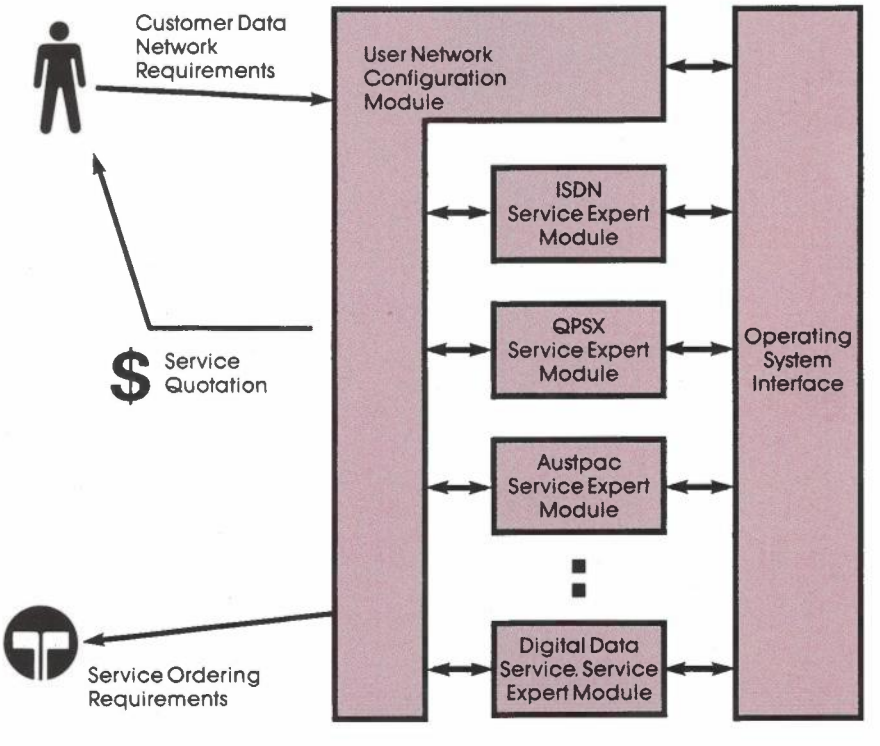
The objective in dimensioning a telecommunications network is to ensure that it carries the telecommunications traffic offered to it at the grade of service required by network users and at minimum cost to the operating authority. This can only be achieved by optimally distributing the switching and transmission plant in the network so that it matches the offered traffic distribution, providing just the right number of circuits on all traffic routes to meet the required end-to-end grade of service.

Currently used network dimensioning methods go a considerable way towards achieving the above objective, but they fall short of it. Over a number of years, a new method, based on the techniques of operations research, has been developed in collaboration with Dr L.T.M. Berry, Director of the Teletraffic Research Centre, University of Adelaide, to overcome the shortcomings of the established methods. Studies of typical networks have suggested that, in "desert study" conditions, savings of between 5% and 10% in the capital costs of inter-exchange circuits could be achieved with improved network dimensioning.

Telecommunications network planners typically require two types of specialist planning tools for their daily work:

- a sophisticated design tool which accurately determines the circuits and transmission media needed, to determine equipment ordering programmes, and
- a design tool which enables different network scenarios to be studied rapidly, but which is compatible with the more sophisticated tool.

The MINDER network design tool attempts to satisfy both these criteria, by providing a powerful set of computer programs based on the Berry network dimensioning



An integrated data network design tool for optimising specific customer services from Telecom's service options.

model. The acronym, MINDER, translates into Modular Interactive Network Design and Enquiry Routines. MINDER is a menu-driven software package which enables a network planner to construct a network database and to produce an optimal network design based on the Berry Digital Network Design Method.

The system was specifically designed to provide network planners and network managers with essential design and network management information to meet the challenges of more complex and flexible network designs which have been made possible by advances in stored processor controlled exchanges. One of the many advantages of the MINDER system is the ability to specify end-to-end grades of service for origin-destination pairs using the network, to ensure that each such pair receives an equitable grade of service. At the same time, the model tries to ensure that wide fluctuations in end-to-end grade of service are reduced. Such wide fluctuations have characterised previous design systems. The reduction of these fluctuations assists minimisation of network cost without detriment to the grade of service being experienced by customers. As another advantage, MINDER assists the determination of the most cost effective mixture of transmission media types in a given link. Finally, an interactive planning aid enables users of the MINDER system to override the automatic allocation of circuits, defined by the optimisation process, in order to take account of local conditions, additional factors or administrative procedures.

The interactive MINDER system can also be used to conduct post-optimality analysis of a network, encompassing such matters as changes in traffic distributions, altered cost information and new transmission media types.

The MINDER system is currently undergoing trial evaluations in several engineering planning areas of Telecom Australia with a view to incorporating it into routine planning processes. In the meantime, further research work is being undertaken to develop suitable algorithms for non-hierarchical network design so that they can be incorporated into the MINDER system. Further extensions of the optimising algorithms are expected to be used in the design of future multi-services networks employing packet switching principles.

COMPUTER-ASSISTED NETWORK TRAFFIC MANAGEMENT

Any telecommunications network will occasionally be offered more calls than it can possibly handle, since it would cost far too much to build a network that could always carry the peak traffic at the standard grade of service. For example, very high traffic loads are generated at Christmas and Easter. Natural disasters such as floods or bushfires can also stimulate massive calling rates and overload the network. Repeated call attempts by customers encountering busy tone can increase the effect of an overload, causing yet more repeated attempts and setting up positive feedback with disastrous effects on throughput.

When such overloads occur, network traffic managers must decide how to control the flow of calls to ensure that the network gives the best possible performance under the prevailing adverse conditions. Control decisions must be made quickly and accurately to prevent the situation from getting worse.

In the present telephony network, almost all control decisions are made by human operators, acting on the basis of information presented on computer monitors and display screens. The operators must have a high level

of skill and experience, and must be able to exercise judgement quickly in an emergency to vary traffic routing through the network. Some form of computer assistance would be a valuable support to the operators in such circumstances. Some functions may ultimately be fully automated; others may require an operator to oversee the working of a computer, but human judgement will always remain an indispensible ingredient in network traffic management.

In investigations of means by which the power of computers to analyse large amounts of data quickly can be brought to the aid of the human operators, the Laboratories have developed a prototype computer program which takes data from an overloaded network and recommends the best possible set of flows through the network. The program is based on a "linear program" model of the network which approximates all inter-exchange circuit groups and exchanges by simple saturating devices. The object of the program is to optimise either the number of successful calls (ie, end-to-end grade of service provided to customers) or revenue, or a combination of the two. At present, a standard package is used to solve the linear program, although quicker algorithms will be needed for real-time use. The program can also estimate the benefit of network management actions by predicting the results of sub-optimal flow patterns.

It is intended that the program will become part of a computer-assisted network traffic management system, together with other systems that have been developed elsewhere in Telecom.

The Laboratories and the Network Management Division of Telecom's Headquarters worked together to test the prototype program during the Christmas holiday peak traffic period of 1987. Preliminary assessments of the results of this trial suggest that the program will be of use to network traffic managers in Telecom's present and future networks. The trial has also proved helpful in determining what additional data is needed from the network, and what facilities will be needed in future computer-assisted network traffic management systems. Further work will be undertaken to make the program run faster for real-time network applications and to automate the translation of the optimal flow patterns generated by the program into the appropriate set of traffic routing control actions in the network.

Below:
Computer Assisted Network Management helps control communications network overloads during natural diasters, such as the Cockatoo bushfires in Victoria.

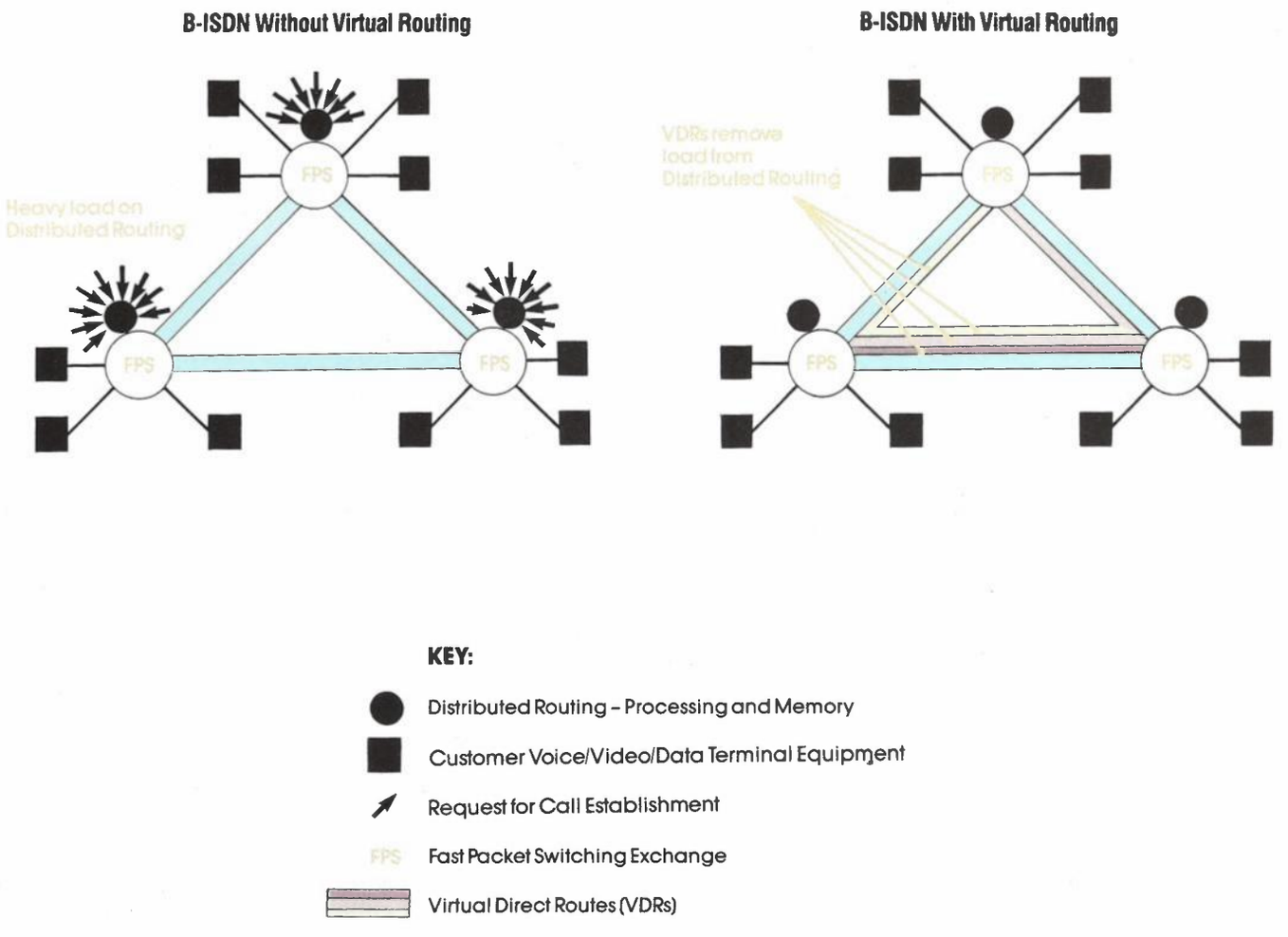
ROUTING AND RESOURCE ALLOCATION IN THE BROADBAND ISDN

Although the telephone service still dominates telecommunications network traffic, increasingly widespread use of computers in recent years has led to a range of data and image services such as file transfer and videotex. In the future, the use of optical fibre transmission systems will provide the high traffic capacities required to support a range of video services such as video conferencing, video retrieval and entertainment video.

The characteristics of these services vary widely. For example, an entertainment video call must carry far more information than a voice call and thus requires much more network capacity. As another example, one feature of a videotex service is that there are short periods where a large amount of information is sent (when a new screen of information is transmitted) and long periods during which no information is sent (while the user reads the information on the screen). This time varying use of network capacity is a feature inherent in many voice, video and data services.

There are significant advantages in the operation, administration and maintenance of a single network supporting a wide range of services when compared with a number of service-dedicated networks. It is now widely accepted that the best approach for meeting the uncertain future demand for different services is to design a Broadband Integrated Services Digital Network (B-ISDN) that is capable of supporting a wide range of services.

Packet switching techniques can provide a time varying share of the network capacity to different services and are currently accepted as the best means of information transfer in the future B-ISDN. The B-ISDN will be markedly different from any telecommunications network in existence today. Because of this, a range of new design problems are being investigated by telecommunications researchers throughout the world, including Telecom Australia's Research Laboratories.



Virtual Routing reduces processing loads for resource allocation in the Broadband ISDN.

One of the most important and fundamental topics for study is the allocation of network capacity to the different voice, video and data services which will be provided over a B-ISDN.

To establish a call in the B-ISDN, the following sequence of network operations must be performed:

- determination of a route between source and destination
- allocation of sufficient capacity along the route to successfully carry the call
- storage of information at various points along the route describing the details of the established call.

In today's telephone network, the information needed to determine the route is distributed throughout the network rather than being centralised in any single place. Also, the capacity allocated to each call is a small fixed amount of network capacity.

Work recently performed at the Laboratories suggests that the information needed to determine the route should also be distributed in the B-ISDN. However, the call establishment process is more complicated than that of the existing telephone network because of the need to allocate different amounts of network capacity to calls of different types. There is also a need to ensure very short call establishment delays for services such as electronic funds transfer and interconnection of local area networks. One factor which makes these reduced call establishment delays difficult to achieve is the increased volume of requests for call establishment forecast for B-ISDN. Studies performed at the Laboratories indicate that extremely high performance processor and memory technology is marginally adequate for servicing the volume of individual requests for call establishment in the B-ISDN.

To overcome this problem, a new resource allocation technique referred to as "Virtual Direct Routing" has been developed at the Laboratories. In this technique, available knowledge of network traffic patterns is used to determine paths, reserve network capacity and store connection information along those paths, before individual requests for call establishment are made. The capacity reserved along a path is referred to as a Virtual Direct Route (VDR) and each VDR would normally be allocated sufficient capacity to carry many calls. Because the route determination, capacity allocation and information storage have been performed when the VDR is set up, the distributed routing information does not need to be accessed to establish an individual call. The grouping of a number of calls into a VDR also allows easier control of network traffic flows and provides a means of managing the large capacities provided by optical fibre transmission facilities.

ROUTING MESSAGES THROUGH LARGE HIGH SPEED PACKET SWITCHING NETWORKS

The next generation of packet switching networks will be orders of magnitude larger than those known today, with many thousands of local networks interconnected via a single high-speed packet switching network. The determination of the best route from source to destination in such communications networks is a problem which grows in size combinatorially as the size of the network grows. Poor routing procedures will lead to congestion problems and inefficient utilisation of plant. The design of an effective routing algorithm is critical to the proper operation of such networks and accordingly, such algorithms have been the subject of recent Laboratories' investigations.

In a static situation where all parameters of a network are known, it is possible to determine a routing strategy which maximises network throughput. The dynamic behaviour of real networks, such as those involving link failure or merely changing traffic patterns over a normal day, means that a routing algorithm must itself be dynamic if it is to approach optimum performance.

The need for an adaptive routing algorithm requires that network parameters are measured and the resultant information is forwarded to the control processors where the routing tables are computed. Information that would be used in computing possible routes might consist of the states of communication links, their capacities, estimated traffic and hence idle capacity, link queueing delays, processing time, processor queueing delays and the number of processors in service at a node. Based on this measured information, costs are assigned to each node and link in the network, and routing assignments can be made by determining which of the possible paths between any source-destination pair have sufficiently low costs to satisfy the network performance criteria.

A computer program employing artificial intelligence techniques has been developed within the Laboratories to address this problem. The program stores both nodes and links as weighted objects in a database. As new information on the status of the network is received, the database is updated and nodes or links which have been added, removed or modified are investigated further. By using a variety of different search techniques, the database is optimised locally, in a manner which is independent of the size of the network. The heuristics used are powerful enough to ensure the robustness and global optimisation of the database.

By updating the database dynamically, the program can maintain a near-perfect route map, even for very large networks. When a packet transfer is to take place, the best available route is found by table lookup, enabling the packet routing problem to be solved in minimum time.

CONGESTION CONTROL IN FAST PACKET SWITCHING NETWORKS

One of the most complex and difficult problems in the design of a future broadband integrated digital services network (ISDN) utilising fast packet switching techniques is congestion control. Congestion arises because users can vary the rate at which they send packets, and it is possible for a number of users together to send packets at a rate in excess of that which the network can transmit. Congestion control techniques compromise between simplicity and efficiency, and the most suitable compromise is dependent on the application. Because fast packet networks will be required to handle integrated services that have different requirements, it is not appropriate to use the same congestion control technique for all services. Hence, the Laboratories are investigating appropriate techniques for application in the Australian Broadband ISDN.

The difficulty of congestion control depends on the type of traffic handled. For low bit rate, variable rate traffic such as voice, congestion control can be achieved by limiting the number of calls handled and by discarding packets on the rare occasions when buffer overflow occurs. For high bit rate, fixed rate traffic, control can be achieved by pre-allocation of the bandwidth required, if it is available. The most difficult type of traffic to control is high bit rate, variable rate traffic, and most attention has been given to methods of congestion control for this type of traffic.

Congestion control methods for high, variable bit rate traffic can be classified into two categories, namely, packet loss and packet buffering.

The packet loss technique can be controlled to give a required maximum packet loss rate. However, there is a compromise between packet loss rate, the ratio of network link bit rate to individual service peak bit rate, and network link usage efficiency. For example, higher network link usage efficiency can be obtained by allowing a high rate of packet loss in the network and allowing the sending end to re-transmit lost packets. It is feasible to implement selective re-transmission by the use of modern VLSI device technology to allow high bit rate operation.

The packet buffering technique of congestion control can be used in conjunction with an end-to-end "window" flow control scheme. The effect of such a scheme is to put a limit (called "the window") on the number of packets that a virtual circuit can have in transit through the network. This means that the switches that carry the virtual circuit may need a window's worth of buffering for that virtual circuit. In extreme cases, this can be a significant quantity of memory since it equals the peak bit rate multiplied by the round trip time delay. For example, for a 150 Mbit/s virtual circuit from Melbourne to Sydney, the amount of memory required is 1.5 Mbits.

It is possible to use all of the above techniques in one network if the network switches implement delay and loss priority. One possible approach is to have three service classes, categorised as high priority, packet loss allowed, and packet delay allowed. When congestion on a link occurs, the high priority packets are given first preference for link usage. The packet loss allowed packets are given second preference. If there is not enough capacity for the loss allowed packets, some of these packets are lost. Finally, if there is any remaining capacity, the delay allowed packets are sent. If there is not enough capacity for these, they are saved in a buffer until capacity is available. The service classes could be further subdivided into sub-classes. By having a number of service classes, each class can obtain maximum possible utilisation without affecting the service quality of higher classes.

There is a considerable range of techniques that could be used for congestion control in fast packet switching networks. Designing switches with delay and loss priority makes it possible to use several techniques simultaneously.

The Laboratories have been carrying out analyses to determine the requirements and performance of a number of congestion control techniques. The results of these analyses will be useful for determining dimensioning specifications covering hardware requirements and call limiting in future fast packet switching networks developed by Telecom Australia in the evolution of an Australian Broadband ISDN.

STANDARDS FOR THE BROADBAND ISDN

Telecom Australia will be introducing the Integrated Services Digital Network (ISDN) to its business customers in 1989 and to other customers in the early 1990s. This network will be based on international standards that have been developed over the last ten years. The next major step in the continuing development of the ISDN will be its evolution towards a Broadband ISDN. This network will enable a much wider range of services to be provided to customers - ranging from low rate data services transferring data at a few hundred bits per second to video services operating at hundreds of millions of bits per second.

As in the more immediate ISDN, a single connection from the customer's premises to the Broadband ISDN will be used to provide access, at times concurrently, to a very wide range of services which can connect with similar services on a global scale. Complex signalling protocols will be employed, and a standardised switching technique known as packet switching will be used to transfer information at very fast rates in "cells" through the network.

The adoption of fast packet switching in the Broadband ISDN will provide a flexible and powerful interface between the customer and the network. Essentially, whatever service is being used by the customer, the necessary information signals will be transferred in "cells" or "packets of data" through the network. However, successful worldwide implementation of the Broadband ISDN depends on the ongoing development of international standards for matters such as the signalling protocols to be employed, the customer/network interface, and even the structure of the cells or packets.

In the Broadband ISDN, each call must incorporate signalling and control information with customer data.

The current work of the Laboratories in the field of fast packet switching networks provides the basis of a variety of contributions by Telecom to the international standardisation processes of bodies such as the CCITT and the ISO. As with many standardisation organisations, the CCITT and ISO operate on a collegiate approach, developing international standards by addressing particular technical issues of evolving services and networks, discussing technical contributions from national organisations and achieving the required consensus necessary for worldwide interconnectivity.

One example of a recent Laboratories' contribution to international standards development in the CCITT concerned the cell format for the Broadband ISDN. The work was based on experimental and analytical work performed in the Laboratories during 1987.

In the cell format proposed by the Laboratories, the cell carries addressing information to identify the channel over which data is transferred, an error checking mechanism, and some information to indicate the nature of the service being carried. The latter piece of information is used to differentiate services. For example, voice needs low delay, while computer file transfer requires low data loss. Each cell carries the customer's data as a set of up to 448 data bits and is transferred to the network at about 155 million bits per second.

A technique has been developed at the Laboratories to reduce cell processing at transit exchanges. The technique, called Virtual Direct Routing, requires a slight increase in address length in cells. As a result, the Laboratories proposed that 24 bits of address space be allowed.

Below:
The Laboratories' experimental fast packet switch demonstrates simultaneous switching of several voice channels and a video channel.

FAST PACKET SWITCH ELEMENTS ON A CMOS VLSI WAFER

A number of studies are underway in the Laboratories to determine how best to evolve towards a Broadband ISDN using fast packet switching. In one of these studies, several fast packet switch structures, based on the AT&T Starlite architecture, have been designed and fabricated onto a silicon wafer. High level design techniques, including behavioural modelling and simulation and the use of advanced layout tools, have been applied in the design of the switch.

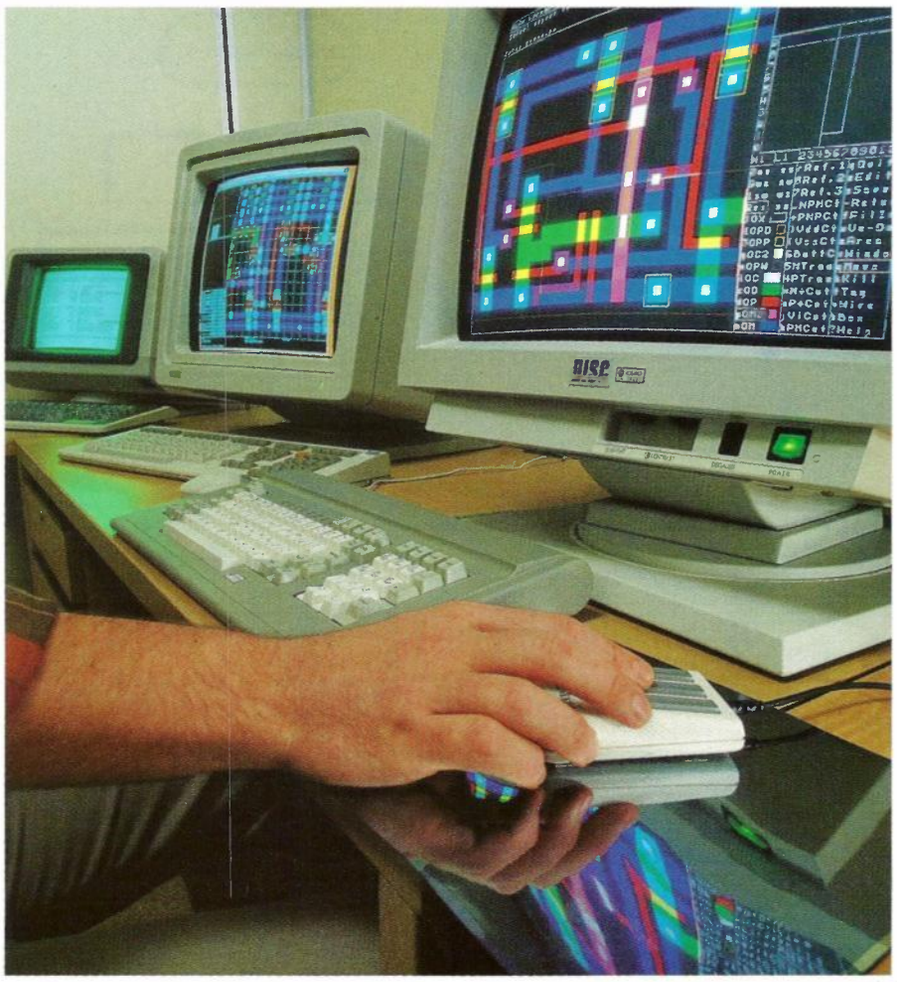
The design consists of two 8-line bitonic sorters, two 8-line Omega switches, interface circuitry (I/O pads and drivers), a clock generator and test structures. The complete 8-line sorter, with associated control, totals 1700 transistors and occupies an area of 2000 by 650 microns. The Omega array (with contention handling logic) contains 1900 transistors and is of a similar size. The whole design contains over 8000 transistors and occupies an area of 6 mm x 6 mm.

Test structures were included in the layout and evaluated to provide device process parameters. These parameters were then used in a re-simulation of the design for comparison against actual test results. This approach resulted in more accurate parameters and thus greater confidence in future simulation results.

The wafers were manufactured at a semiconductor foundry in California using a 2 micron double metal CMOS process. An Australian company acted as brokers for the realisation of the wafer design, arranging for the production of the phototools and subsequent manufacture of the wafers in a multi-project approach to small volume production prototyping.

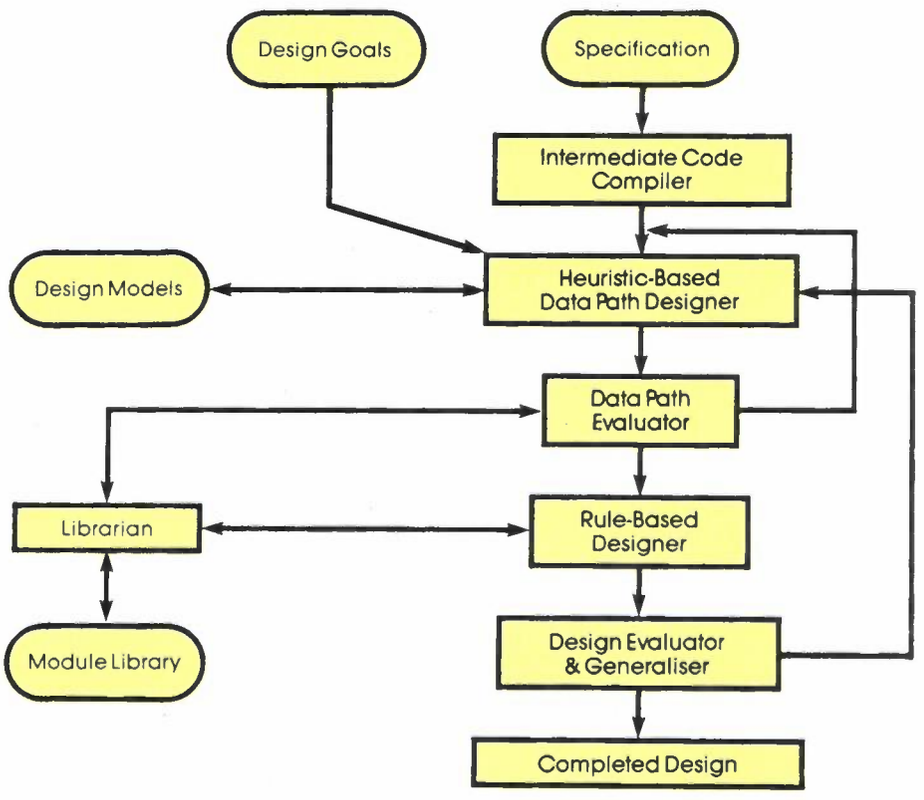
Test results showed that the prototype exceeded all of the specifications which were drafted during the design phase. In particular, the maximum clock frequency achieved at room temperature was 40 MHz, compared with 30 MHz as specified.

Below:
Software tools played an important role in the Laboratories' design of a VLSI fast packet switching device.



AN AUTOMATED SYSTEM FOR VLSI DESIGN

The Laboratories have developed a new approach to automating the design of VLSI components. Called the VLSI Architecture Design Automation System (VADAS), the new approach uses artificial intelligence techniques and an advanced model of the design process to provide a widely applicable design system that chooses appropriate design strategies for different design tasks and learns from experience. As a result, this prototype automated design system is capable of generating a wide range of hardware architectures from a high-level behavioural specification. By incorporating design heuristics and rules for new hardware architectures, VADAS can be expanded to encompass new design strategies. Similarly, by adding hardware modules to its library, the system can be tailored to a variety of implementation technologies.



The VADAS approach to automated VLSI design.

Hardware technology is progressing rapidly, driven largely by advances in the very large scale integration (VLSI) of semiconductor devices on a single chip. Already, complete systems can be implemented on a chip, and the achievable complexity is still growing. However, the ability to design such systems quickly and reliably has not kept pace with the fabrication technology. The use of computer-aided design (CAD) tools to assist the design process is commonplace, but these tools only address low-level design tasks such as design editing, circuit simulation and verification, and they are inadequate for more complex systems. There is a need for automated design systems which can transform high-level system behavioural specifications into complete hardware implementations that are "correct by design" both quickly and cheaply.

While attempts have been made at developing such systems, early approaches have been restricted to certain types of hardware systems, and performance has been limited due to the use of inflexible design strategies. The design of a VLSI system is not a purely mechanical process. A typical human designer makes many decisions throughout the design process that are based either on general rules of thumb or previous experience. The solution space is large, and there are many paths to an end result.

In addressing these aspects of the design process, recent approaches to design automation adopt artificial intelligence techniques. Although they have met with some success, they still operate within constrained areas of the design process. Design is a complex, knowledge-intensive activity that aims to integrate and organise constraints and resources in a purposeful way to satisfy some requirement, and the structure of an automated design system is a model of the design process. Design is therefore an obvious field of application for artificial intelligence techniques, such as heuristic and rule-based systems, to limit the size of the solution space search and learning to improve performance.

The prototype VADAS approach developed in the Laboratories will be applied to the experimental design of VLSI components in support of R&D projects in the fields of new switching systems and new value added customer services.

VERIFICATION OF LAYER 3 OF THE AUSTRALIAN ISDN PRIVATE NETWORK PROTOCOL

During 1987, Telecom's Corporate Customer Division released specifications for the Australian ISDN Private Network Protocol (AIPNP), a D-channel based signalling scheme designed for communications between Integrated Services PABXs (ISPBXs). The protocol allows ISPBXs to communicate via the public ISDN, as well as by tie-line signalling channels between adjacent ISPBXs. AIPNP is based on the Australian ISDN Primary Rate Interface Standard, which is detailed in Telecom's Specification TPH 1856.

In support of the work to develop the specifications, the Laboratories verified the Layer 3 call control procedures of AIPNP using the PROTEAN software developed in the Laboratories. For the verification of a protocol, PROTEAN requires the protocol specification to be described by Numerical Petri Nets (NPNs). In the case of AIPNP, this entailed translating a relatively informal mixture of specifications in both the structured Specification and Description Language (SDL) and also in ordinary text into a precise NPN model of the ISPBX-ISPBX interface. The model also had to include representations of activities not explicitly provided by the AIPNP specification. These included the reception of upper layer requests to Layer 3 and sending/reception of Layer 3 messages to/from a peer Layer 3 entity via the Layer 2 service provider, as well as a representation of the communications channel.

The NPN description developed in this Laboratories' investigation used an abstraction of the Layer 2 service provider and the interaction with the upper layer. The simple model also assumed that the transmission medium was ideal, that is, that no messages were lost, replicated or transmuted.

The Layer 3 call control protocol comprises several independent procedures. Partitioning the protocol allowed more concise verification of each individual procedure but did not check the overall procedure. The call establishment, maintenance, clearing, detaching, status, facility and restart procedures were subject to analysis by PROTEAN. These procedures were checked for livelocks and deadlocks under the assumption of an ideal transmission medium. No livelocks were found. Although deadlocks were found, these were found upon further investigation to be expected states either due to the partitioning of the protocol or because the procedure had reached an expected termination state.

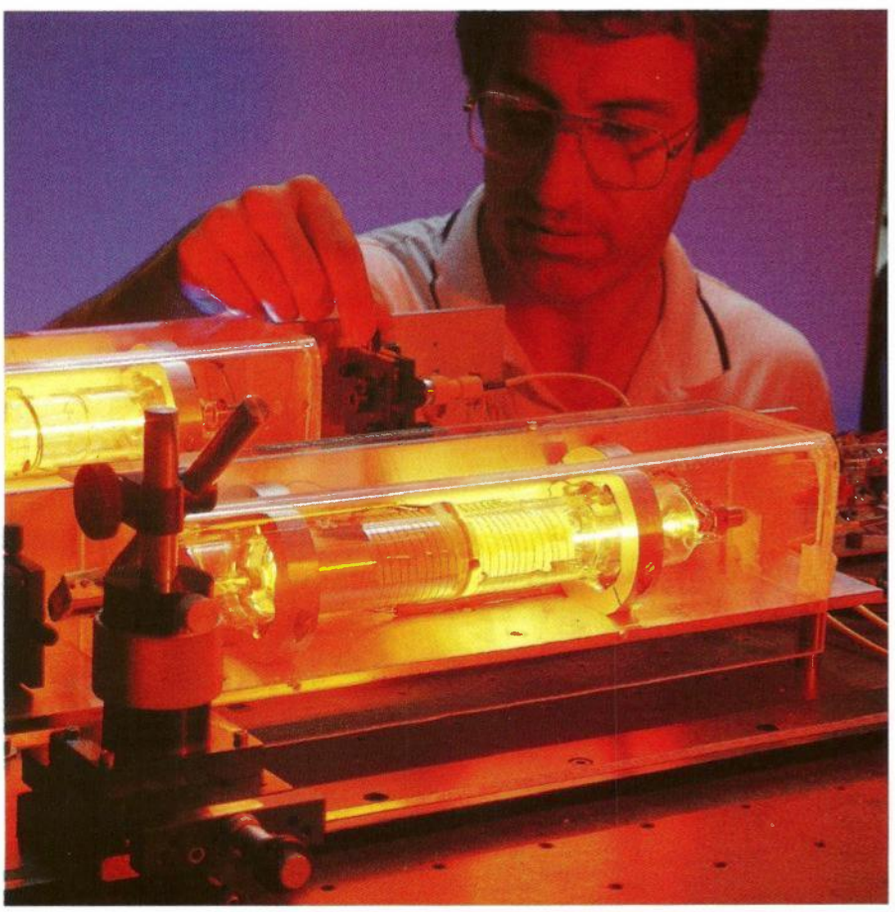
Under more realistic assumptions about the transmission medium, the protocol may prove to have errors. However, increased confidence in the correctness of Telecom's Australian ISDN Private Network Protocol has been gained from this further application of PROTEAN to protocol verification.

COHERENT DPSK OPTICAL TRANSMISSION SYSTEM EXPERIMENTS

Coherent optical transmission systems offer an attractive means for future upgrading of the transmission capacity of Telecom's installed single mode optical fibre trunk routes, particularly if combined with the use of optical amplifiers. In the longer term, coherent systems using optical frequency division multiplexing of many channels may also find application in the customer access network. The Laboratories are investigating suitable coherent system implementations for these purposes, with current emphasis on inter-exchange applications.

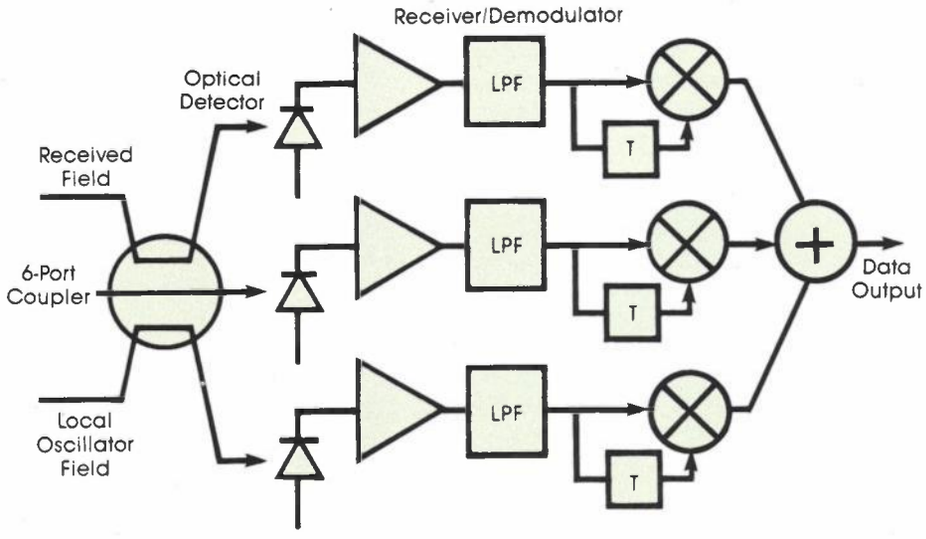
One attractive system implementation undergoing Laboratories' evaluation is that based on a phase-diversity receiver. In such a receiver, the received and local laser optical signals are combined in an optical hybrid device which splits the combined field into two or three outputs for separate detection by photodiodes. The resulting signal current from each photodiode has a fixed phase relationship with respect to the others. The signal currents can be derived at baseband by tuning the local laser frequency. After amplifying and demodulating each signal current, the resulting outputs are summed to recover the transmitted data signal directly at baseband. This receiver arrangement provides advantage for high bit rates. Since it operates at baseband rather than at an intermediate frequency as in a heterodyne receiver, the electronic circuit design is simplified and the receiver noise is reduced.

Below:
The experimental coherent DPSK optical transmission system.



An experimental system has been constructed in the Laboratories, operating at 140 Mbit/s with differential phase-shift keying (DPSK) modulation. The lasers used in the system are He-Ne lasers at 1523 nm wavelength. The receiver employs a 6-port optical fibre coupler as the hybrid device to combine the received and local laser optical signals, giving three optical outputs. The three outputs are detected and demodulated in three matched receivers and then combined to recover the data signal. A number of system tests have been conducted successfully, including operation over 113 km of single mode fibre loaned to the Laboratories by Optical Waveguides Australia Pty. Ltd.

These investigations have demonstrated that the phase-diversity receiver is a relatively attractive approach to realising coherent systems. Further experimental work is planned on this system, in which the He-Ne lasers will be replaced by narrow-linewidth semiconductor lasers.



Schematic diagram of the optical phase-diversity receiver.

LASER DIODE MODULES FOR COHERENT OPTICAL FIBRE TRANSMISSION SYSTEMS

To realise coherent optical transmission systems, the optical devices used as transmitter sources must have reasonably high output power, a high degree of frequency stability and very narrow spectral width. Semiconductor laser devices are attractive for use as sources for coherent systems because of their compact size and high output power, but their frequency stability and linewidth are poor. In one aspect of recent Laboratories' investigations of coherent systems, techniques for improving the latter two operational parameters have been studied.

The oscillating frequency of a laser diode varies with the temperature of the device and with the operating current. The frequency of a 1300 nm laser diode varies by approximately 20 GHz for a one degree Celsius temperature change, and by approximately 1 GHz for a 1 mA change in operating current. Hence, close control of the operating temperature and current of a laser diode source is required for coherent system applications. The spectral linewidth of typical single mode Fabry Perot laser diodes is of the order of 100 MHz. This must be reduced by a factor ranging from 10 to 1000 depending on the modulation format, to obtain good error performance in coherent systems.

In the Laboratories, stabilised laser diode modules have been developed which control the temperature and operating current of a 1300 nm laser. Short-term temperature stability of 50 micro-degrees Celsius and long-term stability of 0.5 milli-degrees Celsius have been achieved, while the laser diode drive current has been stabilised to within about 10 parts per million.

Below:
Stabilised laser diode with an external cavity laser.

Linewidth reduction has been achieved in the laboratory by the use of an external cavity to introduce weak optical feedback to the laser diode. These external cavities consist of a short length of temperature controlled optical fibre with a mirrored endface. With this configuration, about a one thousand fold reduction of spectral linewidth has been achieved. Measurement of the narrow linewidth is performed using the delayed self-heterodyne technique.

In the current experimental programme, different configurations of external cavities are being investigated. The cavities provide frequency selective feedback, either by meams of a bulk diffraction grating or a fibre-grating deposited near the core of a side-polished fibre.

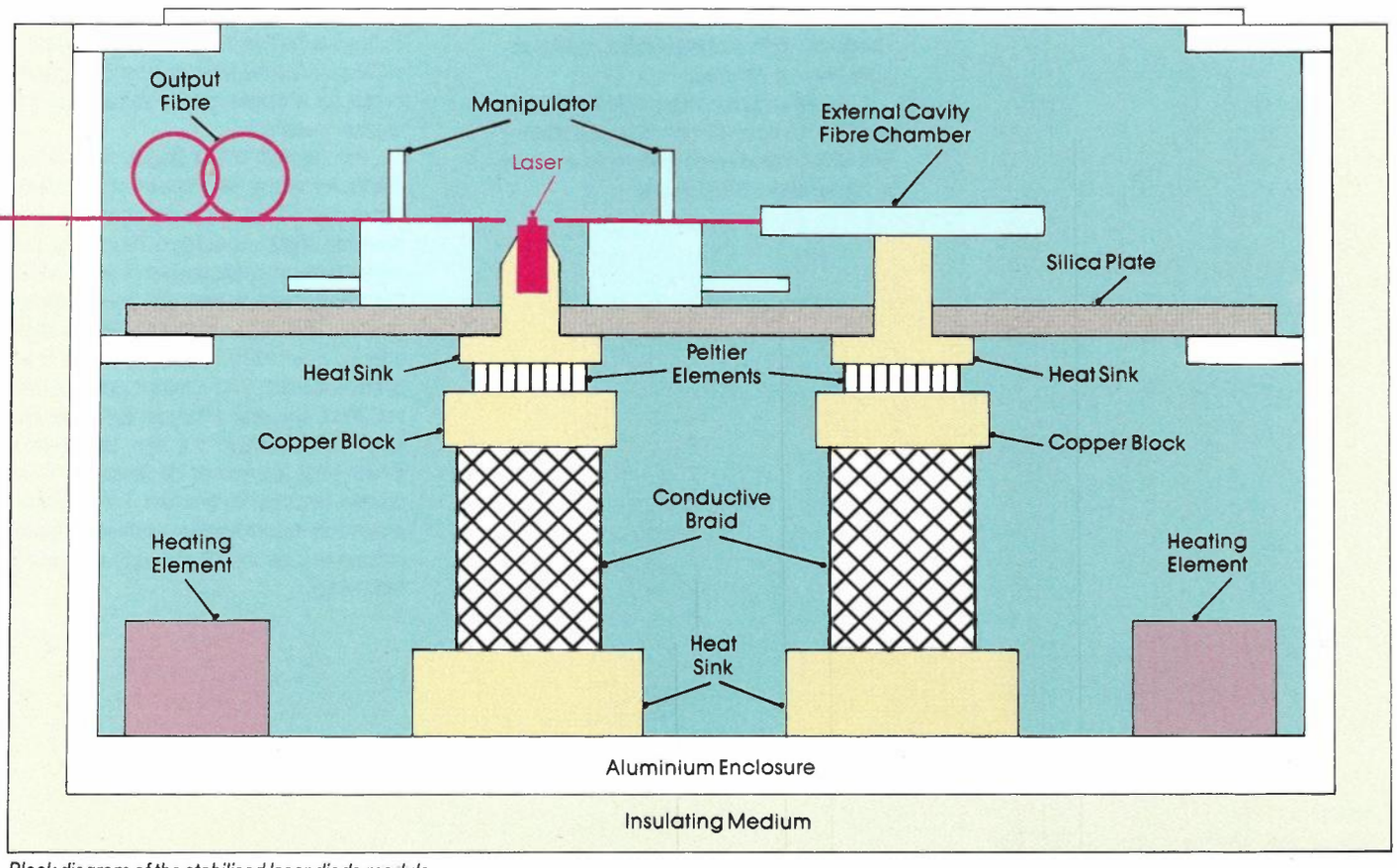
When suitably developed, the stabilised laser diode source modules will be incorporated into an experimental coherent optical transmission system suitable for field experiments and demonstration.

OPTICAL FIBRE TRANSMISSION SYSTEMS FOR THE CUSTOMER ACCESS NETWORK

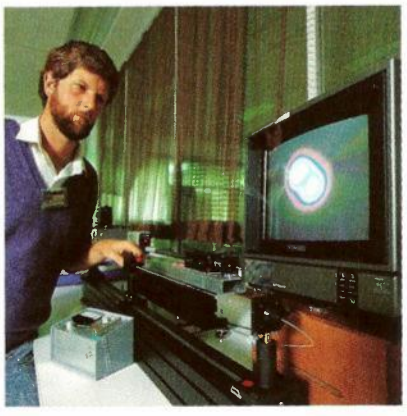
Optical fibre transmission systems are now routinely used in Telecom Australia's long distance trunk and inter-exchange networks. The technology of such systems is maturing and research attention, both in the Laboratories and elsewhere in the world, is turning to the application of optical fibres in the customer access network, that is, between the terminal exchange and the customer's premises. In this application, optical fibres offer several advantages over current copper wire based technologies. Optical fibres will allow economic provision of wideband services such as interactive video services, high definition television services and videophones. Their potentially very large traffic carrying capacity also provides future flexibility for telecommunications administrations to offer a wide variety of as yet unspecified services to customers, without any corresponding future need for costly re-building or expansion of the customer's network access connection.

It is generally agreed on technical grounds that the installation of single mode optical fibre systems provides greatest flexibility for the future, since single mode fibres offer much greater bandwidth than multi-mode fibres. However, the extensive nature of the customer access network makes this aspect of Telecom's operations extremely cost sensitive. Further, the choice of fibre must also consider the costs of the optical components used in optical transmission systems. Some of these costs are currently high enough to restrain the widespread use of optical fibres in the customer access network.

The Laboratories are assessing a variety of optical fibre network architectures and the devices required for their realisation, in order to obtain comparisons of the technical and cost trends of alternative means of developing the customer access network. Among other considerations, these assessments have suggested that an approach using single mode fibres and optical devices at a wavelength of 850 nm may provide a minimum cost interim solution, pending future alternatives which require reductions in device costs to make them more cost-competitive.



Block diagram of the stabilised laser diode module.



It is clear that the optical fibre transmission systems installed in the customer access network will ultimately be operated in single mode at a wavelength of approximately 1300 nm. Hence, longer term capital cost considerations require that any optical fibres installed in the near future in the customer access network should be single mode rather than multi-mode fibres.

The current costs of 1300 nm optical devices are high compared to those operating at 850 nm, since the technology to manufacture 850 nm devices is well established. On the other hand, optical fibre transmission performance at the shorter 850 nm wavelength is degraded in a number of respects when compared with that at 1300 nm. On balance, there may be a short term application for systems using 850 nm devices and operating at this wavelength over single mode fibres until the costs of 1300 nm devices are reduced through improved manufacturing techniques and larger production volumes.

The Laboratories have studied this latter option, both theoretically and experimentally. At the 850 nm wavelength, the optical fibre constructed for single mode operation at 1300 nm propagates six modes. Thus, the studies considered issues such as modal dispersion and modal noise. In the pursuit of the studies, several experimental systems, using both light emitting diodes and lasers, have been constructed.

The investigations have indicated that, for example, using an 850 nm laser, satisfactory 140 Mbit/s transmission performance can be achieved over 3.5 km of fibre.

Above:
Viewing the intensity pattern in the fibre assisted modal noise measurements on experimental 850 nm optical transmission systems for the customer access network.

PLANAR INTEGRATION OF OPTOELECTRONIC DEVICES

Optoelectronic devices are finding application in high speed interconnects for computers, in sensors and, importantly for Telecom, in the customer access network. Telecom's requirements are for high-performance, highly reliable, low-cost systems for location at the customers premises. To achieve this, integration of electrical and optoelectronic components on the one semiconductor chip is essential. However, a major problem in realising such integration arises from the incompatibility of various optical device structures with the LSI and VLSI technology used for integration of the electrical components. In particular, the use of non-planar device geometries, common for single optical devices, causes significant problems for any integration technology.

The Laboratories have recently developed a technique which allows integration of optoelectronic devices in a manner which is simple and results in a near-planar device structure, suitable for most LSI lithography stages. The technique uses Molecular Beam Epitaxy (MBE) to grow the required structure for the optoelectronic device in a well which is etched into the substrate material. After growth of the material, the wafer is essentially planar except for a narrow groove surrounding the regrown material.

For the most critical stages, such as the delineation of the gate regions of field effect transistors (FETs), planarity is critical, and even the slight degradation caused by the regrowth step is unacceptable. To ensure that this requirement is met, the optical device structure is added as a post-processing step, after the most critical lithography stages have been completed. This makes it essential that the initial processing stages use materials which can withstand the high temperature growth stage required for the deposition of the optoelectronic device structure. This is already a common requirement for many self-aligned processes used in LSI and VLSI fabrication technology.

The Laboratories' technique has been tested using gallium arsenide, since this material system offers the possibility of integrating high speed MeSFET-based electrical circuitry with many of the optical components fabricated in III-V compound semiconductor materials, such as detectors, lasers, light emitting diodes, modulators and waveguides. However, the technique is applicable to other material systems for which MBE is appropriate.

The use of this approach, in combination with VLSI technology available in commercial foundries, will enable the fabrication of low-cost state-of-the-art systems for potential application in Telecom's future customer access networks.

MATERIALS FOR MID-INFRARED OPTOELECTRONIC DEVICES

An essential requirement for the development of future generations of long distance optical fibre transmission systems operating in the mid-infrared region of the spectrum is the availability of suitable optoelectronic devices. To achieve optimum device operation, an important semiconductor parameter, the band gap, must be matched closely to the frequency of the radiation being either generated or detected.

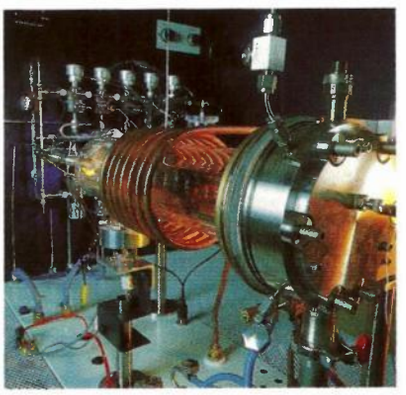
One of the most promising semiconductor materials for the fabrication of these devices is mercury cadmium telluride (MCT). This material has the feature that its band gap can be tailored right across the infrared region of the spectrum by varying the relative proportions of mercury and cadmium in the compound. Unfortunately, because of its predominantly military usage, MCT material is very expensive and difficult to obtain commercially.

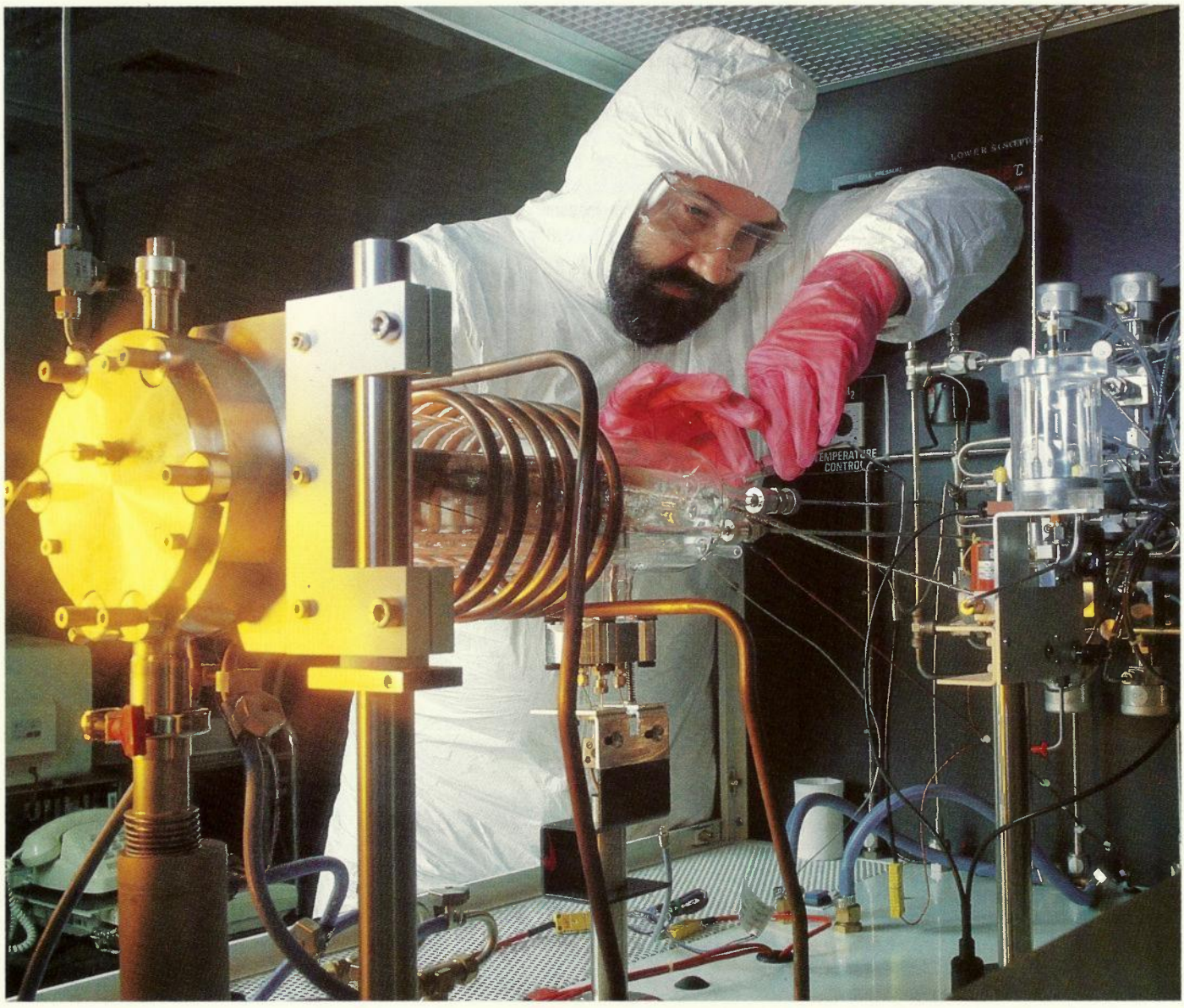
In order to provide for the development of a range of mid-infrared devices, the Laboratories have recently installed a state-of-the-art Metal Organic Chemical Vapour Deposition (MOCVD) system. This facility will be used for the growth of multiple thin film epitaxial layers of MCT and related compounds. These layers will then form the basic material for the laboratory production of prototype optoelectronic devices and integrated circuits.

The MOCVD process is already well established industrially for the production of near-infrared laser diodes using III-VI semiconductor compounds. The process involves the reaction at 200-400°C of vapour phase mixtures of metal organic materials (alkyls) using hydrogen as a carrier gas.

For the growth of MCT, which is classed as a II-VI compound, alkyls such as the liquids diethyl tellurium and dimethyl cadmium are used. Growth takes place on a substrate which is usually an orientated single crystal wafer of cadmium telluride, gallium arsenide or sapphire. Precise quantities of very high purity hydrogen are delivered via mass flow controllers to the temperature controlled bubblers containing the liquid metal organics. The vapours containing the materials to be deposited are then passed to a special chamber where they are mixed and dilution with pure hydrogen takes place before they enter the reaction vessel.

Below:
The vapour deposition chamber in the Laboratories' MOCVD facility.





Above:
The Laboratories' MOCVD facility.

The reactor itself contains a resistively heated mercury pool and an RF inductively heated susceptor on which the substrates are placed. The various deposition parameters such as gas flow rates, flow times and reactor temperatures are precisely controlled and monitored by a microprocessor-based control system. This system also ensures that the system automatically shuts down in a safe mode should any fault occur during the process.

In support of the Laboratories' R&D in this new materials technology, a number of other research projects are being pursued. These include mathematical modelling of reactor design, synthesis rare organo-metallic chemicals, and design and construction of vital ancilliary equipment such as a recirculating inert atmosphere glove box.

The first results obtained using the MOCVD technique have proved to be very encouraging. Growth of cadmium telluride on gallium arsenide has been achieved, and the layers have been subjected to extensive physical, chemical and electrical analysis. Depth profiling, using the Laboratories' scanning auger spectrometer in conjunction with sputter etching, has indicated that the important interface region between the layer and the substrate is very narrow and as good or better than any previously reported in scientific journals. Further runs, involving the deposition of mercury telluride on cadmium telluride, have shown interdiffusion resulting in the formation of MCT. This result gives confidence that the technique will produce material of the desired quality and characteristics.

The aim of current work is to optimise the growth of high quality material over large area substrates with good uniformity of thickness and composition.

SURFACE CHARACTERISATION OF II-VI SEMICONDUCTOR MATERIALS

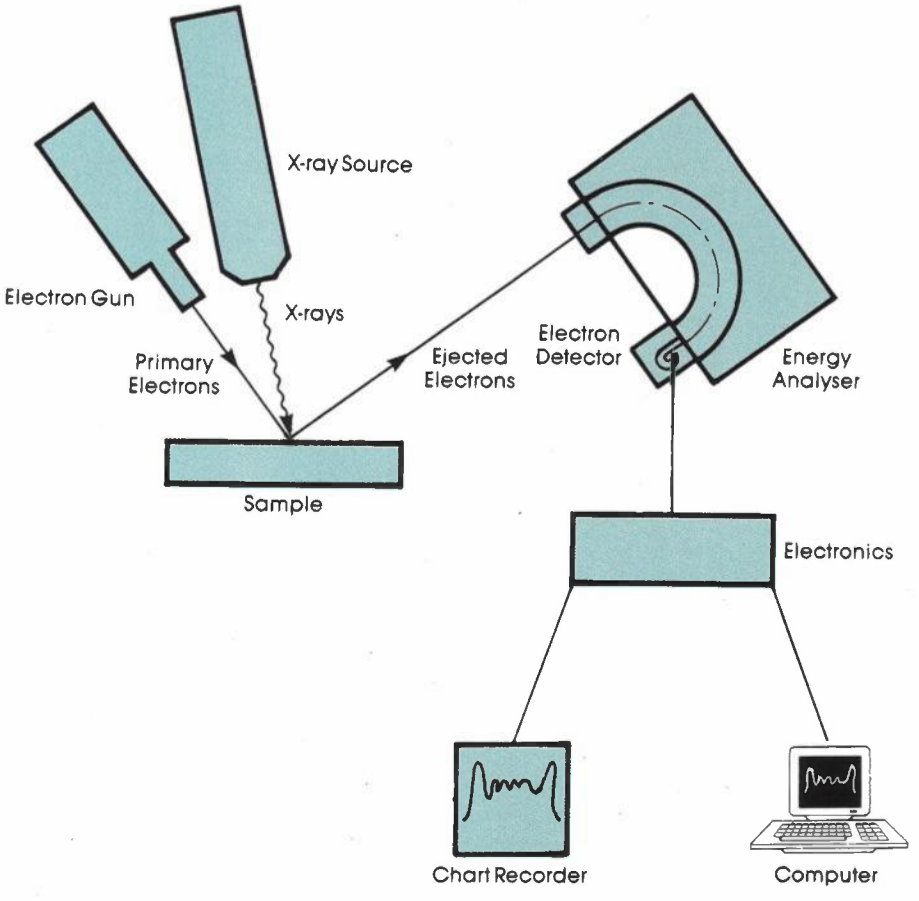
The Laboratories' surface analysis facility has been employed during the past year to characterise new, high-technology, II-VI semiconductor materials for two potentially important applications. The techniques used were X-ray Photoelectron, Energy Dispersive X-ray Spectroscopy and Scanning Auger Microanalysis.

Cadmium telluride (CdTe) has an optimum band-gap for photovoltaic energy conversion and hence it is ideally suited for use in solar cells. The ability to produce large-area homogeneous thin films of high purity with economy is extremely important in making these cells commercially viable. Thin CdTe films have been produced within the Laboratories by electro-deposition from solution, and examination by the abovementioned surface analysis techniques played an indispensable part in establishing the parameters required to produce films of the correct composition routinely.

A related material of even greater technological importance is mercury cadmium telluride (HgCdTe). Careful analysis of the surface of this material by electron spectroscopy is one of the more effective and least destructive methods for determining composition. Knowledge of the detailed elemental concentration of the material is critical, since the band gap, and hence the wavelength window, varies as a function of x in $Hg_{1-x}\ Cd_x\ Te$

Initially, a well characterised single crystal of HgCdTe was examined in order to ascertain the ability of the instrument to analyse such material. Subsequently, commercially produced bulk material was studied, to verify that its composition was such that it would operate within the required wavelength window.

Recently, both CdTe and HgCdTe have been produced within the Laboratories using a Metal Organic Chemical Vapour Deposition (MOCVD) reactor. Surface characterisation of the materials produced using the above spectroscopic analysis techniques provided almost immediate feedback on the quality and purity of these "home-grown" materials.



Schematic representation of the components necessary for X-ray Photoelectron Spectroscopy and Scanning Auger Microanalysis.

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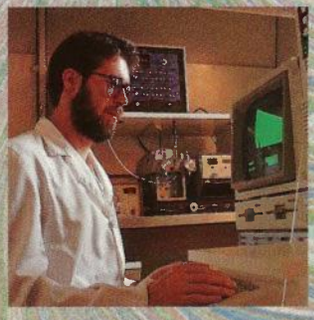
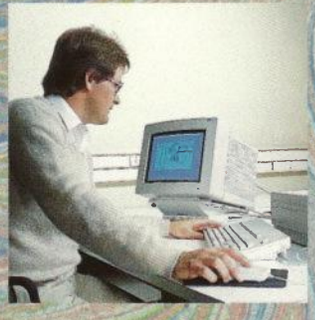




QUALITY ASSESSMENT & RELIABILITY STUDIES

Telecom Australia seeks to ensure that its customers are provided with world-quality telecommunications services which are economical and reliable. To achieve this objective with the ever-increasing sophistication of telecommunications systems and equipment, a high level of quality and reliability in both hardware and software is required, together with efficient maintenance and assured safety of Telecom's personnel and customers.

To achieve this aim, all materials, components and parts which make up the systems and equipment should perform their specified functions for their entire design life spans in the variety of environments which might be encountered anywhere in Australia. Degradation of materials or components can cause equipment malfunctions or down-times resulting not only in costly repair or replacement, but more importantly, in customer dissatisfaction and losses in revenue far in excess of the cost of the part which caused the problem. Another implication of equipment malfunctions, inadequate equipment specifications or incorrect work practices is their potential reflection as occupational safety and health issues, or in worst cases scenarios, as potential causes of personal injury or damage to plant and property.

By assessing new Telecom products, the Laboratories assist Telecom's Product Managers and Design Engineers with material selection and the assessment of parts, components and assemblies to ensure network reliability. This involves the measurement of relevant parameters, comparison with specifications and sometimes improvising environmental test methods, to ensure that all factors which may have detrimental effects on product reliability or performance in the operational environment are considered. This work often requires the application of sophisticated test and analysis techniques, aimed at simulating, in accelerated laboratory tests, the stresses and conditions to which the product may be exposed during its service lifetime. This approach provides the required information in the product design phase, rather than after the product has been launched and possibly even failed. When problems arise in the field, similar analytical techniques can be applied by the Laboratories to determine causes and produce remedial measures quickly.

The materials characterisation, reliability assessment and failure analysis activities performed by the Laboratories are often carried out in close co-operation with telecommunications manufacturers supplying materials or equipment to Telecom. The items investigated cover the whole spectrum of Telecom's equipment, ranging over very large scale integrated circuits, metallic or optical cables, power sources, moulded plastics parts, automotive parts, paint systems for radio towers and many more.

The following section of this Review describes some of the special Laboratories' facilities applied in work related to quality assessment and reliability assurance and includes examples of investigations performed in the past year. They are representative of literally hundreds of such investigations successfully carried out every year by the Laboratories to support Telecom's goal of maintaining high and sustained quality of its services, and thus to achieve business success and customer satisfaction.

INTEGRATED CIRCUIT PROCESS CHARACTERISATION

The Application Specific Integrated Circuit (ASIC) approach to circuit design provides the electronic engineer with a flexible means of generating a completely customised integrated circuit to suit a specific application. Using computer-aided design tools, the circuit is designed and converted to a chip layout, which is then transferred to a silicon foundry for fabrication. Among the penalties of this increased design flexibility are requirements for much greater design effort, complete reliance on the foundry to provide accurate process specifications, and a need for thorough testing of the completed integrated circuit by the designer.

At least two requirements are essential for the success of this design approach. The designer must have an adequate knowledge of the process parameters used by the foundry to fabricate the individual components on the silicon wafer, and the computer simulation models used to design the circuit must accurately predict the behaviour of the devices on the completed chip.

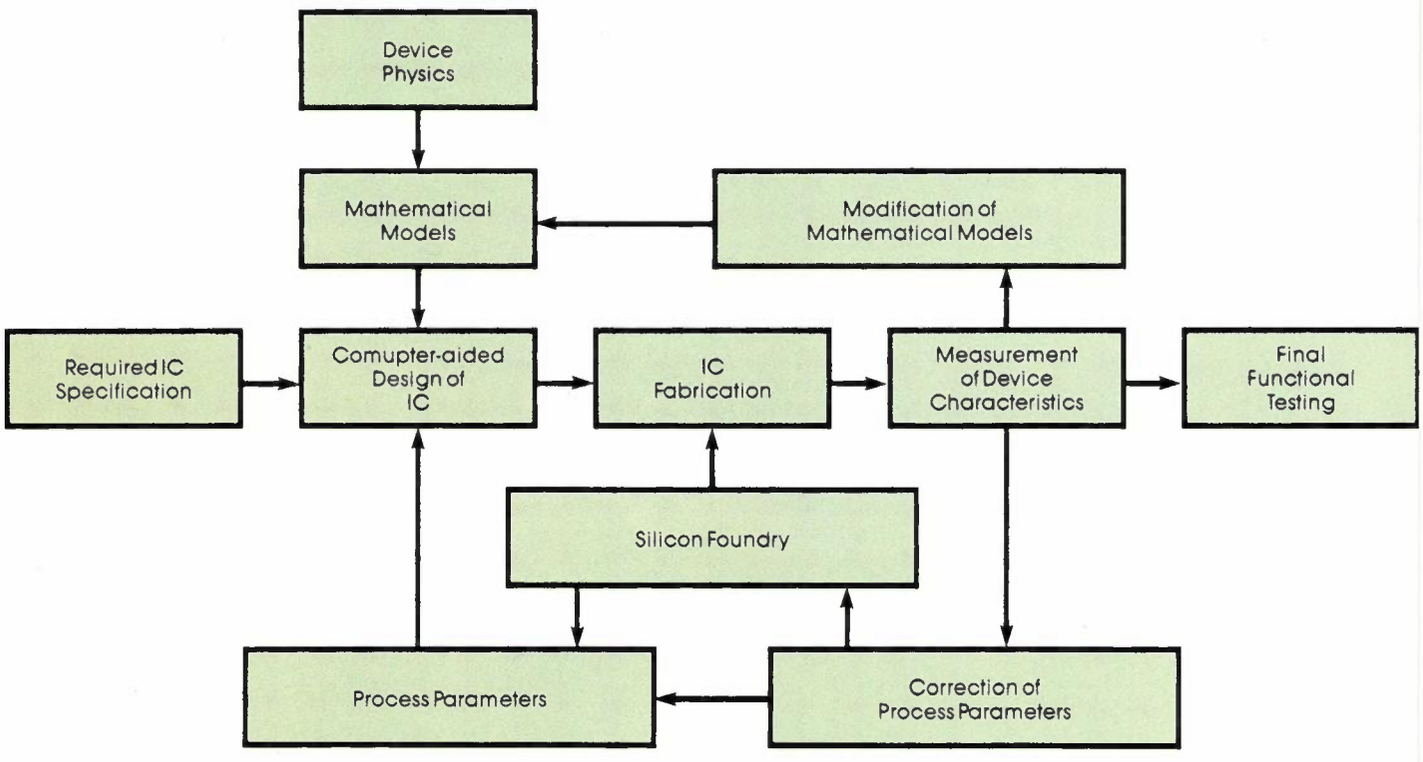
The Laboratories have been studying the efficacy of this design approach for MOSFET circuitry, initially with 5 micrometre NMOS process technology and, more recently, with 2 micrometre CMOS process technology. For these studies, a special set of test structures

was designed and submitted to a silicon foundry for fabrication on a chip. The test structures included transistors, capacitors, diodes and resistors of various sizes and geometries. By measuring the current-voltage and capacitance-voltage characteristics of the various devices and employing the simulation models in reverse, a set of numbers was obtained which reflected the values of the process parameters. These values were then compared with the manufacturer's specifications to give a check of the fabrication process. It was found, for example, that for one particular NMOS process, the manufacturer had produced devices with a gain factor about twice that specified.

The derived process parameter values also allowed a check of the simulation models. MOSFET transistors have characteristics which are particularly dependent on size and geometry. An indication of the ability of the models to accurately simulate these dependencies was obtained by comparing the process values for the various transistors in the test structure. It was determined that the popular simulation model used for MOSFET devices was unable to predict accurately the behaviour of devices of small dimensions.

The final step required to complete this circle of self-consistent checks is in hand, to produce mathematical models which simulate the behaviour of small devices more accurately. Until recently, improvements in the models have been centred on adding equations to include more of the subtle physical processes occurring in these devices. This has required more knowledge of the process parameters and has increased the complexity of the simulation mathematics, thence requiring greater computing power and more time to run each simulation.

The results of these and further Laboratories' investigations are being used to develop simpler empirical models which, while not necessarily following the physics of device operation, will quickly generate the correct characteristics for ASIC devices.



An illustration of the iterative process involved in the fabrication of integrated circuit devices.

Left:
The Laboratories-developed vacuum chamber for improved secondary ion mass spectrometry.

DEVELOPMENT OF A STAND-ALONE SECONDARY ION MASS SPECTROMETER

The properties of materials used in the production of semiconductor devices and optical fibres are sensitive to extremely low levels of impurities. Secondary Ion Mass Spectrometry (SIMS) is one of the techniques capable of detecting and analysing such low impurity levels.

The SIMS technique involves detection by mass spectroscopy of secondary ions generated when energetic primary ions (usually argon ions) strike the surface of a sample. The technique enables the surface atomic layer of the sample to be analysed with a sensitivity of up to a few parts per million (depending on the element).

In past years, the Laboratories have operated its SIMS facility in conjunction with a scanning electron microscope (SEM). The compromises required to operate both SEM and SIMS in the same vacuum chamber reduced the achievable sensitivity of the analysis. To improve the sensitivity achievable, a separate vacuum chamber was recently designed and constructed in the Laboratories exclusively for SIMS.

The sensitivity of the SIMS technique is improved by increasing the number of secondary ions reaching the detector. The new chamber does this in two ways. Firstly, the spatial arrangement of the ion gun, the mass detector and the sample is optimised. This was not possible on the old SEM/SIMS system as other detectors had to be accommodated around the sample. Secondly, the new chamber has much improved vacuum (less than 10-9 mBar, compared with 10-6 mBar previously). This decreases the probability of a secondary ion colliding with another ion or molecule and being deflected from the detector. It also reduces the background noise caused by ionisation of the residual gas.

The new chamber has been constructed to ultra high vacuum standards by utilising type 316 stainless steel and copper gasket seals. An additional "bake-out" facility, which raises the temperature of the whole chamber to 200°C, has also been designed and built in the Laboratories. This will greatly enhance the quality of the vacuum by removing any gas molecules which may adhere to the internal chamber surfaces.

UTW-EDX - A NEW DIMENSION IN SURFACE ANALYSIS

The surface analysis techniques of Scanning Auger Microanalysis (SAM) and X-ray Photoelectron Spectroscopy (XPS) in the Laboratories' electron spectrometer are used to determine solutions to problems experienced in a wide range of areas, including electrical contact resistance, oxidation, corrosion, adhesion and passivation.

The recently commissioned Ultra-Thin Window Energy Dispersive X-ray (UTW-EDX) analytical facility is a powerful adjunct to the spectrometer. This new facility provides a rapid quantitive compositional analysis capability. Unlike conventional EDX, UTW-EDX can also detect the light elements boron, carbon, nitrogen, oxygen and fluorine in micrometre thick layers, complementing the techniques of SAM and XPS, where the information arises from the first few mono-atomic layers. The UTW-EDX technique permits the rapid identification of many corrosion products, inclusions and other contaminants. It also allows the analysis of microcrystals on electrically insulating materials such as polymers and optical fibres. Such small area analyses are not possible on insulating materials when using SAM or XPS.

Additionally, by utilising the X-ray source designed for XPS and the X-ray detector designed for UTW-EDX, the bulk materials analysis technique known as X-ray Fluorescence (XRF) has been successfully implemented in the spectrometer at no additional capital expense. XRF excels at trace element detection and this capability has recently been applied to the analysis of optical fibre preforms made of fluoride glass. In this example, several preforms which were made under "identical" conditions exhibited different transmission characteristics and different colours. Whilst neither SAM, XPS nor UTW-EDX could establish any difference between the preforms, XRF readily identified several differences at the trace element level. This information assisted other Laboratories' studies of processes for the production of a fluoride glass optical fibre with improved transmission characteristics.

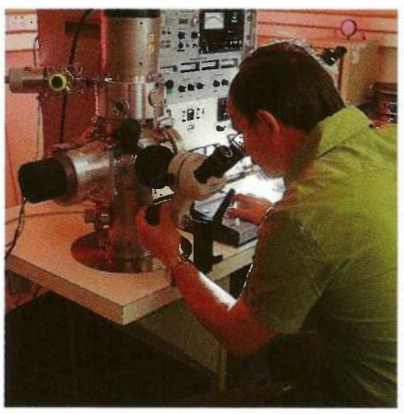
A SAMPLE PREPARATION FACILITY FOR TRANSMISSION ELECTRON MICROSCOPY

As a result of an R&D contract placed with JAVAC P/L, an Australian company, the Laboratories have acquired a unique modular sample preparation facility for transmission electron microscopy. The system is designed to facilitate investigations into materials for use in the future optical fibre network. These investigations require atomic level evaluation of the interfaces between different materials, and the sample preparation technique must yield extremely thin transparent samples. The preparation of such samples can be very difficult and time-consuming, especially in cases involving multi-element materials.

The new sample preparation facility provides a choice of either ion beam or atom beam etching, and it uses turbo-molecular pumping to achieve the high level of vacuum necessary to avoid sample contamination. The equipment is also equipped with a cooled specimen stage to prevent the specimens heating during the thinning process, since high temperatures may result in modification of the interfaces being investigated.

The ability to choose between the two etching modes gives the user increased flexibility when dealing with difficult substrate materials. For instance, sputter etching using beams of atoms (typically argon) allows faster thinning with better uniformity and is especially useful with multi-element materials such as the infra-red semiconductor mercury cadmium telluride. In contrast, the use of a beam of ionised particles gives more precise control of etching rates, and it also provides the option of further expansion at a later date to allow surface element and concentration profile analyses.

This new facility is a valuable addition to the existing arsenal of advanced facilities for materials research available in the Laboratories.



Right:
The new Laboratories' facility for preparing samples for electron microscopy.

A NEW CORROSIVE GAS EXPOSURE FACILITY

For over a decade, the Laboratories have had the capability to perform industrial atmosphere tests according to established International Electrotechnical Commission (IEC) and Australian standards. Equipment, designed in-house, could cover exposure to sulphur dioxide or hydrogen sulphide gases, in concentrations between 10 and 30 parts per million, in a temperature and humidity controlled atmosphere. This equipment has been used in the laboratory to test the susceptibility to corrosion of a wide variety of materials in broader studies of the reliability of telecommunications equipment and components. One important field of application of the facility has been in the reliability testing of contact materials used to achieve low resistance connections in telecommunications equipment. For instance, the hydrogen sulphide test has been widely used in the past to assess the reliability of silver relay contacts, but is now required only occasionally. The sulphur dioxide test is applied to other metallic surfaces, including gold platings used in printed circuit and many other connector applications.

With the increasing complexity of Telecom's switching equipment, the associated use of very large numbers of connectors and the stringent reliability requirements in the transmission of digital data, the stability of low contact resistance components in a variety of environments becomes a key element in network reliability. In

the past, contact problems could generally be solved by the application of generous layers of gold on all relevant surfaces. However, the dramatic increase in the price of gold in recent years has seen steady movement in industry towards the reduction in the thickness of gold platings and the development of composite platings incorporating other metals. As a result, there is considerable renewed interest and activity in the Laboratories in studies of contacts and the effects of the environment on them.

In recent years, the understanding of surface corrosion has progressed significantly as a result of the intensive worldwide study of the actual environments experienced by electronic components and advances in corrosion chemistry. One outcome has been the realisation that traditional industrial atmosphere tests, which rely on relatively high concentrations of sulphur dioxide, produce reactions that are not representative of the type of corrosion found in equipment in real environments. More complex test atmospheres are now being proposed as industry standards. Characteristically, these atmospheres comprise mixtures of two or three gases in lower concentrations of between 0.01 and 0.2 parts per million, which through synergistic effects achieve realistic simulation.

The role of water vapour in the surface corrosion process is considered to be crucial and proposed new standard test atmospheres demand high relative humidity, controlled to tighter limits.

The Laboratories have recently installed a new dual chamber environmental test facility for gas corrosion tests in which the temperature, relative humidity and concentrations of up to three corrosive gases can be varied and controlled over a wide range. This equipment provides new flexibility in test conditions and much better accuracy and control than the chamber used by the Laboratories over the past 12 years. It will allow more realistic modes of corrosion to be investigated, leading to a more confident assessment of the reliability of equipment in adverse conditions. It will also enable the Laboratories to perform in-depth research into the limitations of existing single gas tests and to contribute to the international debate on the proposed new standards for mixed gas corrosion tests.

Above:
The Laboratories' dual chamber gas corrosion test facility.

Left:
An example of contact degradation caused by corrosive gases.

ANALYSIS OF THE ABRASION PROPERTIES OF HARDFACING ALLOYS

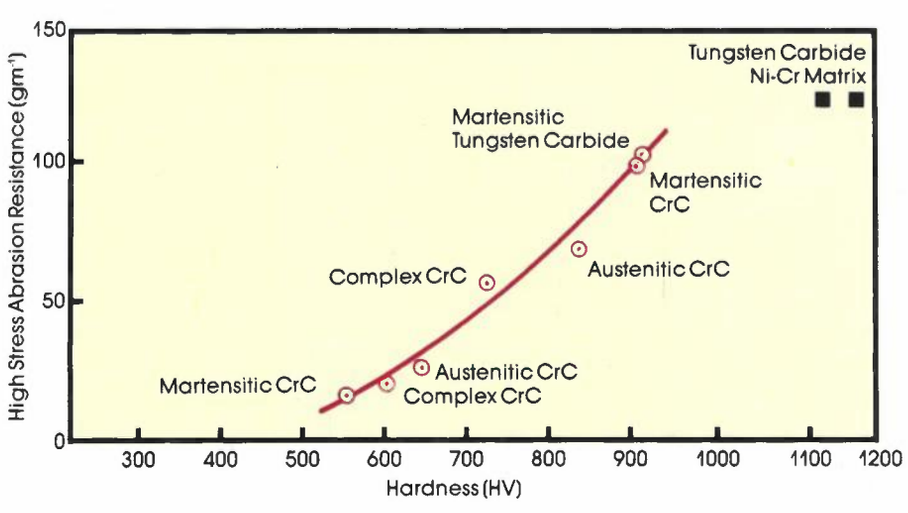
The replacement of earth digging tools is a significant cost component in the earthmoving activities of Telecom (such as in cable trenching or direct cable ploughing). Premature alteration in tool dimensions due to abrasive wear can also seriously reduce the efficiency of the tool/machine system. To overcome these problems, layers of hard facing alloy are frequently applied to the cutting faces of digging tools during manufacture. But, since hardfacing alloys are typically intended for abrasive environments, there is a lack of detailed information on their properties which are relevant to a variety of earthmoving applications.

To gain such information, the Laboratories have recently performed an extensive programme of assessments of the abrasion properties of chromium carbide alloys and tungsten carbide composites. These materials represent the classes of hardfacing deposit typically used in environments of severe abrasion.

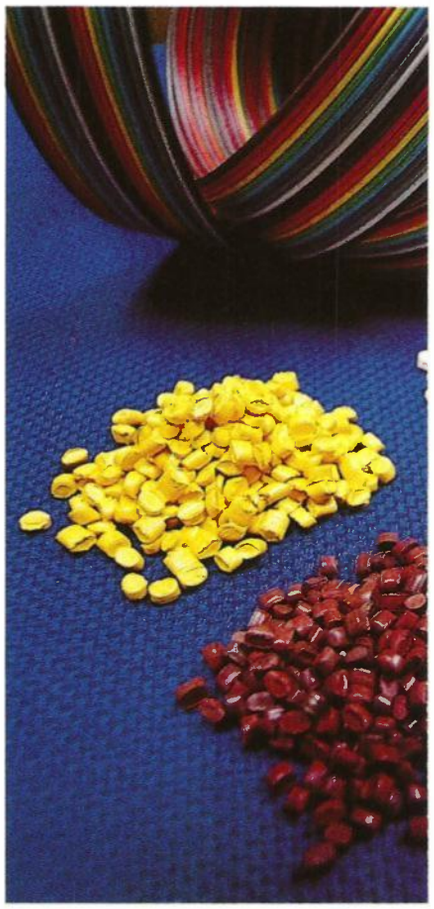
A series of proprietary alloys, containing varied volume fractions of the dispersed hard carbide and differing in type of matrix, were selected in order to correlate microstructural variation with abrasion properties. As appropriate to the alloy composition, the deposits were prepared either by the welding processes of open arc, manual metal arc or by powder spray fusion. The influence of the preparation method on abrasion properties was also monitored.

An essential feature of the assessment programme was the accurate simulation of the abrading environment of the soil in a laboratory test. An identification of the abrasion damage sustained by digging teeth which were operated in a variety of locations revealed that grinding abrasion or high stress abrasion was the predominant mechanism. Consequently, conditions of high stress abrasion were reproduced in laboratory tests using equipment made available by the BHP Research Laboratories and using standard specimen geometrics and test procedures. Both 80 micrometre alumina and 120 micrometre garnet abrasives were evaluated, representing the upper limit and typical value of mineral hardness encountered in soil.

The results of the programme have confirmed the general superiority in abrasion properties of tungsten carbide composites over chromium carbide alloys. Also of significance was the finding that the abrasion resistance of chromium carbide alloys containing a high volume fraction of carbide can approach that of the more expensive tungsten carbide composites. Any increase in abrasion resistance of the chromium carbide alloys was critically determined both by the volume fraction of carbide and by the alloy hardness. The method of deposition of the hardfacing layer was found to have significant influence on the abrasion resistance through its consequent effect on microstructure.



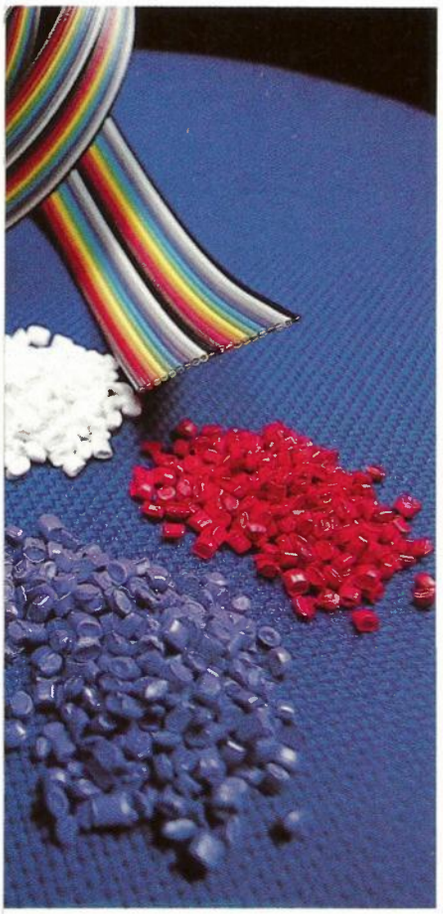
A plot of abrasion resistance for a series of hardfacing alloys. The terms austenitic and martensitic refer to matrix types, while the complex CrC type refers to the presence of additional alloying elements.

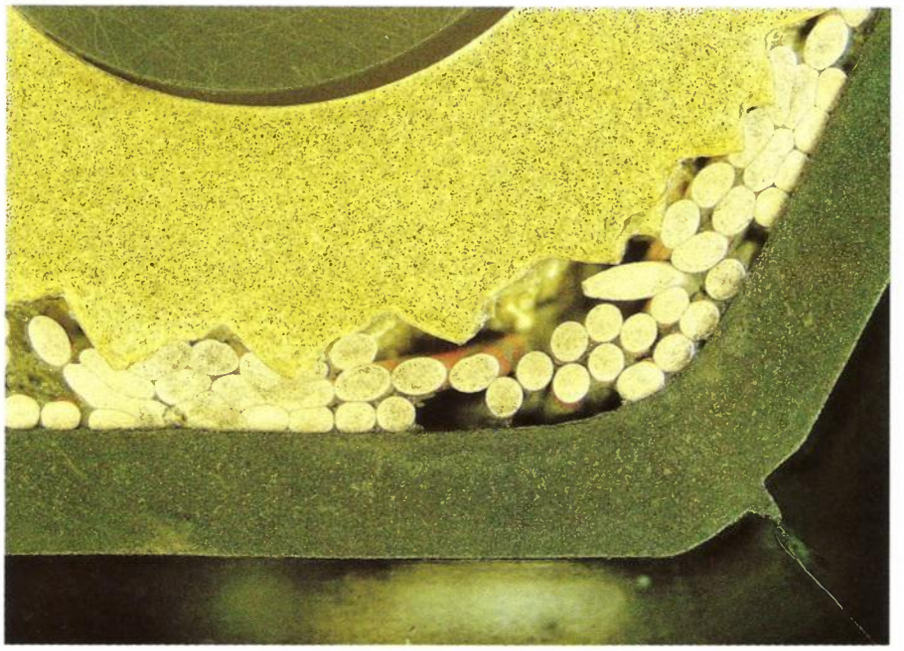


POLYPROPYLENE CONNECTORS FOR SUBSCRIBER DISTRIBUTION CABLE

For many years, Telecom has used imported polycarbonate connectors to joint all small-size subscriber distribution cables. The connectors contain a petroleum-based filling compound to prevent moisture entry and are housed in jointing enclosures, above and below ground. Although polycarbonate is a tough material, its susceptibility to stress cracking and poor chemical resistance, particularly in the moist alkaline conditions frequently found in below-ground jointing enclosures, has caused a high incidence of connector faults. The service lifetimes of these connectors have been far shorter than the expected 30 year life, and significant maintenance and repair costs have been incurred.

Consequently, alternative materials and designs for this type of connector were sought internationally by Telecom from connector manufacturers. The Laboratories contributed to the development of more stringent material specifications and improved performance tests to assess the long term reliability of the connectors offered. Several types of





connector were evaluated, and polypropylene connectors of UK manufacture were selected for purchase by Telecom under a three year contract commencing in 1987. Under the terms of the contract, the supplier is required to produce connectors in Australia during 1988.

Chemical analyses conducted by the Laboratories detected significant deficiencies in the composition of the first batches of connectors received from the UK. These deficiencies related to the type, concentration and uniformity of dispersion of thermal stabilisers added to the polypropylene and modification of the wax in the filling compound. Recommendations by the Laboratories overcame these deficiencies and local production has now been commenced without further difficulty.

COLOUR CONCENTRATES FOR POLYETHYLENE INSULATION

The solid and cellular polyethylene insulation on copper conductors used in cables is colour coded to identify the wire pairs for connection and fault finding purposes. Colouring is achieved during extrusion of the insulation by the addition of 2-3% of a colour concentrate to the polyethylene pellets.

In previous Laboratories' studies of cable reliability, the composition of these concentrates was found to affect the lifetime of the insulation and therefore to be one of a number of important factors to control when designing polyethylene insulation to achieve the required 30-40 year service lifetime.

Following investigations of all degradative effects of the components comprising these materials, the Laboratories have developed a comprehensive technical specification for colour concentrates to be used in cables supplied to Telecom. The principal requirements are that:

- the coloured pigments are free of heavy metals
- the concentration of the titanium dioxide pacifier is kept to a minimum
- the carrier for the pigments is free of low molecular weight polymer components and dispersion agents.

Meeting the demanding Telecom specification presented a challenge to the capabilities of the concentrate manufacturers who participated in the work. Success was finally achieved in developing colour concentrates to the specification, as a result of close co-operation between the Laboratories and Australian industry. As a result of this work, Telecom has fostered the development of local sources of supply of the concentrates and is no longer dependent on overseas suppliers.

RELIABILITY PROBLEMS WITH COAXIAL CONNECTORS

Telecom uses a large number of coaxial connectors in its network systems and their reliability is very important. Recently, a change from European to locally made cable resulted in a significant increase in reported faults. Also, fitting connectors to the new cable required crimping with a hand tool, an operation reportedly causing abnormal incidences of muscular strain.

Investigation in the Laboratories established that most faults arose because of dimensional differences between the local and imported cables. After crimping, the braid was not sufficiently compressed for reliable electrical and mechanical connection. As a result of recommendations arising from the Laboratories' investigations, modification of the material composition and dimensioning of the aluminium crimp sleeve has been effective in achieving more reliable connection and reducing the crimping force required.

Above:
Partial cross-section of coaxial connector crimped joint shows that correct materials selection and parts dimensioning are necessary to ensure metal-to-metal contact (including cold welding).

Centre:
Colour concentrates for polyethylene cable insulation.

Above:
Telecom's Touchfone 200.

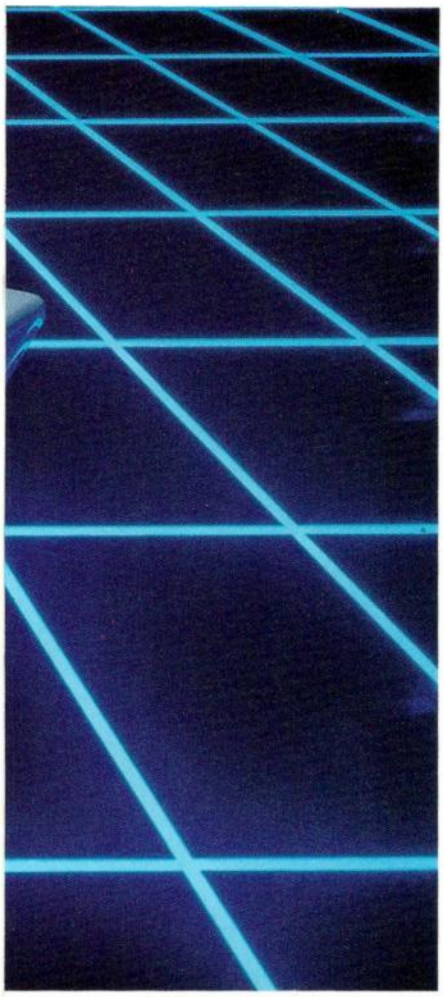
TESTING TELECOM'S NEW STANDARD TELEPHONE

The Laboratories have made significant contributions to the development of Telecom Australia's new standard telephone, the Touchfone 200. The telephone has been a joint development by Telecom and two Australian telecommunications companies, Alcatel-STC Pty. Ltd. and Amalgamated Wireless (Australasia) Ltd. Intended for home and business applications, the new telephone has been successfully developed for production by the two companies to Telecom's design specifications. Whilst the Touchfone 200 will become Telecom's new standard "first phone", it is hoped that it will also find export markets.

When compared with its predecessor, the Touchfone 200 is a radically new design. It combines a stylised appearance with many new technical features, including a membrane keypad, ringer pitch control, additional functionality and memory.

The Laboratories have provided reliability assessments, associated specialised testing and consultative services to the project. In particular, the telephone's keypad has undergone extensive testing during its development. The keypad contacts and tracks are formed by screen printing silver ink onto a thin plastic sheet, which is then folded into a sandwich construction. The tactile feel of the contacts is provided by domes formed in a plastic overlay. In the evolutionary development of the keypad, it was necessary to progress through several prototyping stages, as environmental and mechanical life testing detected cracking and sticking of the silver contacts, silver migration between adjacent tracks of the keypad and premature cracking of the plastic domes in early models. The faults associated with the silver trackwork were rectified by coating the silver surface with a thin carbon film and the life of the domes was improved by modifying the shape and forming conditions of the plastic.

Although most difficulty was experienced with the development of the keypad, environmental, mechanical and general suitability testing were also required for other components. These included the casing material (an ABS grade not previously used by Telecom), the handset cord (a change to



polypropylene insulation) and the wall plug (a revised moulded design).

By providing specialised test facilities and expertise not otherwise available, the Laboratories were able to support this local development of a new generation telephone which will provide Telecom with a quality product to offer to its customers, and hopefully also find a niche in overseas markets.

EVALUATION OF LEAD-ACID STATIONARY BATTERIES EXPOSED TO SOLAR CYCLING

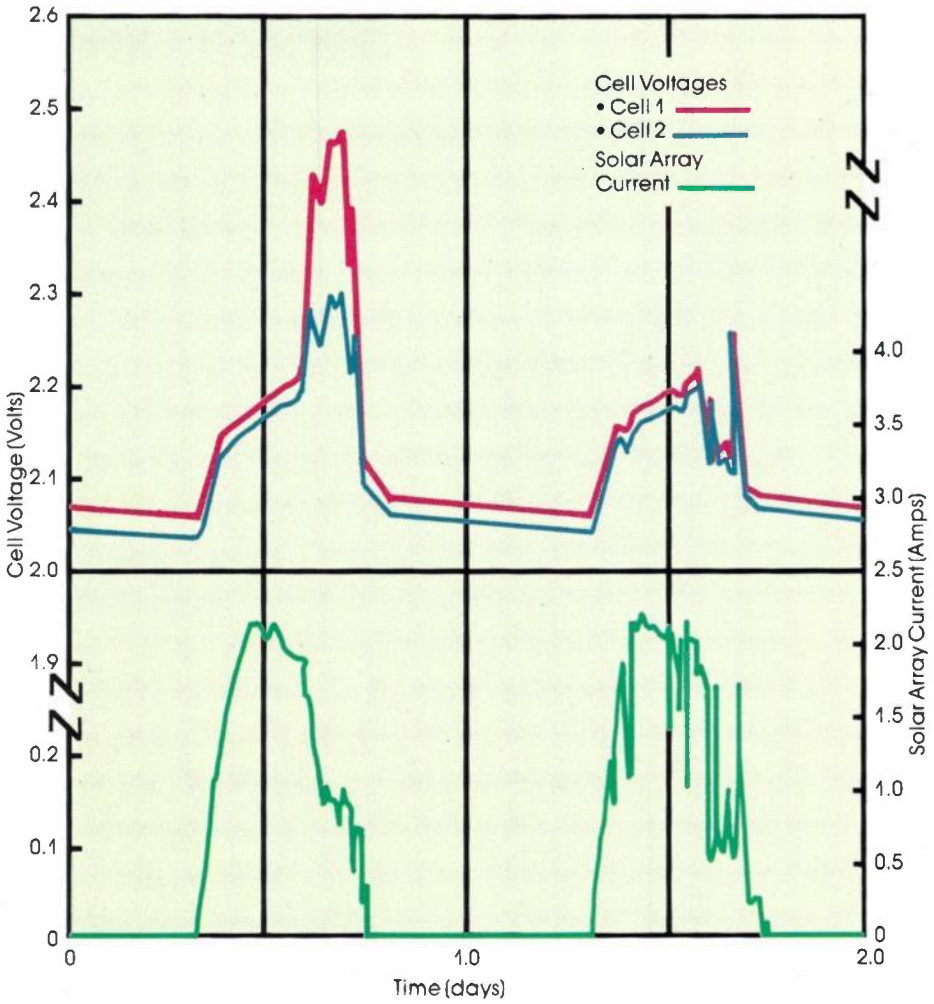
Since 1974, Telecom Australia has employed solar photovoltaic systems to power communications equipment located in remote, inaccessible areas of Australia. The storage battery is a very important component of these photovoltaic power systems, storing excess energy produced by the array during periods of high solar radiation and supplying the load during periods of low radiation and at night. However, increasing costs of batteries, relative to the total cost of the power system, has required that closer attention must be paid to optimising battery size and performance, in relation to cost, service life and the reliability requirements of the telecommunications network.

For several years, the Laboratories have been studying the performance of a number of stationary lead-acid batteries when subjected to solar cycling in the field. Field tests are being carried out at three locations, namely, at Cloncurry and Innisfail in Queensland and at Melbourne, Victoria. The batteries are subjected to extensive electrical and analytical tests before and after solar cycling, to determine any changes in battery ageing and performance characteristics caused by the solar cycling.

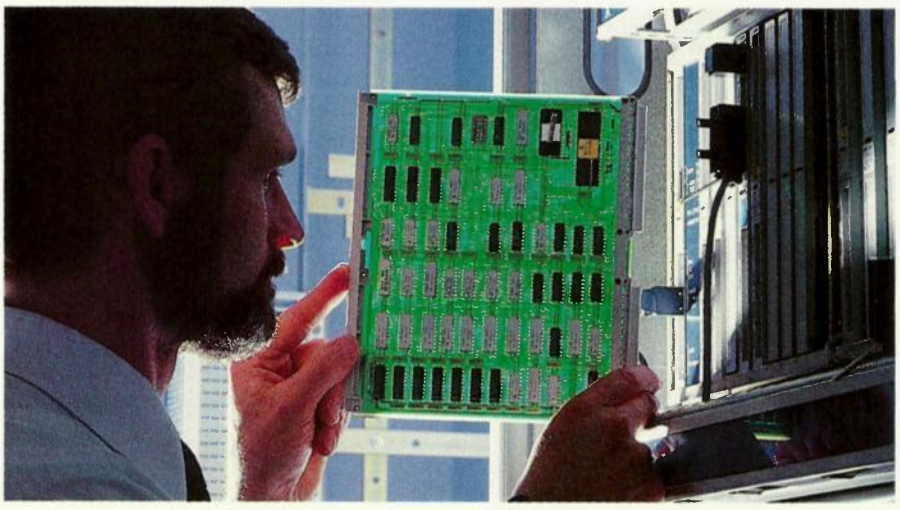
In recent tests conducted by the Laboratories, the batteries had been subjected to solar cycling for three years and most cells showed some degree of positive grid corrosion. Similar corrosion problems have been observed in solar batteries installed in trunk routes in many parts of Australia, requiring cell replacement within three to six years of installation, much less than the 10-year lifetime predicted by earlier studies.

The field test programme has shown that capacity of the positive plate initially increases, but that the capacity of the negative plate decreases by ageing during the solar exposure period. Increased temperatures in hot climates accelerate this process. Overcharging can also be detrimental. The individual cell potentials on charge are not uniform, due to the presence of different levels of impurities in the components of the individual cells.

These results indicate that it may be possible to use the float current of the cell (ie, the current drawn by a fully charged cell for a constant applied potential at controlled temperature) to predict the relative performance of different cells, in order to obtain optimum service life in solar power systems. This conclusion is being verified by further observations.



Solar power system parameters over a 2-day test period, showing potentials of two lead-acid cells versus solar array current.



ELECTRICAL PROTECTION OF THE AXE RURAL EXCHANGE

The AXE-104 Rural Exchange was designed jointly by L.M. Ericsson (Australia) and Telecom Australia as a transportable exchange with a maximum capacity of 2048 subscriber lines, which can be quickly installed to supplement an existing exchange or to provide a new exchange. In order to minimise the size and mass of the exchange, extensive use was made of the latest digital technology to provide all subscriber services using only one or two integrated circuits per line. As this technology had not been used before by Telecom Australia in this type of application, it was considered necessary to determine the type and extent of electrical protection that was required to enable the exchange to withstand the various types of electrical disturbances which can occur in the range of Australian network environments.

The two most common sources of disturbances are lightning strikes and the mains power system, while less common sources are electrostatic discharges and the signals used within the exchange, particularly the ring signal. All of these sources can cause voltage differences between conductors connected to the exchange equipment. These conductors include subscriber lines, trunk lines, mains power conductors, power earth, signal earth (if present) and protective earth.

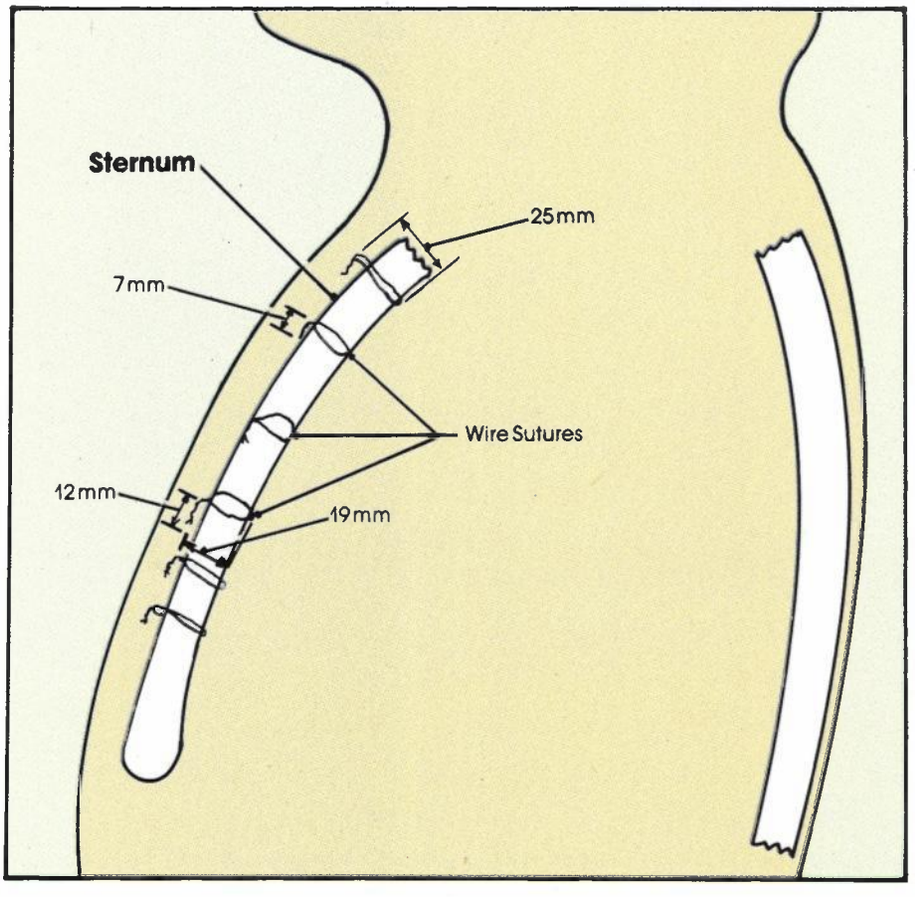
One method of determining the effect of disturbances is to artificially produce the electrical environment known to cause them. While this is the preferred method, it is often difficult to achieve in practice due to the limited energy capacity of available test equipment. The most commonly used method involves injecting artificially produced voltage and current waveshapes directly into the equipment being tested. The results obtained, however, depend upon the test parameters chosen, particularly the waveshape.

For the AXE-104 evaluation, a portable impulse generator (30 kV or 30 kA) was used to simulate lightning strikes, a smaller generator (6 kV or 125 A) was used to directly inject impulses of the type used to model the effects of lightning strikes on cables, and a specially constructed transformer (1500 Vmax, limited to 3 A) was used to inject timed surges of 50 Hz voltages. Tests were also performed to determine the effects of electrostatic discharges and accidental injections of the ring signal.

The AXE-104 exchange was found to have an acceptable ability to withstand electrical disturbances when it was protected with gas-filled protectors fitted to the main distribution frame. Only one failure mode was identified which might occur even when gas-filled protectors are fitted, but additional protective measures were not specified since the cost of providing the additional protection would easily exceed the cost of any damage over many years.

Left:
The AXE-104 rural exchange was jointly developed by Telecom Australia and L.M.Ericsson (Australia).

Below:
The AXE-104 Rural Exchange provides a versatile switching facility in the Australian rural environment.



Schematic side view of the sternum showing implanted wire sutures.

METALLIC IMPLANTS AND EXPOSURE TO RADIO FREQUENCY RADIATION

It has been recognised for some years that radio frequency radiation (RFR) may interfere with cardiac pacemakers, and the manufacturers of these units have taken steps to prevent this interference. However, it is less well recognised that other metallic implants and surgical prostheses may act as antennas in an RFR field and possibly cause adverse health effects through localised heating of body tissues.

During the past year, the technical expertise of the Research Laboratories has been joined to the medical expertise of Telecom's Human Resources Department and the wide operational experience of its Network Engineering and Operations Departments to develop a thorough approach to the investigation of particular RFR risks to which Telecom staff with such implants might be exposed in the performance of their duties.

The following steps are taken in each particular investigation:

- Information is obtained on the type of implant, its anatomical location, geometry and type of metal used.
- Information is obtained on the frequencies, field strengths and likely duration of exposure.
- The interaction between the incident fields and the implant is modelled on a computer and rates of energy deposition in surrounding tissues are calculated.
- The effect of any excess heat in tissues surrounding the implant is then considered in the light of the cooling efficiency and sensitivity of that tissue. The interaction must not cause more than a 1°C temperature rise.
- Medical advice is then given to the individual and to management on what precautions, if any, are to be taken.

The above approach is illustrated below for a case study of a male radio technician, aged 32 years, who had undergone cardiac surgery and still had the wire sutures securing his breast bone (sternum).

- Chest X-rays and clinical notes revealed 1 mm stainless steel wires forming loops and near-vertical twists of wire some 2 mm in diameter.
- It was ascertained that the subject is predominantly exposed to frequencies between 6 MHz and 22 MHz at very low levels (less than 2 mW/cm^2) but could possibly be exposed to levels up to the allowable limit of 25 mW/cm^2 for up to 8 hours, with provision for a short term exposure limit (STEL) of less than 6 minutes to levels up to 100 mW/cm^2. In future, he may be required to work at

Frequency (MHz)	Exposure Limits (mW/cm^2)	Temperature Rise (°C)
1650-3000	1	0.27
1650-3000	5 (STEL)	1.4
80	1	0.15
80	5 (STEL)	0.77
9.5	10	0.011
3	100	0.0045

Table 1: Tissue temperature rises at the exposure limits.

frequencies above 30 MHz, where the exposure limit is 1 mW/cm^2 for up to 8 hours, with provision for a STEL of 5 mW/cm^2.

- The calculated tissue temperature rises were as listed in Table 1. For the resonant range of the implants of 1650 MHz to 3000 MHz, corresponding to wire twist lengths of 12 mm and 7 mm respectively, the tissue temperature rise exceeded 1°C at the STEL. For the resonant range of the human body at about 80 MHz, the tissue temperature rise approached 1°C at the STEL.
- The implants were embedded in cartilaginous bone which was in contact with skin tissue capable of readily dissipating heat. Although some of the wire loops protruded inside the rib cage, the most critical parts were found to be the tips of the wire twists which were external to the rib cage and not in contact with sensitive tissue.
- The advice given to the subject and management was that the subject could safely work at exposure levels up to the occupational limits for frequencies below 30 MHz. However, no STEL work was permitted, particularly at frequencies between 50 MHz and 150 MHz and in the gigahertz range.

Future work to be performed in this topic area will include the evaluation of implanted plates, particularly those in the skull, and solids such as hip replacements.

A FREQUENCY DIFFERENCE METER

In the performance of the Laboratories' responsibilities to develop and disseminate standards of time interval and frequency throughout Telecom, a digital frequency difference meter has been developed for portable use in the calibration and monitoring of precise oscillators used in a variety of Telecom's network operations. Unlike other commercially available instruments, the frequency to be measured (as well as the reference frequency) may be any multiple of 1 kHz. One widely available reference source is the 1 kHz signal derived from the Laboratories' caesium beam frequency standard and distributed by a two-tone transmission technique throughout Telecom's network.

The frequency difference meter provides a numerical display of the fractional frequency difference, while an auto-scaling display continuously indicates the variation of the frequency with time, to facilitate the adjustment of oscillators. A separate truncated-scale analogue output is also provided to drive a chart recorder.

The instrument operates by measuring the inherent phase drift between the frequency being monitored and a reference standard frequency, when both are divided down to a common 1 kHz level. Time interval averaging techniques are used for high resolution phase measurement, with a varactor-controlled clock in-built to ensure the required non-coherent counting. A line of best fit gradient computation then produces the frequency difference reading. With a stable reference frequency, the achievable accuracy is substantially better than 1×10^{-10} for a 10 second measurement time. The facilities designed into the instrument cater for accuracies up to 1×10^{-13} for a measurement time up to 1000 seconds.

With the testing of the Laboratories' prototype instrument now successfully completed, further instruments are being produced for use by Instrument Calibration and Transmission Measurement Centres throughout Telecom Australia in the calibration of frequency sources applied in Telecom's operations.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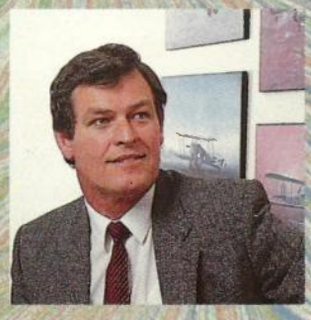


TECHNOLOGY & INFORMATION TRANSFER

The primary role of the Research Laboratories is to ensure that Telecom Australia has timely and relevant advice regarding new and existing technologies. The Laboratories' work programme is guided, established and reviewed by corporate processes to ensure its relevance to Telecom's needs for such advice. It comprises a number of R&D projects which generally seek to develop technical knowhow across the spectrum of evolving telecommunications science and technology and to transfer the knowhow to Telecom "client" Divisions, for application in specific projects relating to the planning, implementation or operation of services and networks. These processes of technology and information transfer are ongoing and multi-faceted. They occur through day-to-day working interactions between Laboratories' staff and those of the client Divisions and through other formal and informal technology and information transfer mechanisms.

In general, significant and conclusive outputs from the Laboratories are documented in technical reports and papers, published by Telecom Australia or presented for publication in the learned journals or conference proceedings of external organisations. These publications provide a formal means of information transfer from the Laboratories to specific Telecom clients, to interested Telecom management and staff, and to external R&D organisations, industry and academia. In addition, the Laboratories participate in the presentation of technical seminars and training courses which aim to transfer information to wider audiences in both Telecom Australia and the wider telecommunications community.

Other formal and informal processes provide avenues for technology and information transfer to and from the Laboratories. The Research Laboratories enlist the expertise and assistance of other R&D organisations, industry and academia through formal contracts for the performance of particular R&D projects, collaborative R&D arrangements and less formal peer group interactions.

Outputs from Laboratories' projects also yield inputs to national and international standardisation activities.

On occasion, industrial property licences are negotiated with external organisations for the commercialisation of inventions and other forms of industrial property arising out of the work of the Laboratories or other parts of Telecom Australia.

The following items illustrate some of the more noteworthy examples of technology and information transfer from and to the Laboratories which have taken place over the past year.

QPSX - STANDARDISATION AND TECHNICAL SUPPORT

The concept of a Queued Packet and Synchronous Circuit Exchange (QPSX) as the basis of a Local Area Network (LAN) or a Metropolitan Area Network (MAN) was invented by the University of Western Australia. The concept was successfully developed to laboratory prototype stage by the University with the assistance of an R&D contract issued in February 1985 to the University by Telecom Australia. This contract was managed by the Laboratories and provided a vehicle for close interaction between Telecom's Laboratories and the University during the prototyping phase. The successful conclusion of the prototyping and testing phase showed that QPSX was a promising innovative telecommunications product, such that in mid-1987, the University and Telecom formed a joint venture company, QPSX Communications P/L, to produce and commercialise QPSX products.

Telecom's confidence in the QPSX product was demonstrated by its execution in late-1987 of a contract with QPSX Communications P/L for the supply of QPSX pilot networks for field evaluation in one or more major Australian cities. This latest phase in the QPSX project is being managed by Telecom's Corporate Customer Division, with ongoing technical assistance from the Laboratories.

QPSX is a distributed broadband communications switch which is suited to application as a LAN or MAN. As a MAN covering areas up to 50 km diameter, it can be used at data rates to 150 Mbit/s for interconnection of LANs, computer mainframes and PABXs, with considerable performance and reliability advantages over competing technologies. Since QPSX provides integrated packet and circuit switching facilities, it offers particular advantage as a means of meeting the voice and data services needs of corporate and business customers.

In the 3-year history of the QPSX project to date, there has been close interaction at technical levels between the University and the

Laboratories. Over this period, the Laboratories have provided significant technical support of the QPSX development in two areas, namely:

- international standardisation of QPSX concepts
- QPSX performance analysis and optimisation of flow control in QPSX.

QPSX Standardisation

When the key advantages of QPSX as a MAN were first recognised, Telecom and the University approached the relevant standards group within the IEEE P802 Committee for LAN standards. A submission was prepared and two researchers from the University and one from Telecom attended the July 1986 meeting of the IEEE P802.6 MAN standards group, which was developing a slotted ring based standard at that time. The same level of representation of the QPSX concepts has been maintained at subsequent meetings of this IEEE Committee, and it has attracted several US telecommunications companies to take interest in the more computer-oriented standardisation activities of the IEEE.

Telecom's contributions to the case for international standardisation of the QPSX concepts have comprised assistance to the University staff with the drafting of a proposed standard, the joint presentation of a tutorial on QPSX to the IEEE 802 plenary meeting in November 1986 and the preparation of a document on the functional requirements for MANs. The latter was adopted by the proponents of all competing MAN proposals within IEEE 802.6.

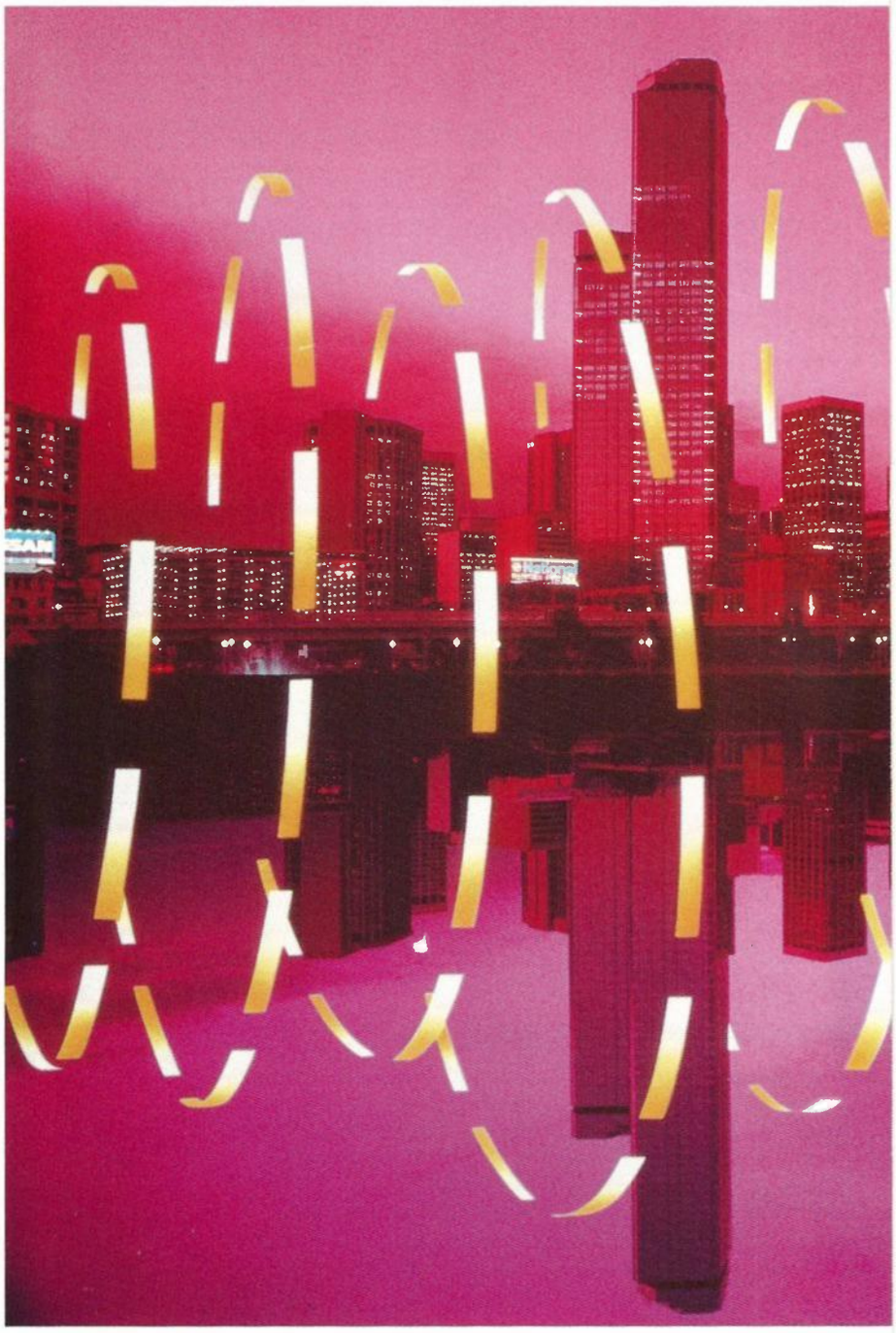
Outcomes of the QPSX standardisation effort thus far are that QPSX has received strong support from Bell operating companies and other key groups in the USA, to the extent that it has been chosen as the only Medium Access Control (MAC) protocol on which IEEE 802.6 will continue to work. The QPSX MAC is to be coupled in the proposed IEEE 802.6 architecture with an AT&T proposal for a multiport bridge based on fast packet switching technology for interconnection of QPSX access networks.

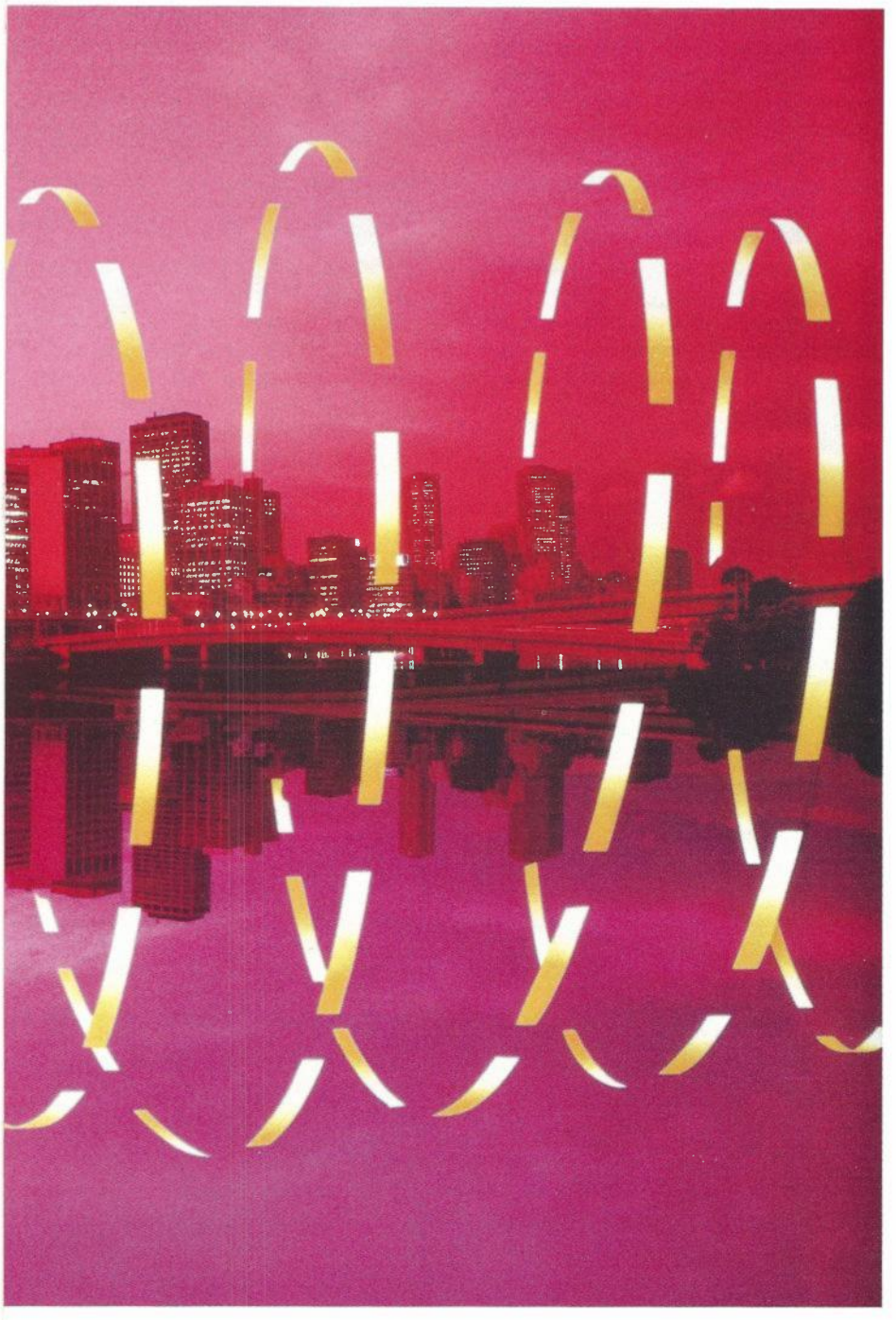
QPSX Performance Analysis and Flow Control Optimisation

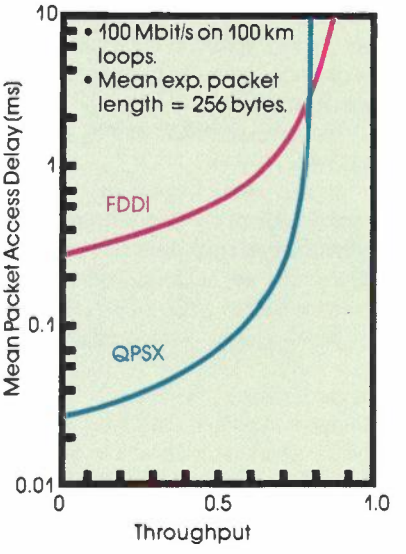
In addition to supporting QPSX standardisation, the Laboratories have undertaken comprehensive analysis and simulation of the performance of QPSX, comparing it with other available systems. The Laboratories have also developed a flow control mechanism to increase QPSX efficiency and to maintain a high level grade of service under heavy traffic loads.

In providing integrated packet and circuit switching, QPSX has part of its capacity dynamically allocated for synchronous circuits and the remaining capacity is available for packet switched traffic. In the framing structure of QPSX, time is divided into fixed length frames. Every frame is divided into slots, each consisting of 31 octets (excluding overheads) available for transmission. At any point in time, some of the slots are allocated to synchronous circuits. These slots are designated "isochronous". The slots which are not allocated to synchronous circuits may be used for packets and are designated "non-isochronous". Each of the 31 octets within an isochronous slot is used as a voice channel. Hence, each isochronous slot can be regarded as 31 synchronous channels. Even if only one octet out of the 31 available in a slot is allocated to circuit switching, the entire slot is designated isochronous, thus becoming unavailable for packet switching. To minimise this potential waste of QPSX capacity, an efficient circuit allocation and flow control mechanism was developed.

Initial studies of the performance of the packet-access protocol were based on assumptions of fixed or zero synchronous traffic. These studies enabled an analytical formula for the mean access delay performance of the QPSX packet switch to be







Comparison of access delay performance of QPSX and FDDI.

Left:
QPSX offers a new means of providing integrated voice and data services for corporate and business customers.

Below:
The concepts of QPSX being discussed.

determined as a function of the packet throughput. Comparison of this mean access delay with the published results for mean delay of other MAN protocols such as the FDDI token ring indicated the superiority of the QPSX distributed queueing protocol.

A more general case was investigated in which the capacity allocated to synchronous circuits is permitted to change with time, requiring consideration of the interaction of the circuit capacity and the packet queue. Traffic burstiness and fluctuations in the capacity made available for packets cause "overload periods" in which the service rate is lower than the arrival rate, although the average service rate during the entire period is higher than the average arrival rate. Avoiding such overload periods is especially important in hybrid switching systems. This is due to the fact that the duration of packet overload, caused by the access capacity used by circuit switching, is in the order of minutes and constitutes a very long time duration relative to the packet service and arrival rates, which are in the order of milliseconds.

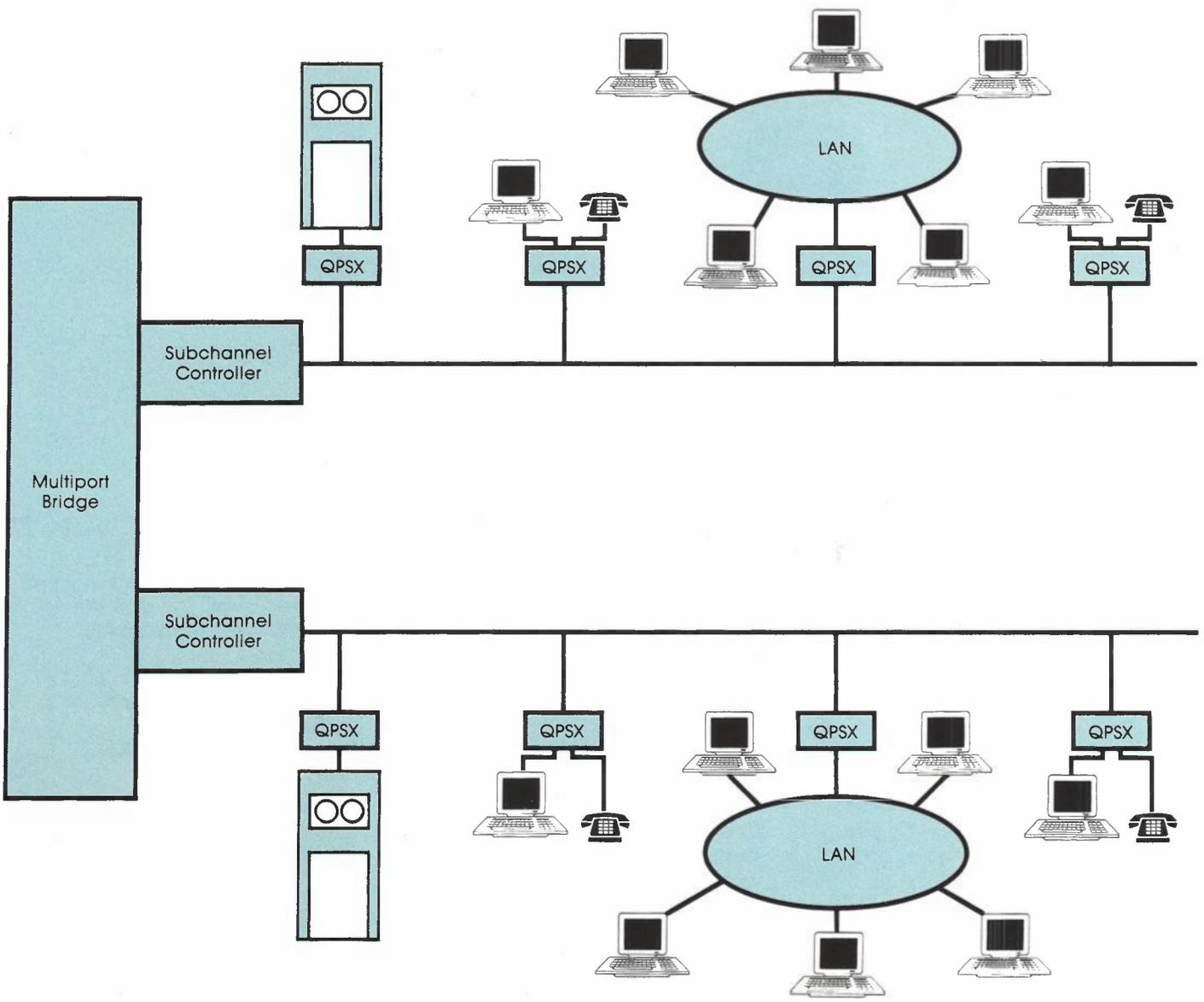
These general analyses performed in the Laboratories provided a tool for design, dimensioning and optimising flow control policy

to avoid the possibility of long overload periods. The tool was applied in the study of QPSX performance in which fluctuating capacity was considered.

The study was conducted in three stages, as follows:

- In the first stage, the statistical characteristics of the packet capacity were obtained, based on analysis of circuit loading under smooth and bursty traffic conditions.
- In the second stage, the performance of the packet queues were evaluated. This evaluation could not be performed using the classic methods available in the theory of queues, since the fluctuation in capacity available to the packets complicates the problem. The utilisation of methods in the new evolving area of computational probability made it possible to gain insights into the packet queueing behaviour. Numerical results for average delay, blocking probability and throughput were obtained for both conventional and fast packet switching applications.
- The third stage resulted in the provision of an efficient flow control mechanism to handle traffic under overload situations and to reduce the waste inherent in the QPSX framing structure, based on understanding of the packet queueing behaviour.

The abovementioned ongoing support provided by the Laboratories to the international standardisation and technical development and performance analysis of QPSX over the past three years has not only been of benefit to the commercialisation of the QPSX product by the joint venture company, QPSX Communications P/L. It has also provided Telecom Australia with new basic tools for planning and dimensioning QPSX networks, and has ensured that any future use of QPSX in Australian MANs will be compatible with such use in overseas countries, because of the international standardisation activity.



A Metropolitan Area Network (MAN) architecture using QPSX.

FLEDGLING FABRICATION OF FLUORIDE FIBRES

In 1984, the Laboratories commenced investigations of new glass materials, the so-called heavy metal fluoride glasses, that offer the potential to provide ultra-low-loss optical fibres for long-distance communications in the mid-1990s. From their outset, the Laboratories' investigations have depended on close collaboration with outside organisations, thereby co-ordinating Australian expertise and focussing the limited Australian research skills on an important future telecommunications application.

In particular, the Laboratories have collaborated closely with Monash University, which has contributed its special expertise in glass chemistry and produced samples of fluoride glasses in a form suitable for fibre drawing experiments in the Laboratories. Telecom has also placed R&D contracts in support of its investigatory programme with the Research Laboratory of Amalgamated Wireless Australasia Ltd. for the design and construction of a modular fibre drawing tower. The tower is now installed at the Telecom Research Laboratories as a means of producing experimental fibres. Other contracts have been issued to Quentron Optics P/L (now Laserex Operations P/L) to research and develop a tunable mid-infrared laser source for use in Laboratories' testing of fibres over a range of wavelengths.

Late in 1987, a major milestone was reached in this programme of investigations of the potential of mid-infrared optical fibre communications systems. The first Australian optical fibres from fluoride glass were successfully drawn at the Telecom Research Laboratories' facility. The optical fibres were made from glass based on heavy metal fluoride compounds and containing no oxides of any kind. During the drawing process, the fibres were coated with a thin layer of teflon to provide protection and additional strength during laboratory testing.

Because of the physical properties of the silica glass materials, oxide glasses absorb light at wavelengths longer than about 1.5 micrometres. This limits their transparency and determines the minimum achievable attenuation performance of optical fibre transmission media made from these glasses. By contrast, fibres made from the new fluoride glasses can transmit light effectively at wavelengths in excess of 3 micrometres, and the physical properties of the glass materials are such that they are potentially much more transparent than oxide glasses. Theoretically, signal attenuation in optical fibres made from fluoride glasses is up to 20 times less than in conventional silica fibres. In transmission engineering terms, this promises distances of up to 1000 km between repeaters in optical fibre transmission systems employing these glasses. Such a significant reduction in the need for repeaters could dramatically reduce the cost of future-generation optical fibre trunk transmission systems, particularly those used in the Australian outback or on submarine cable routes.

However, the practical realisation of these benefits presents a significant R&D challenge, in that fluoride glasses are much more difficult to process than silica glasses. Precise compositions and temperature treatment profiles must be developed in order to form the glass and then draw it into a fibre having the right optical and mechanical properties.

To date, the Laboratories' investigations have sought to draw experimental fibres in relatively short lengths of about 100 metres for laboratory evaluation of the fibre drawing process and the optical transmission properties of the fibres. The recent successes in drawing and coating such experimental lengths of fibre marked an important initial step.

However, before a viable fluoride glass telecommunications fibre can be realised in production, a number of aspects of the task must be researched. These include investigations of refractive index structure and control, the identification and elimination of causes of extrinsic optical loss and microcrystal formation, the purification and handling of ultra high purity raw materials, and development of hermetic coatings.

Above:
Laboratories' scientist, Yasuo Ito, inspects a sample of fluoride fibre.

Left:
The Telecom Research Laboratories optical fibre drawing tower in operation.

Although telecommunications fibres made from fluoride glass are speculation at this early stage of research, this promising new technology merits a significant Australian effort for a number of reasons. These include considerations that Australia has the major world supply of the necessary raw materials, its industries have key knowledge in materials purification and processing, and it is one of the few countries able to gain most benefit from the use of long-distance repeaterless terrestrial fibre links. Other applications of this new technology are possible, including medical, sensor and defence uses of fluoride fibres.

Early in 1987, it became obvious that the research programme on fluoride glass fibres needed to tap further skill areas residing in Australian industry. Accordingly, with Telecom's Research Laboratories acting as a catalyst and R&D collaborator, Monash University submitted an application to the Federal Department of Industry, Technology and Commerce for financial assistance for R&D in the field of fluoride glass technology under the Department's Grants for Industry Research and Development (GIRD) scheme. Industrial collaborators in this submission were ICI Australian Operations P/L, Austral Standard Cables P/L, the Melbourne Research Laboratories of BHP Co. Ltd. and KEL Aerospace P/L.

The application was successful, and more than $800 000 has been allocated to the University for the project over a three year period. These GIRD funds are being used to expand the research teams in the Departments of Chemistry and Materials Engineering at the University. As a condition of the grant, the industrial collaborators are required to commit significant internal resources, thus multiplying the total resources available to the project by a substantial factor. By contributing research expertise and effort to the project, Telecom will gain insights into the total spectrum of technology needed to realise this future generation of fibre communications media; the University will gain vital support for its materials research projects; and Australian industry will gain an opportunity to develop new commercial products.

On the whole, the allocation of the GIRD grant has provided a vehicle for focussing Australian R&D effort in this potentially important new field of telecommunications technology. Telecom's Research Laboratories, as one of the players in this expanded project, looks forward to its future outcomes with confidence.

COMMUNICATIONS PROTOCOL TEST SETS

Protocols are the "rules" which make communications between people easier. When we talk, we usually introduce ourselves, exchange pleasantries, cover the important issues and then finish with further pleasantries. This is an example of a loosely defined protocol. When we write to someone, we use a protocol that is a little more defined, while, in international diplomatic relationships, protocols are much more defined, with rules that are both written and unwritten.

In a similar way, communications protocols define the rules which facilitate orderly and compatible communications between two (or more) pieces of equipment. Different protocols are used in different circumstances, with each designed to perform the required functions to establish the communications link between the equipment and successfully perform the information transfer process.

With the current evolution of modern communication facilities such as the Integrated Services Digital Network (ISDN), computers are, and will increasingly be, used both within the network infrastructure and in customer terminal equipment to provide a diverse array of telecommunications services for the transfer of information in voice, text, data or image forms. Since the ISDN concept provides for a single access interface between the customer's terminal and the network for the provision of this array of services, the associated protocols for such communications are very complex. Even today, quite complex protocols are required to establish the necessary network connections to provide modern data and text services.

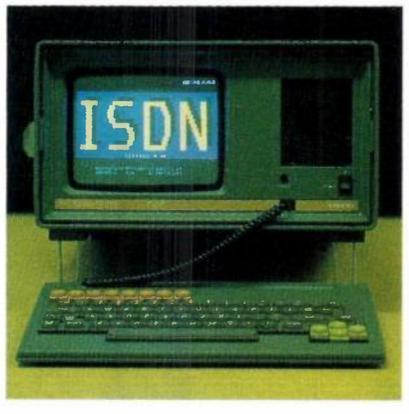
The global nature of telecommunications services requires that these protocols are developed within international standard specifications and that their implementations, in all possible permutations which might eventuate in operations, are carefully tested to ensure that they perform the required network functions without error.

To make sure that the protocols introduced into the Australian network are functioning correctly, the Laboratories have recently undertaken joint development projects with Siemens (West Germany) and Siemens (Australia) to develop an ISDN Protocol Tester and a Common Channel Signalling System (CCSS) No. 7 Protocol Tester. The ISDN tester development was successfully completed in late 1987. The CCSS No. 7 tester development was then begun and is currently well in hand.

The protocol testers are seen as an essential part of providing a capable and reliable network for Australia. The joint development with industry has meant that the combination of skills has brought a better product to market faster than could have been done separately by either organisation. The joint projects have also provided a vehicle for mutually beneficial information transfer between the organisations involved in the more general field of protocol engineering.

The ISDN Protocol Tester has been designed to allow it to be easily modified to suit specific national or private protocol variations. It is already being sold overseas by Siemens.

Below:
The Siemens/Telecom Australia ISDN protocol tester.



AUSTRALIAN USE OF FORMAL DESCRIPTION TECHNIQUES FOR COMMUNICATIONS PROTOCOLS

Despite the sophistication of today's communications systems, design errors are abundant in the protocols (ie, the rules and procedures for information exchange) that support them. Modern protocols are diverse and complex, and sophisticated techniques and computer-based support tools are needed to eliminate these design errors. Formal Description Techniques (FDTs) provide designers with a language for describing protocols and a basis for developing tools to help designers cope with their complex tasks.

The Research Laboratories have been actively supporting and promoting work on FDTs since the early 1970s, when significant contributions to the development of the CCITT's standardised Specification and Description Language (SDL) were made. Subsequently, the Laboratories developed CADDIE, a graphical drawing package for SDL. This work led to the issue by Telecom of R&D contracts to the Royal Melbourne Institute of Technology (RMIT) for the development of a system called MELBA, for producing program code from SDL. A PC-based derivative of MELBA, which is a graphics package for drawing SDL, is now being used within Telecom Headquarters and State Administrations. It has also been offered for sale, and several Australian and overseas companies have indicated interest. More recently, another R&D contract has been placed with RMIT for a study of the ISO FDT standard, LOTOS. As an outcome of the contract, a prototype of a LOTOS tool for specifying and validating protocols will be available early in 1989.

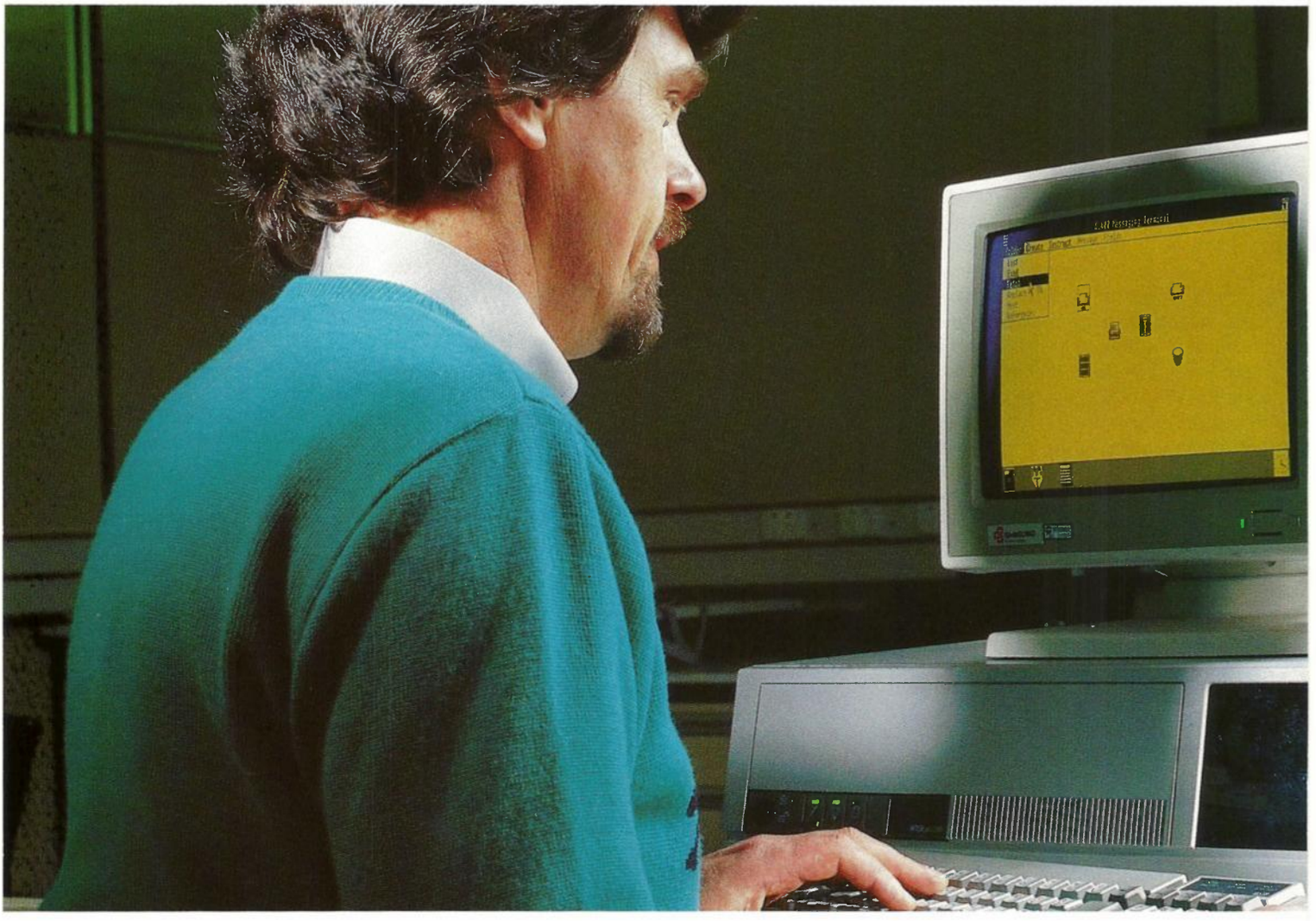
The Laboratories have extensive experience in the use of another FDT based on high-level Numerical Petri Nets (NPNs), and have developed a software tool, called PROTEAN, to identify errors in protocol designs. NPNs are particularly suitable for the development of tools that support the design process, and the Laboratories have encouraged their study by making PROTEAN available to Australian tertiary institutions. PROTEAN is now used by six such academic institutions, a division of CSIRO and Cambridge University (UK). It has also been licensed to Danish, German and New Zealand telecommunications organisations.

It is particularly gratifying to Telecom to note the increasing interest in studies of communications protocols at under-graduate and post-graduate levels in Australian universities and similar institutions. At the Telecom-funded Teletraffic Research Centre at the University of Adelaide, the application of Petri Nets for studying the performance of protocols is being assessed. At LaTrobe University, several students are also investigating protocol verification problems using NPNs. At the Canberra College of Advanced Education, a large study of the application of Petri Nets to transport protocols has recently been performed. At the University of Tasmania and Deakin University, some early work on NPNs is under way. This academic interest augurs well for the future availability of graduates with background knowledge in this important field of telecommunications.

In 1985, an R&D contract was placed with Unico Computer Systems P/L for the development of computer programs to implement transport protocols semi-automatically from a Petri Net specification. The successful completion of this contract led Unico to propose the development of a general tool for automatically implementing NPNs and for providing protocol testing capabilities. This development is being partially financed from Telecom's Product Development Fund.

Several years ago, the CSIRO Division of Information Technology joined the Laboratories in promoting the work on Formal Description Techniques. More recently, the Overseas Telecommunications Commission (Australia) has also become involved. The impetus of this involvement is expected to lead to increased use of FDTs by Australian organisations. In turn, this will improve the quality of protocols and other specified systems and reduce the cost and difficulty of their implementation.

Left:
The Telecom Research Laboratories.



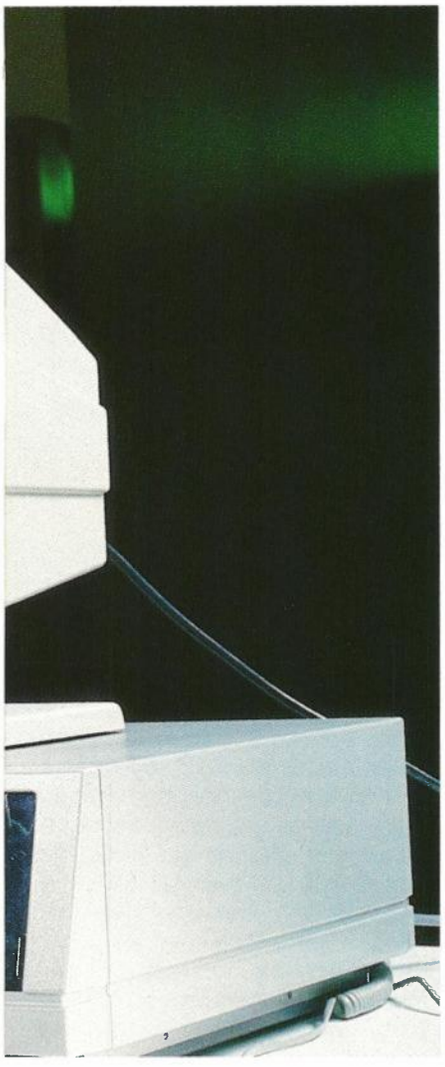
Above:
Laboratories' engineer, Alan Jenkins, tests an implementation of X.400 protocols for PC-based electronic mail.

ELECTRONIC MAIL ON PERSONAL COMPUTERS

Message Handling Systems (MHS) described in the CCITT X.400 Series Recommendations enable users to exchange electronic mail messages within a store-and-forward environment. Users send and receive mail with the help of software called "User Agents", while "Message Transfer Agents" co-operate to perform the store-and-forward function. Although the functionality of a User Agent can be located in the network and accessed with a conventional terminal, it is important to plan also for the future integration of the large installed base of personal computers into a public message handling service.

To determine the feasibility of combining electronic mail with more conventional applications software (such as word processors and spreadsheets) in personal computers, the Laboratories contracted Yezerski Roper and Associates, an Australian company specialising in computer communications, to develop software for an electronic messaging terminal conforming to the X.400 Series of Recommendations.

The CCITT's MHS standards specify a large number of user facilities, and to minimise complexity, this software employs an electronic representation of an office environment, enabling the user to relate familiar objects to possibly unfamiliar functions. From an initial display, a user selects functions such as reading messages from the "IN" tray, preparing a message, consulting a local telematic directory or performing housekeeping activities like filing. Once messages have been prepared, they are "moved" to the "OUT" tray. While the user continues with other work, a background task



formats each message in accordance with the standard and forwards it to a Message Transfer Agent. Incoming documents from the Message Transfer Agent are automatically translated to plain text and transferred to the "IN" tray before the user is notified that mail has been received. The user is thus isolated from all connection protocols and communications aspects of the electronic mail service.

The software developed under this contract has successfully demonstrated that, in addition to other more conventional personal computer applications, it is possible at modest cost to implement a fully functional electronic mail terminal on personal computers which have the computing power of a typical IBM PC AT.

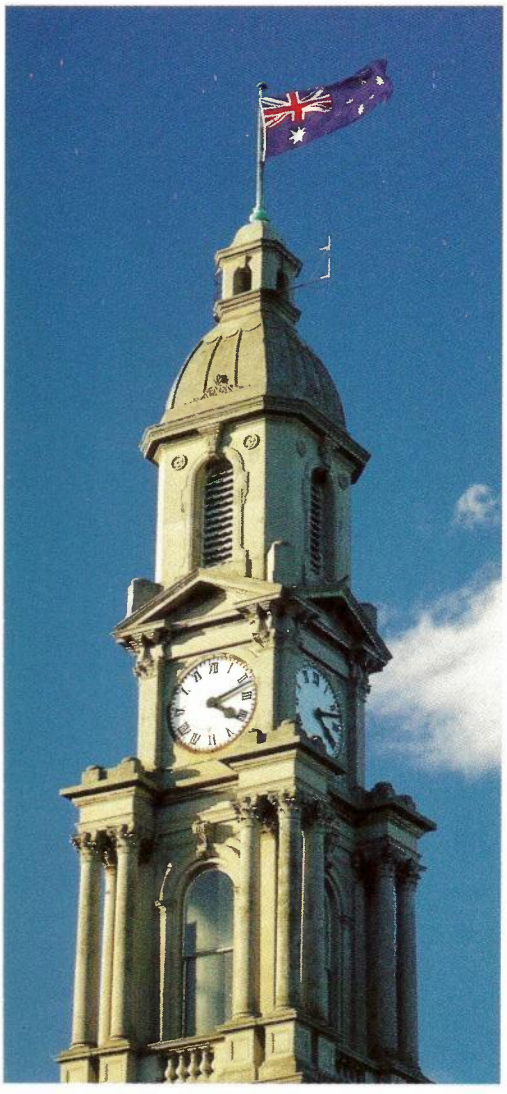
FUTURE MOBILE SYSTEMS

In 1986, Telecom Australia issued a research and development contract to Philips Communication Systems (Australia) Ltd. for a study, over a 2.5 year period, of future digital mobile radio system techniques and design parameters. The study is being undertaken in collaboration with Laboratories' staff, and the contract is also providing a vehicle for technology transfer from the Philips research centre in West Germany, which is also lending expertise to the studies.

The studies encompass next-generation cellular digital mobile telecommunications systems, which will succeed Telecom's present Cellular Mobile Telephone Service and provide enhanced mobile voice and data services to greater numbers of customers.

Many overseas proposals for such systems involve cells which are only several hundred metres in diameter (ie, "microcells") and low-height base station antennas, typically 5 to 10 metres high. For such cells, the automatic switching ("handover") of calls from one cell to another will be much more frequent than with current systems. In addition, the radio propagation characteristics and critical performance parameters of such next-generation systems are relatively unknown. The studies being undertaken under the contract have therefore concentrated on spectral efficiency for micro-cellular systems, handover algorithms and radio propagation characteristics.

Tangible results of the contract to date include two comprehensive reports and associated presentations by Philips' research engineers to Telecom staff, and the outposting of a Philips' engineer to work in Telecom's Research Laboratories.



Above:
The new speaking clock system provides a hi-tech alternative to historic public time-of-day services.

ANNOUNCING UNIT FOR A NEW SPEAKING CLOCK SYSTEM

The electro-mechanical "speaking clock" systems which were established in 1955 to provide Telecom Australia's "Dial-it" Time of Day service are nearing the end of their useful service lifetimes. However, the Time of Day service is one of Telecom's most used "Dial-it" services. In 1987, over 49 million calls were made to the service, accounting for about 38% of calls made to all "Dial-it" services.

In recent years, the Research Laboratories have been developing a replacement system for this service in collaboration with the Network Engineering Department and local industry, with the primary responsibility for system design falling on the Laboratories. The new system will utilise up-to-date solid state circuit technology and microprocessor control techniques to select and assemble the time announcements from stored digitally encoded voice announcements of words and phrases. To ensure system reliability, key units of the system will be duplicated and a supervisory unit will monitor and maintain continuity of the service.

The design of the new speaking clock system and the successful prototyping of its principal units have been completed in the Laboratories. Final production prototyping and supply of the various units of the new system have recently been, or are being, completed with the assistance of local industry.

The complete speaking clock system will comprise:

- duplicated phase locked oscillator units, which are being manufactured under a Telecom contract by Design 2000 P/L
- civil time receiver units, manufactured to a Laboratories' design specification by General Electronic Developments P/L
- a time signal distribution unit, manufactured by the Adelaide Workshops of Telecom Australia
- duplicated announcing units and a system supervisory/control unit, production prototyping of which was undertaken by Assmann Australia P/L in collaboration with the Laboratories under a Telecom research and development contract.

The latter units are the most recently developed units and their realisation completes the new speaking clock system development. The announcing units contain the digitally encoded recorded words and phrases required for the voice announcements of the time of day. Every 10 seconds, the announcing units select the appropriate words and assemble them into the correct voice announcement. The supervisory unit then checks the form of the announcement, adds the time signal "pips" and transmits the announcement. The supervisory unit also conducts regular checks of the local clock oscillators, the audio output level and system alarms.

This research and development project is now reaching a satisfactory outcome and this has been achieved by Telecom with the co-operation of local industry. New speaking clock systems will be installed by Telecom in all capital cities of Australia (including Darwin) as the vehicle for providing its Time of Day service for the foreseeable future.

TELECOM AUSTRALIA'S PRODUCT DEVELOPMENT FUND

Telecom Australia has undertaken a number of initiatives, particularly since 1984, to encourage Australian design and development of telecommunications-oriented products. To further increase its commitment to local industry, Telecom proposed the establishment of the Product Development Fund (PDF) in a submission to the Inglis Review Committee on Government Technology Purchasing Arrangements. The Fund was launched on 27 January 1987 with an annual budget of $5 million. It is specifically aimed at small and middle sized Australian companies. It makes funds available to selected local entrepreneurs and inventors who wish to promote ideas, concepts or developments for possible adoption within the Australian telecommunications network. In addition to such financial assistance for new product development, Telecom will, on occasion, lend some projects the benefits of Telecom's engineering knowledge and facilities as development aids. In return for these funds and assistance, Telecom seeks industrial property rights in a particular product commensurate with its inputs to the project.

The PDF is controlled by a Committee of Senior Management under the Chairmanship of the Executive Aide to Telecom's Chief General Manager. The inaugural PDF Committee comprised Ross Carruthers (Chairman), John Harrison (Commercial Services Department), Fred Campbell (Network Engineering Department), Fred Symons (Research Laboratories) and John Higginbottom (Accounting and Supply Department). The full-time Manager of the Fund is located in the Research Laboratories, but co-opts resources from throughout Telecom to assist in the assessment of applications for funding. In particular, the Technical Liaison Office (Network Engineering

Department) and the Industrial Property Section (Research Laboratories) play significant roles in the operation of the Fund. All Laboratories' Branches have, on occasion, been involved in technical aspects of the assessment procedure, and several are now involved in continuing liaison with successful applicants during the product development phase.

In the first year of operation of the PDF, 10 contracts for a wide variety of product developments were let by Telecom at a cost of over $1.5 million. This is expected to increase dramatically as the fund becomes better established and more widely known throughout local industry.

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

Telecom Australia is aware of the external R&D capabilities in telecommunications science and technology which exist in local industry, in academia and in specialised Australian research institutions such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Recognising the mutual benefits of co-operative effort, it actively supports pertinent projects in these organisations through formal contracts and agreements and through its participation in the activities of bodies such as the Australian Telecomunications and Electronics Research Board (ATERB).

The Telecom Research Laboratories act as one channel for the provision of such support by Telecom, in particular, for research studies on telecommunications topics having potential application in the longer term development of the telecommunications network. The Laboratories also contract out development projects in specialised fields to meet an instrumentation or similar technical need which cannot be met from the usual sources of supply.

In addition, as outlined in the previous item, the Laboratories administer Telecom's Product Development Fund. Through the Fund, Telecom provides financial and occasional technical assistance to selected industrial entrepreneurs proposing to develop new and promising telecommunications-oriented products.

During 1987/88, the Research Laboratories have managed a portfolio of 17 R&D contracts with industry (total value $3.5 million) and 26 R&D contracts with other R&D institutions and academia (total value $2.7 million). The durations of the contracts vary from less than one to several years.

Total expenditures on extramural R&D by the Research Laboratories in 1987/88 will be approximately $2.3 million. Of this total, $0.25 million will be disbursed to academia via ATERB for R&D on telecommunications topics. The remainder comprises direct payments made to R&D contractors and occasional specialist consultants.

R&D contracts administered by the Laboratories during the past year concerned the study topics or developmental projects listed below:

Contracts with Industry

Research investigations of:

- Services Interworking, Communications Protocols and Interfaces Utilising an Experimental ISDN Exchange
- Cellular Digital Radio Transmission Systems for Mobile Services
- Interconnect Technology in Metal Oxide Semiconductor (MOS) Devices

Development of:

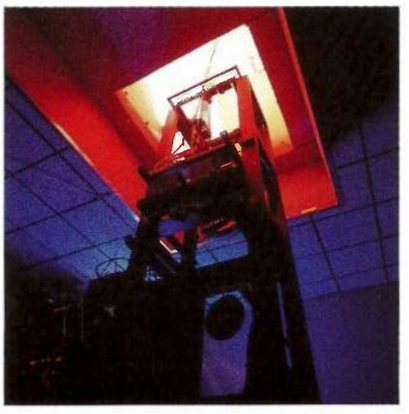
- A Gas Corrosion Test Facility
- An Optical Regenerator Test Instrument
- An Announcing Machine for the Speaking Clock Service
- A X.400 Messaging Terminal
- An Antenna Rotator
- Calibration Facilities for Photovoltaic Cells
- Mobile/Portable Earth Terminal for Satellite Communication
- A Sample Preparation Facility for Electron Microscopy
- Digital Microwave Test Sets
- A Continuous Solar Simulator and Cell Testing System
- Enhancements for a Optical Parametric Oscillator
- Electrical Transient Recorders
- An Optical Distribution System
- Software Enhancements for a Protocol Engineering Tool

Contracts with Academia and CSIRO

Research investigations of:

- Spectral Properties and Error Probabilities of Block Codes in Digital Transmission
- Receiver Structures for Optical Fibre Transmission Systems
- Stress Relaxation in Thermo-shrink Cable Jointing Sleeves
- Equalisers for Digital Subscribers Loops
- Metal-Insulator Semiconductor Structures
- A Double-ring Local Area Network
- Fluoride Glass Systems for Mid-Infra-Red Optical Fibres
- Packaging Techniques for VLSI Circuits
- On-line Computer-based Directory Database Structures
- Integrated Voice/Data Local Area Networks
- Advanced Design and Testing Techniques for VLSI Circuits
- Millimetre Wave Digital Radio Systems
- Optical Phase Modulators
- Circuit Design Techniques for Optical Communications Systems
- Optical Switch Technology
- Digital Switchblock Device Technology
- Wideband Switching in the Optical Domain.
- A Software Tool for Common Channel Signalling (CCS) Network Planning
- A Real-Time Fibre Tension Measuring Instrument
- Telecommunications Traffic Engineering
- A Mid-Infra-Red Objective Lens
- Fault Tolerant Microcomputer Systems.

In addition, the Laboratories occasionally participate in joint projects with other national and international bodies such as the Overseas Telecommunications Commission (Australia), Aussat Pty. Ltd., the CSIRO, international standardisation bodies such as the CCITT and CCIR, and overseas telecommunications administrations.



VISITORS TO THE LABORATORIES

The work of the Laboratories often calls for close liaison with Australian universities and other tertiary educational institutions and with the research establishments of Government Departments, statutory authorities and private industry. Reciprocal visits are made by the staff of the Laboratories to these and other establishments for mutual participation in discussions, symposia and lectures. In some instances, visitors with expertise in particular fields contribute directly to the work of the Laboratories as consultants.

The Laboratories' activities are also demonstrated to specialist and non-specialist groups from business, industry, professional societies, Government Departments and academia. This is achieved through arranged discussions, inspection tours and demonstrations and, at longer intervals, by formal "Open Days", when the work of the Laboratories is exhibited to invited guests from many walks of life.

During the year, experts from overseas telecommunications authorities, academia, Government Departments and manufacturing companies have also visited the Laboratories.

Some of the groups and individuals who visited the Laboratories during the year are listed below:

- Mr F. Vaurinek, Area Manager, Electrical Applications, FIRET bv, Holland, visited the Laboratories for technical discussions on the application of water-swellable tapes and oil-barrier tapes for optical fibre cables.
- Messrs G. Harber and G. Pandey of the Department of Local Government and Administrative Services, accompanied by Mr D. Maloney, Telecom's Account Manager, Canberra, visited for demonstrations and discussions of potential future business and ISDN services.
- Dr M. Alexander visited the Laboratories for discussions with the Health Sector Information Flow Study Team, Customer Services and Systems Branch, on design approaches to medical-social research projects. Formerly a Research Fellow in General Practice of the Royal Australian College of General Practitioners and the University of Newcastle, Dr Alexander is a Melbourne general practitioner and Associate of the Department of Community Medicine, Melbourne University.
- Messrs S. Hogberg, N. Artlove, J. Bergstrom and U. Larsson from Televerket, Sweden (Swedish Telecom), visited for technical discussions on materials used for optical fibre cables.
- Mr I. Brodniak of Racal Ltd. (UK) visited to discuss techniques for access control and authentication in relation to future computer-based services.
- A group of senior academics from Deakin University visited to obtain insights into the Laboratories' R&D activities and to explore means and topics for increased R&D collaboration. The group comprised:
  - Professor F. West, Pro-Vice Chancellor (R&D)
  - Professor B. Garner, Professor of Computing Sciences
  - Professor A. Bond, Professor of Chemistry
  - Associate Professor V.N. Tran, Director, Centre for Research on Intelligent Systems
  - Professor B. Crassini, Professor of Cognitive Science & Psychology
  - Dr S. Oldfield, Research Fellow in Cognitive Psychology.
- Dr P. Pentony, Director, Network Acquisition, Australian Bureau of Statistics, accompanied by Telecom's Mr N. Cammack, Major Business Account Manager, visited for discussions and demonstrations R&D projects relating to future data services in an evolving ISDN environment.
- Professor H. Schumman, Institute for Inorganic and Analytical Chemistry, Technical University of Berlin, visited for discussions on the chemical aspects of MOCVD and presented a lecture on "Gallium, Indium and Phosphorous: Contributions to the Organo-metallic Chemistry of Three Elements Relevant to Microelectronics".
- Dr N.A. McDonald of the Department of Communication and Electronic Engineering, RMIT, visited the Laboratories to participate in a Seminar on "Electromagnetic Field Penetration through Apertures in Screens". Dr McDonald reviewed recent advances and solutions to problems in related R&D projects performed at RMIT with support from ATERB.
- A delegation from the Health Insurance Commission, led by Mr A. Coates and accompanied by Mr F. O'Rourke, Telecom's Director of Federal Government Accounts, and Mr R. Lacey, Telecom Account Manager, visited for discussions and demonstrations of projects relating to electronic directories and messaging services, electronic document interchange services and health sector information flows. The delegation comprised:
  - Mr A. Coates, Assistant General Manager, Systems
  - Mr P. Hatch, Manager, Systems Operations
  - Mr B. Schacht, Manager, National Network
  - Mr C. Farrelly, Manager, Communications and Office Automation.
- Mr G. Boggio, Head of the Division responsible for S&T Co-operation with Industrialised Countries, Commission of the European Communities, visited the Laboratories for discussions on the RACE and ESPRIT Programs for international co-operation. Mr Boggio was accompanied by Mr G. Nastri of the French Embassy and Messrs B. Barret and D. Stewart of the Federal Department of Industry, Trade and Commerce.
- Messrs Ma Joinping, Deputy Director, Design Division, Fourth Engineering Corporation of MPT and Yang Jin, Assistant Engineer, Main Transmission Line Engineering Division, MPT, from the People's Republic of China, visited the Laboratories whilst on an optical fibre work experience tour arranged under the terms of Telecom's Memorandum of Understanding with the People's Republic of China. The visitors discussed and inspected Laboratories projects related to optoelectronics materials and device technologies, fluoride glass fibre technology and the application of optical fibre systems in trunk, junction and local access networks.
- Messrs T. Hilsberg and A. Gray of the Department of Industry, Trade and Commerce visited for discussions of R&D projects related to optoelectronics device and optical fibre technologies and their applications in future optical transmission systems.
- Messrs N. Skaperda, H. Suckfuell, O. Van Zyl, J. Green, W. Dyczmon and B.E. Fernandez from Siemens Ltd., visited for discussions of projects relating to protocol engineering, the X.32 interworking unit and fast packet switching in the future broadband ISDN environment.
- Mr B. White of the Maritime Services Board, accompanied by Telecom's Mr H. Quek, Account Manager, Mr F. Pezzimenti, PABX Division, and Mr B. Spencer, Communications Consultant, visited for discussions of optical transmission systems, potential future ISDN services and fast packet switching techniques for a future broadband ISDN.
- Professor J. Woodward, Director, Telecom Corporation of New Zealand Ltd., visited for discussions on protocol engineering, optoelectronic materials and devices, and the evolution of the ISDN in Australia.
- Mr F. Cook, MP, House of Commons, Great Britain, visited the Laboratories for a short tour and discussions of alternative forms of energy. Mr Cook is Vice-Chairman of the All-Parliamentary Group for Alternative Forms of Energy. Mr A. Pears, Manager, Program Development, Victorian Department of Industry, Technology and Resources,

accompanied Mr Cook on the visit.

- A group of senior academics from the Department of Electrical Engineering, Monash University, visited the Laboratories to discuss the spectrum of Laboratories projects and potential areas of mutual interest for collaborative R&D. The visiting party comprised:
  - Professor R.A. Jarvis, Chairman, Department of Electrical Engineering
  - Dr K.K. Pang, Reader
  - Dr J.A. Bennett, Senior Lecturer
  - Dr L.N. Binh, Senior Lecturer
  - Dr G.K. Cambrell, Senior Lecturer
  - Dr D.B. Keogh, Lecturer
  - Dr L. Kleeman, Lecturer
  - Mr P. Hudson, Director, Montech P/L.
- A group of ANZ Bank Ltd executives comprising Mr D. Gall, General Manager, Electronic Network Services, Mr L. Smith, Marketing Executive, and Mr A. Bennett, Technology Executive visited, accompanied by Telecom's Mr R. Liggett, Executive General Manager, Corporate Customer Division, Mr A. Lockwood, Manager, Dedicated Network Services Marketing, Mr G. Searle, Account Manager, and Mr D. Humberstone, Commercial Sales Manager.The visitors toured the Laboratories and discussed future ISDN services and networks, protocols for EFTPOS services, and Laboratories' activities in the general field of communications protocol specification, implementation and testing.
- Mr D. Schilke and Ms L. Logan of the United States Consulate visited the Laboratories to obtain an overview of the Laboratories and to inspect projects relating to new fluoride glasses, the ISDN experimental exchange, the PROTEAN protocol testing software package and developments in digital cellular mobile telecommunications services.
- A group of twenty visitors from the Australian Electric Vehicle Association visited for a tour and discussions on energy management and battery research.
- Mr A. Elfving, Business Manager, Polyethylene Pipe, Wire and Cable, Neste Chemicals, Sweden, visited for discussions on halogen-free flame-retarded polymers for use as a replacement for PVC insulated wire and PVC cable sheath. The properties and stabilisation of linear low density polyethylene for use as external cable sheath were also discussed.
- A delegation from the Bundestag (the Parliament of the Federal Republic of Germany) Committee for Research and Technology visited the Laboratories for discussions on telecommunications R&D in Australia and particularly, within Telecom Australia. The members of the delegation were Messrs E. Maass, J. Vosen, U. Briefs, K. Schmoelling and Mrs M. Ganseforth. They were accompanied by Mr H. Muellers, FRG's Deputy Consul-General in Australia, and Messrs W. Will and A. Scholz of the Consulate.
- The delegation was received by the Executive General Manager, Research and after introductory discussions with Laboratories' management, the delegation toured the Laboratories. In particular, the visitors inspected and discussed projects relating to photovoltaic devices and their application in hybrid power systems for telecommunications equipment in remote areas of Australia, optoelectronic device technology and its application in optical transmission systems and the evolution of the Australian ISDN.
- Messrs J. Poepjes and B. Marchant of the Building Management Authority, Western Australia, accompanied by Telecom's Mr S. Dalby, Account Manager, Mr J. Websdane, Senior Business Sales Representative, and Mr K. Mackin, PABX Division, visited the Laboratories for discussions on electronic directories, electronic document interchange services, digital cellular mobile radio telecommunications systems, protocol engineering and potential ISDN services.
- Dr W. Djojonegoro, Assistant (General Planning) to the Minister of State for Research and Technology and Deputy Chairman of the Agency for the Assessment and Application of Technology, Indonesia, visited the Laboratories as part of the International Development Program of Australian Universities and Colleges. Ms J. Wraight, of the IDP Agency and Mr B. Jong of Telecom Australia International accompanied Dr Djojonegoro. After general discussions with Laboratories' management on the telecommunications R&D environment in Australia, discussion centred on the role and R&D programme of the Telecom Research Laboratories and their relationships with industry, academia, R&D institutions and standards bodies. A tour of the Laboratories followed, with inspections of projects relating to optoelectronic materials and devices, mid-infrared fibre technology, integrated circuit reliability assessment, and solar energy technology.
- A group of senior Japanese business executives visited the Laboratories during a visit to Australia sponsored by the Victorian Department of Industry, Technology and Resources. The visit sought to promote the development of business relationships between Australian and Japanese companies and corporations. The visitors included:
  - Mr H. Inoue President, EOS Corporation
  - Mrs Y. Tsutsui, Director, Tokai Medical Products Co. Ltd.
  - Mr A. Nagamatsu, President, Meitho Co. Ltd.
  - Mr S. Matsuda, Manager, Matsusuda Precision Devices Inc.
  - Mr K. Mizuno, President, Hal Engineering Co. Ltd.
  - Mr N. Ikedo, President, Fuji Consulting Co. Ltd.
  - Mr S. Suziki, President, Astro Design Inc.
  - Mr H. Tagaya, General Manager, Research Department, Industrial Technology Association of Japan
  - Mr T. Yamawaki, Marketing Manager, Hakuto Co. Ltd.
  - Mr H. Kishida, Manager, Nippon Tectron Co. Ltd.
  - Mr S. Miyano, Manager, Tokyo Calculation Service Pty. Ltd.
  - Mr N. Enya, Senior Managing Director, Kawasaki Steel Systems R&D Corporation, and
  - Mr Y. Sakurai, President, Sakurai Kibai Co. Ltd.
- Overseas business associates of Austral Standard Cables Pty Ltd visited the Laboratories for an inspection of experimental projects and discussions of cable and transmission related research. The overseas visitors, Messrs B. Lindley, N. Dean, S. Spedding and A. Willis of BICE, UK and Mr B. Wardley of Phillips Cables, Canada, were accompanied by Messrs G. Dangerfield, P. Robinson and L. Ding of Austral Standard Cables Pty. Ltd. The visitors inspected

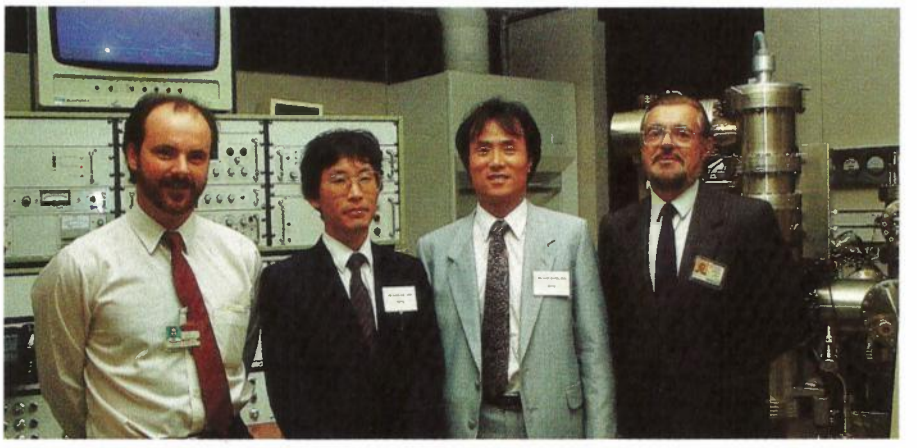
Below:
Members of the visiting delegation from the Bundestag (FRG) Committee for Research and Technology discuss solar energy R&D with Laboratories' scientist, Alan Murfett (extreme right).

Laboratories' facilities for the environmental testing of external plant and discussed the application of polymers in telecommunications. They also inspected laboratory activities concerned with the evaluation of new developments in glass materials and optoelectronic devices, as might be applied in future optical fibre transmission systems for trunk and local networks.

- Mr R. Beesley, Area Manager, Cabot Plastics Ltd. (UK), visited the Laboratories for discussions on additives and materials for halogen-free flame-retarded insulation for wire and cable used in internal telecommunications plant environments.
- A group of senior executives of Siemens Ltd. visited for discussions of the (then current) collaborative development of ISDN Protocol Test Equipment and to gain an overview of the Laboratories' work programme, particularly projects relating to new fast packet switching techniques, protocol engineering and evolutionary ISDN services. The group included:
  - Mr T.F. Korpel, General Manager, Telecommunications
  - Dr O. Van Zyl, Manager, Communications Networks
  - Mr J. Green, Manager, Public Voice Switching Products
  - Mr P. Burch, Manager, Communications Products
  - Mr A. Bairektar, Manager, PABX Communications.
- Dr A. Ogawa, Director of the Sydney Liaison Office of Kokusai Denshin Denwa Co. Ltd. was accompanied by Professor A. Kawamata of the Faculty of Electronic Engineering at Nagoya University, Japan, and former Director of the Ibaraki Telecommunication Research Laboratories of Nippon Telegraph & Telephone Public Corporation, on a visit for familiarisation discussions with the Executive General Manager and senior staff of the Laboratories. They also inspected project work on optoelectronic device and fluoride glass fibre technologies and discussed their potential for application in future optical transmission systems.
- Mr R. Meek, Business Development Manager, Wire and Cable, Pacific Region, BP Singapore Pty. Ltd., visited for technical discussions on polyethylene for wire and cables applications.
- Mr B. Guerin, Manager, Nylon Resins Development, Engineering Plastics Division, Atochem, France, visited for technical discussions on new polymer developments in France.
- Mr E. Corran, Head of the Australian Nuclear Science & Technology Organisation's Reliability Engineering Section, and Dr G. Ballard, Head of the National Centre of Systems Reliability (UK), visited to exchange information about their organisations' expertise and services and to gain insights into the Laboratories' role and capabilities in reliability assessment and quality assurance of plant and equipment applied by Telecom in its network infrastructure.
- Mr D. Herringer, Director, Apple Computer (Australia), and Messrs P. Askin and M. Medeiros of Apple Computer (California) visited for exploratory discussions on innovative technologies of mutual interest.
- Messrs K. Harris, B. Wraith, B. Godfrey and A. Law, senior executives of the Department of Social Security, visited for discussions of R&D activities related to electronic messaging, electronic document interchange, access control and authentication in new computer-based communications services and the evolution of the Australian ISDN.
- Messrs A. Abrahart and R. White, senior executives of the Department of Employment, Education and Training, accompanied by Mr J. Henderson, Telecom Account Manager, visited for discussion of similar topics to those addressed during the abovementioned visit by Department of Social Security executives.
- Nine members of a Field Project Group of Session 74 of the Management Development Program conducted by the Australian Administrative Staff College visited for discussions of the role of the Laboratories in the Telecom Australia organisation and the corporate policies and processes involved in the determination and management of the Laboratories' Business Plan and ensuing Research Programme.
- Representatives of companies in the Wormald International (Aust.) Pty. Ltd. Group, namely Mr J. Higginbotham, General Manager, Wormald Technical Centre, Dr S. Rashleigh, General Manager, Australian Optical Fibre Research Pty. Ltd. and Mr E. Travoh were accompanied by Mr L. Guy, Telecom Account Manager, in a visit to discuss research activity of mutual interest, including that relating to optical device and fibre technology, optical transmission systems and future data communications services.
- Dr I.M. Ross, President, AT&T Bell Laboratories, and colleague Mr S. DeCaro visited the Laboratories to exchange experiences with Laboratories' management on the roles of their respective Laboratories in the US and Australian telecommunications environments and to share ideas on policies and processes for resourcing and managing Research Programmes in the best interests of their corporate bodies.
- A number of people separately visited the Laboratories specifically to inspect the MOCVD and related laboratory facilities and to discuss techniques used in the growth of mercury cadmium telluride materials. They included:
  - Dr L. Posadas, University of the Phillipines
  - Professor D. Neilson, University of New South Wales
  - Drs G. Nyberg and T. Gengenback, LaTrobe University
  - Professor R.S.C. Smart, South Australian Institute of Technology
  - Drs C. Adams, T. Spurling, N. Ham and M. Murray, CSIRO
  - Dr J. Neila, Royal Melbourne Institute of Technology
  - Mr R.S. Owens, Australian Communications and Telemetry Pty. Ltd.
- Senior executives of the Department of Social Security, accompanied by Mr C. Muir, Telecom Account Manager, visited the Laboratories for discussions of future prospectives for business services. The visitors included Messrs R.J. Emerton, T. Trichler, J. Munslow, J. Canning, D. Rowlands, C. Rutten and J. Cannery of the Department and Mr L. Norris, Communications Consultant.
- Messrs J. Watson, Director, BHP Melbourne Research Laboratories, accompanied by Messrs I. Mair and T. Gittens of BHP Co. Ltd., visited for discussions with Laboratories' management of areas of mutual R&D interest and opportunities for R&D collaboration.
- A party from Indonesia, accompanied by Mr T. Pennay, Olex Cables Pty. Ltd., visited to obtain insights into the role of the Laboratories and discuss activities of mutual interest. The visitors included:
  - Mr Iman Santoso, Head of PERUMTEL's Planning Division
  - Mr Satrio Wibowo, Head, Telecommunication Network Division, PERUMTEL
  - Mr Bambang Soekmantoro, Head, Centre of Communications R&D, PERUMTEL
  - Mr Peonggoeh, Head, Testing Division, PERUMTEL
  - Mr D.K. Kariana, Plant Manager, Kabelindo, Indonesia
  - Mr J. Saleh, Marketing Manager, Kabelindo, Indonesia.
- A party from the ANZ Banking Group Ltd., accompanied by Mr G. Riddock and Ms M. Van Kruger of Telecom's Corporate Customer Division, visited to discuss R&D activities

related to future business services in an evolving ISDN. The visitors were Messrs P, Mullholland, L. Fittinahoff, C. Stevenson and P. Mason.

- Mr V. Shrivaster of International Engineers and Project Consultants Ltd., India, and Mr P. Clifton of Telecom Australia International Ltd. visited for discussion of activities of mutual interest.
- Messrs J.R. Seo and S. Jong of the Electronics and Telecommunications Research Institute, Korea, visited the Laboratories accompanied by Mr F. Cox of Telecom's Corporate Strategy Directorate.
- Messrs M. Woolley and G. Latimer and Ms M. Challes of the Department of Finance visited in the company of Mr P. Gilbert, Telecom Account Manager, in their capacity as members of the Federal Inter-Departmental Information Exchange Steering Committee.
- A delegation from the State Science and Technology Commission of the Peoples' Republic of China, led by Mr W. Wufeng, Secretary General of the Commission, accompanied by Mr D. Rumble of the Department of Industry, Trade and Commerce, visited to gain insights into Australian telecommunications R&D and exchange experiences. The visitors included Messrs L. Guangning, X. Wenchang, Z. Shiyony, D. Tianwen and C. Futeo.
- Messrs B. Woods and A. Young, executives of the Group Information Systems Division of the National Bank Australia Ltd., visited in the company of Mr K. Dearsley, Telecom Account Manager, for discussions of future developments of interest with staff of the Laboratories and Telecom's Corporate Customer Division.
- Messrs P. Dunlop, D. Holmes, A. Talulelei and L. Brough of the Department of Employment, Education and Training visited to discuss future developments of computer-based services.
- Members of Thailand's Mission on Telecommunications Technology visited to gain insights into telecommunications R&D in Australia and to exchange experiences. The visitors included:
  - Mr K. Snidyongso, Deputy Permanent Secretary, Ministry of Science and Technology, Thailand
  - Professor P. Thajchayapong, Director, National Electronics and Computer Technology Centre
  - Mr S. Muennarintr, Senior Scientist, Public/Private Sector Liaison Office
  - Mr K. Surapunthu, Director of Telegraphs, Telecommunications Department
  - Mr A. Indralagshana, Senior Planning Engineer, Telephone Organisation of Thailand
  - Mrs V. Chaipackdee, Chief Communications Planner, National Economic and Social Development Board of Thailand.



- Mr R. Eddington, Victoria's Surveyor-General and Director of the Landata Project, was accompanied by Landata Project staff, Messrs B. Ackland, G. Taloni and P. Longhrey, in a visit for discussions of new information technologies of potential relevance to the Landata and similar projects.
- Dr C.M. Adams, Director of CSIRO's Institute of Industrial Technologies, and colleagues, Dr T.H. Spurling, M.J. Murray and N.S. Ham, visited for discussions of R&D topics of mutual interest.
- Professor A. Sale, Head of the newly formed Department of Information Science and Electrical Engineering of the University of Tasmania, visited to obtain insights into the Laboratories' Research Programme and to explore potential topic areas and mechanisms for future R&D collaboration.
- A group of information systems experts from BHP Co. Ltd., including Messrs J. Hudson, P. McLure, G. Ferguson, S. White and J. Price, visited in the company of Ms C. Chapkoun of Telecom's Corporate Customer Division.
- The Communications Technology Committee assisting the Australian Industrial R&D Incentives Board and the Department of Industry, Trade and Commerce to administer the Federal Government's Industrial R&D Grants Scheme visited the Laboratories for discussions with management and inspection of selected projects. The visitors included:
  - Dr F. Barr-David, Chairman of the Committee
  - Mr B. Jones, Technical Director, Alcatel-STC Ltd.
  - Dr R. Frater, Director, Institute of Information and Communications Technology, CSIRO
  - Mr C. Howells, Managing Director, Netcomm (Aust) Pty. Ltd.
  - Mr L. Tyrrell, General Manager, Network and Consumer Services, Metropolitan Division, Telecom Australia.
- Mr R. Stafford, Manager, Client and Membership Services, Electronic Research Association, UK, visited for discussions with Laboratories' management and inspected projects of mutual interest.

Above:
Mr Chris Kelly, Laboratories' scientist (left), discusses IC reliability assessment techniques with Messrs J.R. Seo and S. Jang of the Electronics Telecommunications Research Institute of Korea and Mr F. Cox of Telecom's Corporate Strategy Directorate.

Below:
Dr Seng Goh (left), Laboratories' specialist in solar energy technology, pictured with the visiting delegation from the State Science and Technology Commission of the Peoples' Republic of China.

THE LABORATORIES - SUMMARY INFORMATION

THE TELECOM RESEARCH LABORATORIES' ORGANISATION

Deputy Executive General Manager

- General Manager, National Information Resource Centre
- Manager, Plans & Programmes

BRANCHES

Customer Services & Systems	Switched Networks Research	Transmission Networks & Standards
General Manager	General Manager	General Manager

SECTIONS

● Human Communication	● Network Services & Signalling	● Optical Networks
● Integrated Communication Services	● Switching	● Radio & Satellite Networks
● Telematic & Message Services	● Network Analysis	● Electromagnetic Compatibility
● Secure Communication Systems	● Computing Facilities	● Reference Standards & Measurements
	● VLSI Unit	

Research Excellence for Telecom's Success

MISSION

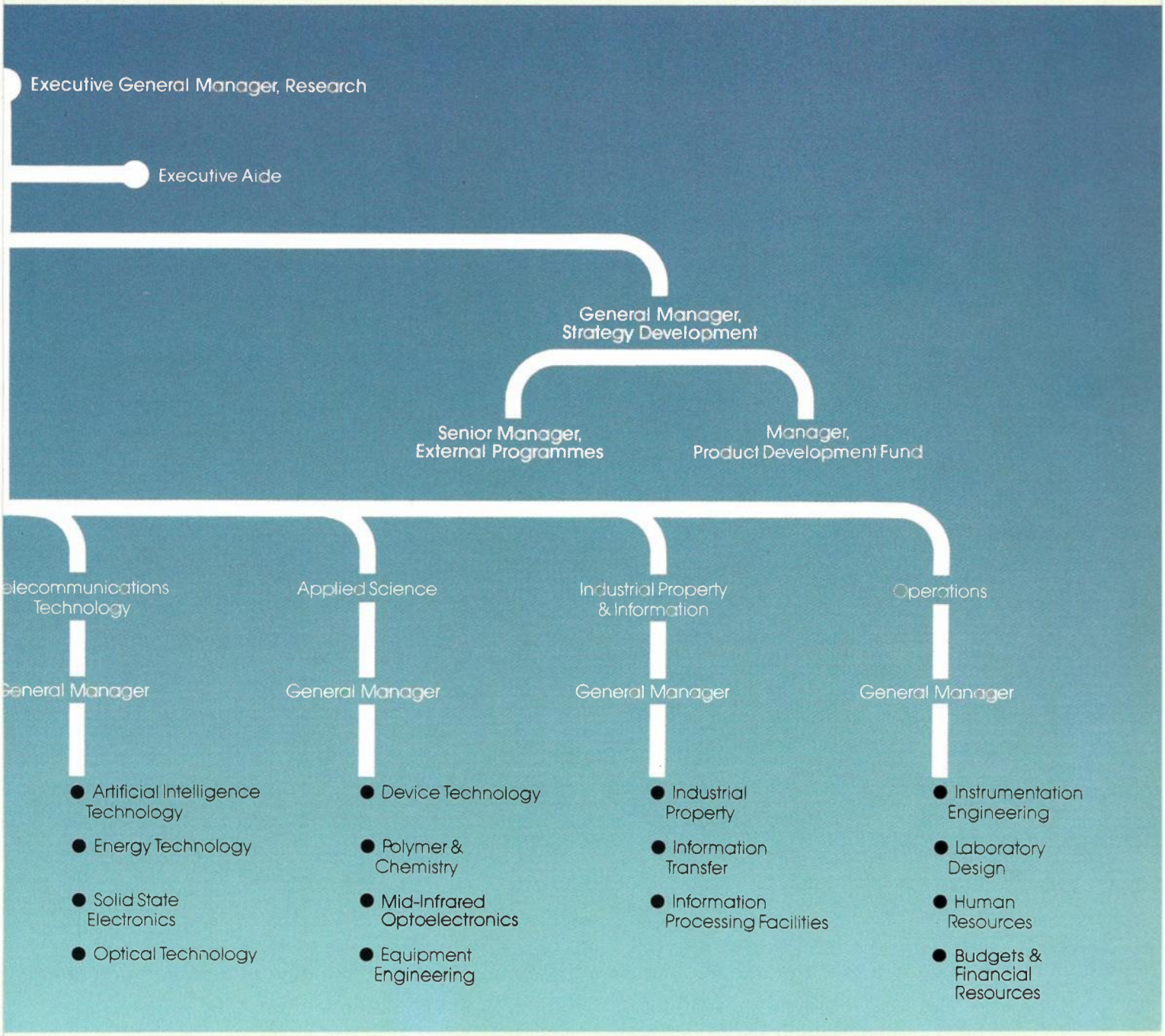
To provide Telecom with technological and scientific leadership, knowledge and expertise so that it can be the best provider of telecommunications and information services.

Overall Objectives of the Laboratories

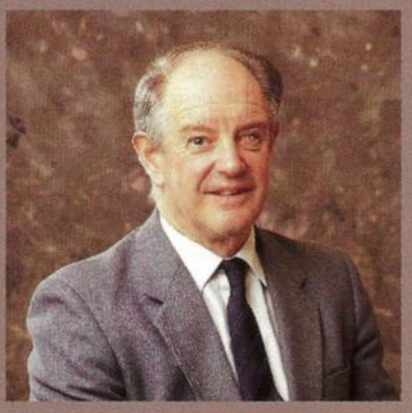
- Maintain a position at the forefront of knowledge in communications science and technology, in order to provide expert participation in the formulation and implementation of policies for the introduction of advances in science and engineering of relevance to Telecom Australia
- Conduct specific development and design projects and scientific and engineering investigations related to telecommunications problems

Organisation

The Telecom Research Laboratories constitute a Shared Resource Unit of Telecom Australia. The Executive General Manager, Research, heads the Laboratories' organisation. He is responsible to the Chief General Manager, who in turn is responsible to the Managing Director of Telecom Australia. The Laboratories comprise the EGM's Office and 28 Sections arranged in seven Branches. The scientific and engineering Sections each possess expertise in particular areas of telecommunications engineering or science.

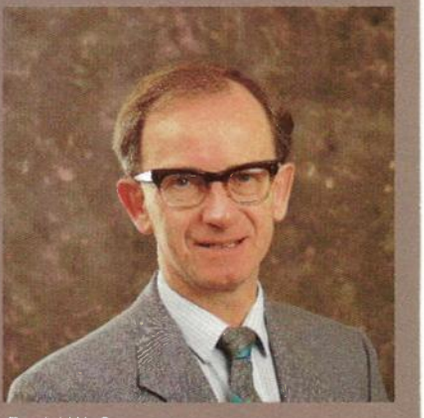


THE LABORATORIES' MANAGEMENT COUNCIL



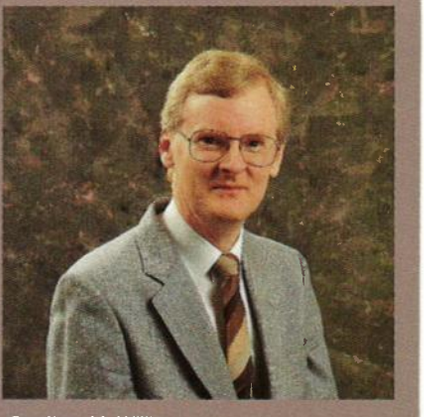
Harry S. Wragge
Executive General Manager
Research

Roger Smith
Deputy Executive General Manager



Fred J.W. Symons
General Manager
Strategy Development

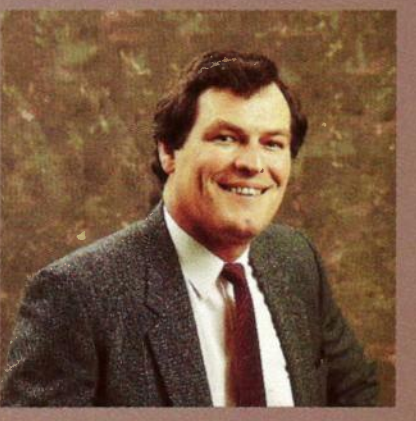
Brian F. Donovan
Executive Aide



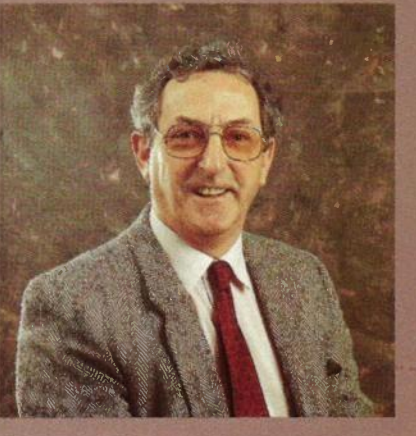
Geoffrey M. Willis
Senior Manager
External Programmes

James L. Park
General Manager
Customer Services & Systems

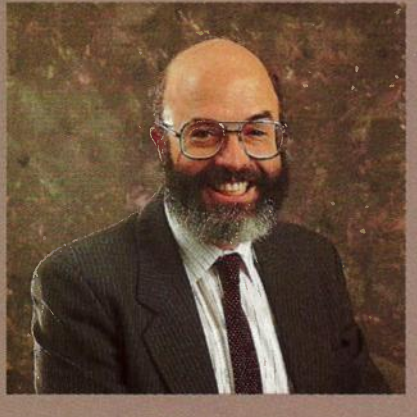
Alan J. Gibbs
General Manager
Transmission Networks & Standards



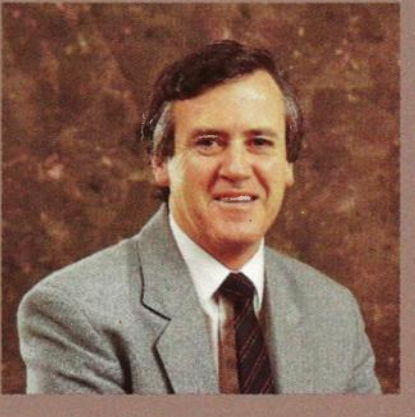
Noel F. Teede
General Manager
Applied Science



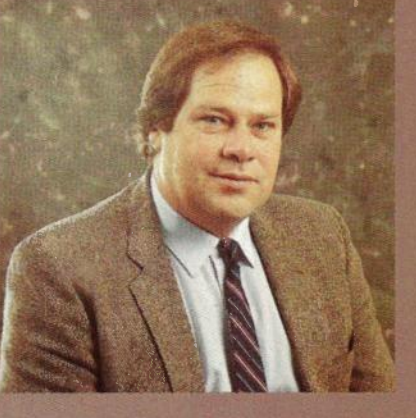
Frank W. Arter
General Manager
Industrial Property & Information



Peter H. Gerrand
General Manager
Switched Networks Research



P.V.H. (Harvey) Sabine
General Manager
Telecommunications Technology



Brian M. Douglas
General Manager
Operations

Functional Organisation and Staff

EGM'S OFFICE

Executive General Manager:
H.S. Wragge, BEE(Hons), MEngSc(Hons), FTS, FIEAust

Deputy Executive General Manager:
R. Smith, BE(Hons), ME, MIEE, SMIREE

General Manager, Strategy Development:
F.J.W. Symons, BE(Hons), PhD, DIC, MIEAust, AIEE, MACS

Senior Manager, External Programmes:
G.M. Willis, FRMIT, MIEAust, SMIREE

Manager, Product Development Fund:
R.A. Court, BE(Hons), BSc, MEngSc, SMIEEE, SMIREE

Manager, Plans & Programmes:
A.J. Stevens, BE, MIEEE

Executive Aide: B.F. Donovan

Support Staff:
H.C. Carbery
J. Cowley
J.E. Dickson

National Information Resource Centre

Functions

- Provide comprehensive information and library services to all Divisions and Directorates of Telecom Australia, including translation of foreign languages
- Integrate information resources within Telecom Australia, with due regard to the development of common standards and systems.

General Manager: H.V. Rodd, BA, Dip Lib

Librarians:
Y.B. Chen, BA, Dip Lib
J.L. McClelland, BSc, Dip Lib
D.J. Richards, BA, Dip Lib
S. Richardson, Dip Lib
E. Roleff, Dip Lib
J.A. Smith, BA, Dip Lib, Dip Ed, ALAA
E.M. Spicer, BA, Dip Lib
K. Sridhar, MA, Dip Lib
E.M. Tunaley, BA (Lib)
G. Woods, Dip Lib

Translation Staff:
K. Bastin
D. Connor

Support Staff:
R. Asplin
G.V. Banik
L.O. Connor
L.A. DeCampo
V.E. Deem
R.M. Forbes
C. Frauenfelder
S.M. Fuhrmann
S.M. Lynch
L. Maio
M. Rankin
M. Siktars

CUSTOMER SERVICES AND SYSTEMS BRANCH

Objectives

In the field of customer services and systems, conduct research, exploratory development and field experiments, contribute to specifications, assist in the assessment of tenders, and provide other advice and recommendations as appropriate relating to:
– user needs for telecommunication services, considering both human and technical aspects
– the evolving Telecom Australia network, the application of network-based facilities to support customer requirements, including service combination and interworking
– technical and human aspects relating to efficient network and service access procedures, and end-to-end performance criteria
– structured techniques for modelling telecommunications services.

General Manager: J.L. Park, BE(Hons), MEngSc, SMIEEE

Branch Administrative Officer: H. Merrick

Support Staff:
L. Browney, BA, Grad Dip App Soc Psych
J. McKinnon
J. Venn

Human Communication Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake theoretical and experimental research into the processes of human communications over telecommunications networks, including user perceived end-to-end performance
- Conduct theoretical and experimental research into the human and related technical aspects of the procedures required to access services and facilities
- Develop models for describing user attributes and perceived needs, and for classifying telecommunications services
- Conduct studies into the needs of communities and organisations for telecommunications services.

Section Head: G.D.S.W. Clark, BEE(Hons), MSc, MIEAust

Professional Staff:
M.A. Cavill, BA(Hons), Dip TRP, MRAPI
J. Chessari, BSc(Hons)
J.K. Craick, BE(Hons), BSc
L.G. Cromwell, BA(Hons), DipViet, PhD
S. Greener, BSurv(Hons), GradDipCompSc
J.B. Guy, BSc, PhD
L. Kennedy, BA(Hons), TSTC
G. Lindgaard, BSc(Hons), MSc, RN, MAPS, MAPA
L. Perry, BA(Hons), MAPS

Technical Staff:
P.S. Bouchier
A.H. Borg
D.J. Lan

Integrated Communication Services Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into the provision of all types of video services; contribute to international standardisation in this area
- Investigate the delivery of voice and data based value added services to corporate and business customers through simplification and customisation of the user interface and through the development of specialised network facilities
- Provide assistance with the definition of customer premises equipment for, and the provision of advanced services on, narrowband and broadband Integrated Services Digital Networks
- Provide advice on the effect on Telecom's services of utilisation of personal computers by Telecom and by Telecom's customers.

Section Head: J.C.N. Ellershaw, BE(Hons), BSc, PhD, MIEEE

Professional Staff:
M.J. Biggar, BEE(Hons), MEngSc, PhD, DIC, MIREE
P.F. Duke, BTech, Dip Maths
N.H. Duong, BE(Hons), MEngSc
M.J. Flaherty, BE(Hons), PhD
A.J. Hopson, BE(Hons)
J. Lacey, BE(Hons)
B.J. McGlade, BEE(Hons)
P.I. Mikelaitis, BE, MEngSc, MIEEE
R.A. Seidl, BE(Hons), PhD
J.S. Spicer, BE(Hons)
M.C. Wilbur-Ham, BEE(Hons)

Technical Staff:
J.B. Carroll
D.A. Drummond
G.R. Leadbeater
P.A. Lindley
T.R. Long

Telematic and Message Services Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into message-based services
- Conduct theoretical and experimental research into interactive database services, including electronic directory services
- Conduct theoretical and experimental research into interworking between these service types
- Develop structured models of telematic and message-based service types.

Section Head: D.R. Manfield, BE, PhD, IEEE

Professional Staff:
M.O. Andrews, BE(Hons), BSc
M. Blakey, BE(Hons), MEngSc
P.C. Craig, BE(Hons), PhD, MIEAust
R. Exner, BSc, BE(Hons), MASc, MIEEE
J.E. Gottschalk, BSc(Hons), PhD
A.R. Jenkins, Dip Comm Eng, ARMIT
S. Legg, BSc(Hons)
I. Lewis, BE(Hons), IEEE
J.B. Nakulski, BE(Hons)
D.Q. Phiet, BE(Hons), PhD
S. Pungsornruk, BE, MSc
B.P. Smetaniuk, BSc(Hons), Dip Comp Sc, PhD

Technical Staff:
B.W. Booth
I.C. Meggs
I.J. Moran

Secure Communication Systems Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into the techniques of providing secure transport of speech signals and user data over telecommunications networks
- Conduct theoretical and experimental research into the techniques of providing secure controlled access to network based facilities, data-bases, etc.
- Conduct theoretical and experimental research into the techniques of providing secure value added services
- Conduct theoretical and experimental research into the techniques of securing the telecommunications network infrastructure used to deliver customer services
- Contribute to and evaluate international standards relating to secure telecommunications.

Section Head: J.L. Snare, BE(Hons), MEngSc

Professional Staff:
T. Batten, BE(Hons), MIEEE
P. Bysouth, BE(Hons)
N. Demytko, BSc, BE(Hons), MAdmin
A.W. Johnson, BE
E.A. Zuk, BE, ME, MIEEE

Technical Staff: R.I. Webster

SWITCHED NETWORKS RESEARCH BRANCH

Objectives

In the fields of switching and signalling, conduct studies, exploratory development and field experiments, contribute to specifications and provide advice and recommendations as appropriate relating to:

- technical aspects of switching and signalling within the Telecom network
- new switching and signalling systems which use extensions of present techniques, or new techniques with particular reference to their integration into the existing network
- compatibility of switching and signalling systems
- cost sensitivity studies
- traffic engineering.

General Manager: P.H. Gerrand, BE(Hons), MEngSc, MIEAust

Branch Administrative Officer: S.J. Chalk

Support Staff:
K.J. Douglas
J. Guthrie
A. Paisley
P. Sweeney
S. Tarpkos

Network Services and Signalling Section

Functions

- Conduct research into switching and signalling networks, systems and techniques in order to provide specialist advice, information and recommendations to other areas of Telecom
- Assess the potential of future switching and signalling networks, systems and techniques in relation to Telecom's needs
- Develop models to validate theoretical studies of switching and signalling networks, systems and techniques
- Contribute to the development of national and international standards.

Section Head: R.J. Vizard, Dip Elec Eng, BEE

Professional Staff:
L.H. Campbell, BSc(Hons), PhD
H.K. Cheong, BE(Hons), PhD
B.T. Dingle, Dip Elec Eng, BE(Hons)
H.J. Everitt, BSc(Hons), MSc
D.H.M. Giddy, BSc, BE(Hons)
D.M. Harsant, BE(Hons)
M.A. Hunter, BE(Hons)
S.M. Jong, BE
B.W. Keck, BSc(Hons), BE(Hons), PhD
S.A. Leask, BE(Hons), MIEEE
R. McNaughton, BSc, Grad Dip Dig Comp Eng, MACS, MIEEE
T. Oetterli, BE(Hons)
P.J. Richardson, BE(Hons)
G.P. Rochlin, BSc, MACS, MIEAust
M. Subocz, BE(Hons), MEngSc, MIEAust
E.M. Swenson, MSc, Grad Dip Data Proc, MAIP, MIEEE, MIE Aust
G.R. Wheeler, BSc(Hons), MSc, Grad Dip Comp Sc

Technical Staff:
R.L. Backway
K.J. Clark
H.G. Fegent
R.J. McKenzie

Switching Section

Functions

- Provide specialist advice, consultation, information and recommendations in relation to future switching techniques and their impact on Telecom services and networks
- Conduct research into new switching techniques that can support future integrated narrowband and broadband services
- Investigate packet switching strategies for future network evolution, particularly maintaining expertise in the protocols and network structures required for the application of advanced services such as Electronic Funds Transfer (EFT)
- Study interworking between different switched networks and develop interworking techniques where appropriate to meet future network needs
- Develop switched data networks performance analysis and monitoring techniques and apply them to switched data networks
- Contribute to the development of standards for packet switched data networks and the Broadband ISDN and participate in their application.

Section Head: P.A. Kirton, BE(Hons), PhD, MIEEE

Professional Staff:
J.L. Burgin, BE(Hons), MIEEE
G.A. Foers, BE(Hons), MIEEE
P.R. Hicks, BE, BSc, MEngSc
D.W. McMillan, BE(Hons), BSc
C.J. O'Neill, BE(Hons), PhD
R.A. Palmer, BE(Hons), PhD, MIEEE
C.J. Scott, BAppSc, MAIP, MIEEE, MIEAust
S.L. Sutherland, BE(Hons), MIEEE
E. Tirtaatmadja, BE(Hons), MEngSc, MIEEE

Technical Staff:
P.S. Ellis
D.J. Hardwick
S.G. Ratten

Network Analysis Section

Functions

- Study the performance of Telecom's circuit and packet switching networks under normal and overload conditions and recommend traffic routing and control strategies needed to maximise traffic throughput at all times
- Develop mathematical models and techniques needed for planning and dimensioning minimum cost circuit and packet switching networks meeting specified performance standards
- Investigate the traffic characteristics and traffic capacity of new switching and signalling systems adopted or being considered for adoption by Telecom
- Recommend traffic performance standards and network structures for new switching and signalling systems being considered for adoption by Telecom
- Operate as a national reference authority providing advice for traffic engineering theory and education
- Maintain a constant review of world developments in traffic theory and its application to telecommunications networks.

Section Head: R.E. Warfield, BE(Hons), PhD

Professional Staff:
R.G. Addie, BSc(Hons), PhD
D.E. Everitt, BE(Hons), PhD
R.J. Harris, BSc(Hons), PhD
A.U. Kennington, BSc(Hons), PhD
S. Michnowicz, BE(Hons), BSc
M.H. Rossiter, BSc(Hons)
J. Rubas, Dip Rad Eng, ARMTC, MIEAust
M. Zukerman, BSc, MSc, PhD

Computing Facilities Section

Functions

- Provide co-ordination and support for the hardware, software and communications facilities associated with the Branch
- Develop the facilities and networks in such a way as to anticipate the directions of future Branch endeavours and requirements
- Advise the Branch of new developments in hardware, software and networking for possible application in Branch facilities
- Provide others outside the Branch with access to the facilities, where such is deemed to be in the interests of Telecom, the Research Laboratories and the Branch, and where capacity is available for such provision.

Section Head: F.R. Wylie, BE

Professional Staff:
J.A. Gilmour, BAppSc, MIEEE
R. Liu, BSc(Hons), Dip Comp Sc, MACS

Technical Staff:
S. Dovile
J. Emptage
L.P. Lorrain
P.C. Murrell

Support Staff: L. Davis

VLSI Unit

Functions

- Maintain expertise and knowledge of the latest VLSI design techniques and capabilities
- Develop skills and facilities to enable telecommunications hardware systems to be designed by application of advanced software design tools and implemented using VLSI tecniques.

Manager: I. Dresser, BE

Professional Staff:
N. Leister, BE, MIREE
B.R. Nigli, BSc, AACS

Technical Staff: S.P. Curlis

TRANSMISSION NETWORKS AND STANDARDS BRANCH

Objectives

In the field of transmission networks and standards, conduct research, exploratory developments, system applications and field experiments, contribute to specifications, assist in the assessment of tenders and provide advice and recommendations as appropriate relating to:

– the technical aspects of new transmission networks and systems within the Telecom Australia networks including their integration into the existing network

– the electromagnetic compatibilty (EMC) of electronic/communication systems and equipment and prototype hazards of electromagnetic (non-ionizing) radiation from this equipment

– the provision of a sound scientific basis for all measurements made by and within Telecom Australia by arranging traceability of accuracy of measurement of fundamental engineering and physical quantities to the Australian National Standards.

General Manager: A.J. Gibbs, BE(Hons), ME, PhD, SMIEEE, SMIREE

Branch Administrative Officer: A. Mehmet

Information Systems Co-ordinator:
J.L. Kelly

Support Staff:
C. Anderton
J. Higgins
K.M. Kingstone
M. McKinstry
S. Simpson

Optical Networks Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research and exploratory development into the transmission characteristics of optical media and conduct research into transmission systems and networks which utilise optical media
- Evaluate the potential applications and utilisation of systems using such media for the transmission of telecommunications services in the local, junction and trunk networks
- Investigate the interworking of such systems with other parts of the transmission and switching network
- Maintain an awareness of, and evaluate and advise on, emerging techniques relating to optical transmission systems for the distribution of services within the customer's premises using local area network techniques and associated contention resolution methods, taking into account:

  (i) the interworking of such systems with other parts of the transmission and switching network and the requirements of existing and emerging telecommunications services, and

  (ii) network maintenance, reliability and security to provide customer service integrity
- Conduct experiments and participate in field trials designed to demonstrate the feasibility of new optical fibre systems and networks.

Section Head: B.M. Smith, BE(Hons), PhD, SMIEEE

Professional Staff:
J.L. Adams, BSc(Hons), PhD, IEEE, GradAIP
R.W.A. Ayre, BE(Hons), BSc(Hons), MEngSc, MIEEE
D.J. Bakewell, BEE(Hons), MIEEE, MIEAust
B.R. Clarke, BE(Hons), PhD
G. Cowle, BSc, BE(Hons), MIEEE
C. Desem, BSc(Hons), MSc, PhD
D. Gates, BE(Hons), MBBS
M.D. Hayes, BE(Hons), BSc
K.J. Hinton, BE(Hons), BSc, PhD
I.M. McGregor, BE(Hons), MEngSc,PhD
G. Nicholson, BE(Hons), MEngSc, MIEEE
P.G. Potter, BE(Hons), PhD, MIEEE
G.J. Semple, BE(Hons), MEngSc
T.D. Stephens, BE(Hons), MEngSc, MIEEE
M.R. Warner, BE(Hons), MIEEE

Technical Staff:

L.W. Bourchier	R. Owers
G. Dhosi	G. Prete
E.A. Dodge	D.J. Temple
J.H. Gillies	R.C. Witham
R.G. Hand	N.W. Wolstencroft

Radio and Satellite Networks Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into transmission systems which utilise radio media, including both terrestrial and satellite systems and networks
- Evaluate the potential application of wireless access systems and networks for existing and emerging telecommunications services
- Conduct theoretical studies, hardware development and field investigations to demonstrate the feasibility of new wireless access systems
- Investigate the interworking of such systems with other parts of the telecommunications network
- Investigate and develop systems and testing methods/apparatus.

Section Head: R.P. Coutts, BE(Hons), BSc, PhD, SMIEEE, SMIREE

Professional Staff:
D. Ben-Meir, BSc(Hons), BE(Hons), MIEEE
G. Bharatula, BSc, MSc, MTech
F.G. Bullock, BE(Hons), GradIEAust, MIEEE
A.J. Bundrock, BE(Hons)
J.C. Campbell, BE(Hons), MEngSc, MIEEE
Z. Debanic, Dip Elec Eng
R.K. Flavin, BSc, MSc, SMIREE
R.A. Harvey, Dip Rad Eng, BSc, MIREE
I.T. Hawkes, BSc(Hons)
J.G. Hollow, BE(Hons), PhD, MIEEE
G.F. Jenkinson, BSc
A.B. Johnson, BE(Hons), MIEEE
I.C. Lawson, BEE
L.J. Millott, BE(Hons), MEngSc, SMIEEE
P.R. Murrell, BE
S. Sastradipradja, BE, SMIREE, MIEEE, MARPS
A.R. Urie, BE(Hons), MIEEE

Technical Staff:

F.S. Beyer	A.D. Martinus
D.K. Cerchi	P.S. Richardson
M.J. Durrant	J.J. Sekfy
J. Gravina	B.W. Thomas
D.A. Jewell	D.J. Thompson
G.W. Kay	

Electromagnetic Compatibility Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research and exploratory development of techniques for achieving electromagnetic compatibility (EMC) of electronics/communications systems and equipment
- Conduct research and exploratory development of techniques for the assessment and prevention of the biological hazards of electromagnetic (non-ionising) radiation from electonics/communications systems and equipment
- Conduct research and exploratory development of new, advanced and novel antennas for telecommunications applications
- Investigate and develop specifications, standards and methods of measurement of incidental electromagnetic (EM) emission and susceptibility levels for electronics/ communications equipment and systems
- Investigate, evaluate and develop measurement and calibration facilities of both the indoor and outdoor types (including chambers and test ranges) for antenna, EMC and EM hazard assessments, measurements, tests and calibration applications
- Maintain and promote an awareness of EMC, EM hazards and antenna applications and implications for systems, equipment and network performance, and provide consultancy and technical advice to Telecom on a national basis.

Section Head: I.P. Macfarlane, Dip Elec Eng, BEE, SMIEEE

Professional Staff:
W.S. Davies, BE, MEngSc(Hons), PhD
A.H.J. Fleming, BSc, MIEEE, MAMS
S. Iskra, BE(Hons), MIEEE
K.H. Joyner, BSc(Hons), PhD, Dip Ed, MARPS, MIEAust, MBEMS
E. Vinnal, BE(Hons),MIEEE

Technical Staff:
G.J. Bail
A.J. Cole
P.R. Copeland
D.M. Farr
R.J. Francis
B.C. Gilbert
S.J. Hurren
N.J. Whitaker
C.F. Wilson
M.P. Wood

Reference Standards and Measurements Section

Functions

- Plan and oversight the implementation, operation and further development of a system of engineering references and calibration facilities for Telecom Australia
- Operate, maintain and calibrate Telecom Australia's central engineering references in terms of the Australian National Standards of Measurement
- Develop improved engineering references, calibration and measuring techniques and procedures to meet Telecom Australia's developing technology and operational needs
- Develop special techniques, systems and equipment for the application of measurement technology to the solution of engineering plant problems
- Operate as a Verifying Authority and Signatory in accordance with the requirements of the National Standards Commission and the National Association of Testing Authorities
- Liaise with other sections of Telecom Australia to ensure that all standards of reference have an appropriate authenticity of calibration as required by the Weights and Measures Act
- Liaise with other national and international measurement laboratories and authorities, particularly the International Telecommunications Union, Union Radio Scientific Internationale, the Standards Association of Australia and the National Association of Testing Authorities.

Section Head: R.W. Harris, BSc(Hons), BE(Hons), BComm

Professional Staff:
J.P. Colvin, Dip Elec Eng, BE
D.A. Latin, BE, MEngSc
E. Pinczower, Dip Elec Eng, MIEAust
R.W. Pyke, Dip Elec Eng, BE(Hons), MIEAust
B.R. Ratcliff, Dip Comm Eng, ARMIT

Technical Staff:
J.H. Baldock
K.J. Bassett
A.S. Doherty
J.B. Erwin
C.R. Flood
B. Juska
G.F. Lucas
T.W. Pearson
R.H. Yates

TELECOMMUNICATIONS TECHNOLOGY BRANCH

Objectives

Conduct studies, exploratory development and field experiments, provide advice and recommendations, and contribute to equipment specification and assessment relating to:
- the application of newly emerging, extended or improved technologies in telecommunications engineering
- the characteristics and properties of new devices, circuits and techniques in communications applications
- the impact and compatibility of new technology and new applications of existing technology with those already in the Telecom Australia network
- the forecasting and evaluation of developing trends in telecommunications technology particularly suitable for application in Australia.

Maintain and develop liaison with appropriate research establishments in Australia and overseas to provide information and advice on emerging technologies of interest to Telecom Australia.

General Manager:
P.V.H. Sabine, BSc, BE(Hons), PhD

Branch Administrative Officer:
C.J. Chippindall

Support Staff:
G. Kotsomitis
M. Oliver

Artificial Intelligence Technology Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into artificial intelligence (AI)
- Identify opportunities for the application of new and existing AI technology; assist in the process of developing these opportunities
- Develop specialised AI systems for application in systems, networks, services and infrastructure areas; assist in the transfer of this technology.

Section Head: A.J. Jennings, BE(Hons), PhD, SMIEEE, SMIREE

Professional Staff:
L.A.R. Denger, ENSEMN, MIEEE, MSocFrElec
A. Kowalczyk, MAppSc, PhD
C.A. Leckie, BSc, BE(Hons)
P.L. Nicholson, BE, MIEEE
C.D. Rowles, BSc, BCommE, MIEEE

Technical Staff:
R.B. Coxhill
P.F. Elliott

Energy Technology Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into energy, its sources, conversion, storage, utilisation and conservation, including electrical and thermal forms for both stationary and mobile applications
- Evaluate and make recommendations on the potential impact of changing energy technology on Telecom Australia's operations
- Undertake the design, exploratory development and experimental assessment of new devices and techniques for power generation and cooling, and make recommendations on their application in Telecom Australia's operations, particularly in remote areas.

Section Head: D.J. Kuhn, BE(Hons), MEngSc

Professional Staff:
J.J. Der, BSc, ARACI
E.E. Gibbs, BSc(Hons), PhD
S. Goh, BSc, MSc, PhD
S. Hinckley, BSc(Hons), PhD, MIEE, GradAIP
I. Muirhead, BSc(Hons), MEnvStud
A.J. Murfett, BSc(Hons)
T. Robbins, BSc(Hons), MSc, MIREE

Technical Staff:
L.O. Barling
E.D.S. Fall
R.W. Garner
B.K. Hawkins

Solid State Electronics Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into solid state electronics, including the exploratory development and fabrication of devices and circuit elements which have functions based on the exploitation of special material properties
- Develop and provide specialised facilities in the field of solid state electronic materials and devices arising from the above.

Section Head: G.L. Price, BSc(Hons), PhD, FAIP, MAPS, MIEEE

Professional Staff:
J. Dell, BEE(Hons)
J. Hubregtse, Dip Comm Eng, MIREE
M.J. Joyce, BSc
P.C. Kemeny, BSc(Hons), PhD, GradAPS
J. Szymanski, MSc, PhD
B.F. Usher, BSc(Hons), PhD, Dip Ed, MAIP

Technical Staff:
F. Gigliotti
K.J. Moseley
L.G. Powell
R.C. Tarran

Optical Technology Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Undertake fundamental investigations into the generation, amplification, modulation, detection and waveguiding of coherent electromagnetic radiation having submillimetre or shorter wavelengths, and into techniques or phenomena which can effect the propagation characteristics of such radiation
- Investigate and advise on active and passive circuit configurations of opto-electronic devices and their application in telecommunications systems.

Section Head: G.O. Stone, BE(Hons), MEngSc, PhD, MIEEE, MIREE

Professional Staff:
A.M. Duncan, BSc, BE(Hons)
Y. Ito, BE(Hons), ME
Y.H. Ja, BE, PhD, MAOS
P.M. McNamara, BSc(Hons), MSc, PhD
G.E. Rosman, BEE, ME
T. Warminski, MSc, PhD, DSc

Technical Staff:
W.C. Andrews
C.G. Byrne
B.P. Cranston

APPLIED SCIENCE BRANCH

Objectives

Conduct scientific research, exploratory development, laboratory and field experiments, provide expert scientific advice and recommendations contributing to the establishment of design, performance and assessment criteria relating to:
- the characteristics and properties of new materials, devices and equipment technologies for application in the telecommunications network
- the mechanisms of degradation and service failures and the development of mitigation techniques
- impact of the environment on personnel and plant and the development and implementation of appropriate protective measures
- the assessment of the operational reliability of materials, components and devices
- the evaluation and development of advanced materials, the application of emerging scientific technologies, and research into improved scientific or analytical procedures
- the processing and application of new materials and methods for the realisation of specialist electro-mechanical and mechanical hardware.

Maintain liaison and exchange information with appropriate research establishments and learned institutions and participate in material and international standardisation activities.

General Manager: N.F. Teede, BE(Hons), PhD, Dip Mgt

Computing and Programmes Co-ordinator:
A.M. Fowler, MIEAust

Branch Administrative Officer: L. Roberts

Support Staff:
M.A. Cieslak
S.M. Collins
A. Hodges
T.D. Lindsay

Device Technology Section

Functions

- Conduct research into:
- the reliability of electronic components and devices
- the properties of metals and alloys
- the physical properties of materials and components and their performance under environmental and high potential stresses
- materials surface - related phenomena
- Conduct scientific studies into high potential phenomena and their effects on Telecom Australia's plant and equipment; investigate protective devices and develop measures for the protection of staff, subscribers and plant
- Conduct scientific studies into the properties and life expectancy of components, devices and assemblies and investigate causes of failure and degradation
- Conduct scientific studies into the influence of surface characteristics on the behaviour of materials and devices
- Develop and maintain expert skills and knowledge in the above fields
- Conduct scientific studies into the behaviour of metal products and investigate electrical contact or interconnection systems
- Devise and develop specialised test measurement or analytical techniques as needed.
- Research testing methods applicable to the characterisation and failure analysis of materials and components
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: G.G. Mitchell, BSc(Hons), MSc

Professional Staff:
E.J. Bondarenko, Dip App Phys, BAppSc, MAIP, MIEAust, SMIREE, FRAS
S.J. Charles, BAppSc
P.W. Day, BE
S.J. Faulks, BSc(Hons), PhD
J.R. Godfrey, Dip Met
P.J. Gwynn, Dip App Chem
C.G. Kelly, BAppSc, AAIP, MAXAA, MAVS
T.J. Keogh, Dip Sec Met
M.H. Kibel, BSc(Hons), PhD, MAVS, ARACI, CChem
T.P. Rogers, BAppSc, MAppSc
I.K. Stevenson, BAppSc, Dip Elec Eng, GradIEAust
D.C. Willis, BEE(Hons)

Technical Staff:
G. Allison
D.A. Clifford
J.C. Ellery
F.I. Hanratty
S.F. Harper
M. Jorgensen, Dip Sec Met
I.E. Long
D. McCallum
S.F. Molnar
S.L. Parkinson

Polymer & Chemistry Section

Functions

- Conduct exploratory research in the field of polymer science and technology and develop polymer materials systems and processes specifically suited to Telecom Australia's network and the Australian environment
- Conduct scientific studies into environmental factors and their effects on materials, components and equipment; measure the incidence and distribution of climatic factors
- Conduct exploratory research into the chemical properties, composition of materials and their effects on plant and personnel
- Develop and maintain expert skills and knowledge in the above fields
- Devise or develop specialised test methods and analytical techniques as needed
- Operate as a verifying authority and signatory in accordance with the requirements of NATA in the field of temperature and humidity measurements
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: B.A. Chisholm, Dip App Chem, MSc, Grad RACI, Grad PRI

Professional Staff:
D.J. Adams, Dip App Chem, GradRACI
F.C. Baker, DipAppChem, DipChemEng, MAppSc, FRACI, AAIST, CChem, MRSC
R.N.M. Barrett, BSc(Hons), CChem, FRSC
R.J. Boast, Dip App Chem, Grad Dip Pol Sc, ARACI, CChem
T.J. Elms, Dip App Sc, Grad Dip Anal Chem, ARACI, CChem
S. Georgiou, BAppSc, Grad Dip Anal Chem
G.W.G. Goode, BSc
A.W. Kruijshoop, Natlr(Delft)
B.J. Keon, BSc, Grad Dip Pol Sc, Grad RACI
P.R. Latoszynski, Dip App Sc, Grad Dip Anal Chem, ARACI, CChem
D.E. Thom, BSc, Dip Ed, Dip Proc Comp Systems

Technical Staff:
S.D. Barnett
D. Coulson
D.A. Holding
M.C. Hooper
R.R. Pierson, Dip Res Cons Stud, ARACI, CChem, MAIST
A.S. Impey
B.L. James
I.M. Tippett

Mid-Infrared Optoelectronics Section

Functions

- Conduct exploratory research on optoelectronic devices suitable for mid-infrared optical fibre communications
- Conduct studies and experimental work on Metal-Organic Chemical Vapour Deposition techniques for the growth of materials applicable to infrared devices
- Develop fabrication procedures suitable for processing materials into optoelectronic devices for telecommunications applications
- Develop test and characterisation procedures for mid-infrared optoelectronic devices
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: J. Thompson, BA(Hons)

Professional Staff:
G.I. Christiansz, BSc(Hons), PhD, Dip Ed
M. Kwietniak, BSc, MEngSc, PhD, MIEEE, MAPS, MAVS
P.W. Leech, FRMIT, MAppSc, PhD
G. Pain, BSc(Hons), PhD, ARACI, CChem
G.K. Reeves, BSc(Hons), PhD, MIEAust

Technical Staff
R.J. Anderson
G. Brinson
M. Crarey
G.C. Longridge
G.K. Smith

Equipment Engineering Section

Functions

- Conduct research into the application of new materials, components fabrication and assembly techniques applicable to the design and construction of mechanical, electrical and electronic equipment and tools required within the Research Laboratories and elsewhere in Telecom Australia
- Provide for Telecom Australia a specialist design facility, including mechanical and electromechanical engineering design of the hardware aspects of telecommunications models; arrange for production of these designs within Telecom Australia or industry or, when necessary, within the Section; establish specification criteria for performance and quality, and the necessary measuring equipment, and employ these to ensure adequate performance of the items produced
- Oversight on-the-job training in mechanical engineering fields for the Research Laboratories
- Prepare and modify drawings incorporating associated design drafting, investigations and computations
- Ensure that the standard of engineering documentation prepared in the Department conforms to Telecom Australia's policies and standards
- Provide consultative services on the standard or specification of contractor supplied engineering documentation.

Section Head: J.R. Lowing, Dip Sec Met

Professional Staff:
A.R. Gilchrist, Dip Mech Eng, BE(Hons), GradIEAust
W.F. Hancock, Dip Elec Eng, MIEAust
V. Lee, BSc(ME), MSc(ME)
P.F.J. Meggs, Dip Mech Eng, ARMIT, Grad Dip Ind Mgt, MIEAust, SMSME

Technical Staff:

K.L. Everett	L. McCallum
T.J. Hand	D.J. McMillan
A.L. Johnson	P.N. McMullen
J.W. Kalisz	R.N. Nicoll
J.D. Kisby	W.L. Reiners
S.J. Lloyd	B.W. Walker

Chief Draftsman: M.K. Brown

Drafting Staff:

A. Carratelli	A.J. Lynch
M.P. Haslinghouse	A.J. Norrish
R.N. Jackel	D.G. Peck
B.C. James	M.F. Rogers
B.J. Kerr	

INDUSTRIAL PROPERTY AND INFORMATION BRANCH

Objectives

Conduct studies, participate in policy formulation, contribute to specifications for and assessments of tenders, develop and operate systems, facilities and processes, and provide advice and recommendations as appropriate relating to:

- the identification, securing and exploitation of industrial property rights relevant to the interests of Telecom Australia, including industrial property aspects of Telecom Australia's relationships with other parties
- the management and operation of the Research Laboratories' programme of R&D contracts and related processes for R&D collaboration with external organisations
- technology and information transfer from the Research Laboratories to other units of Telecom Australia, industry, academia and other external organisations
- co-ordination of the participation of staff of the Laboratories' in the activities of external organisations
- recruitment and development of professional and technical grade staff of the Research Laboratories'
- the investigation development and operation of centralised, integrated networking computer-based facilities - in support of the Research Laboratories' management, administration and investigatory functions.

General Manager: F.W. Arter, BEE, MEngSc

Branch Administrative Officer: T.M. Walsh

Support Staff: E.E. Hornak

Industrial Property Section

Functions

- Interpret and execute Telecom Australia's policy on industrial property and provide specialist advice and assistance to management and staff of Telecom Australia on the industrial property aspects of their activities within Telecom Australia and with external organisations
- Identify, secure and, where relevant, exploit Telecom Australia's interests in industrial property arising out of its internal activities or those with external organisations
- Co-ordinate, establish and manage the Research Laboratories' programme of R&D contracts, collaborative research agreements and related activities
- Develop and participate in the execution of strategies for the transfer of technology developed within Telecom Australia, and in particular, the Research Laboratories, to industry.

Section Head: O.J. Malone, BEE

Professional Staff:
P. Gretton, Dip Elec Eng
A.P. Mizzi, BEE

Support Staff: C.F. Wilson

Information Transfer Section

Functions

- Develop and implement methods and programmes for the effective transfer of technical information generated within the Research Laboratories to other units of Telecom Australia, and where appropriate, to external industrial organisations, R&D institutions and academia
- Co-ordinate and oversight technical publications emanating from the Research Laboratories, including the development and operation of efficient publication processes and procedures
- Perform editorial functions and oversight approval/classification/issue procedures for technical publications of the Laboratories
- Provide a focus for technical liaison with, and representation of Laboratories' activities to, external organisations and persons, including the development and operation of information retrieval services, talks, visits, displays, etc.
- Assist in the recruitment of professional and technical grade staff for the Research Laboratories, and develop, co-ordinate and execute programmes for their technical development.

Section Head: L.N. Dalrymple, Dip Elec Eng, GradIEAust

Technical Staff:
C.A. Block
A.M. Johnson
K.M. Matthews
A.K .Mitchell
M.F.Phipps

Support Staff:
G.E. Cock
M.F. Urbancic

Trainee Technical Staff:
M. Armstrong
D.A.Calwell
B.J.Edwards
P.J.Grounds
P.J.McIntosh
I.D.Moyer
D.A.Nolte
J.R.J.Valadon

Information Processing Facilities Section

Functions

- Conduct relevant research, develop and operate integrated, networking computer-based information processing facilities for the Research Laboratories, to provide effective, universally compatible facilities for automated office processes, management information systems, text/graphics communications, numerical/data analysis, computer simulation and control, etc., in support of the Laboratories' management, administrative and investigatory functions
- Prepare software and hardware specifications for and co-ordinate the acquisition and commissioning of such facilities, liaising with other units of Telecom Australia and industry as required
- Provide consultant advice and assistance to staff of the Research Laboratories on the application of the facilities
- Develop and co-ordinate training programmes for users of the facilities.

Section Head: P.J. Tyers, BE(Hons), BSc, MIEEE

Professional Staff: P.Y.F. Hui, BSc

Technical Staff:
R.B. Gotch
S.R. McAllister
W.W. Staley

Support Staff:
D.J. Noble
B.L.P. Stone

OPERATIONS BRANCH

Objectives

To provide support to professional and technical staff of the Telecom Research Laboratories in the areas of:
- laboratory design and instrumentation facilities
- human resources management
- financial resources management and purchasing
- general administration

General Manager: B.M. Douglas

Project Officer: T.H. Brown

Branch Administrative Officer: M.T. Lambert

Support Staff:
E.C. Bailey
B. Chivers
J.H. Darbyshire
S.J. Hoare
R.A. Nelson
D.A. Pritchard
E. Williamson

Instrumentation Engineering Section

Functions

- Study instrumentation trends relevant to present and future Telecom Australia applications; design and develop novel instrumentation systems for specific Telecom Australia needs which cannot be obtained from commercial sources
- Develop and maintain facilities, including calibration standards, required for the calibration and maintenance of advanced laboratory test equipment and apply these facilities to ensure the high standard of performance required of the Research Laboratories' instrumentation
- Conduct the procurement programme for all new equipment for the Laboratories, including preparation of technical specifications, tender evaluations and technical reports; perform acceptance testing of new equipment.

Section Head: A.M. Collins, BSc

Professional Staff: P. Standaert, BE(Hons)

Technical Staff:
H.W. Anders
G.F. Brownfield
B.J. Churchill
P.J. Dalliston
S.B. Davenport
D.C. Diamond
D.M. Gellert
D. Goulding
S.J. Heath
M.J. Leary
R.B. Rizzo
K.L. Rogers
D. Wilson

Laboratory Design Section

Functions

- Plan and specify, in conjunction with other Telecom Australia staff, accommodation requirements of the Laboratories in future and existing buildings; liaise with construction authorities and contractors as appropriate; plan and co-ordinate the occupation of new accommodation
- Maintain special laboratory buildings, fittings, services and facilities; liaise with Buildings SRU to arrange all buildings and building services, repairs and maintenance required within the Laboratories
- Co-ordinate all safety, security, and fire protection matters within the Laboratories.

Manager: T.W. Crichton

Professional Staff: R.J. Day, Dip Elec Eng, Dip Mech Eng, MIEAust

Technical Staff:
W. Alkemade
S.R. Collins
R.I. David
R. Fodero
B.J. Maloney
J. Scicluna

Human Resources Section

Functions

- Provide a value added service to assist the achievement of the Research Laboratories' Business Plan by developing and implementing strategies in the field of human resource management, in particular:
  - staff development
  - personnel services
  - recruitment and selection
  - performance appraisal
  - manpower and organisation planning
  - industrial relations
  - legislation/administrative law
  - occupational health and safety

Manager: P. Farnes, BA

Manpower and Organisation Officer:
T.W. Dillon
Staff Development Officer:
P.S. Dawson, BBus
Personnel Services Officer: P.G. Rodoni

Support Staff:
C. Costello
R.P.E. Johnstone
K. Schwarzenberg
L. Singleton
S. Van Den Heuvel

Budgets and Finance Section

Functions

- Provide a co-ordinated framework of resources, systems and advice for the management of all Laboratories' financial, budget control and purchasing activities

Manager: M.A. Chirgwin

Budgets Officer: K.J. Sexton
Management Information Officer:
M.J. Holmes
Senior Supply Officer: J. Utan

Support Staff:
C.C.M.R. Bernhard
L.B. Phung, BA
D.J. Clutterbuck
R. Fernandes
V. Flanagan
F. Skidmore
J. Stonehouse
R.E. Zelley

Stores Staff:
M. Gie
P.A. Long
A. Malatesta
R.J. Mullins

Staff Affiliations with External Bodies

Staff of the Laboratories are active members of advisory committees of educational establishments, governing bodies of professional and learned societies, technical committees of standards organisations and advisory committees convened by other national and international organisations. These include:

NATIONAL EDUCATIONAL BODIES

Technical and Further Education Board, Victoria	
• Science Laboratory Standing Committee	T.J. Elms
Melbourne University	
• Faculty of Engineering	H.S. Wragge
• Committee of Convocation	H.S. Wragge
Monash University	
• Research Associate - Department of Materials Engineering	M.S. Kwietniak
Chisholm Institute of Technology	
• Advisory Board, Centre for Business Technology	H.S. Wragge
• Chairman, Digital Electronics Course Advisory Committee, Faculty of Applied Science	H.S. Wragge
• Course Advisory Committee, Department of Chemistry and Biology	R.J. Boast
• Course Advisory Committee, Division of Information Technology	A.J. Jennings
• Course Advisory Committee, Electrical Engineering Department	A.J. Jennings
Royal Melbourne Institute of Technology	
• Course Advisory Committee, Communications Engineering Department	P.H. Gerrand H.S. Wragge
• Course Advisory Committee, Metallurgy and Mining Department	P.V.H. Sabine
Victracc	
• Director	H.S. Wragge

NATIONAL PROFESSIONAL BODIES

Australian Institute of Energy	N.F. Teede
Australian Telecommunications and Electronics Research Board	R. Smith F.J.W. Symons
Australian X-Ray Analytical Association	
• Victorian Branch - Committee Member	B.F. Usher
Commonwealth Special Research Centre for Electronic Structure of Materials	G.L. Price

Institute of Electrical and Electronic Engineers

- Australian Council
  - Committee Member — L.J. Millott
- Victorian Section Committee
  - Chairman — L.J. Millott
  - Secretary/Treasurer — R.A. Palmer
  - Committee Members — R.A. Court, R.P. Coutts, A.J. Gibbs, A.J. Jennings
- Communications Chapter
  - Committee Members — T.J. Batten, E. Vinnal

Telecommunications Society of Australia

- Council of Control — G.F. Jenkinson
- Board of Editors: "Australian Telecommunication Research" — G.D.S.W. Clark, A.J. Gibbs, R.J. Harris, M.A. Hunter, G.F. Jenkinson, D.J. Kuhn, I.P. Macfarlane, G.K. Reeves, H.V. Rodd, J. Thompson

The Institution of Engineers, Australia

- National Committee on Computers and Information Technology — F.J.W. Symons

The Royal Australian Chemical Institute

- Polymer Division Committee — B.A. Chisholm

NATIONAL STANDARDISATION BODIES

Standards Association of Australia (SAA)

- Australian Electrotechnical Committee — N.F. Teede
  - IEC Quality Assessment Scheme for Electronic Components — N.F. Teede
  - Environmental Testing Procedures — N.F. Teede, M.C. Hooper
- Co-ordinating Committee on Fire Tests — D.J. Adams
- Plastics Standards Board — B.A. Chisholm
- Telecommunications and Electronics Standards Board and Executive — G.M. Willis

SAA Technical Committees

- Acoustic Standards
  - Acoustics, Instruments and Measuring Techniques — R.J. Day
- Battery Standards
  - Primary Cells and Batteries — J.J. Der
  - Secondary Batteries — J.J. Der
- Chemical Industry Standards
  - Adhesives — R.J. Boast
  - Examination of Workplace Atmospheres — R.N.M. Barrett
  - Heavy Duty Paints — D.J. Adams
- Computers and Information Processing Standards
  - Data Communications — C.J. O'Neill, P.R. Hicks
  - EFT Authentication and Security — J.L. Snare
  - EFT Communications — C.J. O'Neill, J.L. Park
  - EFT Integrated Circuit Cards — J.L. Snare
  - Information Systems — F.J.W. Symons
  - Open Systems Interconnection — P.C. Craig, R. Exner, J.L. Park, M.C. Wilbur-Ham
  - Programming Languages — G.P. Rochlin
  - Text and Office Systems — R. Exner, B.P. Smetaniuk
- Electrical Industry Standards
  - Control of Undesirable Static Charges — G.W.G. Goode
  - Electrical Accessories — E.J. Bondarenko
  - Electrolytes — R.N.M. Barrett
  - High Voltage Testing — E.J. Bondarenko
  - Indicating and Recording Instruments — E. Pinczower
  - Lightning Protection — E.J. Bondarenko
  - Plastics — B.A. Chisholm
- Mechanical Engineering Industry Standards
  - Hand Tools — P.F.J. Meggs
- Metal Finishing Standards
  - Armouring Cable — T.J. Keogh
  - Electroplating & Methods of Test — T.J. Keogh
  - Metal Finishing — J.R. Godfrey
  - Tin and Tin Alloys — J.R. Godfrey
  - Solder and Solder Fluxes — P.J. Gwynn
  - Surface Preparation — T.J. Keogh
  - Zinc and Cadmium Coatings — T.J. Keogh
- Metal Industry Standards
  - Galvanised Products — T.J. Keogh
  - Precious Metals — J.R. Godfrey
  - Steel Wire Rope and Strand — T.J. Keogh
- Plastics Industry Standards
  - Flammability of Plastics — D.J. Adams
  - Fuel Tanks and Containers — D.J. Adams
  - ISOTC 61 Plastics Advisory Committee — B.A. Chisholm, D.J. Adams
  - Mechanical Testing of Plastics — B.A. Chisholm
  - Outdoor Weathering of Plastics — G.W.G. Goode
  - Plastics for Telecommunications Cables — D.J. Adams
- Safety Standards
  - Industrial Safety Gloves — T.J. Elms
  - Industrial Safety Helmets — R.J. Boast
  - Laser Safety — R.W.A. Ayre, P.V.H. Sabine
  - Safety of Electronic Equipment — E. Bondarenko
  - Safety of Information Technology Equipment — E. Bondarenko

- Telecommunications and Electronics Industry Standards
  - Electromagnetic Interference — S. Iskra, I.P. Macfarlane
  - Environmental Testing — N.F. Teede, M.C. Hooper
  - Hazards of Non-Ionizing Radiation — K.H. Joyner, S. Sastradipradja
  - Measurement Methods for RF Radiation — K.H. Joyner, I.P. Macfarlane
  - Passive Electronic Components — S.J. Charles
  - Photovoltaic Modules — D.J. Kuhn
  - Polyethylene Insulation for Telecommunications — D.J. Adams
  - Semiconductor Devices — G.G. Mitchell
  - Siting of Radiocommunications Equipment — R.K. Flavin, K.H. Joyner

National Association of Testing Authorities (NATA)
- Assessor for Environmental Testing — M.C. Hooper
- Assessor for Laboratories Engaged in Acoustical Testing — E.J. Koop
- Assessor for Laboratories Engaged in Electrical Testing — E. Pinczower, J.B. Erwin
- Assessor for Laboratories Engaged in Testing Plastics — B.A. Chisholm
- Organic Materials Technical Group — B.A. Chisholm

OTHER EXTERNAL ORGANISATIONS

Australian Government Paint Committee — D.J. Adams

Commonwealth Special Research Centre for Electronic Structures of Materials — G. Price

CSIRO
- Standards Advisory Committee — G.M. Willis

Daratech P/L (Victorian Department of Agriculture and Rural Affairs)
- Director — O.J. Malone

Department of Industry, Trade & Commerce
- Advanced Electronic Materials Committee — B.F. Usher

Department of Resources and Energy
- Committee for the Japan-Australia Collaborative Program on Remote Area Power Supplies — N.F. Teede

National Energy Research, Development and Demonstration Council
- Technical Standing Committee on Solar, Wind and Nuclear Energy — N.F. Teede

National Occupational Health and Safety Commission
- Working Party on Non-ionising Radiation, Standing Committee on Standards Development — K.H. Joyner

National Protocol Support Centre
- Deputy Chairman — F.J.W. Symons

Overseas Telecommunications Commission OTC(A)
- Research & Development Board — F.J.W. Symons

Victorian Solar Energy Council
- Project Steering Committee — N.F. Teede

INTERNATIONAL BODIES

The Laboratories participate in the activities of a number of international bodies and committees.These include:

- The International Telegraph and Telephone Consultative Committee (CCITT)
- The International Radio Consultative Committee (CCIR)
- The Australian and New Zealand Association for the Advancement of Science (ANZAAS)
- The Bureau International de l'Heure (BIH)
- The International Electro-Technical Commission (IEC)
- The International Standards Organisation (ISO)
- The International Federation of Documentation, Committee for Asia and Oceania (FID/CAO).

In particular, staff of the Research Laboratories held offices in the following international bodies during the year:

- IEC Joint Co-ordination Group on Optical Fibres, Working Group O — R.W.A. Ayre
- IEC Quality Assessment System for Electronic Components, Certifications Management Committee, — N.F. Teede
- International Special Committee on Radio Interference (CISPR) Working Groups — I.P. Macfarlane
- Teletraffic Engineering Training Project TETRAPRO, ITU/ITC — J. Rubas
- Special Rapporteur, CCITT SG VII/48 — J.L. Park

Reports, Papers, Lectures and Talks

Research Laboratories Reports and Branch Papers are the vehicles by which the results of research studies and investigations, development projects and other specialised tasks undertaken in the Laboratories are officially documented. Staff of the Laboratories also contribute papers to Australian and overseas scientific and technical journals, and present papers to learned societies both in Australia and overseas. The following lists show the reports, papers, lectures and talks published or presented by Laboratories' staff during the last 12 months.

RESEARCH LABORATORIES REPORTS

REPORT NUMBER	AUTHOR(S)	TITLE
7709*	Standaert, P. Curlis, S.P. Stevens, A.J.	An Automatic Battery Testing & Facility - A Programmable Power Supply and Contactor Controller
7750	Charles, S.J. & Rydz, R.W.	Addendum 1 - Component Reliability Guide - Part 2
7769*	Brunelli, A.	Processing Data for the Manufacture of Production Masters on Photographic Film
7770*	Brunelli, A.	Procedures and Process Specifications for the Processing of Prototype Printed Boards through the Exellon XL2S Numerically Controlled Drilling Machine
7789*	Tan, K.H. Davies, W.S. & Reid, R.L.	Initial Rain Attenuation Results for a Parallel 13/38 GHz Point-to-Point Local Radio System Field Experiment
7795*	Brunelli, A. & Barker, G.J.	Development of a Draft Standard for High Reliability Thick Film Hybrids
7815*	Ruddell, H.J. & Cerovac, M.	Nylon Jacketed Optical Fibre Cable for Darwin/Katherine Route
7839	Georgiou, S.	Quantitative Determination of Anti-oxidants and Metal-ion Deactivators in Polyethylene by High Performance Liquid Chromatography
7851*	Prete, G.N. & Witham, R.C.	Multiple Access Spread Spectrum Communications
7852*	Sekfy, J.J.	A Wide Dynamic Range Measurement Receiver
7856	Copeland, P.R. Gilbert, B.C. & Sastradipradja, S.	Microwave Radiation Level Measurements at the Telecom Australia ITERRA Network Earth Station in Bendigo
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Jenkinson, G.F.	'Satellite Communications Research in Telecom', ANZAAS Congress, Townsville, August 1987
Jennings, A.J. & Nicholson, P.L.	'Artificial Intelligence in Communications Networks', Computing Systems and Information Technology Conference, Brisbane, June 1987
Jennings, A.J.	'Machine Learning in Intractable Domains: A Pragmatic View', Australian Artifical Intelligence Conference, Sydney, November 1987
Jennings, A.J. & Kowalczyk, A.	'Representation of a Database by a Reduced Number of Attributes', Applied Mathematics Conference, Sydney, February 1988
Johnson, A.B.	'Digital Implementation of a Demodulator Using a Digital Signal Processing Chip', International Symposium on Signal Processing and Its Applications, Brisbane, August 1987
Joyce, M.J.	'The Use of Solitons in Optical Communications', 12th Australian Conference on Optical Fibre Technology, Surfers Paradise, December 1987
Joyce, M.J. Orders, P.J. & Usher, B.F. (TRL); Gal, M. Tann, J. & Grant, K. (Uni. of NSW)	'Photo-luminescence Spectroscopy of Strained InGaAs-GaAs Quantum Wells', 8th Australian Institute of Physics Congress, Sydney, January 1988
Joyner, K.H.& Boal, T.J.	'Fifty Hertz Magnetic Field Levels in the Home and Office Environment in Australia', 7th International Congress of the International Radiation Protection Association, Sydney, April 1987

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Joyner, K.H. Macfarlane, I.P. & Hocking, B.W.	'Metallic Implants and Exposure to Radiofrequency Radiation', 7th International Congress of the International Radiation Protection Association, Sydney, April 1987
Joyner, K.H.	'A Discussion of Possible Mechanisms Via Which ELF Magnetic Fields May Interact with Tissue', Australian Radiation Protection Society, 12th Annual Conference, Brisbane, July 1987
Joyner, K.H. Copeland, P.R. & Macfarlane, I.P.	'An Evaluation of a Radiofrequency Protective Suit', Australian Radiation Protection Society, 12th Annual Conference, Brisbane, July 1987
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Leask, S.A.	'ISDN Access Signalling Emulator', IREECON'87, Sydney, September 1987
Leask, S.A. & McNaughton, R.A.	'Protocol Testing Using Forth', 1st Australian Forth Symposium, Sydney, May 1988
Leech, P.W. & Jaffrey, D.	'Microstructural Refinement of Aluminium-Silicon Based Alloys by Laser Glazing', 5th Australian Conference on Lasers and Spectroscopy, Surfers Paradise, May 1987
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Legg, S. & Lindgaard, G.	'A Relational Database Architecture for Electronic Aspects of Screen Design', CHISIG Seminar on Designing Interfaces for the User, Monash University, November 1987
Lindgaard, G.	'Matching Telecommunications to People - Human Factors in Telecommunications', ANZAAS Centenary Conference, Sydney, May 1988
Lindgaard, G.	'Strategic Planning for the Implementation of Office Automation - A Case Study', Conference of the Victorian Branch, Australian Computer Society, March 1988
Manfield, D.R.	'Blocking of Series Links Carrying ISDN Traffic', 2nd Australian Teletraffic Research Seminar, Adelaide, December 1987
McGlade, B.J. & Hopson, A.J.	'The ISO Virtual Terminal Service - An Introductory Tutorial', IREECON'87, Sydney, September 1987
McGregor, I.M. & Semple, G.J.	'Macnet - A Shared Customer Access Network', 12th Australian Conference on Optical Fibre Technology, Surfers Paradise, December 1987
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Nicholson, P.L.	'Fast Search Methods for Dynamic Networks', Australian Joint Artifical Intelligence Conference, Sydney, November 1987
Nicholson, G.	'Transmission Performance of an Optical FSK Heterodyne System with a Single-filter Envelope-detection Receiver', IEEE Journal on Lightwave Technology, Vol. LT-5, April 1987
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Palmer, R.A. Tirtaatmadja, E. & O'Neill, C.J.	'The Application of Multistage Interconnection Networks to Fast Packet Switching', IREECON'87, Sydney, September 1987
Park, J.L.	'Fast Packet Switching - Standards and World Developments', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
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Pierson, R.R.	'Instrumentation', Australian Institute of Occupational Hygienists Conference, Adelaide, November 1987
Potter, P.G.	'Reliability and Performance Comparisons for Metropolitan Area Networks', ATERB Workshop on Local Area Networks - New Ideas and Novel Applications, Sydney, March 1987
Price, G.L.	'Broadband Optoelectronics', 8th Australian Institute of Physics Congress, Sydney, January 1988
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Reeves, G.K. & Harrison, H.B.	'Integrated Optics - New Era or the Last Frontier', Opportunities in New Materials, Institute of Metals and Materials Australasia Seminar, Melbourne, November 1987
Reeves, G.K.	'Photoconductive Devices - Sensor Design', Microelectronics'88 Conference, Melbourne, May 1988
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Robbins, T.P.	'Simulation of a Stand-alone Photovoltaic Power Supply with Battery Storage', ANZSES Conference, Canberra, November 1987
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Rowles, C.D. et al	'A Model Based Approach to Automated VLSI Synthesis', IREECON'87, Sydney, September 1987
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Rubas, J. & Harris, R.J.	'Application of Computer Simulation to Telecommunication Network Studies', Simulation Society of Australia Conference, Melbourne, May 1987
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Sabine, P.V.H.	' Optical Fibres - Lighting the Way to the Next Century', IEAust Bicentennial Electrical Engineering Congress, Melbourne, April 1988
Scott, C.J.	'Optical Switching - A Network Perspective', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
Seidl, R.A.	'Voice Driven Transaction Services', IREECON'87, Sydney, September 1987
Semple, G.J. Batten, T.J. & Smith, B.M.	'The Application of Optical Fibre Systems in the Customer Access Network', 12th Australian Conference on Optical Fibre Technology, Surfers Paradise, December 1987
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Snare, J.L.	'Value Added Services and Their Security', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
Snare, J.L.	'Secure Electronic Data Interchange', 5th IFIP International Conference on Computer Security, Surfers Paradise, May 1988
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Subocz, M.	'Intelligent Networks for New Communication Services', IREECON'87, Sydney, September 1987
Swenson, E.M.	'Distributed Databases for Transaction-oriented Processing', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
Symons, F.J.W.	'Review of the Current Status and Likely Future Developments in OSI and Their Implications for Australia', Computing Systems and Information Technology Conference, Brisbane, June 1987
Symons, F.J.W.	'Establishment of the Australian National Protocol Support Centre', Computing Systems and Information Technology Conference, Brisbane, June 1987
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Symons, F.J.W. & Dickson, G.J. (NPSC)	'Using Computer Networking for Competitive Advantage', IEAust Bicentennial Electrical Engineering Congress, Melbourne, April 1988
Szymanski, J.	'Dynamic Correlations in the Electron Gas: The Mean Field Picture and Beyond', 5th International Conference on Recent Progress in Many Body Theory, Oulu, Finland, August 1987
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Szymanski, J. Neilson, D. & Wizewardena, K. (Uni. of NSW)	'Effects of Adsorption on the Surface Properties of CdTe and HgTe', 8th Australian Institute of Physics Congress, Sydney, January 1988
Teede, N.F.	'Solar Powered Remote Area Telecommunications - The Australian Experience', Bandung, Indonesia, June 1987
Thompson, J. Gibbs, E.E. & Charles, S.J.	'Direct Measurement of Model Parameters on VLSI Devices', Microelectronics Conference, Melbourne, April 1987
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Tirtaatmadja, E. Harsant, D.M. Scott, C.J. Palmer, R.A. & Keck, B.W.	'An Experimental Digital Switching System', The Telecommunication Journal of Australia, Vol. 37, No. 2, 1987
Tyers, P.J.	'A Gateway between UNIX and Wang VS', 5th UNIX System Users Group Conference, Wellington, New Zealand, June 1988
Urie, A.R. et al	'Expected Channel Availability in the Wireless Office', IREECON'87, Sydney, September 1987
Usher, B.F. & Orders, P.J.	'GaAs Technology' Link Magazine, December 1987
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Vizard, R.J. & Gerrand, P.H.	'ISDN - An International Perspective', Computing Systems and Information Technology Conference, Brisbane, June, 1987
Vizard, R.J.	'Evolution of Common Channel Signalling', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
Wallis, R.C.	'Non-corrosive Fire-retardant Polymers for Internal Cable' International Injury Prevention Congress, Melbourne, February 1988
Warfield, R.E.	'Trends in Network Traffic Management', Seminar on Future Networks for Service Flexibility, Melbourne, October 1987
Warminski, T.	'X-Ray Analytical Studies of the Bismuth Germanate Crystals', Journal of Physics and Chemistry of Solids, Vol. 48, No. 2, February 1987
Warminski, T.	'Homogeneity and Purity of II-VI Compounds', 2nd Australian Conference on II-VI Semiconductors, Monash University, May 1987
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Warminski, T.	'X-ray Microanalysis of Fluoride Glasses' 12th Australian Conference on Optical Fibre Technology, Surfers Paradise, December 1987
Wheeler, G.R. Wilbur-Ham, M.C. & Fone, R.J.	'Modelling Concurrent Systems Using Petri Nets', Australian Software Engineering Conference (ASWEC'87), Australian Defence Force Academy, Canberra, May 1987
Wheeler, G.R. Wilbur-Ham, M.C. & Pascoe R.V.	'International Standards for Modelling OSI Communication Services and Protocols', Australian Software Engineering Conference (ASWEC'87), Australian Defence Force Academy, Canberra, May 1987
Wilbur-Ham, M.C.	'A Tutorial Introduction to SDL', Australian Software Engineering Conference (ASWEC'87), Australian Defence Force Academy, Canberra, May 1987
Wilbur-Ham, M.C.	'PROTEAN: A Tool for Verifying Protocol Specifications', IREECON'87, Sydney, September 1987
Wragge, H.S.	'Telecommunications R&D in Australia', IREECON'87, Sydney, September 1987
Wragge, H.S.	'An Overview of Current Technologies and Future Directions in Telecommunications', ITR Seminar on Telecommunications - Linking Voice, Data and Images, Melbourne, May 1988
Zukerman, M.	'On Packet Switching Capacity in QPSX', IEEE GLOBECOM'87, Tokyo, November 1987
Zukerman, M. & Rubin, I. (Uni. California)	'Queueing Performance of a Multi-channel System under Bursty Traffic Conditions and State-dependent Service Rates', Australian Telecommunication Research, Vol. 21, No. 2, November 1987

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Zukerman, M.	'Circuit Allocation in a Hybrid Switch' 2nd Australian Teletraffic Research Seminar, Adelaide, December 1987

LECTURES AND TALKS

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Arter, F.W.	'Telecom's Tomorrow', National Science Summer School, Canberra College of Advanced Education, January 1988
Boast, R.J.	'Chemistry for Everyday Life', Chemistry in Schools Week, Royal Australian Chemical Institute, Melbourne, October 1987
Bundrock, A.J.	'Mobile Satellite Systems', Institution of Radio and Electronic Engineers, Deakin University, April 1988
Burgin, J.L.	'Design Issues for Future Telecommunications Networks', Department of Electrical Engineering, Monash University, September 1987
Chisholm, B.A.	'Polymer Materials for Optical Fibre Cables', Plastics and Additivies Group, Chisholm Institute of Technology, June 1987
Chisholm, B.A.	'Materials Technology for Optical Fibre Cables', Hawthorn Institute of Education, Melbourne, August 1987
Clark, G.D.S.W.	'Telecommunications and Urban Structures', International Symposium on Transport and Communications - Urban Forum, Monash University, August 1987
Coutts, R.P.	'Personal Communications - A New Dimension', Telecommunication Society of Australia, Melbourne, August 1987
Craig, P.C.	'Status and Future Plans for DP 9594 - The Directory', Meeting of SAA Technical Committee IS1/21, Canberra, October 1987
Craig, P.C.	'X.400 and EDI Standards', National Protocol Support Centre, December 1987
Craig, P.C.	'X.400 Message Handling and Electronic Business Data Exchange', Telecommunication Society of Australia, Melbourne, March 1988
Demytko, N.	'Secure Data Communications', Secure Data Communications Workshop, Melbourne, July 1987
Demytko, N.	'Security for Value-added Services', Department of Education, Employment and Training, February 1988
Demytko, N.	'Authenticated Messaging', Seminar, Industry Liaison Committee, Melbourne, December 1987
Demytko, N.	'Secure Messaging', Department of Finance, Canberra, April 1988
Der, J.J.	'Battery Testing Parameters and Their Relative Importance', Battery Technologists and Battery Users Group, Melbourne, February 1988
Elms, T.J.	'Chemistry in Everyday Life', Chemistry in Schools Week, Royal Australian Chemical Institute, Melbourne, October 1987
Evans, P.A	'Metropolitan Area Networks: A Telecommunications Perspective', Telecommunication Society of Australia, Melbourne, June 1987
Exner, R.	'Customer Services and Systems Activity in Electronic Directories and Electronic Data Interchange', Department of Local Government and Administrative Services, Melbourne, June 1987
Exner, R.	'Electronic Directories for Tomorrow's Telecommunications', Victorian Chapter, IEEE Communications Society, Melbourne, April 1988
Flavin, R.K.	'Mobile Satellite Systems', Institution of Radio and Electronic Engineers, Melbourne, May 1988
Georgiou, S.C.	'Spectroscopic Case Studies of Polymers Used in Telecommunications', 5th Australian Polymer Discussion Group, Australian National University, December 1987
Gerrand, P.H.	'Software Engineering for Future Telecommunications Services', Australian Software Engineering Conference, Canberra, May 1987
Hicks, P.R.	'Considerations for the Performance Testing of Packet Switched Data Networks', Seminar on Protocol Conformance Testing, National Protocol Support Centre, Melbourne, October 1987
Hinton, K.J.	'Quantum Optics and Communications', School of Physics, Melbourne University, July 1987
Hinton, K.J.	'Who Needs Quantum Physics?', La Trobe University, March 1988
Ja, Y.H.	'Higher Order Finite Element Method to Solve the Non-Linear Coupled-Wave Equations for 2-Wave and 4-Wave Mixing', OSA Topical Meeting on Photo-refractive Effects, Los Angeles, USA, August 1987

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Jennings, A.J.	'Machine Learning: Pragmatico', Computer Science Department, Monash University, March 1988
Joyner, K.H.	'World Health Organisation Fellowship Report', Australian Radiation Laboratory, September 1987
Keon, B.J.	'Chemistry in Everyday Life', Chemistry in Schools Week, Royal Australian Chemical Institute, Melbourne, October 1987
Kowalczyk, A.	'Uniqueness Theorems for Subsets of Riemannian Manifolds', Australian Mathematical Society, Geelong, May 1987
Kuhn, D.J.	Photovoltaic Research at Telecom Australia', ANZSES Meeting, Melbourne, October 1987
Kuhn, D.J.	'Research Activities in Energy for Telecommunications',ANZSES (Victorian Division) Seminar on Photovoltaics and Their Applications, Melbourne, November 1987
Kuhn, D.J.	'Application of Photovoltaic Technologies to Remote Area Telecommunications Systems',Hangzhou (China), Hanoi (Vietnam), Vientiane (Laos), November 1987
Kuhn, D.J. & Murfett, A.J.	'Solar Powered Telecommunications Systems', Institution of Radio and Electronic Engineers, Melbourne, March 1988
Kuhn, D.J. & Goh, S.C.	'Warm Superconductors - A New Energy Technology Frontier', Society of Automotive Engineers Seminar on New Frontiers, Melbourne, March 1988
Kwietniak, M.S. Warminski, T. Stevenson, A.W. & Wilkins, S.	'X-ray Topographic Studies of Mercury Cadmium Telluride Alloys', 2nd Australian Conference on II-VI Semiconductors, Monash University, May 1987
Kwietniak, M.S. Radlinski, A. & Giriat, W.	'Temperature Shift of the Divalent Manganese Luminescence in CdMnTe', 2nd Australian Conference on II-VI Semiconductors, Monash University, May 1987
Macfarlane, I.P. Joyner, K.H. & Davies, W.S.	'The Electromagnetic Environment', Telecommunication Society of Australia, Melbourne, August 1987
Orders, P.J. & Usher, B.F.	'Determination of Critical Thickness in In(x)Ga(1-x)As/GaAs Heterostructures by X-ray Diffraction', Electronic Materials Workshop - 2D Structures and Superlattices in Metals and Semiconductors, University of NSW, December, 1987
Orders, P.J.	'Growth and Characterization of InGaAs/GaAs Heterostructures', Department of Physics, LaTrobe University, Melbourne, June 1987
Pain, G.N.	'The MOCVD of MCT', Monash Chemical Society, Monash University, Melbourne, July 1987
Pain, G.N.	'Metal Finishing for Microelectronics', Australian Institute of Metal Finishing, Melbourne, February 1988
Park, J.L.	'Protocol Engineering', South Asian Association of Regional Cooperation Conference on Software Maintenace, New Delhi, October 1987
Park, J.L.	'Fast Packet Switching', Institute of Engineers, India, New Delhi, October 1987
Price, G.L.	'Optoelectronic Device Materials', Institute of Metals and Materials Seminar, Melbourne, May 1987
Rosman, G.E.	'The Story of Optical Communications', Association for the Blind, Melbourne, March 1988
Rowles, C.D.	'AI Research at Telecom Research Laboratories', Research Day for Computer Science, Monash University, February 1988
Sabine, P.V.H.	'Optical Fibre Communications', University of Adelaide, July 1987
Sabine, P.V.H.	'Future Trends in Optical Fibre Technology', Telecommunication Society of Australia, Brisbane, May 1988
Sabine, P.V.H.	'Advances in Optical Fibre and Optoelectronic Technology', Deakin University, April 1988
Sabine, P.V.H.	'Developments in Optical Fibre Communications', Swinburne Institute of Technology, March 1988
Scott, C.	'The Broadband Switching Future', Telecommunication Society of Australia (NSW Division), Sydney, October 1987
Smith, B.M.	'Optical Fibre in the Customer Access Network', IEEE/Telecommunication Society of Australia, Melbourne, October 1987
Snare, J.L. & Exner R.	'Security in Telecommunications Services', Deakin University, July 1987

AUTHOR(S)	TITLE, ETC.
Snare, J.L.	'Secure Communications Projects', Public Works Departments, WA and NSW, October 1987
Snare, J.L.	'Security and X.400', OSICOM X.400 Technical Group, Melbourne, April 1988
Thompson, J.	'Modelling of Devices used on VLSI Circuits', Electrical Engineering Department, Monash University, May 1987
Warminski, T.	'Homogeneity and Purity of II-VI Compounds', 2nd Australian Conference on II-VI Semiconductors, Monash University, May 1987

Industrial Property

It is a policy of Telecom Australia to protect its interests in any worthwhile industrial property, notably patentable inventions but also registerable designs, which might be generated by its staff in the course of their work. Many of the inventions patented by Telecom Australia have been made by Laboratories' staff, and the staff of the Laboratories also contribute to assessments of the novelty and likely usefulness of new ideas as they arise as possible subjects for patent or similar action. The list below summarises the portfolio of industrial property held by Telecom Australia. The portfolio includes applications for letters patent and registered designs.

PATENTS AND PATENT APPLICATIONS

INVENTION TITLE (INVENTOR/S)	APPLICATION NUMBER	PATENT NO. (IF GRANTED)	COUNTRY
Analogue Multiplier (Bruggeman, H.)	855543	3629567	USA
Tip Welding Means (Bondarenko, E.J.)	4714/71	3657512	USA
Self Adaptive Filter and Control Circuit (Mackechnie, L.K.)	98800	3732410	USA
Control of Operation of a System (McLeod, N.W.)	166819 56442/71	3745418 888597	USA Japan
Smoke Detector (Gibson, L. & Packham, D.R.)	367260	3874795	USA
Detecting Signal Components in Multi-frequency Signals (Proudfoot, A.D)	387855 178402	3882283 984068	USA Canada
Fibre Optic Termination (Sabine, P.V.H.)	508451/79	521528	Australia
Noise Assessment of PCM Regenerators (Gibbs, A.J.)	52160/79 1134915 093228	525766 1134915 4300233	Australia Canada USA
Tap Couplers for Optical Fibres (Johansen, E.& Dodge, E.)	87251/82	544705	Australia
Cable Hauling (Alcorn, J.)	17465/83	559320	Australia
Testing Bells and Other Electrically Activated Devices (Sneddon, B.W.)	17570/83		Australia
Instant Speaker Algorithm for Digital Conference Bridge (Phiet, D.Q.)	39841/85 85306496 8600304 490497 201967/85 775549	566718 1232663 4644530	Australia Europe (all states) UK Canada Japan USA
Characterisation of Digital Radio Signals (Martin, A.L.)	43227/85 PCT/AU85/00107 829150 61-502858 8600304 175/85 860176 860100 85902515 1211/85 543131 481293	 551145	Australia PCT USA Japan UK Denmark Finland Norway Europe (all states) Ireland Spain Canada
Cable Laying Apparatus (Vidler, R.A.)	47460/85 491271 213532 8523098 905998		Australia Canada New Zealand UK USA
Conforming the Frequency Spectrum to a Desired Form (Sneddon, B.W. & Beadle, S.G.)	49251/85		Australia
Optical Distribution System (McGregor, I.M.)	PCT/AU86/00277 63790/86 2658/87 87.2148 8605676.2 518923 8602185		PCT Australia Denmark Japan Norway USA Europe (all states) Canada Spain
Method of Initial Synchronisation for Full Duplex Digital Transmission (Jennings, A.J. & Clarke, B.R.)	66929/86		Australia
Switch Number Identifier (Coles, J., Nicholls, R. & Keith, J.)	PCT/AU87/00095 PH5375/86		PCT Australia USA Japan Europe (all states) Canada
VNG Signal Receiver (Latin, D.)	PI2728/87		Australia
Digital Error Logger (Livsey, J. et.al.)	PI4125/87 PI4126/87		Australia Australia

INVENTION TITLE (INVENTOR/S)	APPLICATION NUMBER	PATENT NO. (IF GRANTED)	COUNTRY
Current Injection Modulator (Kemeny, P.C.)	PI6188/88		Australia
Current Injection Laser (Kemeny, P.C.)	PI6189/88		Australia
Electro-optic Modulator (Kemeny, P.C.)	PI6190/88		Australia
Optical Switch (Ja, Y.H.)	PI6409/88		Australia
Trench Digging Apparatus (Vidler, R.)	PI6981/88		Australia
Tooth Removing Device for Trench Digging Apparatus (Vidler, R.)	PI6982/88		Australia
Magneto-optic Device (Ito, J. & Dai, X.)	PI7460/88		Australia

REGISTERED DESIGN APPLICATIONS AND REGISTERED DESIGNS

DESIGN (AUTHOR/S)	APPLICATION NUMBER	DESIGN NUMBER	COUNTRY
Housing (Burland, B.T.)	1186/82	87777	Australia
Table (Burland, B.T.)	1187/82	87679	Australia
Communications Apparatus (Design & Development Group)	8087/84	96141	Australia
Telephone (Burland, B.T. & Joseph, N.E.)	1328/85		Australia
Telephone Plug (Pickering, A.R.)	1327/85	96041	Australia
Base Plate for a Telephone (Atkins, D.)	1765/85	95362	Australia
Telephone Handset (Atkins, D.)	1766/85	95363	Australia
Telephone (Atkins, D.)	1767/85	95364	Australia
Telephone (Atkins, D.)	1768/85	95365	Australia
		934148	USA
	46854/86		Japan
	20868		New Zealand
	1038314	1038314	UK
	86301020		China
	1544/86	26842	Germany
	61624-00	15565.00	Netherlands
	157740	157740	India
Telephone (Atkins, D.)	7595/86		Australia

Overseas Visits by Laboratories' Staff

It is an important responsibility of any viable research organisation to keep abreast with developments and changes in particular fields of interest. To this end, the Laboratories arrange an annual programme of overseas visits through which members of staff are enabled to interchange experience, technical knowledge, opinions and ideas with research personnel of other organisations. The visits are normally to other telecommunications administrations, universities and industry, as well as to international forums and conferences of world telecommunications bodies and related organisations.

The following staff members have travelled overseas during the past year:

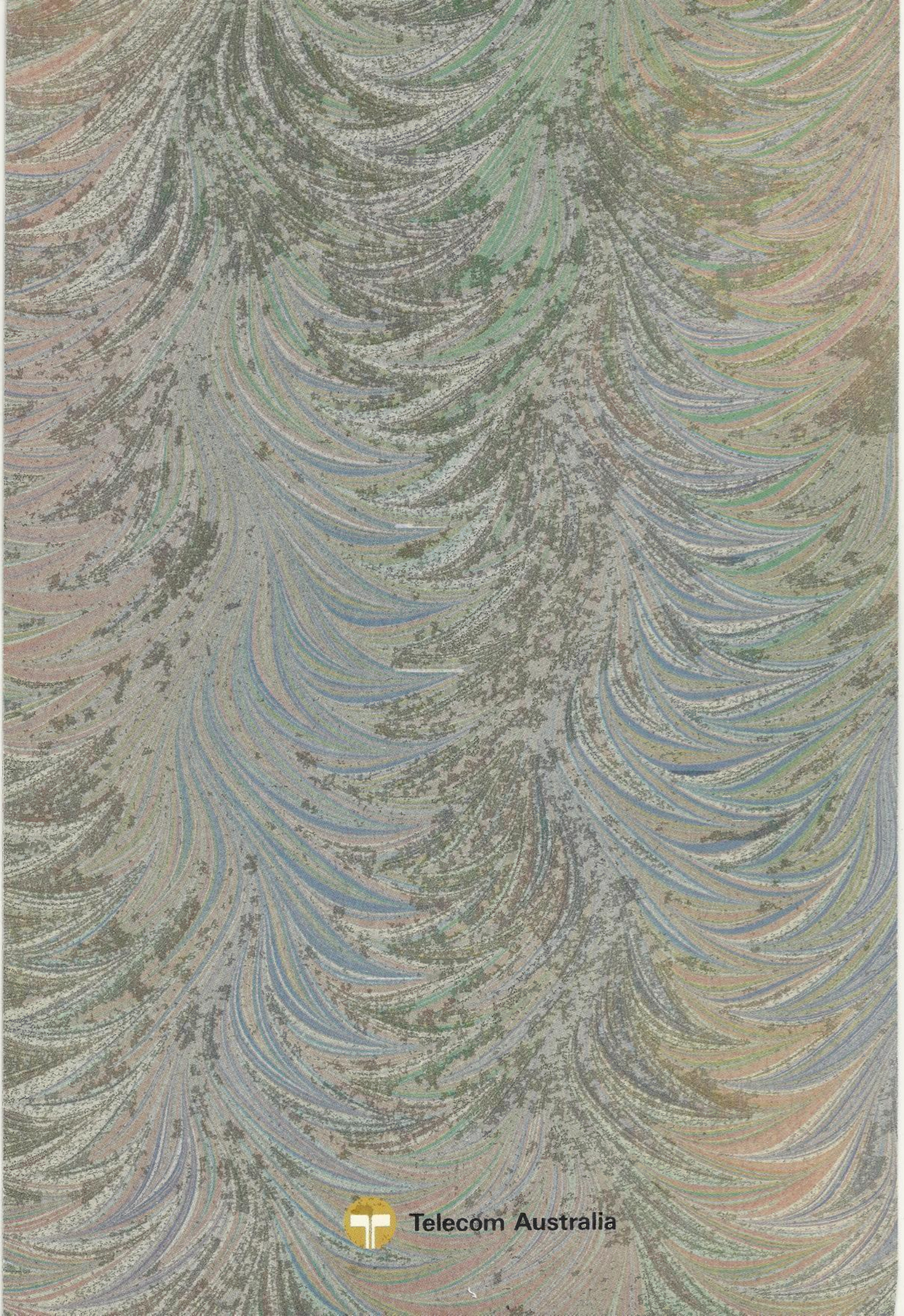
R.W.A. Ayre
T.J. Batten
F.G. Bullock
A.J. Bundrock
L.H. Campbell
B.A. Chisholm
R.P. Coutts
J.J. Der
B.T. Dingle
P.A. Evans
R. Exner
M.J. Flaherty
P.A. Galvin
A.J. Gibbs
R.J. Harris
S.J. Hurren
S. Iskra
G.F. Jenkinson
D.J. Kuhn
M.S. Kwietniak
P.W. Leech
M.J. Littlewood
P. McNamara
J.L. Park
S. Sastradipradja
I.K. Stevenson
M. Subocz
S.L. Sutherland
J. Szymanski
N.F. Teede
B.F. Usher
R.J. Vizard
M. Zukerman

Design & Artwork
Darianne Willmott
Creative Services
Telecom Corporate Communications

Photography
Andrew Lucas
Ern Mainka
Community Relations
Telecom Corporate Communications

Computer Layout
Lisa Curran

Printing
Tudor Printery Pty. Ltd.



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