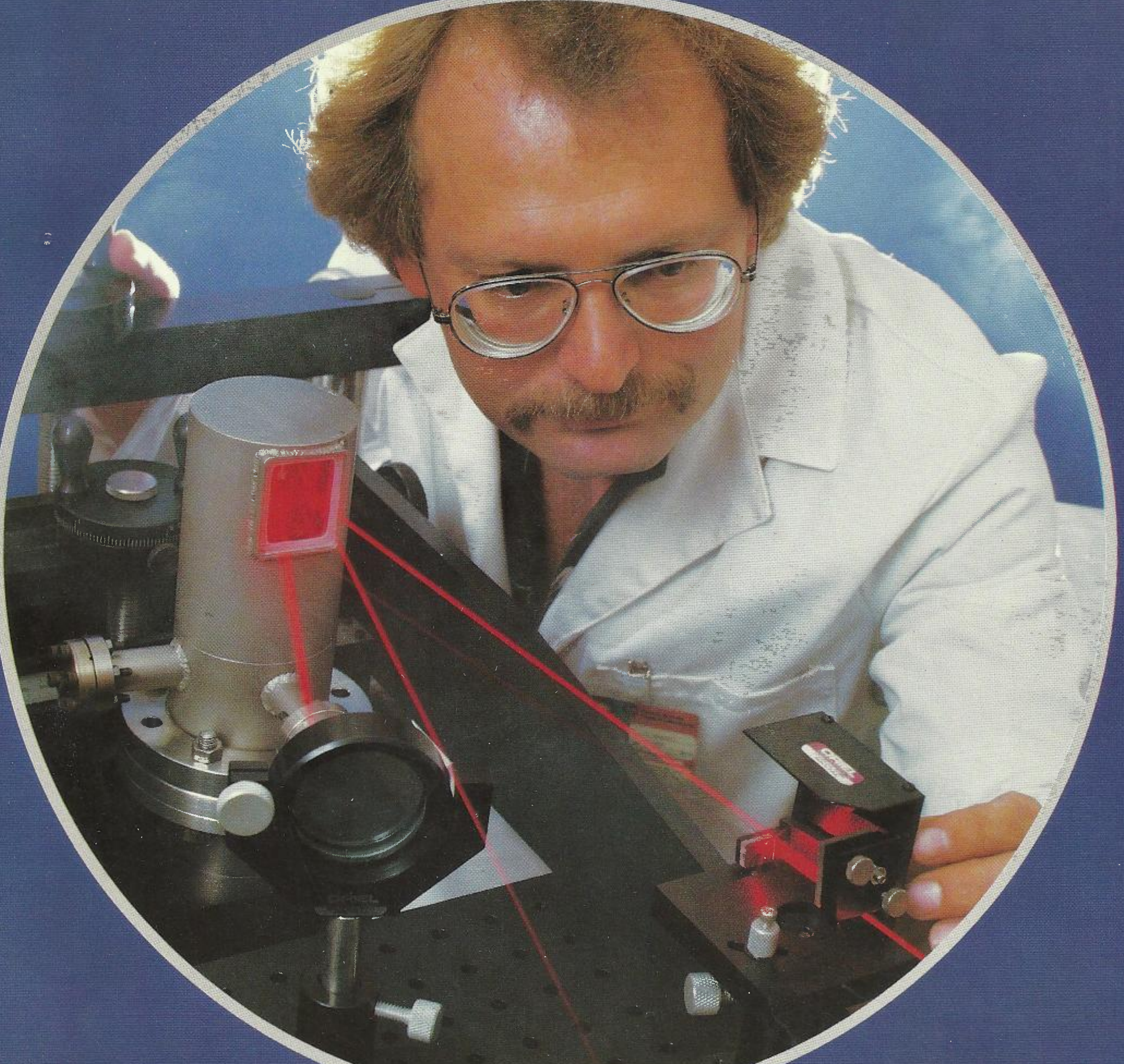
Review of Activities 1986–1987



Research Laboratories

Telecom Australia

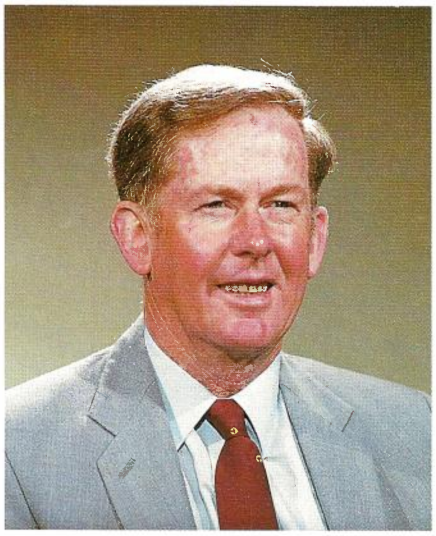
Review of Activities 1986–1987

Research Laboratories, 770 Blackburn Road, Clayton, Victoria 3168 Australia

Telecom Australia

ISSN 0314-1357

Foreword



Telecommunications has now moved to a stage where many industries and organisations are dependent on the provision of a totally reliable telecommunications service, with serious consequences to their customers and business if failures or malfunctions occur.

Technical developments are focussing greater attention on the need for sound engineering and quality of manufacture. In particular, the increasing cost effectiveness of semiconductor chip technology and the consequent more extensive pervasiveness of this technology in the products of manufacturing and information-based industries are both exacerbating the need for increased emphasis on reliability.

More and more functions are being included in single chips, increasing the vulnerability and reliability requirements for the chips. As an example, some years ago memory chips had a capacity to store two thousand bytes of information, whereas the current state of the art is storage of four million bytes.

Another concern is the increasing level of electromagnetic radiation which is polluting the environment. As the signal strengths needed to operate functions in chips is decreasing, higher radiation levels compound the problems arising from this environmental factor.

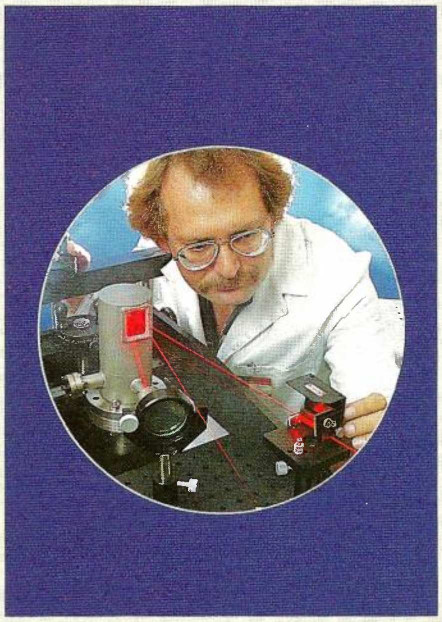
More extensive use of chips is occurring as systems and customer apparatus become increasingly more sophisticated and complex. This trend further focusses the need for reliability to be incorporated into all levels of research, design and development, encompassing components, equipment, systems and networks.

The Research Laboratories play a leading role in Telecom Australia by laying the foundation for Telecom Australia's continual drive to provide a totally reliable telecommunications service. This Review of Activities contains numerous examples of the studies and investigations which are contributing to that objective.

R. K. McKinnon

R.K. McKINNON
Chief General Manager

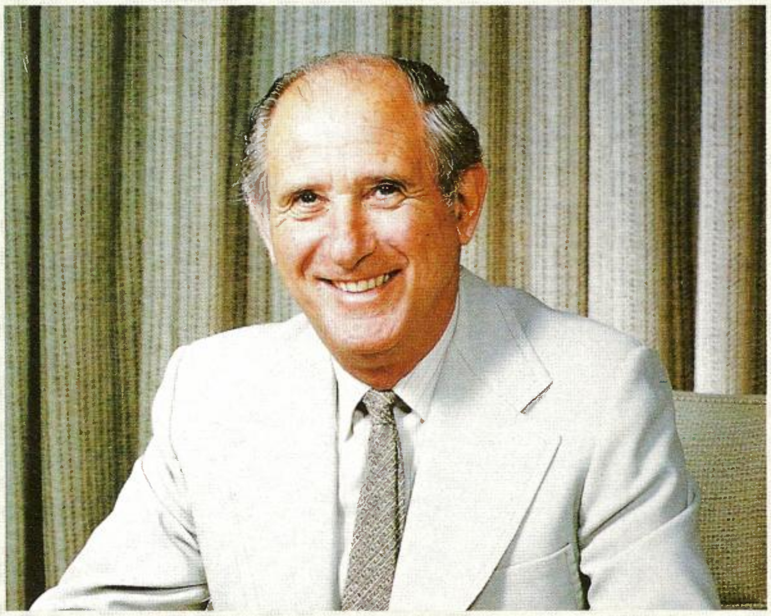
Our Cover



Our cover shows a Laboratories-developed mobile cryostat mounting used in the characterisation of semiconductor materials by photo-luminescence spectroscopy. The mobile mounting improves the convenience and repeatability of measurements to determine the quality and composition of the material as it is grown by the molecular beam epitaxy technique in the laboratory.

Contents

Obituary



GERRY FLATAU

It is with deep regret, the Management of the Research Laboratories announces that on Thursday 9 July 1987, Gerry Flatau, Assistant Director, Applied Science Branch, passed away in hospital after a sudden and serious operation.

Gerry joined the Research Laboratories in April 1951 after qualifying as a physicist. He was for many years engaged in material evaluation and component reliability studies and has to his credit many published Reports and Papers on these subjects. Until 1973 he was in charge of the Physics and Polymer Section of the Applied Science Branch after which he became Staff Scientist with responsibility for overall technical co-ordination of Branch activities. He took up the duties of Assistant Director of the Applied Science Branch in December 1984, the Branch to which he had contributed so much in the many years before, and which he led with such loyalty and distinction until his untimely death.

Throughout his career Gerry gave freely of his time, knowledge and expertise representing Telecom and Australia on both a national and international level in standardisation activities. He was deeply involved in the planning and management of the IEC Quality Assessment System for many years. Until the time of his death he remained actively involved in a number of Standards Committees and was Treasurer of the IECQ and Chairman of the Australian Advisory Committee to this body.

Always providing strong and respected leadership, Gerry was also fair minded, demonstrating sensitivity to the needs of others and enjoyed a strong sense of mateship and a positive approach to life and work. Deeply committed to his wife and children he was essentially a family man who enjoyed nature and simple pleasures such as gardening and travel. The Laboratories' management and staff extend to his wife Vera, and his three daughters, heartfelt sympathies in their sad and unexpected loss.

The Research Laboratories

The mission of the Telecom Australia Research Laboratories is to provide Telecom Australia with the technological and scientific leadership, knowledge and expertise that it needs to carry out its charter of providing world parity telecommunications services nationwide at affordable prices.

The Research Laboratories commenced in 1923 as a Section in the Headquarters of the former Postmaster General's Department with a charter to provide specialist technical advice to the Chief Engineer on "the latest discoveries, inventions and developments in electrical communications and their promising and likely benefits to the Department's telephone and telegraph services". Today, the Research Laboratories form the focus for most of Telecom's research and development, with a staff of just over 500 on two sites in the Clayton suburb of Melbourne and with a total annual operating budget of approximately $36 million.

The scope of the activities of the Laboratories are wide ranging, covering most of the scientific and technological fields of relevance to modern and emerging telecommunications technologies, services and systems. As it is not practical for one telecommunications research establishment in the modern world to completely cover all fields of interest, close interaction is maintained with research establishments in other organisations and universities in fields of mutual interest to widen the pool of knowledge available to the Research Laboratories and to contribute to the development of the overall pool of telecommunications knowledge.

In addition to R&D activities, the Research Laboratories provide the following functions for Telecom on a corporate basis:

- the operation of an intellectual property service, which provides consultancy and advice relating to the application of Telecom's policies on intellectual property and manages Telecom's portfolio of intellectual property
- the operation of an information retrieval and library service
- the operation of scientific standards for the measurement of time interval and frequency, both for Telecom's purposes and as an agent of the National Standards Commission, and the dissemination of signals for the National Time Service
- the provision of scientific reference standards and precise calibration services for electrical quantities, telephone transmission and the physical, chemical and metallurgical properties of materials.

The Research Laboratories carry out their activities under four major thrusts.

The first major thrust is the provision of support to Telecom Australia. This support includes advice concerning the future potential and application of new technologies, services and systems. It involves the monitoring of developments in telecommunications technologies, systems and services on the world scene, assessment of their future potential, and in some cases, the conduct of experimental investigations and developmental studies to further assess potential, gain understanding and acquire expertise for eventual transfer to other parts of Telecom Australia. It also involves assistance in the integration of new systems, services and technologies into Telecom's networks and day-to-day operations. An important aspect is the provision of ongoing support to both Telecom Australia and industry in the resolution of problems associated with reliability and manufacture which become apparent during the service lifetimes of systems and technologies which have been previously adopted by Telecom Australia.

The second major thrust is the provision of support to industry. The objective of this thrust is to ensure that Telecom Australia will be able to obtain the right technology at the right price, at the right time and at an acceptable level of reliability. This is achieved in some instances by direct cooperative development with industry. In other instances, specific R&D contracts are placed with industry under a programme operated by the Research Laboratories with the objective of ensuring that industry has access to, and facility with the use of, new technologies which Telecom Australia wishes to utilise. The Research Laboratories also provide the ultimate resort for resolution of problems related to performance in the field of Telecom Australia's systems and equipment.

The third major thrust is support for tertiary educational institutions, with the objective of ensuring that Telecom Australia will have access to the right skills at the right time in the future graduates which it will recruit. It takes time for new technologies to diffuse into the telecommunications network and it also takes time for new skills to be incorporated into the teaching programmes of the tertiary institutions. The Research Laboratories manages the synchronisation of these two processes on behalf of Telecom Australia by participating in Course Advisory Committees, Faculties, discussions concerning course design, etc. It also encourages research in appropriate telecommunications fields in tertiary institutions through a programme of R&D contracts which are administered by the Research Laboratories for this purpose.

Currently, the Research Laboratories have a policy of encouraging the development of centres of expertise within academia by provision of support to academic institutions which have clearly established leadership in a particular field or have demonstrated clear potential to achieve a position of excellence and leadership. Recently, the Research Laboratories have assisted in the establishment of a Teletraffic Research Centre at Adelaide University.

The fourth major thrust is active participation in the development of standards, particularly in strategic fields related to services, systems, and networks. Most of this work involves participation in the work of international organisations such as the CCITT, CCIR, ISO and IEC. This enables the Research Laboratories to provide advice to Telecom Australia on the status of development of international standards and their likely future directions of develop-

Items of Special Interest

DISTINGUISHED VISITORS TO THE LABORATORIES

Like most research organisations, Telecom's Research Laboratories are frequently visited by a number of people who are notable because of their high distinction or because the purpose of the visit is one of significant importance.

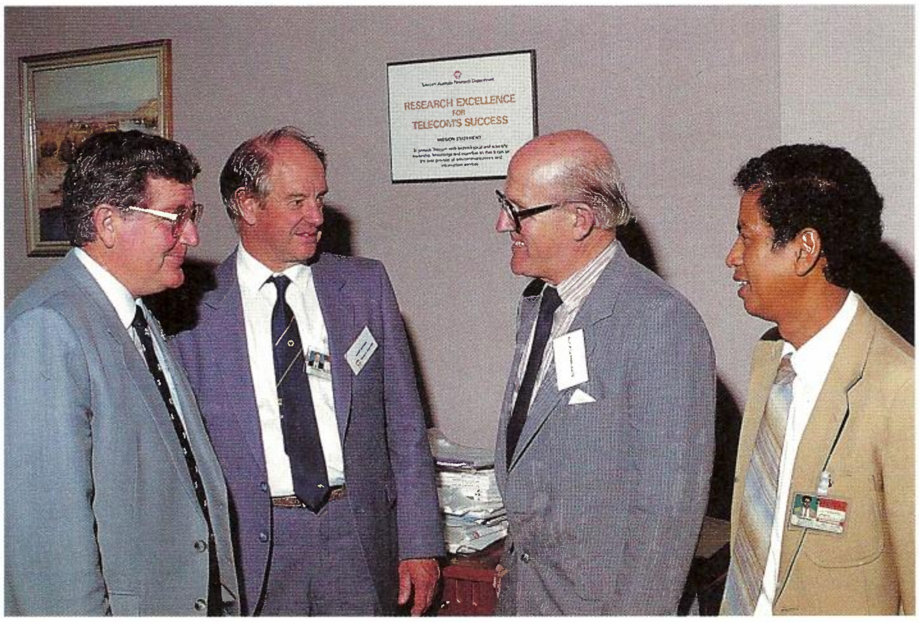
The following paragraphs record details of a number of such notable visits which occurred during the year.

Visit by Mr R.W. Brack, AO, Chairman of the Australian Telecommunications Commission

On 13 October 1986, Mr R.W. Brack, accompanied by Dr B. Godfrey and two other associates from the Australian company Newtech Pty Ltd, visited the Laboratories to inspect facilities and to hold technical discussions with Drs P.V.H. Sabine and G. Price on projects being performed in the fields of advanced semiconductor materials science and associated electronic and opto-electronic device technologies.

Visit by Broadcasting Media Representatives

On 26 March 1987, Mr B. Window, Corporate Communications Manager of the Australian Broadcasting Commission, Ms T. Zanoni, National Account Manager of the Special Broadcasting Service, and Mr F. Tuckwell, a communications consultant, visited the Laboratories. The purpose of the visit was to obtain an overview of the Laboratories in the Australian communications environment and to discuss the potential applications of new technology to new or improved media communications. The visitors also toured the Laboratories to inspect a variety of research facilities and discussed a variety of projects with research staff, including the evolution of the ISDN and potential telecommunications services which it would make possible, and the developments in fundamental enabling technologies for future electronic and optical communications systems.



Professor Peter Clarricoats (2nd from right) chats with (from left) Dr Alan Gibbs, Mr Harry Wragge and Mr Sasty Sastradipradja

Visit by Japanese Survey Mission

On 9 February 1987, a 30-man delegation from the Japanese Survey Mission on the Investment Environment in Australia, sponsored by the Department of Industry, Technology and Commerce, visited the Laboratories. After being welcomed by Mr R. Smith, Deputy Director, and senior management of the Laboratories, the visitors inspected and discussed project work on the reliability assessment and environmental testing of solar cell panel modules, diagnostic techniques for the failure analysis of semiconductor devices, advanced semiconductor materials and device research centred on molecular beam epitaxy, new optical fibre materials research and coherent optical transmission systems.

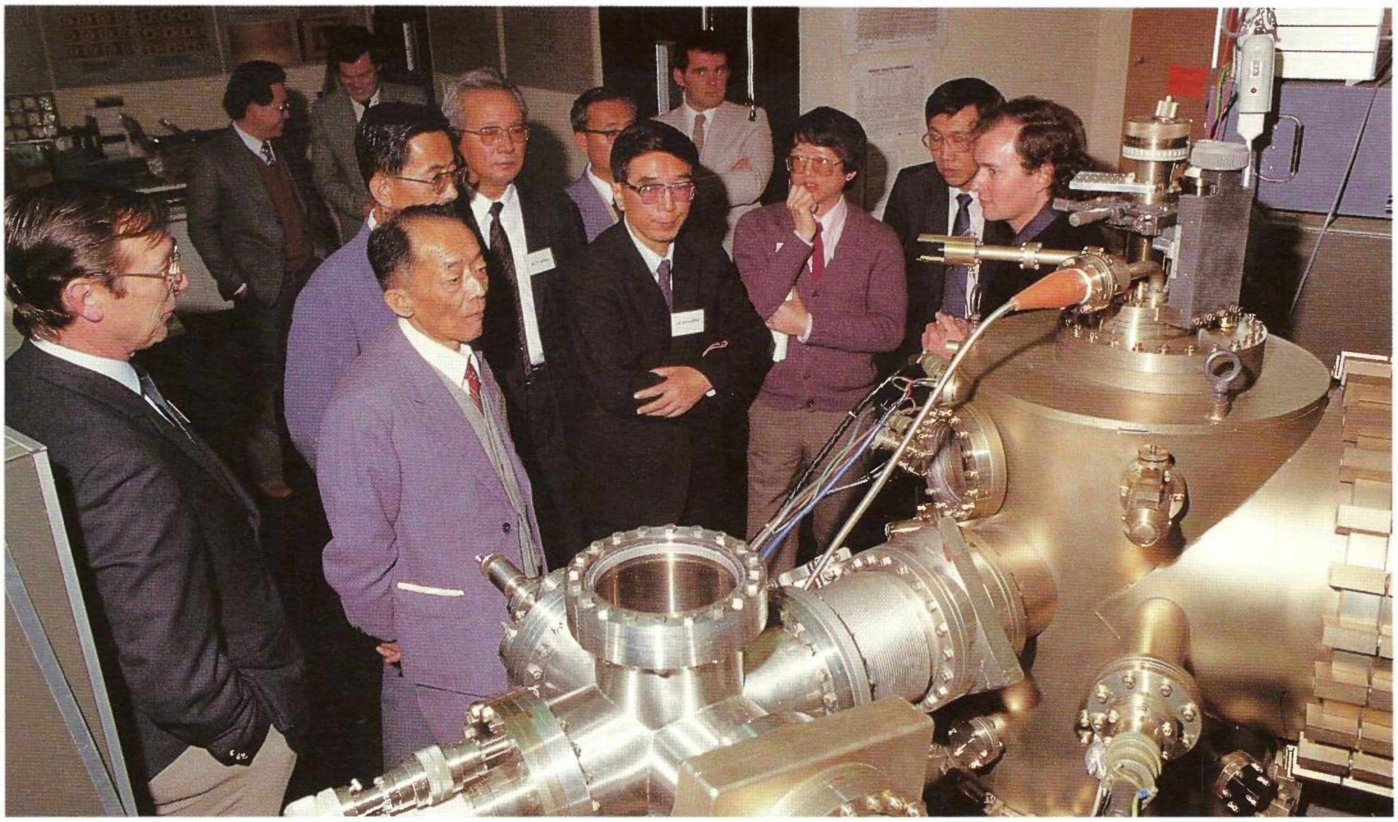
Visit by Professor P.J.B. Clarricoats of Queen Mary College, London

On 24 February 1987, Professor P.J.B. Clarricoats, Head of the Department of Electrical and Electronic Engineering, Queen Mary College, London, visited the Laboratories while in Melbourne to present a lecture to a combined meeting of the four major learned professional engineering institutions incorporated or represented in Australia, namely, the IREE, IEAust, IEE and IEEE. Professor Clarricoats spent some time with staff of the Transmission Systems Branch of the Laboratories in inspections and discussions of work in the fields of antenna research, next generation optical communications techniques and systems and electromagnetic compatibility assessment of telecommunications equipment. He also took the opportunity to inspect the Laboratories' new antenna test range at Caldermeade.

Visit by Science and Technology Delegation from Korea

On 19 November 1986, the Laboratories were visited by a Science and Technology Delegation from Korea, accompanied by Mr P. Lansdown of the Department of Science, Canberra. The delegation comprised:

- Mr Heung Yil Park, Director, Bilateral Research Co-operation Division, Ministry of Science and Technology
- Dr Sung Do Jang, Head, Department of Material Science, Korea Advanced Institute of Science and Technology (KAIST)



Dr Garth Price and Dr Frank Ja (at right) discuss molecular beam epitaxy growth of advanced semiconductor materials with Mr Zhu Gaofeng (centre) and colleagues from the Chinese Ministry of Posts and Telecommunications

- Dr Seong Jong Chung, Director, ISDN Development Department, Electronics and Telecommunications Research Institute
- Dr Mu Shin Lee, Dean of Academic Affairs, Korea Institute of Technology
- Dr Tae Ick Mheen, Director, Technology Service Division, Genetic Engineering Research Centre, KAIST
- Dr Sang Ki Rhee, Senior Scientist, Biochemical Process Laboratory, Genetic Engineering Research Centre, KAIST

After the usual welcome and introductory overview of the Laboratories by its senior management, the visitors inspected a number of laboratory activities and held related discussions with Laboratories' staff. Projects of particular interest to the visitors were those related to communications satellite transmission techniques, a range of customer services-oriented topics including electronic directories and telematic services, the evolution of the Australian ISDN, and semiconductor materials and device technology.

Visit by Delegation from the Ministry of Posts and Telecommunications, People's Republic of China

On 8 August 1986, Mr Zhu Gaofeng, Vice-Minister, and a top level delegation from the Ministry of Posts and Telecommunications from the People's Republic of China visited the Laboratories. After being welcomed to the Laboratories by Mr H.S. Wragge and members of the Research Laboratories Council, the visitors were given an overview of the role and work programme of the Laboratories within Telecom Australia and in the broader Australian and global telecommunications environment. The visitors also toured the Laboratories, inspecting project work related to:

- coherent optical fibre transmission systems
- new glass materials and optical fibre cable technology for optical fibre communications
- molecular beam epitaxy techniques applied to semiconductor materials research, and
- solar energy and hybrid power systems for telecommunications equipment application.

Visit by Delegation from the Academy of Science, People's Republic of China

In December 1987, Professor Yan Dongsheng, Vice President of the Chinese Academy of Sciences, led a delegation of twelve eminent researchers from the Academica Sinica on a visit to the Laboratories, as a prelude to a joint Chinese-Australian Workshop on Advanced Materials. The visitors held technical discussions with senior staff of the Telecommunications Technology Branch on materials research and technology in the semiconductor and optoelectronic fields.

Visit by AT&T Executives

On 23 February 1987, Messrs N. Chaffee, D. Howell, T. Swanson, R. Wegner, D. Parrish, C. Zitney, D. Barclay and S. De Caro, executives from the marketing, design and development divisions of AT&T (USA) visited the Laboratories. After a welcome by Mr H.S. Wragge and senioı Laboratories' management, the visitors discussed the role and work programme of the Laboratories in the Australian telecommunications environment. They then toured the Laboratories to inspect and discuss a number of projects primarily related to developments in common channel signalling networks, communications protocol development, specification and validation, fast packet switching techniques and the evolution of the Australian ISDN.

CCIR WORKING PARTY ON FUTURE MOBILE COMMUNICATIONS MEETS IN MELBOURNE

Although Telecom Australia has only recently introduced its new cellular mobile radio telephone service, it expects a high and sustained demand for such services, such that the growth capacity of the current system could potentially be saturated with some 70 000 customers by the early 1990s. Like many other administrations which have introduced such cellular systems, Telecom is vitally interested in the potential application of the next generation digital mobile systems. Research and development of these new generation systems is already maturing and Europe plans to introduce one of these systems about 1991.

The manufacture and operation of such systems and services, like most telecommunications systems and services, is preferably accomplished under the umbrella of national and international standards. Concurrently with these latest developments in digital cellular mobile communications systems, CCIR Study Group 8, which is responsible for international standards for such systems, set up a Working Party (IWP8/13) in 1985 to consider future systems and to develop and recommend standards.

Working Party IWP8/13 was formally established to develop standards for next generation public land mobile telecommunications systems. The first meeting of the Working Party took place in Vancouver, Canada, in May/June 1986, and was hosted by the British Columbia Telephone Company on behalf of Telecom Canada. An Australian delegate attended this meeting. Given the already mature developments of the next-generation pan-European digital mobile system planned for the early 1990s, the first meeting decided to focus its attention on 'personal' communications systems which would be commercial in the later half of the 1990s. Such systems would operate within buildings and built-up areas, and the terminals would be 'shirt pocket' in size, as opposed to hand-held units provided with current cellular mobile systems. A potentially very large market was foreseen for these personal systems. It was agreed by most that a desirable objective of standards for such systems was world compatibility, including the frequency band used. The technical considerations for such a band were referred for consideration at a second meeting to assist deliberations at the Mobile World Administrative Radio Conference (WARC) meeting to be held in September 1987.

The second meeting of the Working Party was held in Melbourne in March 1987. It was hosted by Telecom Australia and was attended by 47 participants representing 13 administrations from around the world. In addition, the special Rapporteur of CCIR Study Group 8 to CCITT Study Group XI and a member of the CCIR Secretariat took part in the meeting. The meeting considered some 27 input documents covering a wide range of the technical considerations for future generation public land mobile telecommunication systems. While adding significant technical material to the report, the meeting also identified the technical considerations affecting the choice of a frequency band for personal communications systems and developed scenarios for such systems to illustrate the different approaches envisaged.

A third meeting of Working Party IWP8/13 will be convened in January 1988 to draft potential recommendations for such future mobile systems. The draft recommendations will then be considered at the next CCIR Study Group 8 meeting in May 1988.

In addition to the work of the meeting, delegates to the second IWP8/13 meeting enjoyed several social occasions organised by their Australian hosts. Popular tourist attractions visited were a winery and an Australian fauna park at Healesville, in the hills of outer Melbourne. Some of the overseas delegates also took the opportunity to visit Telecom's Laboratories for discussions and inspections of R&D projects of mutual interest to themselves and their hosts.

The Swedish and Australian delegates confer at the meeting of CCIR IWP8/13, Melbourne, March 1987

Pictured in the grounds of the University of Adelaide after launching the Teletraffic Research Centre: Dr Les Berry, Mr Peter Gerrand, Mr Brian Hammond and Mr Harry Wragge

TELETRAFFIC RESEARCH CENTRE, UNIVERSITY OF ADELAIDE

In February 1986, Telecom Australia let a major research and development contract to the University of Adelaide. Under the contract, the University will establish a Teletraffic Research Centre as a centre of Australian excellence in this field, and will pursue R&D projects nominated by Telecom's Research Laboratories for an initial 5-year period. This work will complement teletraffic engineering research being performed at the Laboratories.

This contract is the culmination of a long association between the University's Department of Applied Mathematics and Telecom Australia (and its predecessor, the Postmaster General's Department). For more than 15 years, the University has collaborated with Telecom and its predecessor in the field of teletraffic engineering research, investigating new techniques under a series of small-scale contracts. This latest $1.3 million contract will enable the University to extend the scope of its teletraffic research, supplementing Telecom's own R&D efforts, to develop and apply advanced traffic engineering techniques and computer-based tools for optimising the planning, design, dimensioning of new networks and services and for improving the operational management of networks.

Dr Les Berry, previously of the University's Department of Applied Mathematics, is the Director of the new Centre. It will be staffed initially by two post-doctoral Research Associates, one Research Officer, two Senior Lecturers (part-time) and a Secretary. It is hoped that the Centre will also attract overseas researchers in the field, bringing benefits of fresh expertise to both the University and Telecom.

The activities of the Centre will be guided by an Advisory Committee, on which Telecom is represented by Mr Peter Gerrand (Assistant Director, Switching and Signalling, Research Deparment) and Dr Clem Pratt (Chief Engineer, Computer Support Services, Network Engineering Department).

A ceremony was held at the Centre on 19 March 1987 to mark its creation. Professor Kevin Marjoribanks, acting Vice-Chancellor of the University and Mr Harry Wragge, Director, Research of Telecom Australia joined Dr Les Berry to meet the staff of the Centre and to welcome official guests. Key figures attending the ceremony included Professors Ken Potts and R.R. (Bob) Bogner of the University, Mr Denzil Guscott, Chief Network Management Engineer of Telecom's South Australian Administration, and Dr Clem Pratt and Mr Peter Gerrand, Telecom's representatives on the Centre's Advisory Committee.

DR FRED SYMONS JOINS THE BOARD OF DIRECTORS OF THE NATIONAL PROTOCOL SUPPORT CENTRE

Early in 1987, Dr Fred Symons, Assistant Director, Strategy Development, of the Research Laboratories joined the Board of Directors of the newly formed National Protocol Support Centre, as Deputy Chairman. The Chairman of the Board is Mr Mike Rydon, a former Managing Director of Fujitsu Australia Pty Ltd and one-time President of the Australian Information Industries Association (AIIA). Other members of the Board are Mr Jim Holmes from Telecom's Commercial Services Department, Mr John Mattes of OTC (Australia), Mr Jim Belshaw of the Federal Department of Industry, Technology and Commerce, Mr Neil Pinney of the Victorian Department of Industry, Technology and Resources, Dr Tommy Thomas of CSIRO's Division of Information Technology and Mr Bob Mounic of the AIIA. Mr Gary Dickson, formerly a staff member of the Laboratories and more recently of Computer Power Ltd, is the interim Chief Executive Officer of the Centre.

The National Protocol Support Centre (NPSC) was first proposed in 1985 with backing from federal and state governments, Telecom, OTC(A), CSIRO and local industry. With support from Mr Harry Wragge, Director of the Research Laboratories, Fred Symons played a significant role in bringing the proposal to fruition in February 1987, when the Centre was formally opened.

The primary aims of the NPSC are to assist the development of the communications and information industries in Australia by providing active support in the area of international standards. The Centre will provide an important vehicle for technology transfer to Australian industry by catalysing the adoption and incorporation of evolving international standards for communications protocols in Australian product innovation and thence, the expansion of the local and export markets for such products. Initially, the Centre will place emphasis on the open systems interconnection (OSI) and integrated services digital network (ISDN) standards being developed by the International Organisation for Standardisation (ISO) and the International Telegraph and Telephone Consultative Committee (CCITT) respectively, and on application standards based on OSI principles.

The NPSC will not have a standards setting role, but it will actively support the development and specification of standards by national and international standards setting bodies, especially the Standards Association of Australia (SAA).

The NPSC intends to provide timely and expert information and assistance to local industry about the developments and applications of internationally standardised protocols. This is essential to ensure that Australian-developed communications products and systems interwork compatibly with overseas developments and are suitable for export. The Centre plans to achieve this objective by offering its clients:

- seminars and newsletters on developing standards and their application
- educational workshops and services on OSI and ISDN standards for system planners, designers and developers
- advice, consulting services, staff outposting and participation in industry projects and trials
- special interest groups as catalytic forums for the exchange of information and experience
- in-house development and application of protocol conformance testing facilities for Australian implementors
- advice to industry on future product trends.

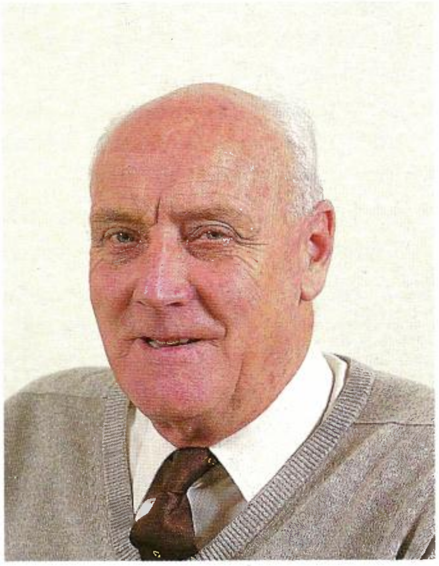
An Advisory Council is being formed by the NPSC to ensure that it liaises adequately with other industry associations and keeps in touch with the needs of Australian industry. Telecom Australia and OTC(A) are members of an NPSC Consultative Committee which has been formed to maximise co-operation and communication between the NPSC and SAA and to assist in the co-ordination of national contributions to the international standards development and dissemination processes of the ISO, CCITT and CCIR.

THE ROYAL AUSTRALIAN CHEMICAL INSTITUTE HONOURS HEC RUDDELL

In a recent initiative, the Polymer Division of the Royal Australian Chemical Institute established a new award, called Polymer Division Citations. Up to three Citations will be awarded annually to scientists who have made significant contributions to polymer science or technology in Australia. In awarding a Citation, consideration is given to the recipient's contributions in the research and development of polymer science and technology in Australia, the development of polymer applications in other technologies, education in and promotion of polymer science and technology, and services to the Institute.

Hector James Ruddell (better known to his colleagues as 'Hec'), Head of the Polymer Section, Applied Science Branch of the Laboratories, was one of three eminent Australian polymer scientists awarded the first of such Citations at the 16th Australian Polymer Symposium on 10 February 1987. The Citation lists Hec's contributions over a long and distinguished career in Telecom's Research Laboratories to:

> "the setting-up and leadership of the successful Polymer Section of Telecom Research; the development of many polymeric products for communications cable applications; the detailed long term investigations into the effect of harsh environments on polymers in service, and the associated problems of antioxidant protection; the scientific



Hec Ruddell, Dip App Chem, FPIA, FRACI, CChem

community as an international leader in the field of materials for telecommunications, and as an advisor to the CSIRO Applied Organic Chemistry Division and the Australian Standards Association."

Hec joined the Laboratories in 1955 as a Chemist Class I after 19 years in private industry, where he worked in the fields of oils, general chemistry, rubbers and plastics. In 1966, he was promoted to Chemist Class 3, heading the newly formed Polymer Division (now Polymer Section) of the Laboratories. In this position, Hec led a team which was, and is, responsible for the investigation, development and application of all plastics, rubbers and adhesives employed in the telecommunications equipment, lines and cables of Telecom's network. Hec currently occupies the position of Polymer Chemist (Class 5) in charge of the Polymer Section of the Applied Science Branch of the Laboratories.

During his distinguished career in the Laboratories, Hec has been closely associated with the introduction of plastics materials in many parts of Telecom's network. His technical expertise has been applied particularly to the early manufacture and installation of plastics cable, including the development and formulation of epoxy resins and the epoxy resin field pack and the design of joints, particularly those for plastics submarine cables laid off the coast of Queensland. More recently, Hec has been closely involved in developments in filled cables, optical fibres and the stabilisation of polyethylene.

Hec has been an associate member of the Plastics Institute of Australia since 1959, and was awarded a Fellowship of that Institute in 1982.

Recognising his many achievements during his career and his undisputed place among Australia's most expert polymer scientists, the management of the Laboratories and of Telecom, together with Hec's colleagues throughout Telecom, congratulate him on the award of his Citation.

INAUGURAL TELECOM AUSTRALIA EDUCATIONAL FELLOWSHIPS

In 1986, Telecom, through the Research Laboratories, introduced a new scheme to assist outstanding undergraduate students to complete the final year of telecommunications-oriented engineering or science degree courses 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 new 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.

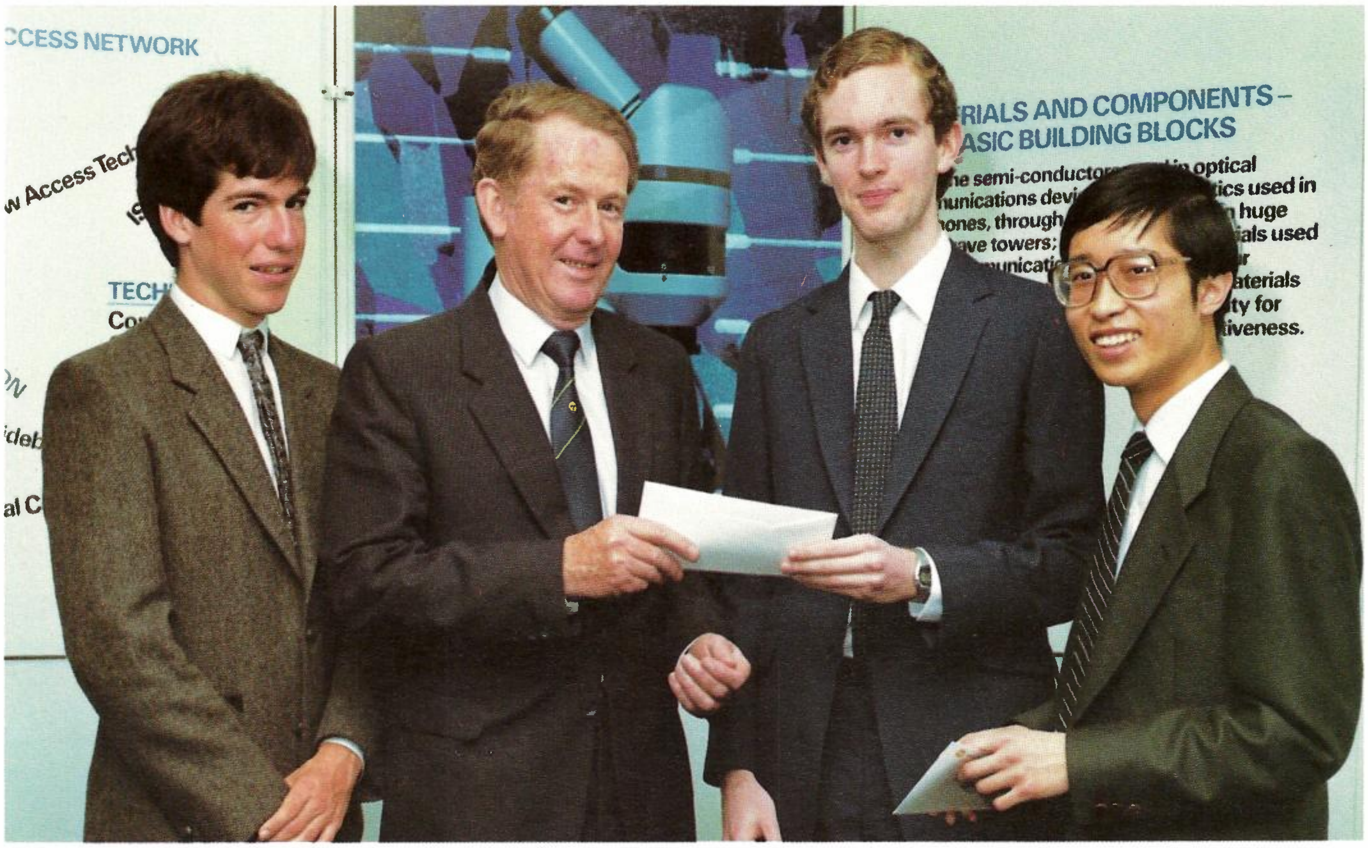
Telecom proposes to award about 10 Educational Fellowships each year to outstanding undergraduates who are about to commence the final year of their Bachelor degree course. The Educational Fellows will receive an award of $6000 without any commitment to Telecom other than undertaking paid employment in Telecom's Research Laboratories in the long university vacation preceding the start of their final year of study. Whilst employed in the Laboratories, the Educational Fellows will undertake research projects which will give them insights into applied telecommunications technology and science and an appreciation of Telecom's role and activities in the Australian telecommunications environment.

In November 1986, after assessing applicants from most Australian centres of higher education, Telecom awarded Training Fellowships to nine students, namely to:

- Jonathon Paul Lacey, completing his BE degree at the University of Melbourne
- Chiat Earl Chew, completing his combined BSc/BE degree at Monash University
- Christopher Andrew Leckie, also completing a BSc/BE degree at Monash University
- Keith Raymond Godfrey, completing his BE degree at the University of Western Australia
- David Christopher Gates, completing his BE degree at the University of Adelaide
- Michael Robert Warner, also completing a BE degree at the University of Adelaide
- Paul Kenneth Tridgell, completing his BE degree at Sydney University
- James Robert Briggs, completing his BSc degree at the University of Tasmania
- Tony Peter Oetterli, completing his BE degree at the University of Tasmania.

The Victorian recipients were awarded their Fellowships by Telecom's Chief General Manager, Mr Bob McKinnon, at a small ceremony to inaugurate the Scheme on 17 November 1986. This occasion also provided an opportunity for the Educational Fellows and their parents to meet some of Telecom's management and representatives of the Universities where the Fellows will undertake their studies. Similar presentations were made to recipients by local Telecom management in other States.

The Educational Fellows subsequently joined the staff of the Laboratories from December 1986 to February 1987, where they undertook a variety of R&D projects. At the conclusion of this period of vacation employment, it seemed that the experience had been both interesting and challenging to the Educational Fellows and had proved to Telecom that the scheme was indeed a worthwhile innovation and that the inaugural Fellows truly offered promise for the future of Australian telecommunications.



Telecom's Chief General Manager, Mr Bob McKinnon (second from left) presents Chris Leckie with his Telecom Educational Fellowship Award, watched by fellow recipients, Jonathan Lacey (left) and Earl Chew (right)

HONOUR TO JIM FISHER, PIONEER ENGINEER OF AUSTRALIAN TV BROADCASTING

The management of the Laboratories and Telecom Australia congratulate their retired colleague, Mr J. (Jim) H.T. Fisher, on his receipt of the Colin Bednall Award in 1986. This national award is made annually by the Television Society of Australia to persons who have distinguished themselves by their lifetime achievements and contributions to Australian TV broadcasting.

The award recognised Jim's long professional career as a pioneer engineer of Australian TV broadcasting, initially in the (then Postmaster General's Department) Research Laboratories and more recently as the Chief Engineer of the Melbourne-based commercial TV broadcasting company, HSV-7.

Jim joined the Laboratories as an engineer in June 1936 soon after graduating from the University of Adelaide. In his early years, he conducted original investigations into cathode ray oscilloscopy as a new measurement technique in electronic engineering. This led to investigations in the late 1930s and 1940s of TV signal generation and broadcasting techniques. His work ranged from early experiments using spinning discs with holes, test broadcasts using radio transmitters and ultimately to recommendations and participation in the development of technical specifications for the introduction of regular black and white TV broadcast services in Australia in 1956. He was particularly instrumental in the decision that Australia should adopt the 625-line PAL system as a national standard, thereby ensuring the technical quality of pictures received by Australian TV viewers.

Jim left the Laboratories in late 1948 to join the engineering staff of the embryonic HSV-7 broadcasting company, and played a prominent role in establishing the company's technical facilities for the commencement of regular TV broadcasting in 1956. Subsequently, Jim rose to the position of Chief Engineer, leading the introduction of new technology and techniques into the company's operations until his retirement. This work achieved steady improvement in picture reception quality and outdoor broadcasting techniques, and notably, the introduction of colour TV broadcasting and the development of broadcasting networks, including the use of satellite communications techniques and systems.

In more recent years, Jim joined the national investigatory team whose work led to the planning and specification of Australia's national AUSSAT communications satellite system. His contributions as a member of the team laid the foundations for the now successful application of satellite technology to bring quality TV broadcast services within the reach of every Australian, even those located in the remote Australian outback.

Now aged 75 years and enjoying retirement after a long and distinguished career, Jim can look back over 50 years of television broadcasting technology, with well-deserved satisfaction that he has played a lead role as a professional engineer to ensure that technological advance has been successfully applied to ensure the ongoing technical excellence of Australian TV broadcasting services.

Telecom Australia Research Department

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.

A Selective Review of Current Activities

In accord with their functions, the Laboratories are engaged in a large 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 standards 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 Departments and Directorates 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.

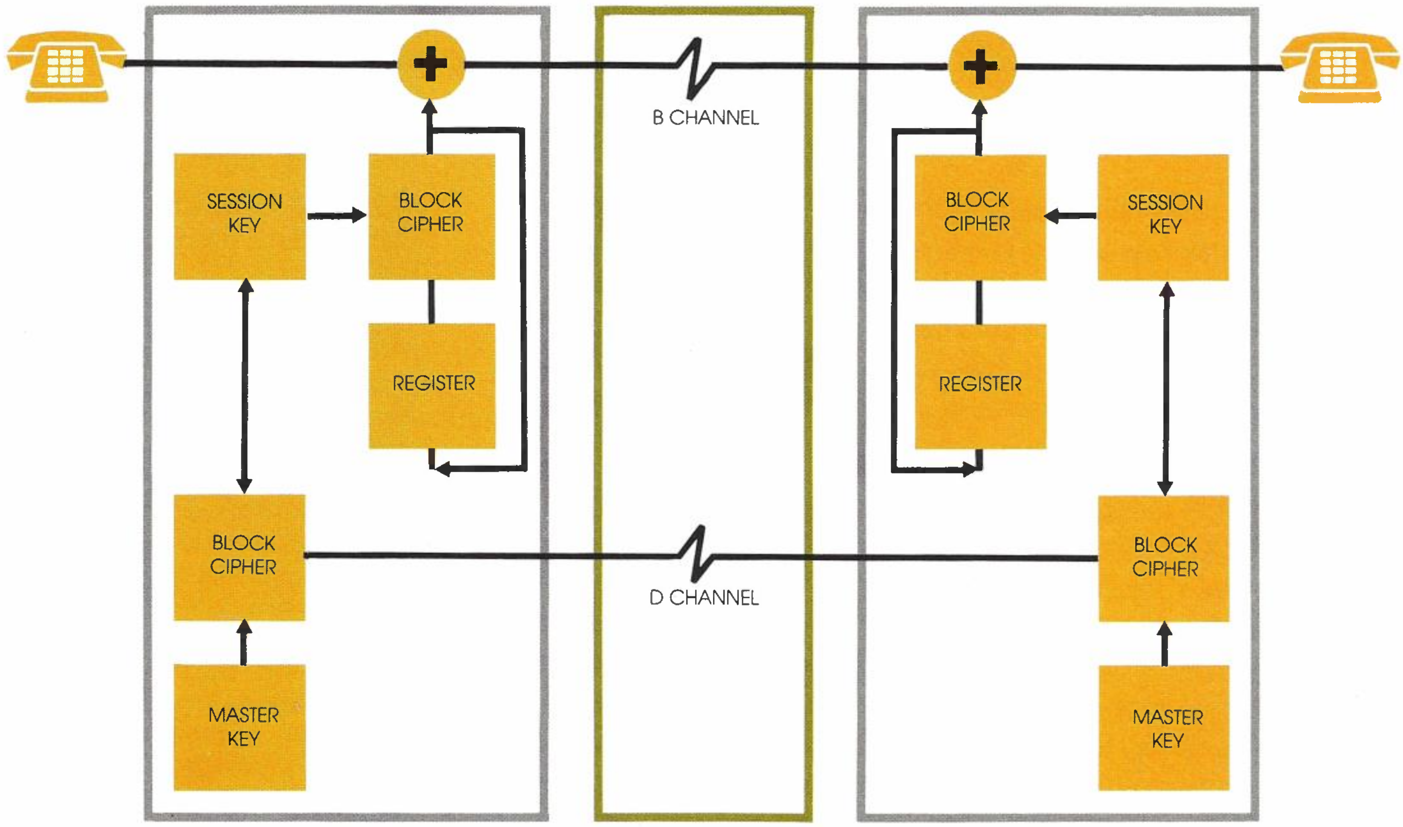
An indication of the scope of these various publications of the outputs of the Laboratories can be gained from the lists given in the last section of this Review of Activities.

SPEECH RECOGNISERS AND TEMPLATE CLUSTERING STUDIES

With the development of the necessary technology to enable computers to recognise speech, it is becoming feasible to use speech recognisers to improve the communications interface between people and computers. In telecommunications terms, this implies that speech recognition techniques could be used to advantage to provide a user-friendly interface between the customer and future telecommunications services provided by computers. With such future applications in mind, the Research Laboratories recently assessed the performance of four commercially available, speaker-dependent, isolated word speech recognisers, both under ideal test conditions and conditions similar to those found in the telephone network.

Each recogniser was trained to recognise a test vocabulary of 15 words recorded on tape by eight people. On another occasion, the same people recorded the same vocabulary again, to test the recognition accuracy. During both recording sessions, two microphones were used. One was a carbon microphone in a normal telephone handset and the other a small electret microphone positioned on the handset's mouth-piece. Three passes were used to train each recogniser, and ten passes were used to test the recognition accuracy.

With the electret microphone, only one recogniser attained an accuracy equal to that claimed by the manufacturer (99%), while the accuracy of recognition of the other three varied from 86% to 93%. With the telephone handset's carbon microphone, the best recogniser still performed well with an accuracy of 98%, while the others varied from 77% to 95%. It was also found that, if the recognisers were trained with speech through one microphone, subsequent recognition accuracy with the other type was significantly degraded. The effect of equalising the frequency response under these conditions was beneficial. The tests also showed that the speech recognisers were not susceptible to steady noise levels similar to those encountered in the telephone network.



A voice scrambler outline for ISDN application

All recognisers evaluated so far have been speaker-dependent. A study is now being made of template clustering techniques with the aim of producing a recogniser that is "speaker-tolerant" (that is, one that will recognise speech from a large percentage of the population). A vocabulary of words has been recorded over the telephone from about 80 people within the Laboratories. Using words from this database, one of the recognisers is being trained with speech from each person, giving a set of templates for each word. By using a facility provided by the speech recogniser which calculates the "distance" between each template in a set, a reduced set of templates is being derived that may provide recognition of all speakers recorded in the database.

Preliminary results from tests using this technique indicate satisfactory performance on a small three-word/eighty-person vocabulary. Work is continuing to determine the degree of difficulty which might be encountered with an extended vocabulary and more speakers.

SPEECH PRIVACY TECHNIQUES

Most conversations over the public telephone network are not of a sensitive nature. Usually, the network provides an adequate general level of information security simply because the time, money and risk involved in eavesdropping would not be matched by any likely returns. However, for a few sensitive conversations that do take place, the network is vulnerable to a number of attacks, ranging from the simple tapping of subscriber lines to the more complex interception of microwave radio and satellite links. Nevertheless, it is economically impractical to upgrade the security of the whole network just to cater for these special circumstances. Consequently, the Laboratories have undertaken a survey of speech scrambling techniques that can be implemented in terminal equipment to enhance speech privacy over public telecommunications networks. This is a more suitable solution for these applications.

The first obstacle in scrambler design arises from the nature of speech. Speech contains an enormous amount of redundancy and the human hearing process has adapted to use this redundancy to achieve satisfactory communications in poor conditions. An example of this is the so called "cocktail party syndrome" where two people are able to talk in the presence of a number of equally loud conversations. The implication for scramblers is that the speech waveform must be significantly modified; otherwise at least a portion of the conversation may be understood (even before any attempt is made to take advantage of the redundancy to reconstruct the speech).

The extent of modifications that can be performed on the speech is limited by the transmission system. Transmitted signals can become very distorted as they travel through the network. Speech copes well with the transmission impairments, but scrambled speech, ideally bearing little resemblance to actual speech, can be adversely affected, producing poor or even unintelligible speech after descrambling.

The most common type of scrambler is based on dividing the speech signal into a number of frequency sub-bands, time segments or both, and then permuting the components. This leaves the speech characteristics essentially intact and minimises transmission problems. Scramblers of this type can provide only a moderate amount of security.

Other scrambling methods include permuting the Fourier coefficients of speech, using spread spectrum techniques and masking or mixing the speech with a pseudo-random noise source. All of these methods require varying degrees of signal processing to compensate for transmission impairments, thereby adding to the cost of the scrambler. In each case, the transformation of the speech is based on a "key" which the recipient must know to reverse the scrambling process and recover the speech.

In a typical "worst case" analogue environment for the application of a scrambler, the hybrid transformers providing 2-wire to 4-wire working in long distance circuits can never be perfectly matched to the possible specific network terminations, causing imbalance and echoes. The echoes consist of random waveforms, adding noise to the signal channel. The channel itself is band-limited and introduces distortions. On long haul circuits, the signal passes through single sideband modulators and demodulators which can leave the signal slightly frequency-shifted. The application of a scrambler in this environment can be expensive yet far from satisfactory.

However, the rapid digitalisation of the telecommunications network offers potentially less expensive and much more satisfactory solutions to ensure the security of information carried. With a fully digital transmission system, speech signals can be processed digitally and more powerful encryption algorithms can then be employed. Theoretically unbreakable systems can be devised in this way.

In a typical digital scrambling scheme for an ISDN environment, the digitally coded voice signal is mixed with a pseudo-random bit stream (PRBS) generated by a block cipher unit. The PRBS is determined by the scheme of logic gates providing feedback from the output of the block cipher unit to its input. This "key" can be randomly varied for each communication session. The ISDN signalling channel (D-channel) is used to transmit the session key encrypted by the block cipher under a mutually known marker key. The encrypted voice signal is then transmitted on the separate B-channel.

Currently, these most secure scramblers tend to be very expensive because they need bit rate reduction schemes and modems to enable them to be used for communications over public networks. The Laboratories plan to keep abreast of developments in this field, seeking to develop expertise to apply the most adequate encryption techniques with developments in voice coding and transmission techniques.

32 kbit/s ADPCM SPEECH CODING

Computers and computer technology are being used increasingly in a wide variety of applications for information transmission, storage and retrieval systems. Because of their evolutionary development as computer-based services, these systems predominantly use digital techniques and technologies suited to the characteristics of data signals. However, the longer evolution of telecommunications services has been founded on telephony as the dominant service, and telecommunications authorities have subsequently developed networks based largely on analogue techniques and technologies suited to the characteristics of voice signals. It is only in the last two decades that digital technology has penetrated voice communications systems and networks, to bring about the convergence of telecommunications and computer-based services and their ultimate common evolution using an integrated services digital network (ISDN).

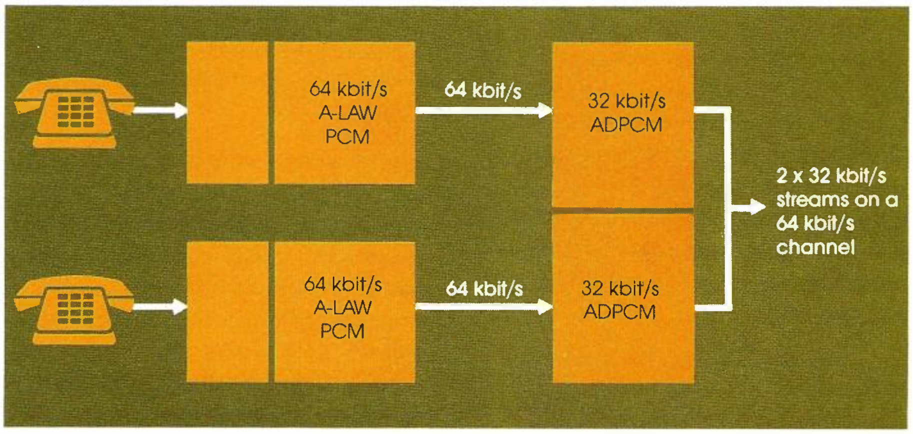
The full realisation of the ISDN concept requires that analogue voice signals are coded into digital signal formats by the inclusion of codecs (coder/decoders) in the telephone terminal and that digital transmission facilities are extended from today's computer-controlled digital exchanges over the customer access network (CAN) to the customer's premises. Thus, voice coding and digital transmission techniques have been the subject of continuing research interest to Telecom Australia and other telecommunications administrations and the telecommunications industry for several decades. Whilst this research has already produced significant results, to allow economic digitalisation of most national networks to become a reality, the research continues to seek more efficient and economic ways to provide existing and new services over the evolving ISDN. Thus, this Review has a larger number of references to R&D projects which relate to the future realisation of the ISDN concept.

Speech will remain an important mode of communication required by customers and its most efficient coding or representation in a digital form is the subject of continuing international research interest. The essence of speech coding is to represent speech signal waveforms as sequences of binary numbers or codes. Pulse code modulation (PCM) techniques are widely applied in today's transmission and switching systems, wherein voice signals are converted to 64 kbit/s digital signals.

In general, a larger number of digits employed to code a given voice signal implies better speech quality but higher bit rates (or transmission channel capacity). The rules for generating these codes are called speech coding algorithms. One of the basic objectives of research into speech coding is the development of algorithms which provide the highest possible speech quality at the lowest possible bit rate subject to various constraints. These constraints include:

- the required speech quality for a given application
- the cost of implementation (algorithm complexity)
- any requirement to support non-voice services, for example, data transmission or facsimile services
- any special requirement for the service to work in noisy electrical and/or acoustic environments, for example, as in satellite or digital radio applications.

Schematic diagram showing how 32 kbit/s ADPCM encoding can double channel capacity



The Research Laboratories are investigating speech coding algorithms and their performance for a wide range of bit-rates. As a result of continuing developments in semiconductor technology, the cost of implementing complex algorithms is decreasing. Whereas existing digital speech encoding in the Telecom network is carried out at 64 kbit/s using a low complexity log-companding system (A-law PCM), a significantly more complex algorithm has been recently accepted as an international standard (CCITT Recommendation G.721) for 32 kbit/s speech encoding using a technique known as adaptive differential pulse code modulation (ADPCM). This lower bit-rate potentially offers a doubling of the number of voice channels over that obtainable with 64 kbit/s encoding. Although there are many commercial applications for reduced bit rate speech coding, existing and possible future network constraints will also determine the acceptability of a specific algorithm.

In the Laboratories, specific attention has been given to the CCITT 32 kbit/s ADPCM algorithm (G.721). A comprehensive document has been prepared to explain the operation of the functional units which make up the algorithm, and real-time and non-real-time computer simulations have been carried out to provide better understanding of the algorithm and its performance. This work is continuing to explore possible applications of this new coding standard in the provision of existing and new voice services over the telecommunications network.

CREATING INTERACTIVE COMPUTER SYSTEMS FOR PEOPLE: USING THE RESULTS OF HUMAN FACTORS STUDIES

The ambition of specialists in the field of human factors is to make the interactive computer systems used for telecommunications readily usable by both novices and experts. This ambition will not be fulfilled until considerably more is known about how people respond to the information they receive from the computer – information about what the system is doing – and to the way in which that information is presented. Two aspects of the human factors research of the Laboratories illustrate the extent of the matters requiring study.

Firstly, are symbols or signs easier to interpret than words? Early Laboratories' studies showed that people cope better with services function descriptions expressed in generic terms rather than in more precise technical vocabulary. For instance, the generic term "sender" is (obviously) better understood than "originator indicator", the latter term being used in a technical description of an electronic mail system. Yet, as the range of services widens, one tends to run out of suitable generic words. The saying, "a picture is worth a thousand words", suggests that information might be better presented as symbolic pictures, or icons. Indeed, it seems attractive to use the power of graphics since pictures can also be more entertaining than text, they save space on the screen, and a pictorial language is supposedly universally understandable. However, no one really knows which concepts are suited for pictorial representation under what circumstances. The Laboratories' research in this area indicates that it is even more difficult to design icons that everyone can understand than it is to agree on an acceptable vocabulary!

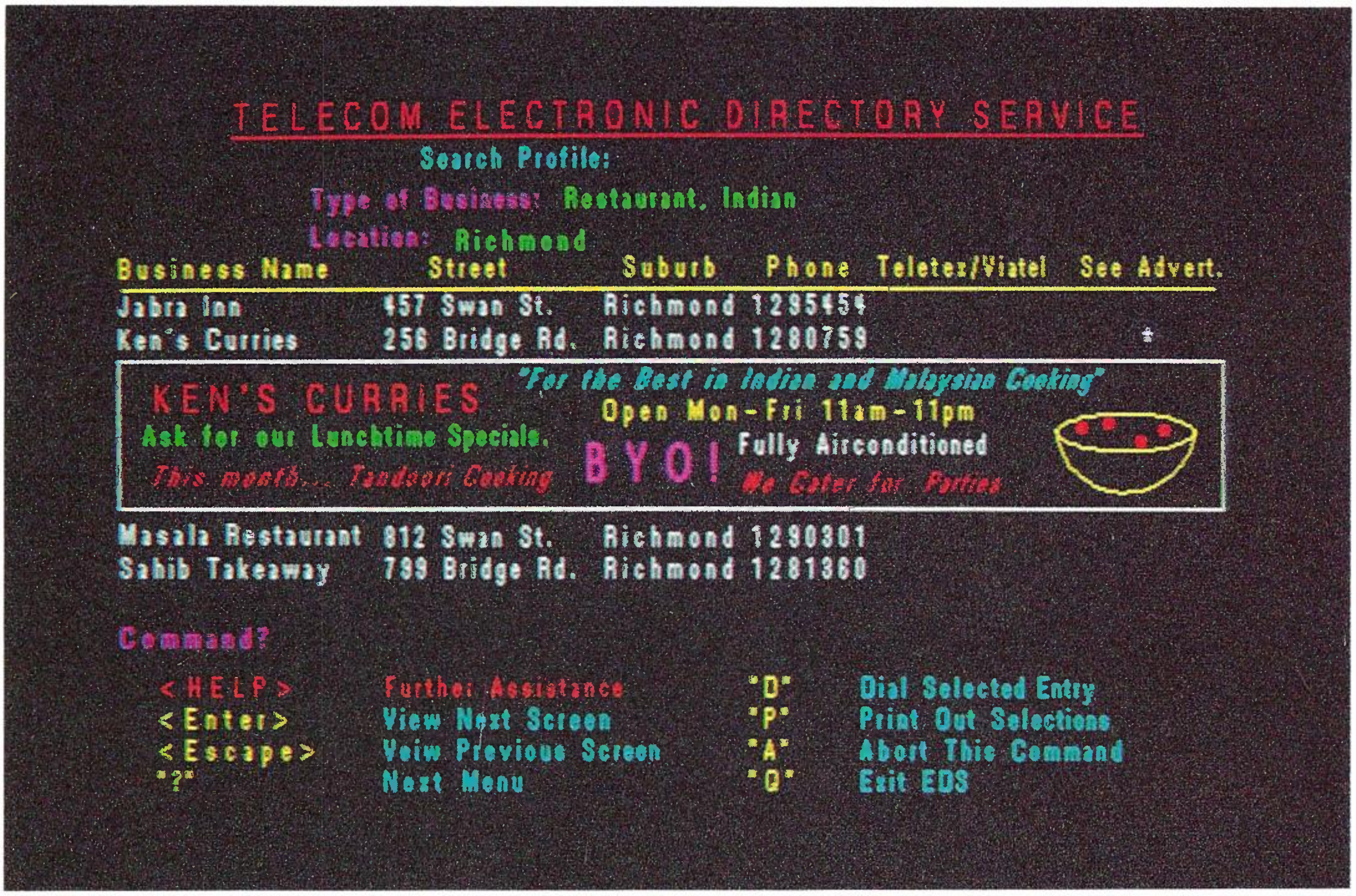
A recent Laboratories' experiment tested the degree to which people could readily interpret icons denoting advanced services in telephone systems. The literature suggests that, as the concept to be captured by an icon becomes more abstract and unfamiliar, the difficulty of designing and interpreting a suitable icon increases. Laboratories' results supported this contention, and also showed that verbal descriptions were understood significantly better than the icons tested. Furthermore, the overall recognition rate was such that less than one half of the icons reached a criterion necessary for standardisation. So, a picture may well be worth a thousand words; but the difficulty is to ensure that it triggers the right words! Attempts are now being made to design a systematic grammar of icon components to ensure that a certain meaning is always expressed in the same manner in different icons. Such a "pictorial" grammar has hitherto been lacking. The objective is to ascertain the degree to which defined rules facilitate interpretation of icons.

Another aspect of this research is the variety of demands placed on users by different tasks and systems. An index of stress would assist the assessment of which tasks or systems impose most pressure on a user. As part of the Laboratories' research programme, an experimental system has been developed which records physiological data whilst simultaneously measuring people's actual performance and their own estimates of performance. All three factors measured appear to contribute to perceived stress. Using an index derived from these measurements, it is possible to determine the level of stress people are under when working at their normal workstations. This can be used to structure jobs in a fashion that best complements people's natural abilities and tendencies. Pilot studies are now complete and the equipment has been found reliable. Early results show that certain complex tasks place more stress on people if they are presented at a rapid pace determined by a computer rather than by the person using the computer. This raises questions about system response time and the degree to which systems should allow the user to be in control of the interactive process.

THE ELECTRONIC DIRECTORY SERVICE

Directory information has traditionally been distributed to customers in the form of paper telephone books. If this information were transferred to a computerised electronic directory system (EDS), a range of improved and new services could be made available to customers. However, the area of directories is one of the last aspects of telecommunications to be automated. Currently, international standards are being developed which will facilitate the interconnection of computerised directory systems to form a "Global Directory". This directory will be capable of storing a range of information such as telephone, telex, Viatel and Telememo numbers, together with the increasing amount of information which will be needed for future more complex and diverse services.

Having on-line directory information available will allow customers to specify the name of the person or organisation with whom they wish to communicate, rather than requiring them to specify a long string of digits. Customers using an on-line directory will also have access to completely up-to-date directory information and will be able to perform useful functions such as automated complex search functions (for example, "find me all Indian restaurants in Richmond") and automatic call-connection (removing the need to dial numbers).



A typical search profile obtained from a computer terminal interacting with an Electronic Directory Service

Telecom's Commercial Services Department has been assisted by the Research Laboratories with on-going consultancy on the theme of automated directory systems. The basis for this consultancy has been provided by recent Laboratories' studies of the technical requirements of on-line directory systems. These studies have also enabled the Laboratories to actively contribute to and participate in the development of international standards for the Global Directory. As standards for this Directory emerge in 1988, many companies worldwide will be implementing products based on the standards for release in 1989/90.

The Research Laboratories are currently exploring user interfaces for an on-line electronic directory service and investigating the mapping of Telecom's Yellow Pages and White Pages directory information onto an electronic directory system (EDS). A simple prototype EDS, based on the evolving international standards, has been constructed in collaboration with the Computer Science Department of Monash University through a research and development contract. This practical approach has provided valuable experience for both Telecom and the University on the requirements of an EDS.

The planned further experimental implementation of an electronic directory system will allow Telecom Australia to be in a strong position to provide an internationally compatible Electronic Directory Service in a timely and competent manner.

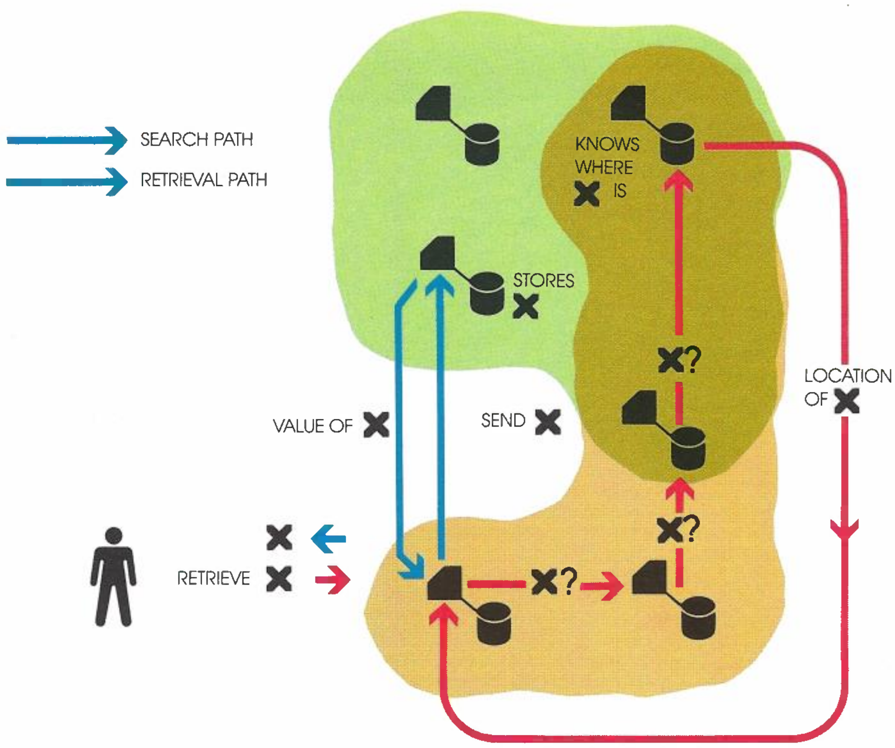
PARTIALLY INFORMED DISTRIBUTED DATABASES

Recent developments in computers and communications technologies are enabling a richer variety of advanced information-based services to be offered over public networks. These services typically exploit database technology and offer customers the potential to access and share information widely. Database technology is also likely to be employed within Telecom to assist in the management of its network resources.

Implementing these services on a national scale typically requires that databases are distributed across a number of computers at different locations. This reduces the amount of data each computer must maintain and permits incremental system growth as more computers are added to the network. Such distributed databases (DDBs) are expected to play an essential role in supporting the diverse range of value-added services that may be offered by Telecom in the future. The establishment of on-line telecommunications directories and value-added telephony services (for example, call forwarding) are typical applications of new services based on this technology.

Nationally or internationally distributed applications are likely to involve hundreds of co-operating computers. Such networks present special problems to the maintenance of the data directories that constitute each computer's knowledge of what data exists and where it resides in the network. These directories enable the system to determine the location of data automatically without manual intervention. Data may then be referenced as though the entire database resided at the local computer.

Recognising the need for a suitable technology, the Laboratories are developing a sophisticated knowledge model to augment the traditional data dictionary. The emphasis of the project has been directed at developing a conceptual framework suitable for large networks. A new class of Partially Informed Distributed Databases (PIDDB) has been developed in which each computer has limited rather



An example of the data location process in a PIDDB: the retrieval of 'X' involves an initial exploration of the network to find the computer storing 'X'

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. This proposal partitions the data directory. Each computer need only know selected data but can discover the location of other data items as required. 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. It is unlikely that any computer would know the entire global directory. The PIDDB class provides the conceptual framework for a wide range of information retrieval and transaction processing applications. Formal descriptions for precisely describing this framework have been developed.

The initial emphasis of the Laboratories' project has been directed towards developing techniques to automatically discover the location of data as it is required. This data location problem has been found to be inherently intractable, so that it was necessary to find an heuristic basis for the data location and other operational algorithms.

While these algorithms are of value in providing a precise description of the operational aspects of a PIDDB, the principal purpose behind their development was to demonstrate that the conceptual framework and heuristics proposed are both efficient and complete. Aspects of the PIDDB model are also being experimentally investigated to substantiate the effectiveness of the proposed model. Later work will examine how data ownership may be distributed and how security and privacy may be controlled.

STUDY OF NETWORK DESIGN FOR THE DEDICATED DIGITAL NETWORK

Telecom's Digital Data Network (DDN) provides digital leased line services at speeds ranging upwards from 2400 bit/s. In order to cater for the rapid growth of this network, Telecom has specified and called for tenders to develop a special type of computer-controlled cross-connection system known as a Time Division Cross Connect (TDCC). The system is currently under development by GEC-Marconi Australia Pty Ltd in association with Marconi Communication Systems Ltd. of the UK, and it should soon be ready for installation in the network.

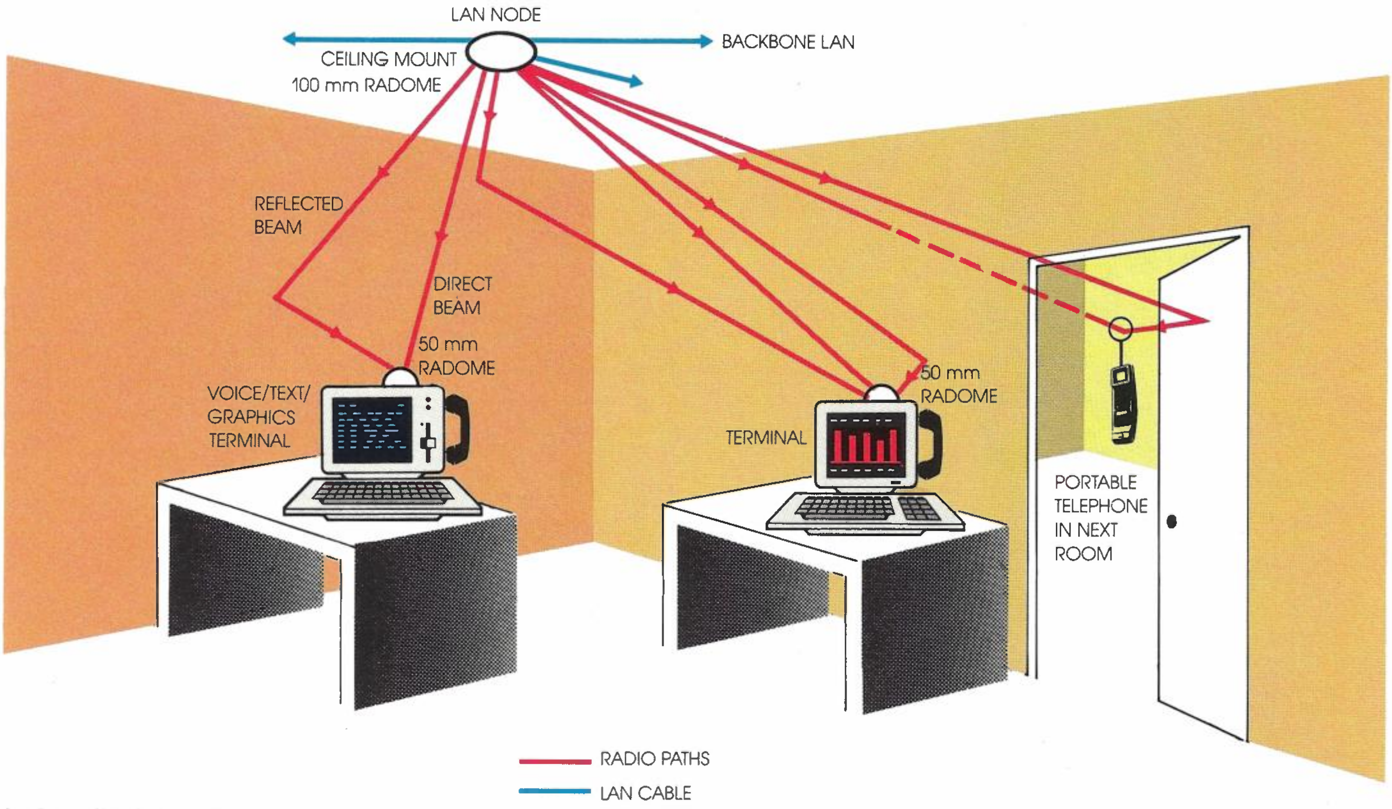
One of the new features of the TDCC is its ability to connect channels within a 64 kbit/s bit stream. These channels must be arranged in accordance with CCITT standard X.50, and hence the term "X.50" is used to refer to aspects of TDCCs which relate to data at these speeds.

The imminent introduction of TDCCs has also necessitated a thorough review of relevant network planning and design procedures. The objective of network design is to achieve a high standard of reliability and responsiveness to users' requests for service, at near to least possible cost. Since the TDCC is made up of a number of different types of components (for example, a 64 kbit/s switch and up to two X.50 switches), it will be necessary to minimise the use of these different types of component in some specific cases. The network must also be structured in such a way that day-to-day management can be performed easily and so that the network can satisfactorily expand, as the level and nature of demand for services changes and the type of equipment which is available to provide these services evolves.

In close co-operation with the Network Engineering Department at Telecom Headquarters, the Laboratories have developed a mathematical model of the network which allows network planners to see, at a glance, the implications of changes in patterns of demand and of network design decisions. On the basis of work with this model, a number of recommendations concerning the structure of the DDN in the next few years have been formulated. Some of these are:

- The network should be viewed in terms of two layers – the 64 kbit/s layer, in which the traffic to be handled is regarded as 64 kbit/s bit-streams and the basic module of transmission is the 2 Mbit/s system; and the X.50 layer, in which the traffic flows at a variety of speeds below 64 kbit/s (the X.50 data rates) and the basic module is the 64 kbit/s channel. This way of looking at the network facilitates the minimisation of the numbers of X.50 switches.

- In the near future, it will be appropriate to use a non-hierarchical approach for handling transit traffic through the network; that is to say, when it is necessary to make a connection between two TDCCs via a third TDCC, any available TDCC should be used – not only a specially designated "transit" switch. Later on when the DDN is much larger, it may be necessary to introduce a more hierarchical structure.



A schematic wireless office

- When transit switching of connections is required, this should be carried out in 64 kbit/s switches wherever possible (to minimise expenditure on X.50 switches).
- Re-arrangements of connections should be used to reduce the cost of the network; the number of re-arrangements of a specific connection should be kept to one or fewer.

These recommendations rely on a limited amount of experience to date, and as the number of TDCCs in the network grows, they may need modification. However, the mathematical model itself should remain valid until the equipment used in the DDN is changed.

WIRELESS OFFICE COMMUNICATIONS SYSTEMS

Forecasts for the 1990s suggest that as many as 20% of office desks will then incorporate picture quality graphics terminals and that traffic in the integrated services digital network (ISDN) and local area networks (LANs) will be predominantly digital graphics and digital telephone traffic. A number of proposals are emerging to interconnect all terminals in an office by short range microwave radio, thus avoiding the cost, delay and disruption of installing and altering fixed wideband distribution cables. The simplest concept is to establish small radio cells, one or more on each floor of a large office building, with a semi-permanent backbone LAN interconnecting the radio nodes in the ceilings. Terminal equipment users could then quickly and easily re-arrange floor plans and add or remove terminals themselves.

To assist Telecom's forward planning and technical evaluation of such wireless office systems, the Laboratories have been investigating microwave radio propagation mechanisms and transmission performance by undertaking field measurements in a number of Telecom's buildings. To date, these investigations have shown that multi-path transmission by scattering from walls, floors, ceilings and furniture causes frequency-selective fading which must be countered by diversity techniques. Shadowing by filing cabinets and people in the office can be excessive, in which case elevated terminal antennas or multiple ceiling nodes will be required. The signals pass moderately well through non-metallic partitioning, while brick walls and concrete floors provide some extra isolation from other adjacent wireless office radio cells.

Multi-path transmission effects also limit the usable modulation rate of simple equipment to about 1 Mbit/s in a 2000 m^2 cell, and to even lower rates in larger cells. As this is the rate required to carry the traffic in an office of this size with acceptable blockage and delay, it sets a reasonable limit on the cell size. The Laboratories' tests also indicate that a cell of this size and capacity can be operated with low power, low cost millimetre wave radio equipment operating at about 30 GHz. This provides the freedom to plan large frequency allocations, as required for successful widespread applications of wireless office systems.

This research is to be continued by acquisition or construction of experimental terminal and nodal equipment, for demonstration purposes and traffic throughput experiments.

SATELLITE-BASED MOBILE COMMUNICATIONS SERVICES

Over the next few years, Telecom Australia plans to extend its cellular mobile telephony service. Using terrestrial transmitters sited primarily around population centres, this system will serve approximately 85% of Australia's population. The remaining 15% are spread thinly throughout the bulk of the continent and providing a modern mobile telecommunications service to them by terrestrial means is neither technically or economically viable. Hence, the Research Laboratories are conducting studies into satellite-based mobile systems to assess their feasibility for these areas of Australia.

The instrumented helicopter and vehicle used to simulate earth-space propagation effects in satellite-based mobile services

A beam from a satellite can cover the whole of Australia, enabling communications with a suitable mobile transmitter/receiver located virtually anywhere on the continent (or on coastal waters). AUSSAT Pty Ltd, Australia's domestic communications satellite owner and operator, is considering including a special "package" designed for mobile services on its second generation satellites and Telecom's studies are centred on the parameters likely for it. The second generation satellites will be launched in the early 1990s and will place Australia at the forefront for this type of service. This means there is little overseas experience to draw on and the work of the Laboratories is important in providing Telecom with the technical details necessary for it to make proper decisions on the introduction of this service.

Australia has previously used satellites for fixed services, with earth stations commonly using parabolic dish antennas several metres in diameter, firmly fixed to the ground. The earth/space propagation characteristics for a fixed service are well understood, but there is limited data for a land mobile satellite service. Factors such as multipath reception due to the scattering of the radio signal by nearby obstacles, variable attenuation due to roadside vegetation, and doppler shifts of transmitted frequency due to the motion of the mobile transceiver must be considered and quantified.

Because there is no satellite which can be conveniently used to conduct measurements of these propagation effects, the Laboratories are using a helicopter. Fitted with a specially made mount carrying three transmitting antennas, the helicopter hovers at a suitable height, while measurements are made in an instrumented vehicle driven along the road under test. Computers are used to collect all data for later analysis in the Laboratories. Three frequencies are measured so that information is collected on possible bands for future use as well as that currently proposed.

The Laboratories are also constructing a path simulator to use the information collected from the helicopter measurements. This will enable testing and development of various system components in the laboratory under controlled conditions and avoid the expense and other technical difficulties associated with satellite-based trials.

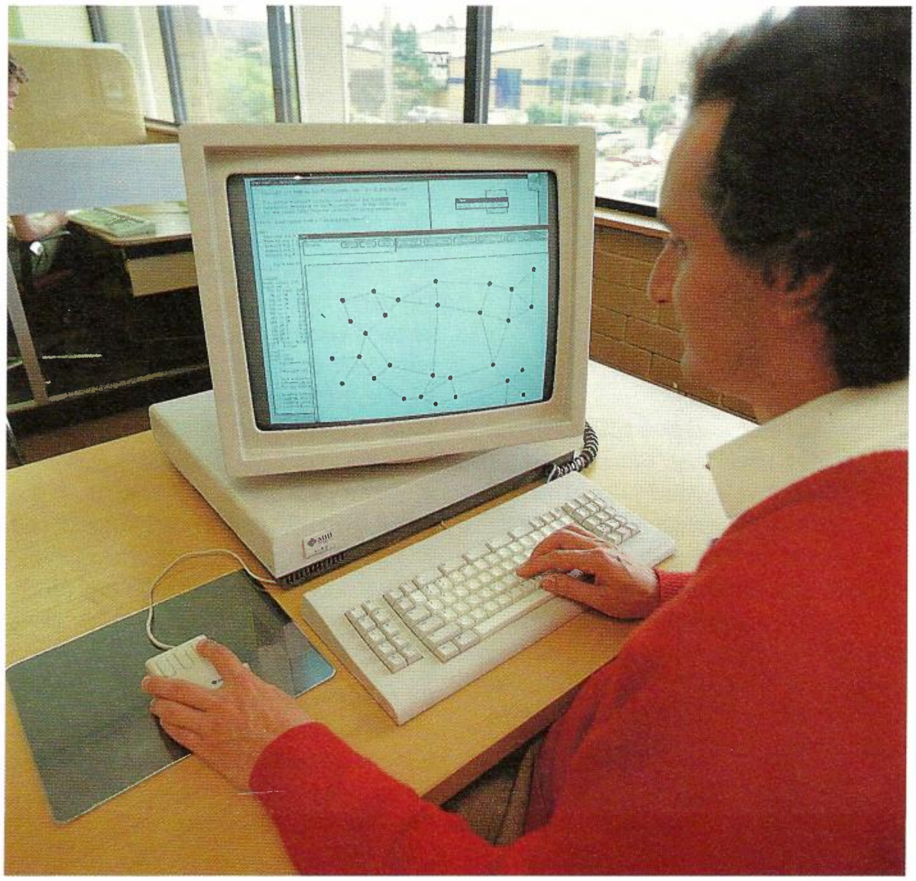
Preliminary work suggests a public switched land mobile satellite system is feasible. Studies have shown that, if the entire capacity available for mobile services on the next satellites was devoted to this one service, between five and ten thousand services could be provided. Telecom is now conducting economic feasibility studies, to which the Laboratories are contributing, aimed at determining whether the mobile satellite service can be offered at reasonable price to the customer. Should this study result in Telecom proceeding to offer the service, further work will be done at the Laboratories to help fully specify a system. It is hoped that this activity will also present opportunities for the Australian telecommunications industry to participate in both R&D and any ensuing product innovation.

ARTIFICIAL INTELLIGENCE IN TELECOMMUNICATIONS

The increasing complexity and heterogeneity of telecommunications networks place heavy demands on network designers, planners and managers. Many of the traditional technologies are simply incapable of dealing with this growth in complexity. However, artificial intelligence (AI) technologies are finding increasing application in network management and design, since they directly address some of the problems that must be faced in the future.

The AI approach to these problems relies on heuristic approaches to problem solving. In a heuristic or "rule of thumb" approach, human experience is used to suggest rapid but approximate strategies for dealing with complexity. An example of a heuristic approach to complex problems is the approach used to navigate a car through city traffic. An experienced driver makes use of background knowledge of the city traffic patterns to guide his selection of a particular route, without exact knowledge of the city traffic prevailing at the time of his journey.

Artificial intelligence techniques offer promise in complex network design



The Laboratories have recently commenced a number of projects exploring the use of AI techniques in telecommunications networks.

One such project is concerned with the LNET system which uses AI techniques to design telecommunications networks from a demand specification. With a graphical display of the network, the designer can quickly design networks to meet quite widely varying demand characteristics. Using traditional techniques, this would involve many hours of costly simulation and optimisation. Instead, LNET makes use of heuristic design techniques to generate a network design with far less design cost. In addition, LNET can learn from its own experience in designing networks. As a number of designs of a similar character are completed, LNET will improve its performance and design networks even more quickly. In this way, it mirrors the human approach to problem solving in that, as more experience is gained, performance improves.

Another project concerns future packet switching networks, which will be several orders of magnitude larger than today's networks. One of the difficult aspects of these large networks will be finding a route between any two nodes quickly. Using AI techniques, a set of simple heuristics are employed to find a route using a heavily pruned search of the possible routes between any two nodes. In this way, a route can be found for the customer very quickly, whereas route determination by traditional techniques can be quite time consuming.

In the realisation of the transmission and switching systems of the future, one of the most demanding tasks is the design of sub-systems from a high level specification. To reduce design costs, higher level specifications have already been developed, but the task of creating actual hardware or software from these specifications remains. Whilst there has been great progress in computer-aided design, there are few design tools that actually assist at the system architecture level. The Laboratories have developed a system using AI techniques to assist in this process. From a brief specification, it uses a heuristic approach to produce a system architecture that satisfies practical design constraints such as minimum-cost or minimum-area.

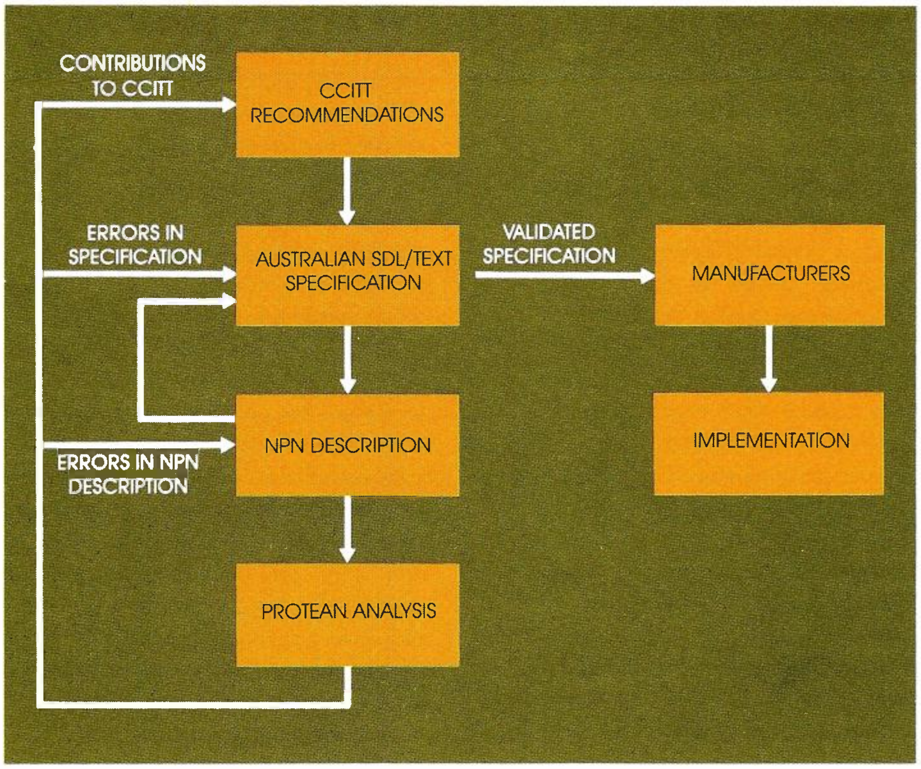
There are many other potential applications of AI technologies to the design and operation of telecommunications networks and services, and the Laboratories plan to extend their investigations in this field. One area of high interest is the application of these new technologies to the interfacing of new customer services and terminals to future digital telecommunications networks.

PROTOCOLS FOR ELECTRONIC FUNDS TRANSFER

During the past year, the Laboratories have contributed to the development of national standards for Electronic Funds Transfer (EFT) Protocols for an Australian EFT network. The body co-ordinating this task is the EFT Communication Implementations Sub-Committee of the Standards Association of Australia.

The Australian EFT network will provide carriage over communications links for EFT transaction data between terminals at retailers' premises and the processing systems of the financial institutions. The standards seek to ensure successful carriage even though the equipment involved may be sourced on different vendors.

The EFT network will be composed of a number of concatenated sub-networks. The sub-networks could include Telecom Australia's public packet switching network (AUSTPAC), Telecom's public switched



Schematic of the processes in the validation of the functional specifications for the Australian ISDN prior to their final publication

telephone network, the future integrated services digital network (ISDN) and a wide variety of possible private networks. To enable EFT transactions to be performed over these networks, an inter-working architecture must be designed and an inter-networking protocol standardised and specified.

Work on the development of inter-networking protocol standards is not yet finalised. However, largely as a result of contributions by the Laboratories, the SAA Sub-Committee has favoured the adoption of the Open Systems Interconnection (OSI) Standard Connectionless Network Protocol set by the International Organisation for Standardisation (ISO) for use as the inter-networking protocol.

The Laboratories made the points that the ISO protocol:

- is an international standard;
- was developed from the DARPA internet protocol, which was developed in USA and has been successfully used over a long period;
- will be the most widely used internet protocol;
- presented a sound basis for the development of an Australian standard, with minimised revision;
- when embodied in locally made EFT equipment, would maximise international market opportunities available to Australian manufacturers.

The SAA, through its collegiate contributory processes, has yet to finalise the Australian EFT Protocol Standard. However, because of Telecom's significant role in the future carriage of EFT transaction data, the Research Laboratories and the Commercial Services Department of Telecom will continue to lend their considerable expertise and experience in the field of communications protocol engineering to the development of the new Australian Standard.

VERIFICATION OF THE ISDN PRIMARY RATE ACCESS INTERFACE USING PROTEAN

Telecom is planning to introduce a primary rate access Integrated Services Digital Network (ISDN) in mid-1988. This will allow PABXs to be connected to the ISDN. The equipment necessary to implement primary rate access must conform to the Australian Primary Rate Access Interface Specification, which was first published by Telecom in August 1986. This specification is based on CCITT Recommendations.

It is essential that the ISDN facilities first put into service meet an exacting quality of service; otherwise customer dissatisfaction will result and expensive retro-fixes of installed equipment will be required.

The best starting point for successful implementations is a specification which is fault-free, complete, unambiguous and easily understood. The Research Laboratories are working towards this goal by thoroughly analysing the specification.

The primary rate access specification is structured according to the ISO/CCITT Open Systems Interconnection (OSI) seven-layer model. Of the three layers relating to the access interface, the Layers 1 and 2 specifications are relatively stable, whereas the Layer 3 specification is still under development. Consequently, the Laboratories analysis has concentrated on Layer 3 of the specification, which is specified using both textual descriptions and the CCITT Specification and Description Language (SDL). To analyse the protocol rigorously, it was first re-specified using a formal specification technique with a strong mathematical foundation. The numerical Petri Net (NPN) technique, developed at the Research Laboratories, was used. In the process of re-specifying the protocol, a number of faults and ambiguities were found.

Once specified using NPNs, a protocol can be analysed. The complexity of modern protocols necessitates the use of automated analysis techniques. The Laboratories have developed a software tool, PROTEAN, which can analyse NPN specifications, generating all possible global states which the protocol can reach. This allows all deadlocks and livelocks to be easily detected. Further analysis can then find other faults.

The Laboratories' analysis of the Layer 3 primary rate access specification has already revealed several problems both within Layer 3 and with the description of the services provided to Layer 3 by Layer 2. As the work continues and further faults are found, the Australian specification is being updated. Contact is being maintained with equipment manufacturers to keep them abreast of these changes as they occur. Where appropriate, contributions have also been, or will be, made to CCITT.

By discovering and eliminating faults in the specification before any equipment is put into the network, the Laboratories are assisting Telecom to develop a reliable error-free ISDN service.

X.32 CAPABILITY FOR PACKET SWITCHING NETWORKS

CCITT Recommendation X.32 is a new Recommendation which provides for "dial in" access to a packet switching network (PSN) via a public switched telephone network (PSTN), and "dial out" access from the PSN via the PSTN to a packet mode terminal. This Recommendation provides a lower cost means of access (via the PSTN) to a PSN, with error detection and correction. Once a physical connection between the terminal and the PSN has been established, the CCITT X.25 protocol is used for call set-up and data transfer between the network and the terminal.

The Research Laboratories have designed and developed an X.32 Interworking Unit that will provide PSNs, such as Telecom's AUSTPAC network, with both 'dial in' and 'dial out' X.32 access. A number of these units are currently being constructed, and will be installed in AUSTPAC to provide a trial service of X.32 access during 1987. The units will provide the X.32 "Unidentified Service" and the "Indentified On A Per-Call Basis" services, by providing a Network User Identification (NUI) in the Call Request packet and using V.22bis 2400 bit/s modems for the PSTN access.

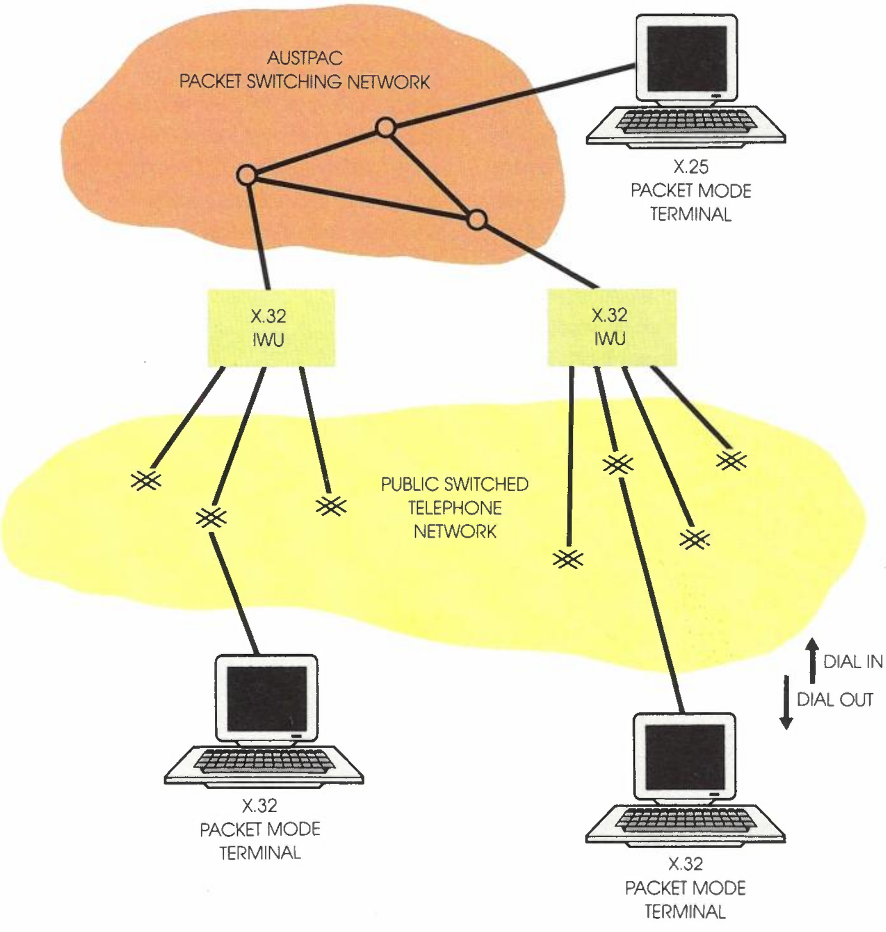
The X.32 Interworking Unit consists of a small chassis containing a commercial processor card (Motorola 68000, VME bus based), a commercial memory card and Laboratories-developed cards to handle the system alarms and the CCITT X.25 communication protocol. PSTN access is provided by standard Datel 2400 bit/s V.22bis modems.

The X.32 Interworking Unit is placed between the PSN and PSTN, and allows the following calls to be made:

- from an X.32 terminal, via the PSTN, to an AUSTPAC terminal. The call may either request a Reverse Charge call or supply an NUI.
- from an X.32 terminal, via the PSTN, to another X.32 terminal. The Call Request must contain an NUI.
- from an X.32 terminal, via the PSTN, AUSTPAC and OTC's network, to an international terminal. The Call Request must contain an NUI.
- from an AUSTPAC X.25 terminal to an X.32 terminal, via the PSTN. The call must not request Reverse Charging.
- from an international terminal to an X.32 terminal, via OTC's network, AUSTPAC and then the PSTN. The call must not request Reverse Charging.

The Research Laboratories contributed extensively to the development of CCITT Recommendation X.32. This, together with the recent research work on AUSTPAC interworking, has enabled the Laboratories to develop the X.32 Interworking Unit quickly. In the absence of a similar commercial product, the unit has potential for local development and international marketing.

The placement of the X.32 Interworking Unit between the packet switching and switched telephone networks

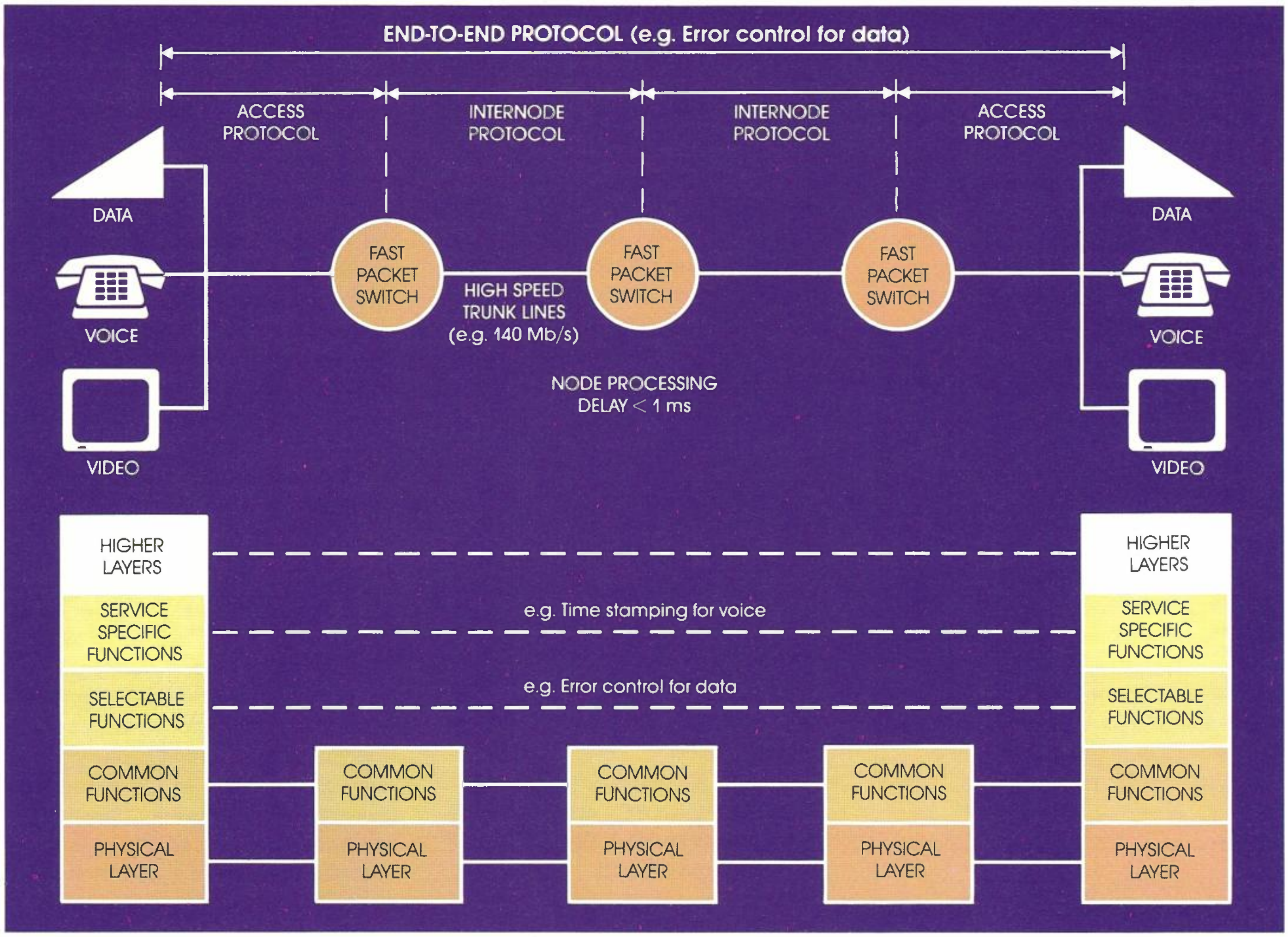


PROTOCOLS FOR FAST PACKET SWITCHING NETWORKS

The current telecommunications environment is characterised by a significant increase in demand for services such as videotex, electronic funds transfer and video-conferencing. In the future, new services with different transmission requirements will emerge. Telecom Australia must then be in a position where it can provide a full range of voice, video and data services in an efficient manner and at reasonable costs to its customers. Research carried out at the Laboratories indicates that an integrated services network based on fast packet switching technology is likely to give Telecom the flexible service provision capability which it will require.

One key research area in the field of fast packet switching networks concerns the rules governing communications between customer equipment and the network switches (or nodes). These rules are called protocols. Access protocols control the communications between the customer's equipment and the network switch to which it is connected. Internode protocols control communications between any two network switches. Access protocols are subject to international standardisation to allow networks operated by different telecommunications providers to communicate with each other. The major body for international standardisation of these protocols is the International Telegraph and Telephone Consultative Committee (CCITT).

The services to be supported by a network will determine the features of the protocols used. Telecom's AUSTPAC network is an



A schematic illustration of an integrated services packet switching network showing the applicability of access and internode protocols

example of a current generation packet switching network. Such networks were designed for reliable transfer of data services. As a result, the access protocol used is based on CCITT Recommendation X.25, which provides features such as error and flow control. In AUSTPAC, the internode protocol also provides error and flow control functions. This means that each network node performs a range of processing functions associated with the detection and correction of errors and the management of flow control. The consequent intensive processing requirements result in a node processing delay of 70 ms for AUSTPAC. This represents very good delay performance for a current generation packet network, but it means that such networks are unable to carry real-time traffic such as packetised voice.

Although voice and video services are delay-sensitive, both can tolerate occasional errors. On the other hand, most data services require error-free delivery, but can tolerate some delay. Thus, problems arise in the design of access and internode protocols to satisfy these conflicting service requirements in an integrated packet switching network. Ideally, the level of integration should extend to the way in which packets belonging to different services are processed at network nodes. This means that the functions defined for the internode protocol should be those needed by all services. Extra functions needed by only a few services would then be provided on an optional basis in the access protocol.

Voice and video services do not require error and flow control. Hence, these functions are not included in the internode protocol. This allows packet processing at intermediate network nodes to be minimised. Error and flow control functions are then defined in the access protocol and these would be selected by data services as needed. The advent of high speed, low error rate optical fibre transmission facilities allows error control for data services to be performed across the network between pieces of data terminal equipment, rather than between each pair of nodes on the connecting path.

International standards defining access protocols for integrated services packet switching networks are being developed and a set of framework recommendations is planned for the end of the next CCITT study period in 1992. Research performed at the Laboratories has resulted in several contributions to the CCITT in this important area. This work is also assisting Telecom to formulate its plans for the evolution of the Australian ISDN.

FAST PACKET SWITCH ARCHITECTURES

The current thrust in modern telecommunications developments is towards an integrated services digital network. This network will provide the customer with more diverse services, together with improved quality and greater flexibility in their use. In the short term, the network that will provide these services will not be an integrated network in itself, but rather a hybrid network consisting of the traditional circuit switching telephony network, the more recent packet switching data network and various other dedicated service networks. However, in the near future, fast packet switching has the potential for providing the most effective solution to the realisation of an integrated broadband digital network.

Probably the most significant advantage that fast packet switching offers over other switching techniques is the flexibility offered to the customer in the use of network bandwidth. Such a network could provide most services (for example, voice, data and video services) using a common high speed switching fabric. The network performance requirements for such services preclude the use of the current generation of packet switches based on general purpose computers. The problem of realising the high capacity, high speed and low delay packet switching network required for these services might be solved by the use of self-routing multi-path switches relying on very large scale integration (VLSI) technology for their economic implementation, in conjunction with high speed optical transmission links. Other switch architectures are also potentially suitable for fast packet switching, for example, architectures employing shared memory, shared buses or ring networks.

Currently, the Laboratories are studying a number of important network issues relating to fast packet switching, such as protocols, network architecture, flow control, congestion control and switch architectures. In particular, switch architectures based on multi-stage interconnection networks are being studied to determine their suitability for fast packet switching, with emphasis on an architecture known as the Starlite switch. The feature that these multi-stage interconnection networks have in common is their ability to route packets automatically by analysing the packet header as the packet passes through the switch. The path that a packet follows through the switch is set up, link by link, as the header passes through the switch, and each link is held only until the packet has passed over that link. The problem that all these switches have in common is the potential collision of packets competing for the same link within the switch. With some architectures, such as the self-routing crossbar approach, this only occurs with packets heading for the same output port. With others, packet collision can also occur for packets heading for different output ports. Since the arrival of packets and their destination is non-deterministic, the problem of packets colliding within the switch must be resolved as it occurs. The solution to this significant problem of packet collision (contention) is to buffer the contending packets in some fashion.

The Starlite architecture incorporates the novel feature of a sorting network situated in front of the self-routing switch stage. This sorting network can be implemented readily in hardware using VLSI technology, and its function is to sort the packets into order of destination. If the packets enter the self-routing switch in sorted order, packet contention or collision within the switch structure between packets heading for different destinations is eliminated. The remaining problem is the contention of packets for the same output port. This can be resolved by one of three buffering techniques, whereby the repeated destination packets are recirculated back to the input of the switch, buffering is provided on the output lines of the switch, or buffering is provided on the input lines of the switch structure. These techniques are being studied in the Laboratories to determine the best approach.

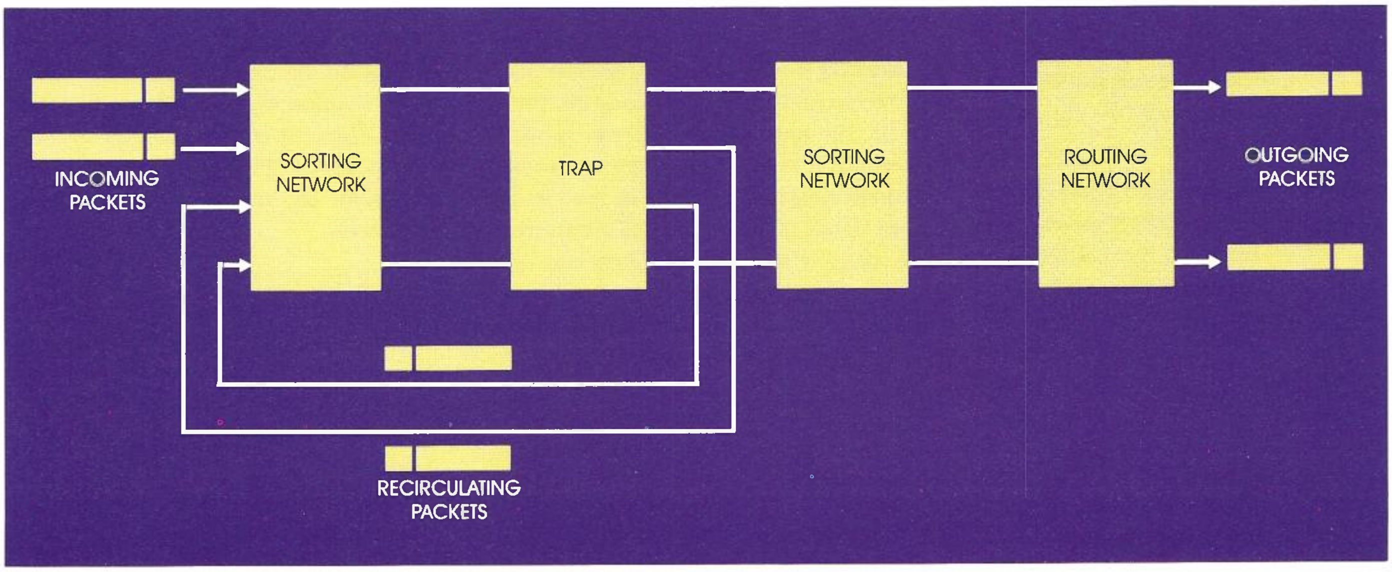
This work on switching architectures is complemented by other Laboratories' projects which are investigating the VLSI implementation of switch components for fast packet switching. In addition, a small experimental switch operating at 40 Mbit/s has been built to demonstrate the capability of such a switch structure for carrying full-motion video signals.

PERFORMANCE MONITORING OF DIGITAL RADIO SYNCHRONISATION BEARERS

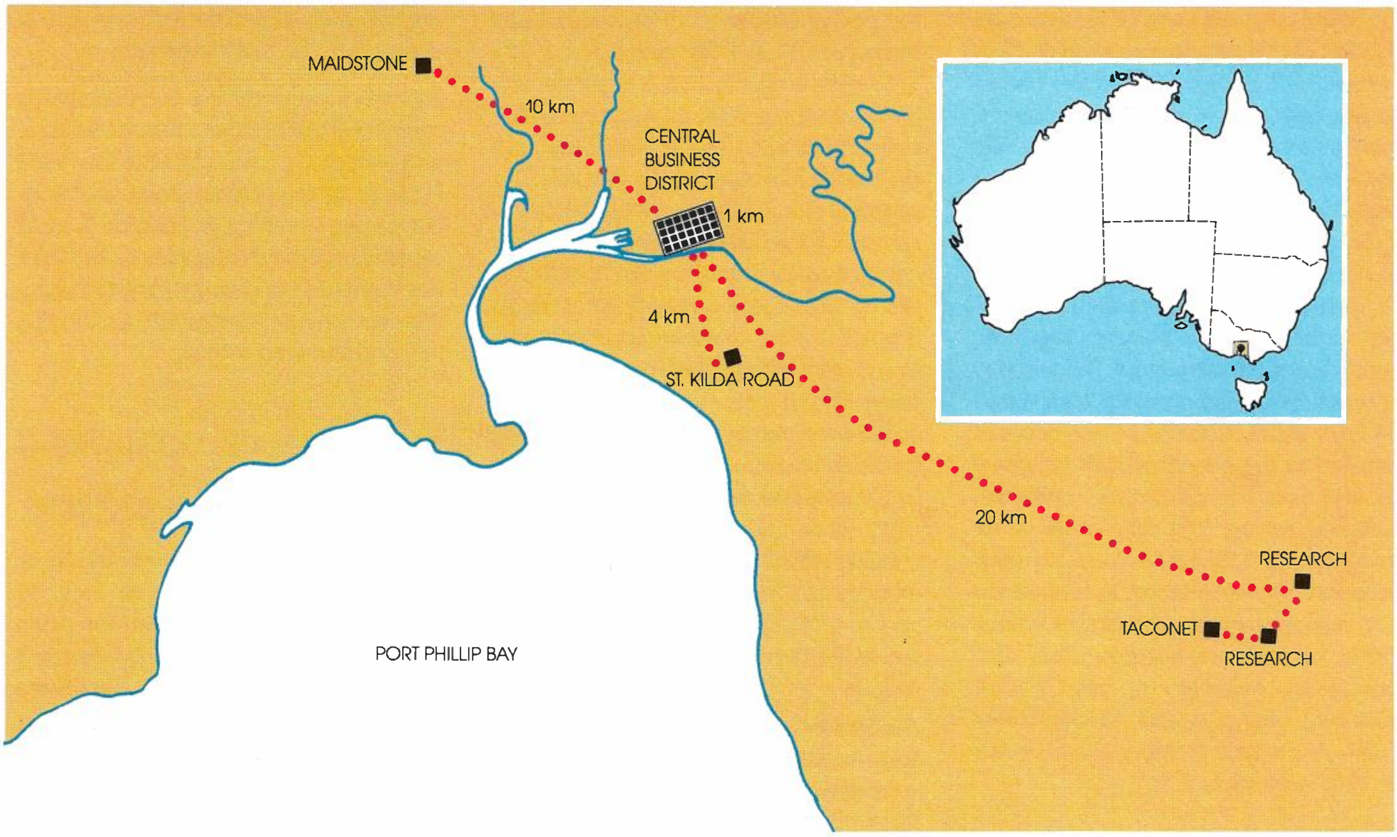
Telecom Australia is rapidly expanding its digital network nationwide. In order to realise its full potential, synchronisation of the network is an essential process now being implemented. Currently, each State Administration of Telecom is synchronising its digital network clocks in a hierarchical order from central clocks in AXE trunk exchanges. The latter, in turn, derive their synchronising reference from the National Reference Clock at the Research Laboratories.

An important element in the network from a synchronisation viewpoint is the digital radio bearer. This type of bearer will be the only one available to interconnect these clocks on many interstate and intrastate routes for some years, until optical fibre systems are introduced on all routes. This is of some technical concern since digital radio systems have several characteristics which make them less than ideal for transmission of synchronisation references. These include:

- fading, which leads to a temporary loss of reference



Schematic fast packet switch architecture in which repeated destination packets are recirculated to the input



The Melbourne CBD optical fibre pilot network, showing spurs to suburban locations

- protection bearer switching, which causes changes in delay and produces phase steps
- jitter hits or bursts of errors which may also cause temporary loss of reference or phase steps.

With suitably sophisticated synchronisation equipment, all of these effects can be accommodated with minimal deleterious effect on synchronisation. However, it is thought that, based on overseas reports, much of the earlier AXE clock synchronisation equipment which Telecom has already installed may be affected by these phenomena which are characteristic of all radio systems. The Research Laboratories have therefore established a field test programme to quantify the effects of these phenomena.

For the test programme, a 2 Mbit/s channel extending over about 500 kilometres has been set up between the Laboratories and Prospect Exchange in South Australia for continuous monitoring. With the exception of PCM cable tails over the 18 kilometres between the Laboratories and the Exhibition Trunk Exchange in Melbourne, the route is over digital trunk radio systems. Monitoring of the outward leg of the path is being carried out at Prospect and of the return path at the Research Laboratories. This will enable some correlation of results to be made.

Analysis of the performance of this digital radio path over an extended period will enable Telecom to determine whether there is a need to upgrade any network synchronisation equipment which is already installed in the network.

MELBOURNE CBD OPTICAL FIBRE PILOT NETWORK

An optical fibre network has been installed by Telecom in the Melbourne Central Business District (CBD) as a pilot project for the development of engineering expertise and work practices in the field of optical fibre distribution and Local Area Networks (LANs). The Laboratories' role in the project has mainly been concerned with the LAN aspects of the project, particularly in providing assistance to other Departments of Telecom in the design and layout of the LANs, the production of relevant technical specifications and the technical evaluation of tenders for the LANs. In addition, the Laboratories have an ongoing involvement in the project to investigate the performance of the LANs and the effects of different interconnection strategies and topologies on their overall performance.

For the project, optical fibre cables have been laid under the streets of the Melbourne CBD in existing tunnels and ducts. Spurs link the CBD network to the Research Laboratories and Telecom's TACONET mainframe computer installation in Clayton (20 km south-east of Melbourne), the External Plant Experimental Centre at Maidstone (10 km west) and the St. Kilda Road Business Sales Centre (4 km south). The Telecom buildings in the CBD which are connected to the network comprise five Headquarters buildings in the west end of the city and two Victorian Administration buildings in the east end. Seven sites have LANs installed as part of the initial phase of the pilot. The LANs are located at four of the Headquarters buildings and the two Victorian Administration buildings in the CBD, and at the Research Laboratories at Clayton. All LANs are interconnected by the optical fibre network. The LANs themselves use coaxial cables with some optical fibres within the buildings, and conform to relevant international standards.

The first key area in which the Laboratories provided assistance was in the choice of the medium access method for the LANs. The access method allows data from the attached devices to be carried on one transmission medium at high speed. As only one device may transmit at a time, the medium access method is required to ensure that all devices obtain fair access. The method chosen is known as Carrier

Sense Multiple Access with Collision Detection (CSMA/CD).

The second area of assistance was in the technical evaluation of the LAN bridges which are required for the interconnection of the LANs. To ensure acceptable performance, bridges must accommodate high speed connections between the LANs and provide internationally standardised interfaces to the Telecom line equipment.

The third area of the Laboratories' assistance was in the technical specification and evaluation of the network control facilities to be provided with the LANs. Issues which were addressed included configuration of the LAN interface devices, access security, network monitoring and fault detection. The Laboratories also ensured that the LANs conformed to the relevant international standards.

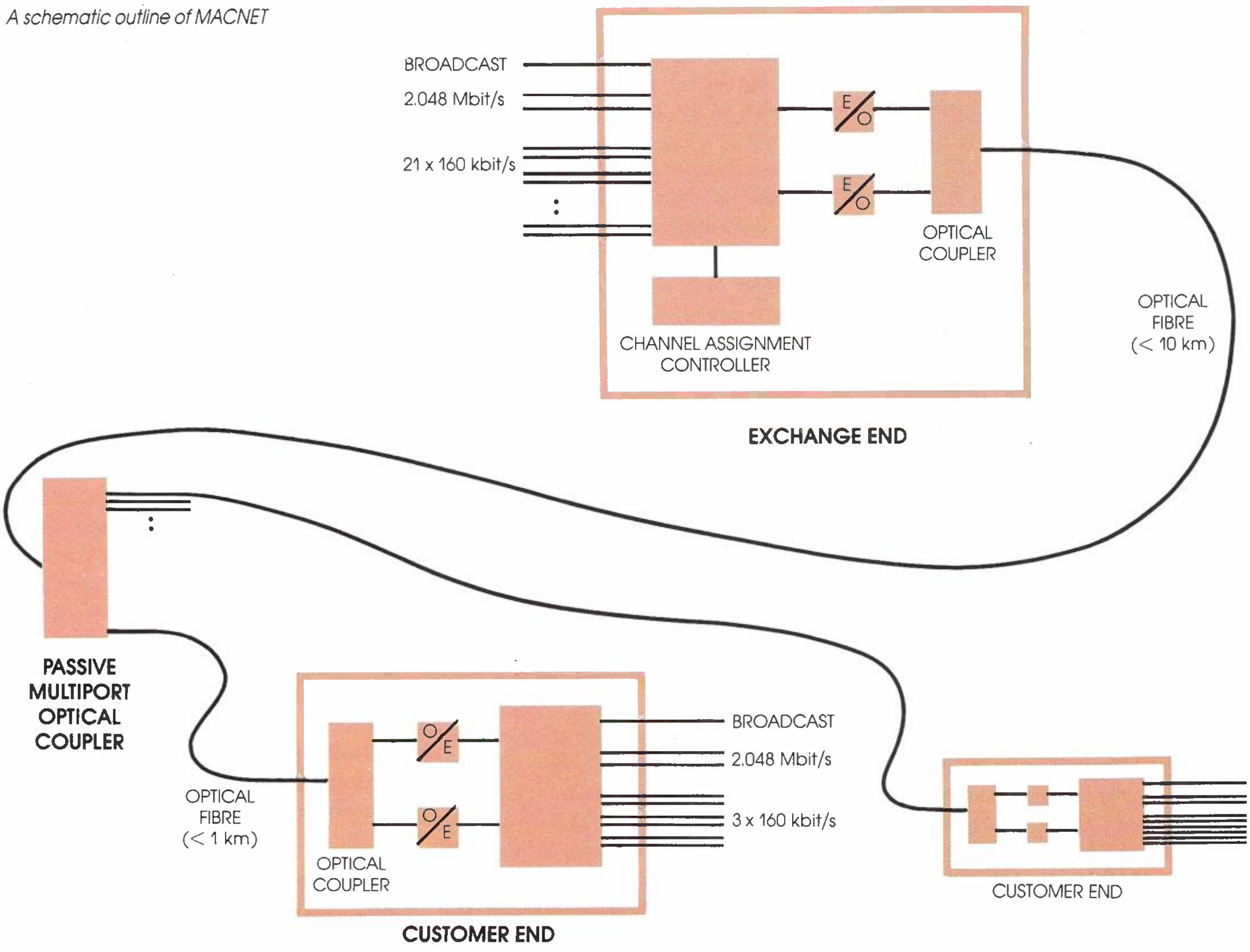
MACNET, A NOVEL CUSTOMER ACCESS SYSTEM

A novel customer access system, known as MACNET (Multiple Access Customer NETwork), was conceived in the Research Laboratories in 1985 and subsequently became the subject of patent applications lodged by Telecom Australia in Australia and a number of overseas countries. The system concepts take advantage of the large transmission capacity and low losses of single-mode optical fibre to realise a low-cost, simple customer access network. Since Telecom's patent applications were lodged, British Telecom and Bell South Corporation have published details of similar systems.

In the present copper local access network, each customer is separately linked to the local exchange with a copper wire pair. The future optical fibre customer access network will allow many customers to share a single optical fibre out of the local exchange, and only in the more immediate vicinity of a cluster of customers will that single fibre be split, using a passive multiport optical coupler, into individual fibres, each terminated at a particular customer's premises. As the coupler is passive, the MACNET system has the advantage of not requiring the outposted electronics and attendant power and environmental requirements of other concentrating and multiplexing approaches. Further, because the coupler can be placed in the street adjacent to the customers' premises, MAGNET is particularly well suited to serving groups of customers such as small business communities, high density apartment blocks and industrial estates.

In MACNET, the information from the exchange is time-division multiplexed. Each frame consists of a frame synchronisation signal followed by as many sets of address and customer information as there are customers. The information to the exchange from each customer is triggered by the reception of the customer address, and if appropriate guard times are left, an individual customer's information will not collide in the part of MACNET which is common to all customers.

A schematic outline of MACNET



Because a single fibre serves many customers, the cables required near the local exchange are potentially much smaller, and therefore put less demand on duct, pit and pipe capacity. Installation is also simplified, as significantly fewer splices are required in the customer access network. Further, because the interfaces in the exchange serve many customers, fewer interfaces are needed, with consequent savings in exchange floor space and main distributing frame size and reduced costs of optical transmitters and receivers in the exchange.

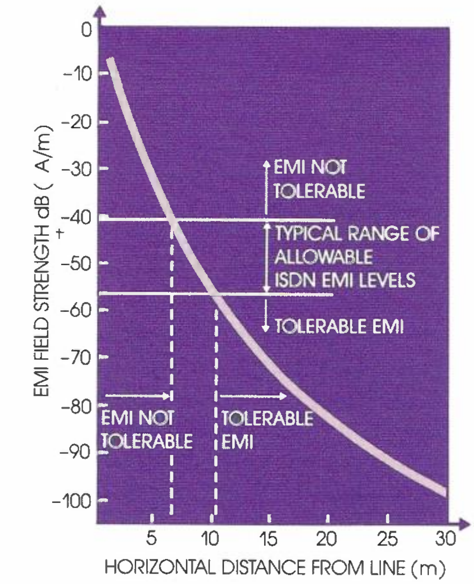
A prototype MACNET is being developed under a Telecom R&D contract by Standard Telephones and Cables Pty Ltd. The optical couplers for the contract are being made by Australian Optical Fibre Research Pty Ltd. The prototype network will be delivered to the Research Laboratories early in 1988, and a field trial will be commissioned shortly afterwards.

The prototype MACNET flexibly provides a 2 Mbit/s broadcast channel, a Primary Rate Access and the equivalent of 21 Basic Rate Accesses among 16 customers. It can be up-graded using wavelength-division multiplexing to provide very high capacity broadcast services. With further development of couplers and wavelength-division multiplexers, it is anticipated that very high capacity bi-directional services will also be achieved.

ELECTROMAGNETIC COMPATIBILITY OF THE ISDN BASIC ACCESS NETWORK

During the introduction and initial spread of an Integrated Services Digital Network (ISDN), the ability or otherwise to use existing quad cables in subscribers' premises and/or the use of current subscriber cable designs and cabling practices can be expected to have significant economic effects in the basic customer access network. The possible effects of electro-magnetic interference (EMI), radiated from ISDN cabling, on the reception of medium frequency broadcast band radio services will influence the choice of preferred cables, cable designs and cabling practices.

Hence, the Laboratories have made a preliminary study to assess possible levels of EMI radiated by cables and to estimate the EMI levels that can be tolerated by amplitude modulated (AM) broadcast receivers, in a variety of different reception situations. The study was based upon a



Calculated EMI field strengths versus distance from a modelled ISDN cable

Notes:
1. Cable modelled as 110 m line, 3 m above ground, with six 10 m stubs attached.
2. EMI field strengths calculated at 1 m above ground.

Graph showing calculated range of tolerance of AM broadcast receivers to EMI in terms of distance from an ISDN cable.

number of computer models developed for the purpose, which allow a range of variables to be investigated for their influence on the levels of EMI produced. Relevant CCITT recommendations on the electrical balance of ISDN equipment and the pulse waveform characteristics required in the ISDN basic customer access network were used to provide some of the important variables in the models.

The most significant source of radiated EMI from an ISDN cable is common mode current produced in the cable by cable and terminal equipment unbalances about earth. The limiting magnitude of the common mode current is a function of the amount of unbalance allowed and the pulse waveform characteristics specified for the ISDN.

Limits for tolerable levels of EMI were estimated for a variety of reception situations, based upon radio field strengths to be protected, as recommended in planning guidelines for broadcast services produced by Department of Communications. Protection ratios to be employed were developed from relevant CCIR recommendations, taking account of the subjective effect to a listener of the audio frequency characteristics of the EMI likely to emanate from the ISDN. Account was also taken of the possible effects of building and wall attenuation, on both wanted signals and unwanted EMI, in deriving the limit levels used in the study. The environments considered ranged from rural through motel/resort to high rise office accommodation.

The results obtained from the preliminary Laboratories' study indicate that there are a number of situations where the ISDN as presently specified may present a radiated EMI problem for AM broadcast reception. Some conclusions were as follows:

- In motel or resort style accommodation in a rural or small urban environment, with ISDN cables co-located with AM broadcast receivers in the same building, unacceptable EMI may be experienced at distances up to more than 10 metres from the ISDN cables.
- On the other hand, in the case of ISDN cables co-located with AM broadcast receivers in a high rise office building located in a large metropolitan area, the receivers may experience unacceptable EMI at distances up to more than 7 metres from the ISDN cabling.

The general conclusion drawn from these investigations was that significant reductions in the amount of EMI potentially radiated from ISDN cabling can be obtained by a reduction in the amount of terminal equipment unbalance allowed in present ISDN recommendations.

VLSI SYSTEM DESIGN

The ability to design innovative hardware solutions for the highly competitive telecommunications market can mean the difference between success and failure. Cost, performance, physical size and power consumption are some of the factors which determine whether a hardware system is viable or not. Silicon integrated circuit technology is becoming available to enable complete systems to be integrated on a single piece of silicon a few millimetres on a side. The attendant benefits of higher performance, reduced production costs, reduced overall system costs, lower power consumption, small physical size and higher reliability are all important for modern instrumentation and telecommunications equipment.

For many applications, general purpose, mass-produced components such as microprocessors suffice. In a growing number of cases, however, specially designed components are warranted. With the continual refinement of silicon technology, coupled with developments in the computer-aided design (CAD) field, these specially designed or "application-specific" integrated circuit solutions are becoming more commonplace in the realisation of highly integrated silicon systems.

The essence of the new design approach for these silicon systems is the ability to match algorithms and architectures to the implementation medium. Furthermore, the critical decisions concerning the choice of algorithm, architecture, design styles, circuit design techniques, design for testability and physical design form a continuum in which each influences the others. The confluence of the above factors marks the emergence of an integrated system, and this confluence is assisted by the availability of powerful and innovative CAD software tools.

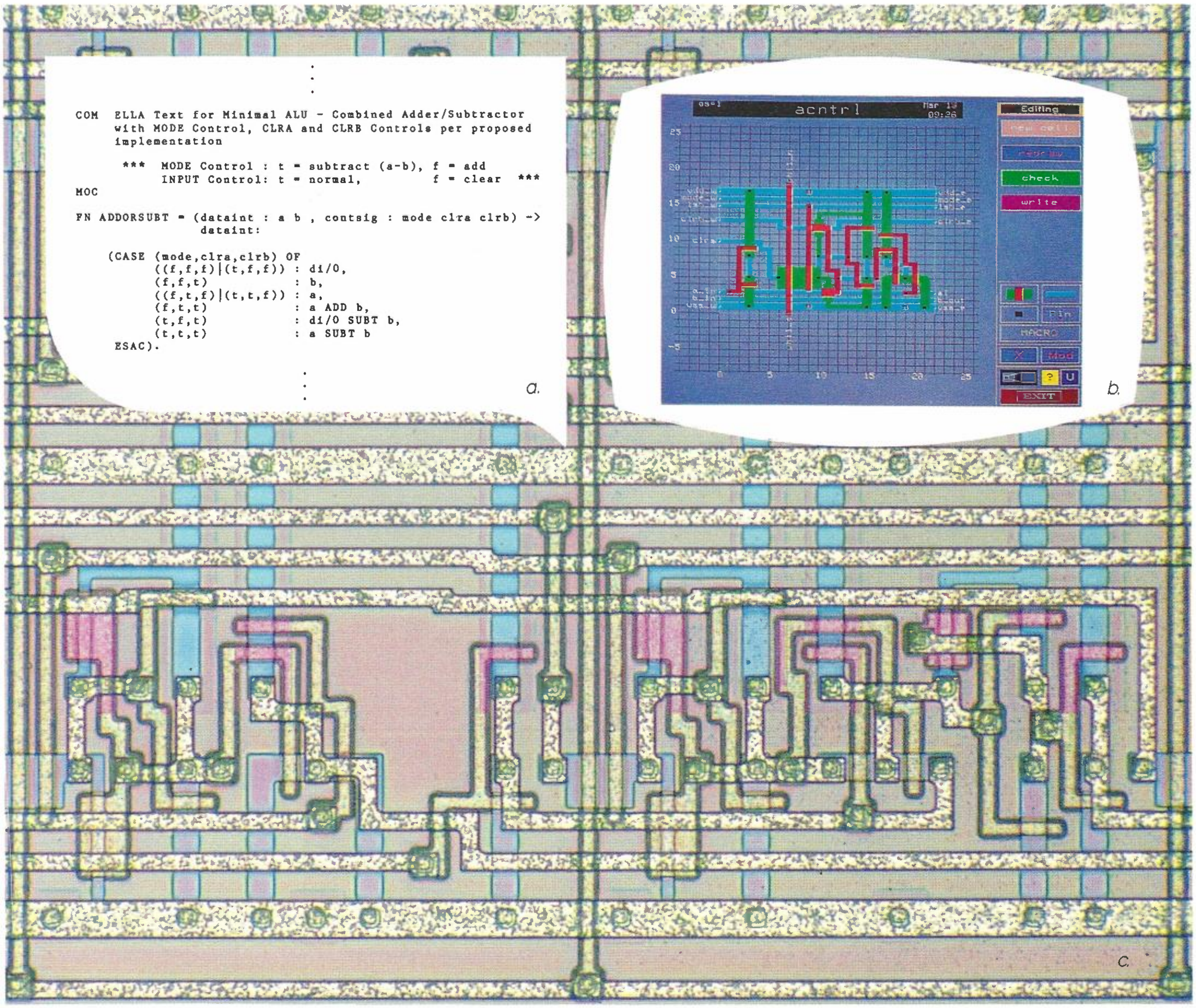
Advanced techniques which focus on the design of very complex integrated systems are now being applied within the Laboratories. A key to this new approach to VLSI system design is the use of high-level modelling and simulation and symbolic layout design techniques.

High level modelling refers to the capturing of desired system behaviour using a suitable hardware description language. Subsequent simulation, together with comprehensive data management facilities, enables the investigation of alternative architectures and thence optimal designs.

Symbolic layout design progresses the system thus modelled by enabling the designer to deal with circuit elements in symbolic form, rather than the myriad rectangles which characterise traditional integrated circuit layouts. Not only is design efficiency increased, but a high degree of process independence is obtained.

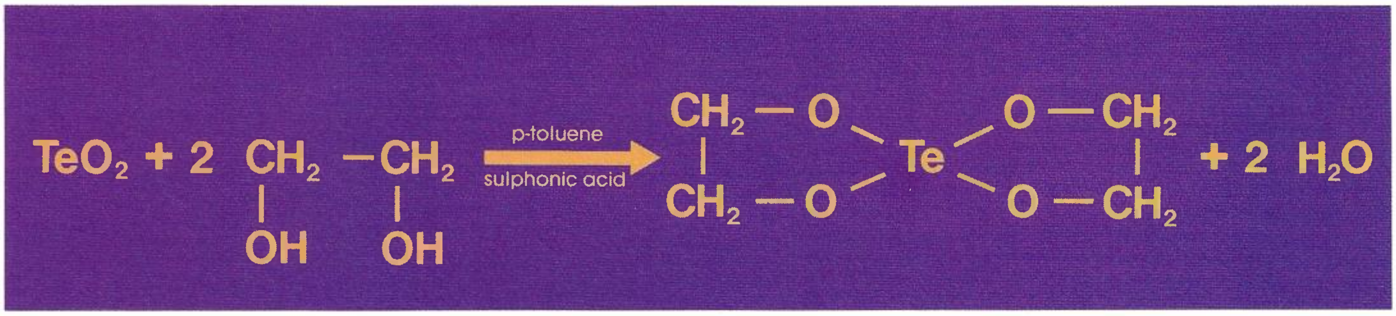
The thrust of such developments is to de-emphasise the low-level (mask) details, whilst allowing the proper emphasis to be placed on the higher level design functions. Only in this way will the enormous potential of the medium be fully exploited.

These techniques are being used in the Laboratories to design prototype VLSI hardware, so that the concepts and techniques central to fast packet switching systems can be experimentally verified and demonstrated. This approach to switching is expected to become dominant in telecommunications networks during the 1990s.

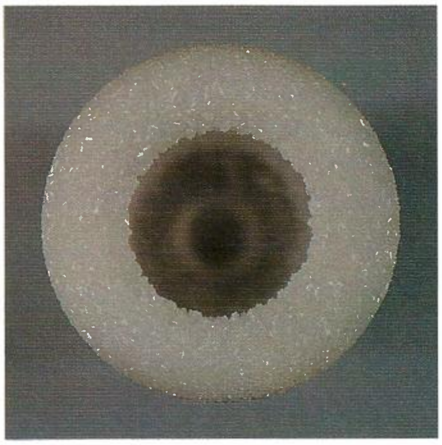


The 3 key stages in VLSI system design:
a. the system is first modelled and simulated at high level, prior to
b. symbolic layout of the optimised design, for
c. fabrication of the integrated system on silicon

Multi-ported electro-chemical cell for characterising tellurium and cadmium compounds



Pure alkoxytellurane is prepared by heating tellurium dioxide with excess ethylene glycol and a trace of acid catalyst



Crystalline mass of bis-ethylene glycol tellurane sublimed onto the water cooled condenser of the sublimation apparatus

SYNTHESIS OF TELLURIUM COMPOUNDS FOR NEXT GENERATION PHOTOVOLTAIC DEVICE MANUFACTURE

The solar cells currently being used to power remote telecommunications equipment are made from very high quality silicon wafers, cut from a single large silicon crystal. Due to the purity requirements and cost factors of producing such cells, increasing effort is now being directed towards the manufacture of low cost, stable and efficient amorphous silicon cells. However, in terms of the efficiency of converting solar energy to electrical energy, the semiconductor material cadmium telluride (CdTe) is fast emerging as the optimum material for the next generation of photovoltaic cells, promising to surpass the performance of amorphous hydrogenated silicon cells.

Research both in Australia and overseas has identified electro-deposition as the probable method of laying down photovoltaic grade CdTe films on an economic basis. All electro-deposition studies conducted to date have been based on aqueous systems, typically involving a cadmium salt (such as cadmium sulphate) and a soluble tellurium species (usually tellurous acid) in a dilute sulphuric acid electrolyte. The quality, stability and efficiency of the films produced to date have been encouraging, exceeding the minimum viable 10% conversion efficiency.

A project to deposit such films at the Research Laboratories was recently initiated. In an attempt to deposit films of superior quality to those produced thus far, an electrolysis technique based on a non-aqueous solvent system is being developed.

The first phase of the project is currently centred on the preparation of suitable, organic solvent soluble, tellurium compounds. Literature surveys indicate that a range of tetralkoxy telluranes (such as the bis-ethylene bis-glycol tellurane) would be suitable starting materials for the deposition of very high purity tellurium. In the Laboratories, the pure alkoxytellurane is prepared by heating analytical grade tellurium dioxide together with an excess of ethylene glycol and a trace of acid catalyst under an inert atmosphere. The semi-pure product, which precipitates on cooling, is collected by filtration, washed, dried and finally sublimed to produce the high purity alkoxide.

In future phases of the project, the tellurium species thus obtained, together with a dimethyl formamide soluble cadmium salt, will be subjected to an electrolytic reduction in the presence of a suitable supporting electrolyte, such as tetrabutyl ammonium perchlorate.

It is anticipated that a number of tellurium and cadmium compounds will be examined for their electro-chemical characteristics during the course of this investigation, and a vacuum line system for manipulating air and moisture sensitive compounds has been designed and installed for this purpose. A multi-ported electro-chemical cell has also been designed and constructed for this research project and work on the deposition of photovoltaic grade cadmium telluride on suitable substrates such as indium tin oxide films has commenced.

INTEGRATED DEVICE DESIGNS FOR THE OPTICAL CUSTOMER ACCESS NETWORK

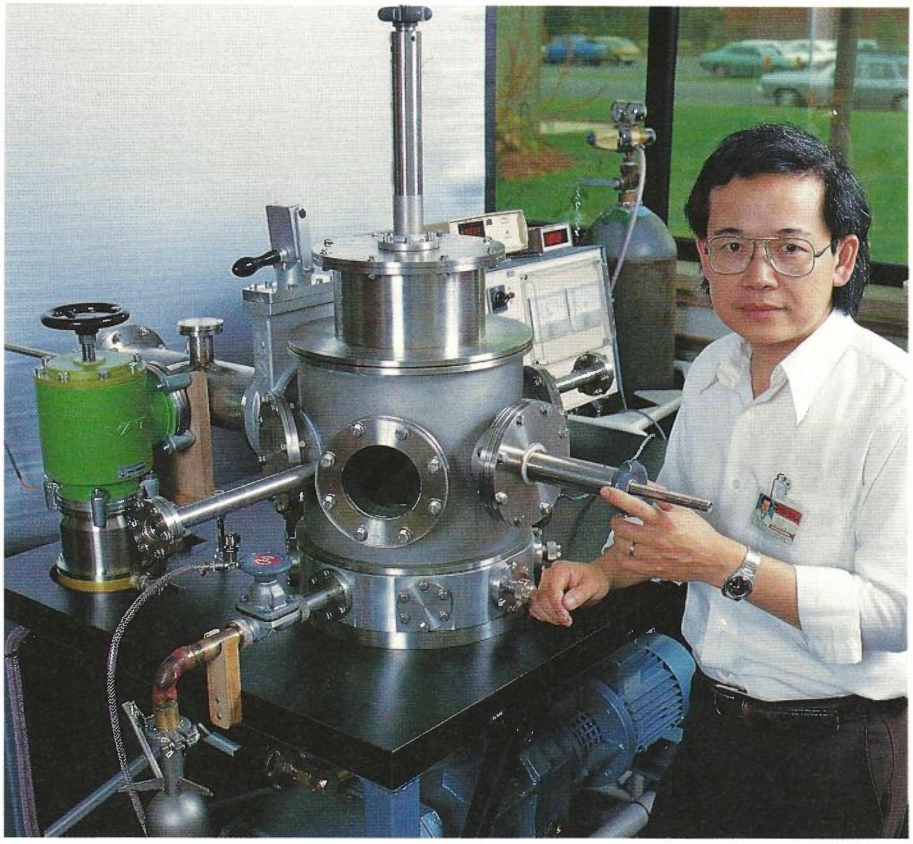
The commercial viability of the optical customer access network will be determined ultimately by the source and detector technology chosen to realise reliable, inexpensive, high performance receivers and transmitters. To achieve the best possible performance at the lowest cost, it is essential that the optical and electronic components be integrated on the same chip. The design techniques and production technologies which will enable such devices to be realised are thus of research interest in Telecom Australia.

In the Laboratories, integrated receiver optoelectronic modules for the customer access network (CAN) have been designed using a readily available CAD package which has been extensively modified to reflect the new gallium arsenide (GaAs) and indium gallium arsenide (InGaAs) technologies being developed concurrently in the Laboratories. The major benefit of this package is the ability to lay out and model various GaAs/InGaAs optoelectronic integrated circuits. It has been used as an aid to design a low cost, high bit rate, integrated photodetector/preamplifier receiver for realisation as an optoelectronic integrated circuit specifically for an optical CAN. The design process not only included the circuit design and mask layout, but also processing development and specification, and material specification. The interaction between all of these facets of the overall design is significant, and it is essential that changes in the process design are quickly translated into changes in final mask design. In combination with the Laboratories' ability to prototype the designs and develop processing techniques, this new design capability allows Telecom to take a leading role in the development and design of a fundamentally important communications technology.

The GaAs/InGaAs material system was selected since it allows the use of standard device configurations for the amplifier stages of the receiver while still giving light sensitivity in the crucial 1300-1550 nm wavelength range. This material system has only recently received attention as a possible basis for device fabrication. For initial material and process designs, a layered material structure and a non-planar processing strategy was adopted. This specifies the processing and material growth stages sufficiently to allow circuit and mask design to be completed. The mask set was designed to allow some flexibility in the processing stages. If required, rapid alterations to the mask designs can be made to reflect a major processing change.

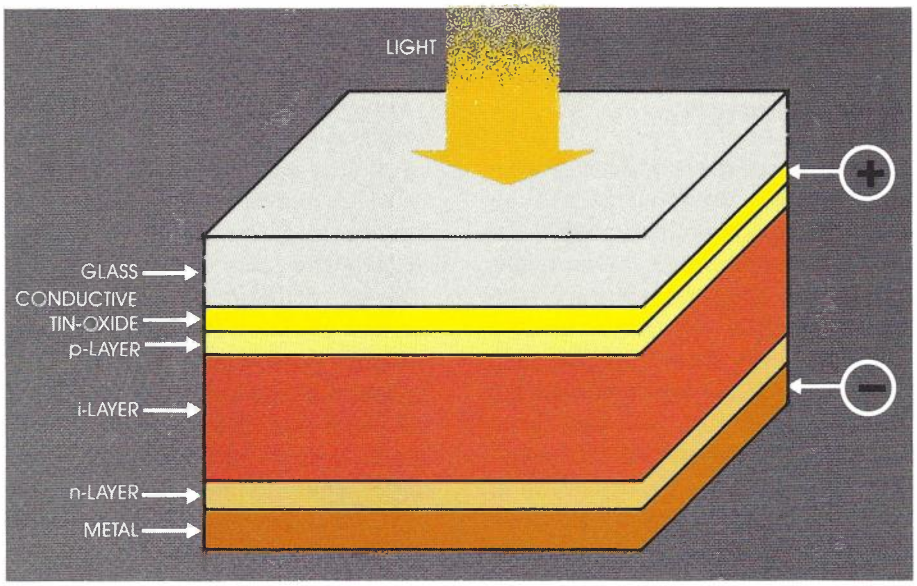
Once the process stages have been finalised, they can be represented as a set of fundamental design rules in a manner similar to that found in silicon integrated circuit design. While the GaAs/InGaAs material system has been specifically chosen in the Laboratories' application, the design tools and concepts may be readily applied to other material systems such as indium phosphide based technologies or mercury cadmium telluride material systems, should the need arise.

The successful interaction between the material growth techniques, viable processing techniques and novel device and circuit designs will determine the commercial success of the GaAs/InGaAs material system as a basis for integrated optoelectronic circuits. The work being pursued in the Research Laboratories seeks to develop Telecom's expertise and capabilities to understand and design integrated optoelectronic circuits and to promote the transfer of this technology to Australian industry. The ultimate objective of the work is to develop Australian capability to produce inexpensive, effective receiver modules for an optical customer access network.



Chemical vapour deposition equipment used in the fabrication of amorphous silicon solar cells

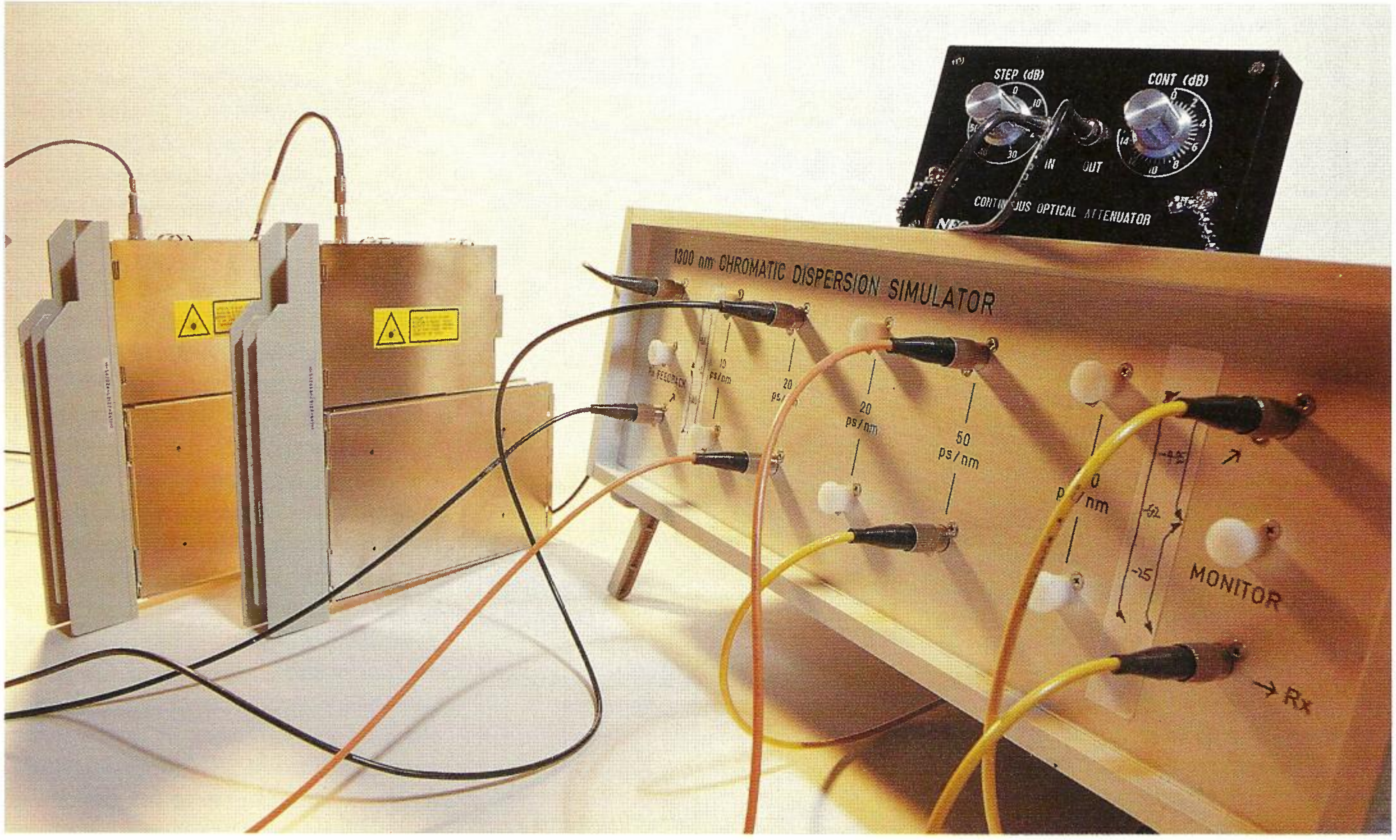
Typical amorphous silicon p-i-n solar cell structure



NEW LOW-COST THIN FILM SOLAR CELLS

During 1986, the Laboratories successfully fabricated a thin film amorphous silicon solar cell, so joining the leaders in the exciting field of thin film solar cell research. Telecom's R&D interest in this field of technology stems from a belief that it could yield significant improvements in the reliability, and thence cost-effectiveness, of Telecom's services and networks in the more remote parts of Australia.

The amorphous silicon solar cell belongs to a new class of thin film solar cells which are characterised by a structure which is only a few microns thick. These thin film cells are generally produced by a chemical vapour deposition method, sometimes in the presence of a direct current or radio frequency plasma. This technique has completely avoided the conventional and more expensive crystal growing and crystal slicing method used in the production of crystalline solar cells. As a consequence, it is estimated that an amorphous silicon solar cell can be produced at one-tenth the cost of a single-crystal silicon solar cell having similar output capacity. This translates



The Laboratories-developed optical dispersion simulator

approximately to a 25% cost reduction for every solar power system that Telecom might install in the future.

As a result of significant R&D effort by overseas manufacturers, several amorphous silicon solar cell modules suitable for power generation are now being manufactured and sold commercially. However, there remains a general lack of understanding of the detailed physical processes which occur within an amorphous cell. Further, testing of amorphous cells have raised doubts about their long term stability.

As a major Australian user of solar cells for remote power generation, Telecom is vitally interested in their reliability and service lifetimes. Thus, the primary interest of the Research Laboratories is the long term stability of the cells and its implications for typical telecommunications applications.

The successful fabrication of an amorphous silicon solar cell marked the completion of an important stage in the Laboratories' evaluation of this new technology. The cell has a typical glass/conductive tin oxide/p-i-n layers/metal structure. Its performance is now being evaluated.

The next stage of the programme involves the further improvement of cell efficiency and the application of various diagnostic techniques to study the stability problem. Specifically, the highly sensitive Raman spectroscopic method will be employed to probe into the glow-discharge plasma in order to correlate the cell performance with the process of cell formation. Accelerated testing under intense simulated sunlight will then be carried out to induce degradation in the cell, to provide a starting point for the understanding of cell degradation processes.

DISPERSION IN SINGLE-MODE OPTICAL FIBRE SYSTEMS

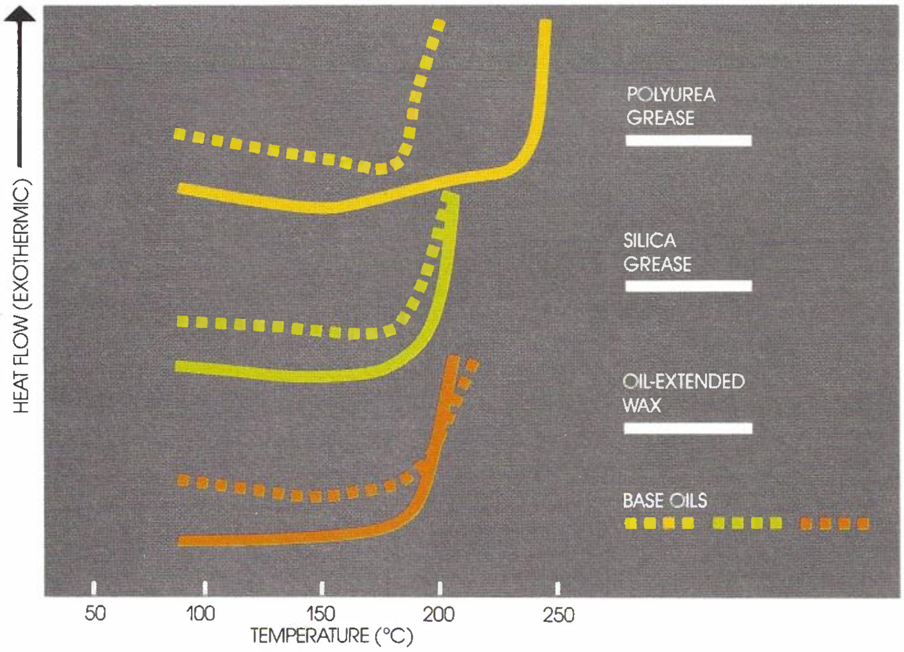
Telecom Australia is currently installing 565 Mbit/s single-mode optical fibre systems, operating in the 1300 nm wavelength region, to expand its trunk network. Optical signal dispersion in the single-mode fibres can present a limitation on the performance of such high bit rate systems. This is particularly the case since statistical design techniques are applied to the route design of such systems, resulting in repeater spacings up to about 50 km.

With these factors in mind, the Laboratories have developed test equipment and measurement techniques to evaluate the dispersion effects in high bit rate systems.

The dispersion of the optical fibre link, when combined with the significant spectral width of the laser diode transmitter, causes the received optical pulses to be broadened in time. This broadening of the pulses arriving at the receiver increases the bit error rate over that of a system without such dispersion. To achieve error rates that are comparable, the optical power of the broadened pulses arriving at the receiver must be increased. The increase in optical power required at the receiver is known as the dispersion penalty. Investigations of the factors contributing to the dispersion penalty indicate that it should be limited to within 1.0 to 1.5 dB for reliable system operation.

The Laboratories have constructed an instrument to simulate dispersion in a fibre link. The instrument, called a dispersion simulator, is combined with a variable optical attenuator to simulate the optical link between the transmitter and receiver line equipment. By performing bit error rate measurements for the system, with and without dispersion, it is possible to determine the dispersion penalty.

The dispersion simulator comprises a number of easily interconnected fibre sections which have varying dispersion values. The dispersion simulator is designed to allow any link dispersion in the range from 10 to 200 ps/nm to be selected, in 10 ps/nm steps, at the 1300 nm wavelength.



Thermogram showing the relative stabilities of various cable filling compounds against oxidation

The dispersion simulator has been used in the Laboratories to test a sample of commercial 565 Mbit/s equipment prior to its installation on the Melbourne-Sydney optical fibre route. The effect of stray reflections from an optical connector back into the laser diode is of particular concern for the satisfactory operation of these systems since they have the potential to degrade the laser diode performance and increase the dispersion penalty. The dispersion simulator was therefore used in a measurement system developed to give a controlled amount of reflection into the laser diode. The tests indicated that the dispersion penalty can increase due to reflections and that proper attention needs to be paid to the choice of optical connector to minimise the level of stray reflections.

FILLING COMPOUNDS FOR OPTICAL FIBRE CABLES

The concept of filled telephone cable was pioneered by the British Post Office in 1964. This remarkably simple yet effective method of preventing water ingress into telephone cable, and the consequent adverse effect on the electrical properties of the cable, has become widely accepted. Filled, polyethylene-insulated multi-pair cable has been in use in the Australian telecommunications network for over a decade. More recently, the concept has been extended to optical fibre cable, and the Research Laboratories have been investigating potential filling compounds for this application.

Glass fibres under stress are prone to fatigue degradation which can seriously undermine the long-term reliability of the cable. As water can play a leading role in this process, the fibres require effective isolation from the external environment. The likelihood of its occurrence can be reduced by proper cable design and the use of selected cable filling compounds. The compounds currently used to fill Telecom's optical fibre cables suffer from a number of problems such as oil-release during storage, rheological instability and low resistance to thermal oxidation. Periodic shortages of consistent quality raw materials also occur in Australia, and these can seriously affect the timely availability of cable required for Telecom Australia's network development projects.

These considerations furnished the impetus for the Laboratories to search for alternative materials.

Attention was focussed on polyurea (PU) greases as these possess a number of important characteristics which make them attractive for cable filling applications – for example, room temperature processability, high resistance to thermal oxidation, excellent oil retention and stable viscosity over a broad temperature range. Rather importantly, PU greases have been approved as lubricants for food-processing machinery and therefore are not expected to pose any health risks for personnel who come into contact with them.

Due to the unavailability in Australia of any PU grease with which to conduct a preliminary evaluation, a number of compounds have been synthesised in the Laboratories. The results obtained to date are encouraging and appear to support the original assumptions which led to the selection of these materials for investigation.

In the Laboratories' investigations, the thermo-analytical technique of Differential Scanning Calorimetry was used to compare the thermo-oxidative stability of a synthesised PU grease to that of compounds currently in use for filling optical cables. Thermograms obtained under pure oxygen showed that cable filling compounds based on PU grease are able to withstand higher temperatures before oxidation ensues, rendering them inherently more stable then the other compounds tested. This ability to withstand elevated temperatures in an oxidising atmosphere can be directly translated into the realisation of a more reliable cable.

Telecom's studies are continuing with the preparation and testing of PU greases. If this work proves successful, it will be necessary to involve local industry in their manufacture. Preliminary discussion has already yielded an encouraging response.

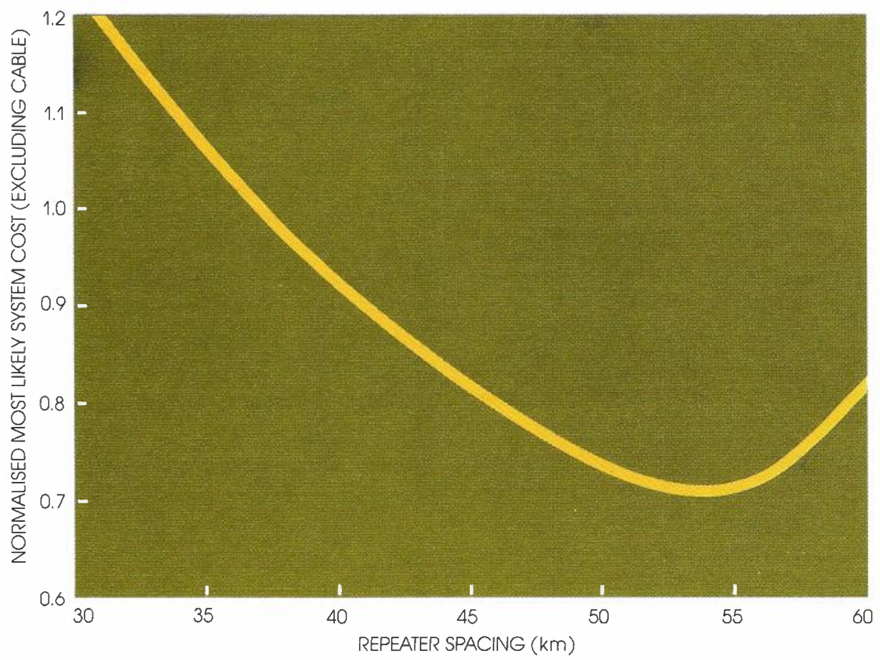
STATISTICAL DESIGN OF LONG OPTICAL FIBRE ROUTES

Telecom Australia is in the process of designing, installing and commissioning a number of inter-city optical fibre cable routes throughout Australia, to cope with expected increases in demand for transmission capacity. Many of these cable routes are hundreds of kilometres long. Information is transmitted along them in the form of pulses of light from a laser diode. As a light pulse travels along an optical fibre, it is gradually attenuated due to the material properties of the glass constituting the fibre. It also tends to spread out (that is, suffer dispersion) due to the range of frequencies which the laser light contains and the slightly different propagation speeds of these frequencies through the fibre. Because of these two effects, repeaters must be situated at regular intervals along the cable to amplify and regenerate the light pulses on the fibre.

The question arises as to how far apart repeaters should be placed along an optical fibre cable route. There is a certain amount of variation in the output power of different laser diodes, and different lengths of fibre have a range of dispersion and attenuation characteristics. In the past, "worst-case" values have been used for all these parameters in the calculation of the required repeater spacing. This led to the adoption of very conservative values of repeater spacing, for example, of the order of 35 km for a 565 Mbit/s single-mode system operating at a wavelength of 1300 nm. More recently, for instance on the Melbourne-Canberra-Sydney route, longer repeater spacings have been used. This has been justified by showing statistically that, because they contain less repeater equipment which can fail, such systems are in fact more reliable than those designed on a worst-case basis.

The Research Laboratories, in conjunction with the Network Engineering Department of Telecom Headquarters, have recently investigated design strategies in which all system parameters are modelled statistically. Within the Laboratories, attention has been concentrated on developing a design strategy in which the overriding consideration is to minimise the most likely total system cost. This total cost is the sum of the initial installation cost and the cost of making repairs over the lifetime of the system (including the "cost" of having the system unavailable for the time needed to make any repairs). Because of the statistical nature of the system parameters, the repair cost, and therefore the total system cost, must be modelled on a statistical basis.

Graph showing the most likely cost of an optical fibre system (excluding cable costs) for a range of repeater spacings



A simple statistical model of an optical fibre route has been developed, and methods formulated for calculating the optimal repeater spacing based on this model. Results achieved indicate that:

- the optimum repeater spacing for a 1300 nm single-mode optical fibre system operating at 565 Mbit/s is more than 50 km;
- by choosing a repeater spacing 2 or 3 km less than this 'optimum' spacing, a designer does not incur a significant cost penalty and avoids the risk of spacing repeaters above the optimum, where costs can increase quite dramatically;
- fault repair costs have little effect on the estimated optimum repeater spacing, but do influence the projected savings over worst-case design.

COHERENT OPTICAL COMMUNICATIONS SYSTEMS

Telecom Australia is currently installing an extensive single-mode optical fibre network linking Australia's major cities and provincial centres. Transmission systems operating over these fibres at rates of 140 and 565 Mbit/s will meet present requirements, and there is scope for employing higher bit rates in the future. Thus, this network will provide the transmission capacity needed to serve Telecom's customers into the 1990s.

Information is transmitted by these systems in the form of a stream of pulses of optical power. At the receiver, these light pulses are detected and the information is recovered. Such systems are described as intensity-modulation direct-detection transmission systems.

A new generation of "coherent" optical transmission systems is now under development in a number of telecommunications laboratories around the world. As with other administrations, Telecom Australia is vitally interested in future applications of such systems in the Australian long distance trunk network, and the Laboratories are conducting a number of studies to develop expertise to assist Telecom's strategic planning and ultimately, development of technical system specifications and network design rules.

These new generation systems are made possible by the improving performance of semiconductor laser diodes. The systems are called coherent optical systems because they employ optical sources with very high spectral purity. Coherent optical systems employ heterodyne or homodyne receivers which are similar in concept to receivers in established radio technology, but which operate at optical frequencies. They achieve greatly improved sensitivity compared to conventional systems because of the signal gain that occurs in the mixing of the incoming signal with that of a local optical oscillator. Furthermore, transmission schemes involving modulation of the frequency or phase of the optical carrier to convey information can be employed, further enhancing the sensitivity of the optical receiver.

Coherent optical transmission systems offer an improvement in receiver sensitivity over current conventional systems of about 10 to 20 dB, depending on the techniques adopted for modulation and detection. This improvement could be used to achieve either longer transmission spans between repeaters or increased capacity over the same repeater span. But possibly the greater advantage over conventional systems arises because the receiver in a coherent system is frequency-selective; it responds only to optical signals within a narrow band of optical frequencies centered on the local optical oscillator frequency. Thus, it becomes possible to combine a large number of optical carriers onto a single fibre and to choose a particular channel for reception by tuning the local laser oscillator, much as with a radio receiver. In addition, it becomes possible to amplify the combined array of optical carriers in a single optical amplifier so that, at many of the system repeater stations, a single amplifier is required instead of several single-channel repeaters. Thus, coherent systems offer the potential for providing great increases in the capacity of trunk optical fibre cables, installed or planned, without necessitating a commensurate increase in line equipment.

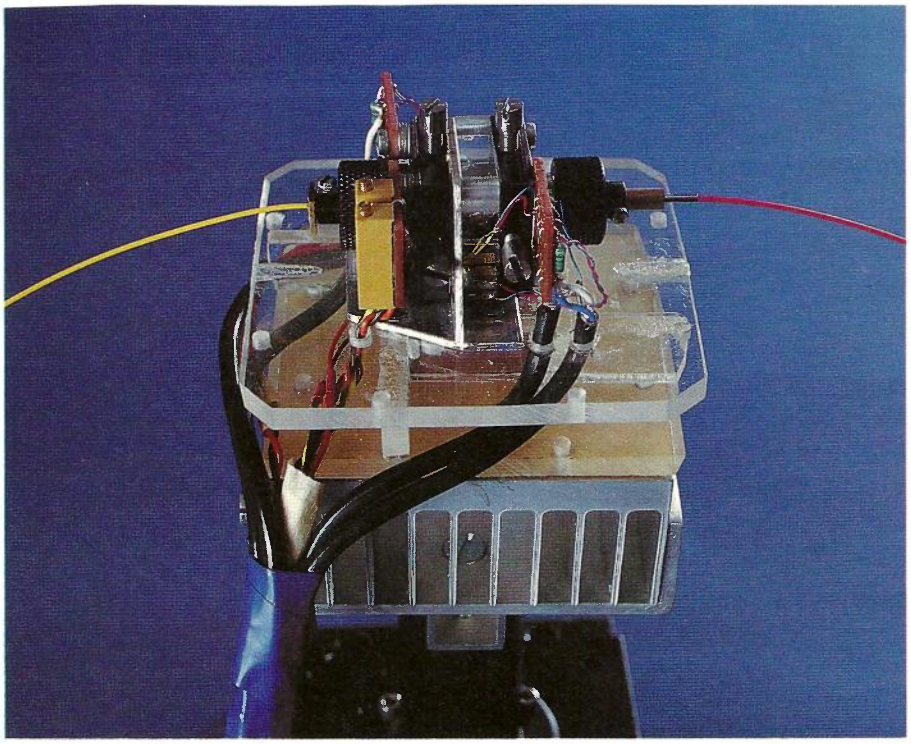
The tunability of the optical receiver in coherent systems also makes them interesting for potential use in a future broadband customer distribution system. In such a distribution system, a large number of optical carriers could be combined onto a single fibre and transmitted through a tree-structured network including couplers and optical amplifiers to a very large number of customers. The customer could then tune between the various service channels offered, by tuning the local laser oscillator in much the same way as he presently tunes a television receiver.

A number of technological problems must be overcome before these systems can be employed in the network, and a great deal of work is being directed to resolving these. In the Laboratories, a programme of analytical work is being undertaken to establish the performance achievable from the various coherent system options. An experimental system, employing differential phase shift keyed (DPSK) modulation, is being constructed to test the theoretically predicted results and to gain experience in the operation and characterisation of these systems.

AMPLIFIERS FOR COHERENT OPTICAL COMMUNICATIONS SYSTEMS

Semiconductor optical amplifiers have application in both intensity-modulation/direct-detection (IM/DD) systems and coherent optical transmission systems, although the amplifier technology is still at an early stage of development. These devices can be appropriately placed along optical fibre routes to amplify attenuated light signals. In these circumstances, the amplification of light is simple and direct, eliminating the need for opto-electronic conversions utilised in conventional repeater units.

Optical amplifiers are especially attractive in coherent optical systems for the simultaneous amplification of a number of optical channels arranged in a frequency division multiplexed scheme. In addition, they are capable of signal amplification at high data rates, so that their introduction would permit easy upgrading of the transmission capacity of optical fibre links. In a long-haul fibre route, it is envisaged that a number of these devices could be placed in cascade between the transmitter and receiver. In an IM/DD system, the number of amplifiers that can be cascaded is small, but coherent optical systems are much less sensitive to noise developed in amplifiers and more amplifiers may be cascaded.



A temperature-stabilised external-cavity laser diode module

In view of the potential beneficial applications of optical amplifier devices in future transmission systems, the Laboratories have commenced a programme of investigations of their characteristics. An optical amplifier device, encased in a temperature-stabilised module, has recently been tested to investigate its properties and limitations. The semiconductor optical amplifier is similar in structure to a semiconductor laser diode, with the exception that the reflectivities of the cavity end-facets, for this particular travelling-wave-type amplifier, have been reduced by anti-reflection coating. In operation, the injection current is kept low enough not to cause lasing but high enough to cause considerable signal amplification. Incident light, coupled from a fibre, enters the amplifier at one end and is progressively amplified in the semiconductor medium as it passes along the device.

The Laboratories' experimental test programme is being complemented by theoretical studies investigating the effect of the amplifier noise (produced inherently in the semiconductor medium of the device) on the operation of coherent systems. In particular, the phase noise accumulation for several amplifiers in cascade in a phase shift keyed heterodyne system is being examined.

OSCILLATORS FOR COHERENT OPTICAL COMMUNICATIONS SYSTEMS

The transmit and local oscillator sources for coherent optical fibre systems require a very narrow linewidth, typically from 50 kHz to 10 Mhz depending on the modulation technique employed. The linewidth of currently available semiconductor laser diode sources must be reduced by a factor greater than 100 in order to satisfy these requirements.

Several techniques for reducing the linewidth have been investigated in the Laboratories, the most promising options being the use of laser diodes with an external cavity or a frequency selective element in the laser diode chip. For experimental purposes, external cavity laser diode modules are being developed, in which a small fraction of the optical output of the laser diode is reflected back into the diode from an external reflector. The external reflector may be either a

The Laboratories' experimental 140 Mbit/s DPSK optical heterodyne system using 633 nm HeNe gas lasers

mirror or diffraction grating, or the cavity may be composed of a short length of fibre.

In addition to the stringent linewidth requirements, the centre frequency of the transmit laser, which is approximately 2.3×10^8 MHz at 1300 nm, must be stabilised to within approximately 20 MHz. This allows the local oscillator laser to track small variations in the transmit laser centre frequency easily. In the Laboratories, this has been achieved by stabilising the temperature of the transmit laser diode to within 1 millidegree.

An operating experimental heterodyne system has been built using visible HeNe gas lasers operating at 633 nm for the transmit and local oscillator lasers. These inherently narrow linewidth gas lasers have been used for preliminary experiments and will be replaced by semiconductor laser sources when laser modules with sufficiently reduced linewidth are available. The laser signal is modulated externally and transmission at 633 nm is through air rather than through a single-mode optical fibre.

The experimental system is presently operating using differential phase shift keying (DPSK) at 140 Mbit/s. It can be configured in a number of ways so that other modulation techniques and receiver configurations can be tested. Currently, the system is being altered to operate with 1523 nm HeNe gas lasers so that experiments over conventional single-mode optical fibre can be performed.

This ongoing programme of experimental work will provide a basis for the development of the practical expertise which will be required in the future to facilitate the introduction of coherent optical fibre systems into Telecom's network.

REFRACTIVE INDEX CHARACTERISATION OF FLUORIDE GLASS OPTICAL FIBRES

Optical fibres are now established as the preferred transmission medium for high capacity point-to-point communications. After much development, the silica glass fibres now being installed have a transmission performance close to the theoretically achievable limits. Recently, researchers around the world have been conducting investigations of new glass materials that promise even better transmission performance.

One such group of materials comprises the heavy metal fluoride glasses. Typical members are multi-component mixes of the fluorides of zirconium, barium, lanthanum, aluminium and sodium. Such glasses potentially offer transmission losses at least one and possibly two orders of magnitude lower than those of silica glass when operated at mid-infrared wavelengths of 2.5 to 3 microns, compared with the 1.55 micron minimum loss wavelength of silica glass. While losses actually achieved in experimental fluoride glass fibres are not yet as good as those for silica glass fibres, continued improvements give rise to optimism.

Although current silica fibres have much lower losses than the coaxial cables which they replace, repeaters are required at regular intervals of about 50 km on high capacity (565 Mbit/s, 7680 channel) trunk routes. The future prospect that the use of fluoride fibre communications systems can greatly reduce the number of repeaters on such routes has important economic implications for land-based and submarine cable communications networks.

In order to realise the potentially very low fluoride fibre loss, a host of technological problems must be solved. Some difficulties that had to be overcome in the development of silica glass fibres have re-emerged with even tighter constraints, for example, material purity. Entirely new problems, such as the tendency of fluoride glass to devitrify or form micro-crystallites, also require innovative solutions. An integral part of this problem-solving process is the examination of individual fibres as they are produced. Important fibre characteristics include compositional variation as measured by electron microscopy, transmission loss as a function of wavelength and fibre refractive index profile.

The Laboratories' experimental facility for characterising optical fibres by refractive index profile using near-field intensity scanning techniques

In order to determine fibre refractive index profiles, the Laboratories have refined a near-field intensity scanning system that was first developed about a decade ago for silica fibre. In comparison with silica fibres, the near-field measurement of fluoride glass fibres requires greater sophistication to detect possible subtle effects. These effects include perturbations at the cladding boundary arising from the preform casting process, diffusion at the core-cladding interface, imperfections caused by impurity inclusions, crystallites or bubbles, and inhomogenieties in the multi-component glass.

In the Laboratories' experimental facility, a short length of fibre is illuminated at one end by a diffuse light source. At its other end, a lens images the output face of the fibre onto a TV camera. The camera output feeds into a video frame store that has noise reduction facilities to improve signal quality and to facilitate measurements at low light levels. The frame store is interfaced to a computer.

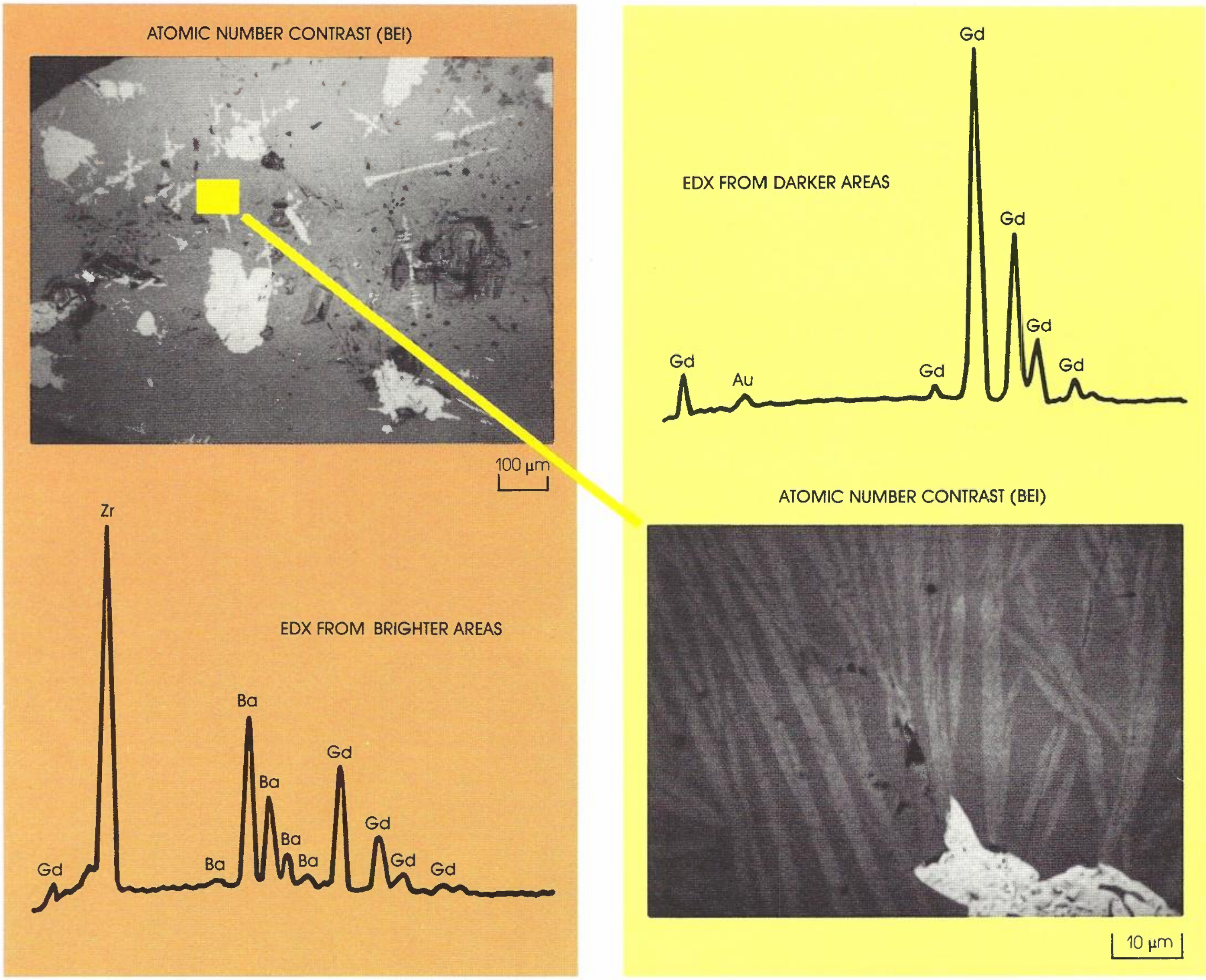
These video techniques allow simultaneous display of the end face of the illuminated fibre and of the light intensity profile across any diameter or number of diameters of the fibre. The light intensity profiles can then be mathematically treated to yield the desired refractive index profile, which in turn can be conveniently correlated with the visual image of the fibre end face and the results of other characterisation measurements.

PHASE SEPARATION IN FLUORIDE GLASS

Fluoride glasses are considered strong candidates for future generations of mid-infra-red optical fibre materials for telecommunications applications because of their intrinsically high transparency (about a hundred times better than silica glass), and thus much better transmission performance over long distances. Fluoride glass technology is thus an important field of investigation in the Research Laboratories.

Glasses are formed when certain liquid solutions are solidified by cooling, but immiscibility in liquid solutions is common. Many single-phase mixtures separate into two phases during cooling, resulting in the formation of a solid with a microscopic structure of distinct regions, which are 0.01 to 2.0 microns (or greater) in size and of different compositions. This phenomenon occurs in many glasses and depends on composition, cooling rate, heat-treatment after solidification and the occurrence of nucleation sites such as inclusions, bubbles, interface defects and inhomogeneous mixing.

Phase separation can influence the properties of the glasses. The coarser the phase separation, the poorer the chemical durability of the glass and the greater the possibility of devitrification. Optically, phase separation means small scale fluctuations in refractive index which cause scattering of light, frequently seen as opalescence (or milkiness) in the glass. This scattering is wavelength dependent. It is greatest when the size of the phase region is equal to the wavelength of the light.



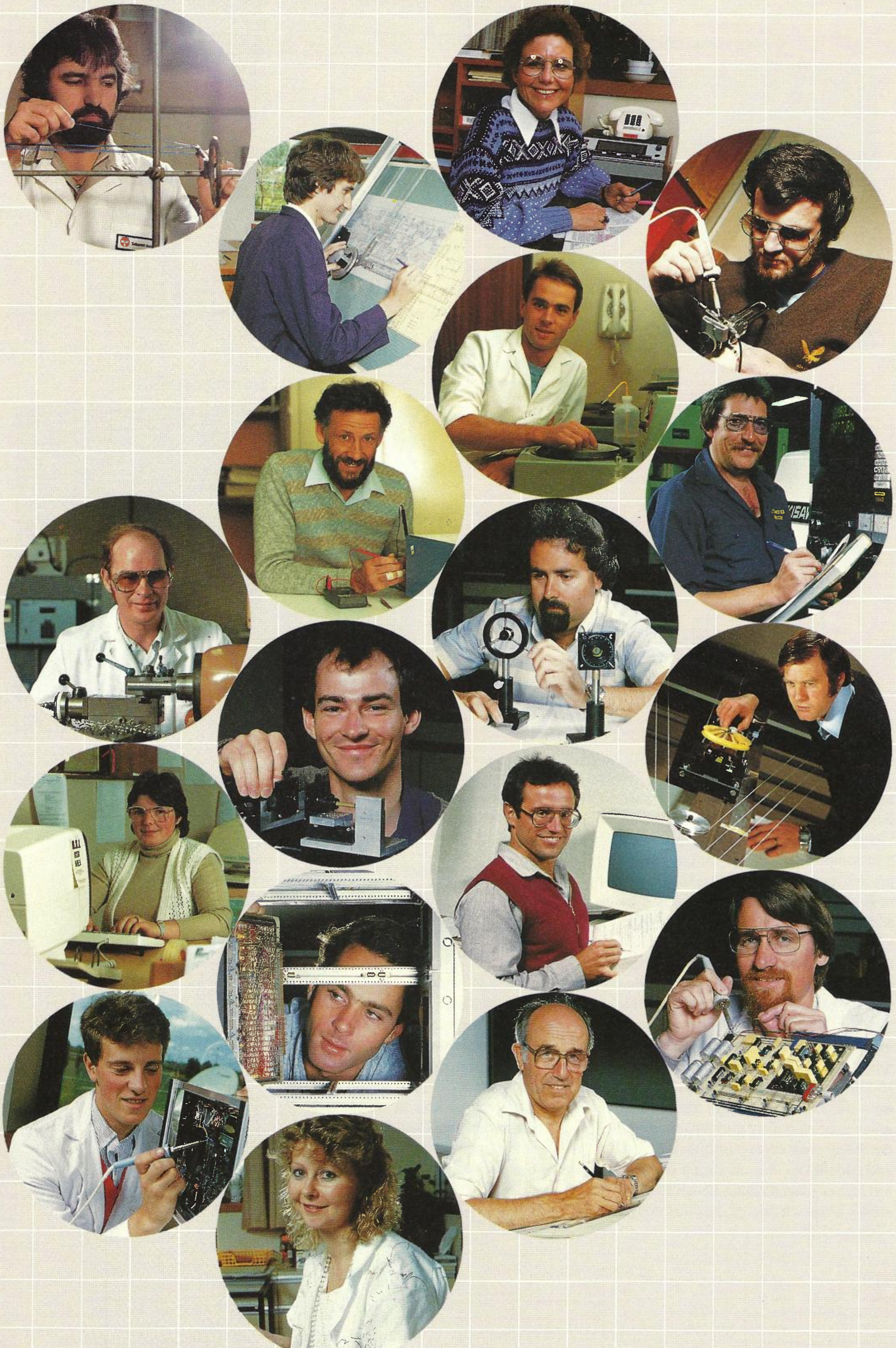
Phase separation in fluoride glass, determined by microanalytical analytical techniques available on a scanning electron microscope

Studies at the Laboratories have shown that phase separation occurs in heavy metal fluoride glasses. The dimensions and compositions of the various phases present have been determined by the use of Backscattered Electron Imaging (BEI) and Energy Dispersive X-ray (EDX) analysis in a scanning electron microscope. In the BEI mode, phases with a higher "average" atomic number appear brighter than phases with a lower 'average' atomic number. The particular example shown in the adjoining illustration is a zirconium tetrafluoride glass which also contains gadolinium and barium. It can be seen from the EDX spectra that the brighter areas contain mainly gadolinium, whilst the darker areas contain zirconium, barium and gadolinium. It is also apparent from the higher magnification image that the darker areas are further divided into two additional phases.

The compositions of the various phases have been determined by quantitative EDX.

In some samples, phases of about 1.8 microns in size have been found. This would not greatly affect transparency at visible wavelengths but would interfere with infra-red transmission.

The problems of phase separation must be eliminated before fluoride glasses can be reliably produced to yield optical fibres for use in telecommunications cables. Hence, the Laboratories plan to continue R&D on this aspect of glass technology. In particular, investigations are now turning to the determination of glass compositions and heat treatments which produce very fine phase separation structures.



Quality Assessment and Reliability Studies

Telecom Australia's Vision 2000 Programme seeks to ensure that Telecom's customers are provided with world-quality telecommunications services which are economical and reliable. To achieve this objective with an 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 to Telecom's personnel and customers.

To achieve this aim, all materials, components and parts which make up these systems and equipment should perform their specified functions for their entire design life spans in a variety of environments, anywhere in Australia. Degradation of properties or parameters can cause equipment malfunctions or down-time 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. Other less direct implications of equipment malfunctions, inadequate equipment specifications or incorrect work practices are their potential reflections as occupational safety and health issues, or in worst cases scenarios, as potential causes of personal injury or damage to plant and property.

Reliability is the consequence of good design and the correct choice of material or components for the intended application. Once design decisions have been taken and manufacture has commenced, it is difficult, if not impossible, to improve reliability without costly and difficult changes and retrofits. This is the reason why product appraisal is best made at the prototype or pre-production stage, when it is still possible to make changes and prevent serious problems before the item is introduced into service. However, a pre-production assessment cannot by itself guarantee freedom from further problems unless the whole production process is kept under strict control and no change in processes or materials and components is permitted without full appreciation of the possible consequences. It is essential that the manufacturer exercises comprehensive quality control and assessment of his product and that this is assured through surveillance by Telecom's inspection staff.

The Applied Science Branch of the Laboratories significantly assists 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 existing specifications where possible, and sometimes improvising new or more severe test methods, to ensure that all factors which may have detrimental effects in the operational environment are considered.

The application of sophisticated test and analysis techniques, aimed at simulating the stresses and conditions to which the product may conceivably be exposed during its life cycle, must be carried out without introducing extraneous failure modes. Most importantly, tests must be performed with a high degree of acceleration in order to provide the required information when it is needed, rather than at some distant time in the future, well after when the product has been launched and possibly even failed. When problems arise in the field, they may be widespread and costly, and it is imperative that analytical techniques should be applied quickly to determine causes and produce remedial measures, or to suggest alternatives which lead to a rapid alleviation of the operational malfunction.

The characterisation, assessment and failure analysis activities performed by the Laboratories are often carried out in close co-operation with the manufacturer, especially when the latter lacks some of the necessary specialist skills and laboratory facilities. At other times, problems may arise many years after installation when the original supplier has ceased to exist. They may be caused by faulty operational procedures, incorrect applications or failures in associated network components.

The Research Laboratories maintain capabilities to conduct such evaluations rapidly and efficiently, to provide timely and relevant advice to "clients" in the Commercial Services, Network Engineering and Operations Departments of Telecom Australia. The items investigated cover the whole spectrum of Telecom's activities, 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 contributions in the next section of this Review include some examples of the activities 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, and thus to achieve business success and customer satisfaction.

SURFACE ANALYSIS SYSTEM

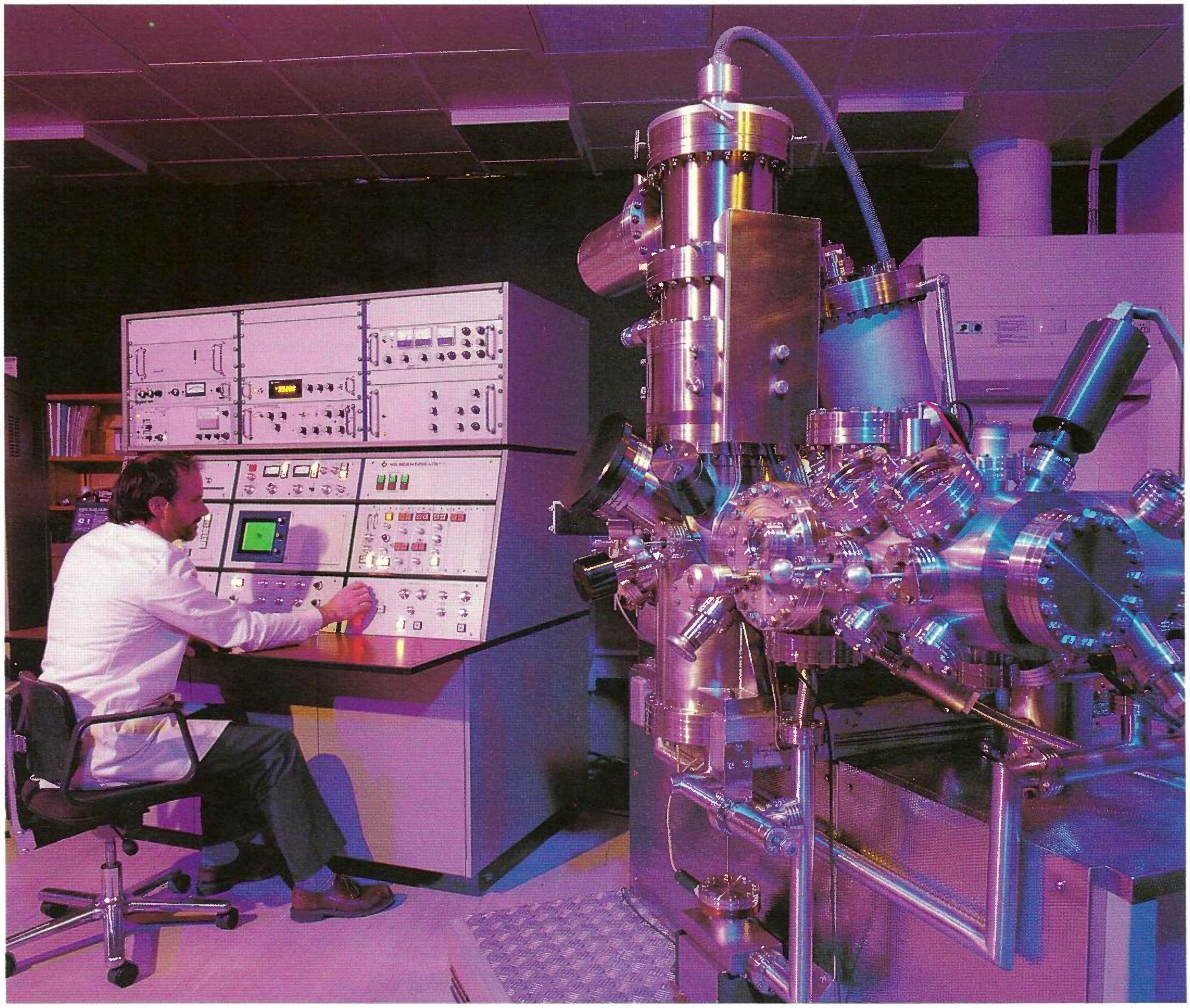
The recent commissioning of a new ultra-high vacuum (UHV) surface analysis system has added a new dimension to materials analysis within the Laboratories. Armed with the ability to examine the outermost atomic layers of a surface, many corrosion, wear and chemical modification problems have been solved quickly and accurately.

Once in the UHV chamber, surface contaminants from the atmosphere are removed by argon ion etching, thus exposing the surface to be examined. It is essential to perform surface analysis studies in the UHV chamber in order to maintain a stable surface once this initial contamination layer has been removed.

The surface techniques available are Scanning Auger Microanalysis (SAM), which provides an elemental analysis of the surface, and X-ray Photoelectron Spectroscopy (XPS), which yields chemical bonding information about surface elements. The third dimension of depth is added by use of the ion etching source to profile into the sample. Subsequent use of SAM (or XPS) at increasing distances from the surface into the sample provides a depth profile, which shows the variation of elements into the bulk. This depth-profiling technique is essential in determining thin film composition and thickness, particularly for modern multilayer device structures.

One of the first field problems tackled with the new equipment was to determine if water had permeated the insulation surrounding the optical fibres used in the Darwin-Katherine link, and if so, whether the surface of the fibres had been affected. XPS indicated that the adhesive had been attacked, presumably by water, and had been modified such that it was no longer bonded to the glass. No evidence was found of any chemical effect or modification of the glass surface.

Another project involved Auger analysis of tin-plated splice connectors, which had become severely tarnished. By performing depth-profiling experiments on both tarnished and non-tarnished connectors, it was shown that the tarnished connectors had high concentrations of carbon well down into the bulk material, whereas the



The Laboratories' ultra-high vacuum surface analysis system

non-tarnished connectors had only a small amount of carbon contamination at the surface. The most probable cause of this excessive organic layer was determined as being associated with poor tin plating procedures.

An investigation into the nature of gallium arsenide (GaAs) oxides, which are used as passivation layers for GaAs semiconductors, is a major project which is currently being completed. The work to date has involved both SAM and XPS to determine what impurities are causing some of the oxides to form incorrectly, thus making them very difficult to remove at a latter processing stage.

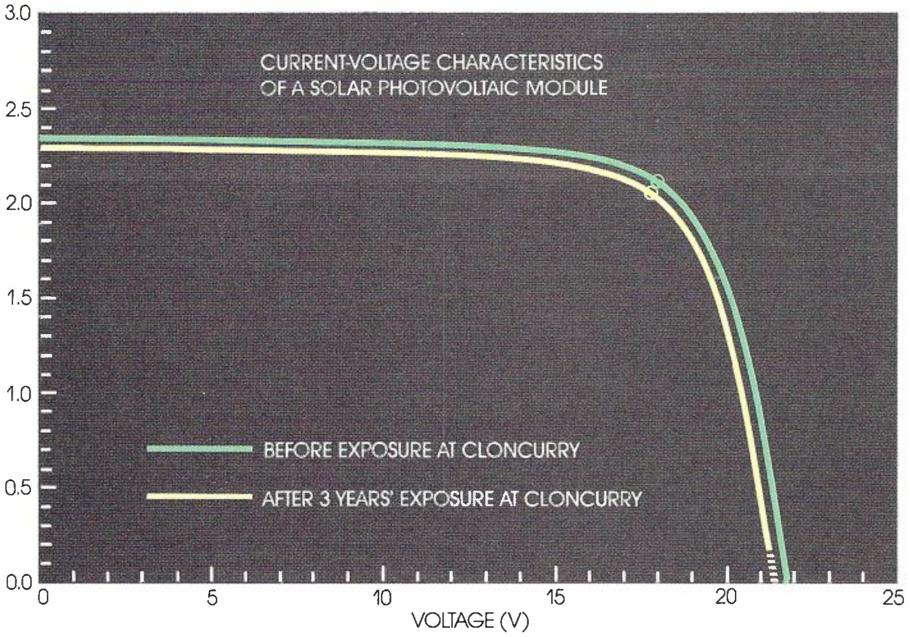
As well as these projects, many other problems have been investigated. They include the wear characteristics of ion-implanted electrical contacts, identification of corrosion products in electronic components and examination of fluoride glasses. Future work will continue in these areas, as well as providing analytical support for the development of new materials, such as mercury cadmium telluride (MCT).

FIELD TRIALS OF PHOTOVOLTAIC MODULES

In 1981, Telecom Australia's Research Laboratories were designated the Australian lead agency for the Japanese-Australian co-operative project for the evaluation of photovoltaic modules, and the activity was supported by a National Energy Research Development and Demonstration Council (NERDDC) grant. Field trials of solar photovoltaic modules were commenced in 1983. Three sites were chosen as being representative of the Australian climatic characteristics expected to produce most weathering stress on the modules. The sites, at North Head in New South Wales and at Cloncurry and Innisfail in Queensland, have temperate coastal, hot-dry and hot-wet climates respectively. The field trials have also been accompanied by an extensive laboratory test programme.

Electrical performance and climatic data have been collected continually at the sites and transmitted to the Research Laboratories daily by telephone data link. Research staff have visited the sites at 3-month intervals to conduct visual inspection of the modules under test and to maintain the data logging equipment.

In 1986, some of the modules were returned for detailed examination in the laboratory. Electrical performance of each module was assessed by accurate measurement, under standard illumination, of current versus voltage (I-V) over the



Solar photovoltaic module performance characteristics before and after 3 years' exposure at Cloncurry, showing a 3% decrease in peak power

module's full output range. The greatest reduction found in peak power was 3% after three years' exposure at Cloncurry; this was not considered to be a serious degradation.

Visual inspection of the modules revealed various types of potentially deleterious changes. In one instance, the originally transparent ethylene vinyl acetate encapsulant gradually became yellow and finally brown at the edges of the module. Other changes in different modules included wrinkling of the tedlar backing sheet, very slight overall yellowing of the encapsulant, delamination of the encapsulant around the edges of the module and deterioration of the edge sealant.

Although NERDDC support ceased on 1 January 1987, agreement has been reached with the Japanese New Energy Development Organisation and the corresponding Japanese lead agency for evaluating photovoltaic modules, the Electrotechnical Laboratory of AIST, to continue the programme. The latest Japanese-made amorphous silicon modules will be included in the future programme of field and laboratory tests, with the new modules being installed at the test sites during 1987.

NOISE SUSCEPTIBILITY IN INTEGRATED CIRCUITS

The Laboratories' expertise and facilities for analysing integrated circuit (IC) operations is often brought to bear in failure analysis of ICs which have become faulty in network and terminal equipment.

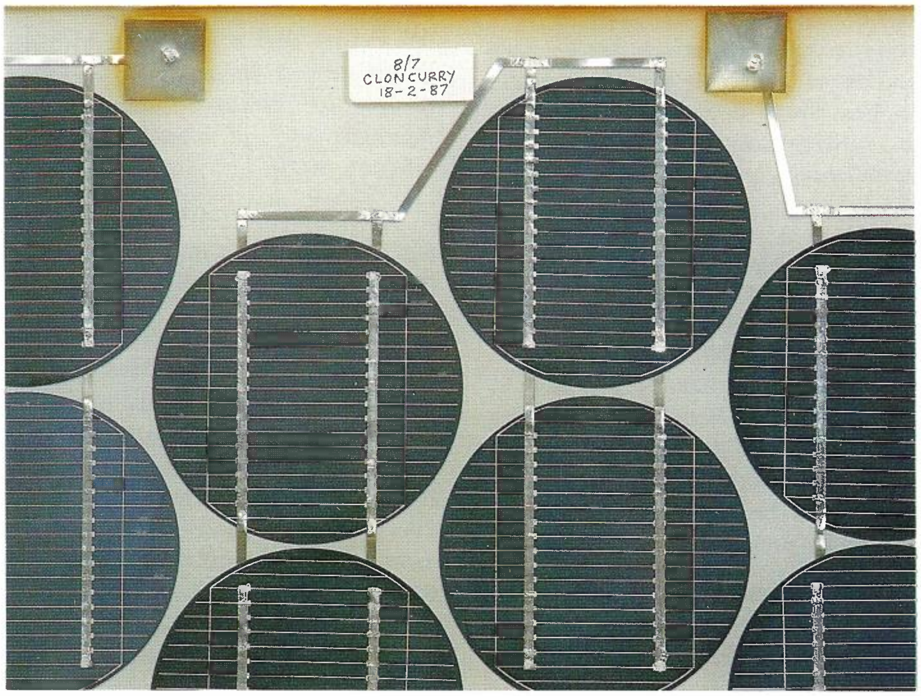
One such case which arose in the past year concerned a number of low power Schottky transistor-transistor logic ICs which had failed in service in AXE exchange equipment. The devices were of the same type and supplied by the same vendor. They had been identified as the cause of intermittent losses of ring tone transmitted from the exchange to the customers' telephones.

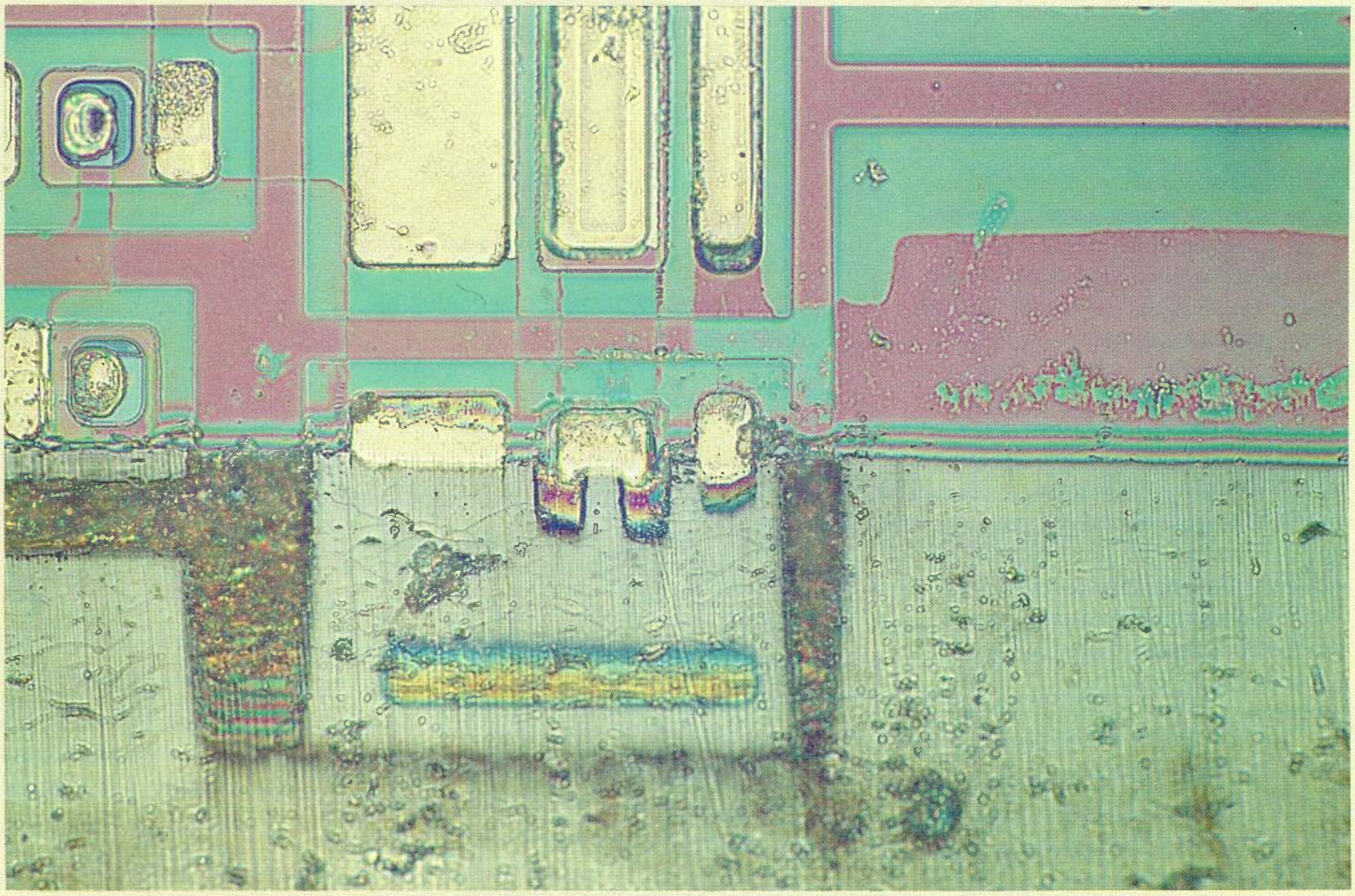
Field investigations showed that the ICs produced spurious output glitches as a direct result of a relatively high level of electrical noise present within the particular type of magazine containing the ICs. It was necessary to determine the reason for this behaviour in order to establish whether the ICs had been incorrectly fabricated, contained a design defect or had been electrically damaged at some time after manufacture, possibly during testing or assembly onto the printed circuit cards. The faulty ICs were therefore subjected to detailed operational analysis in the Laboratories.

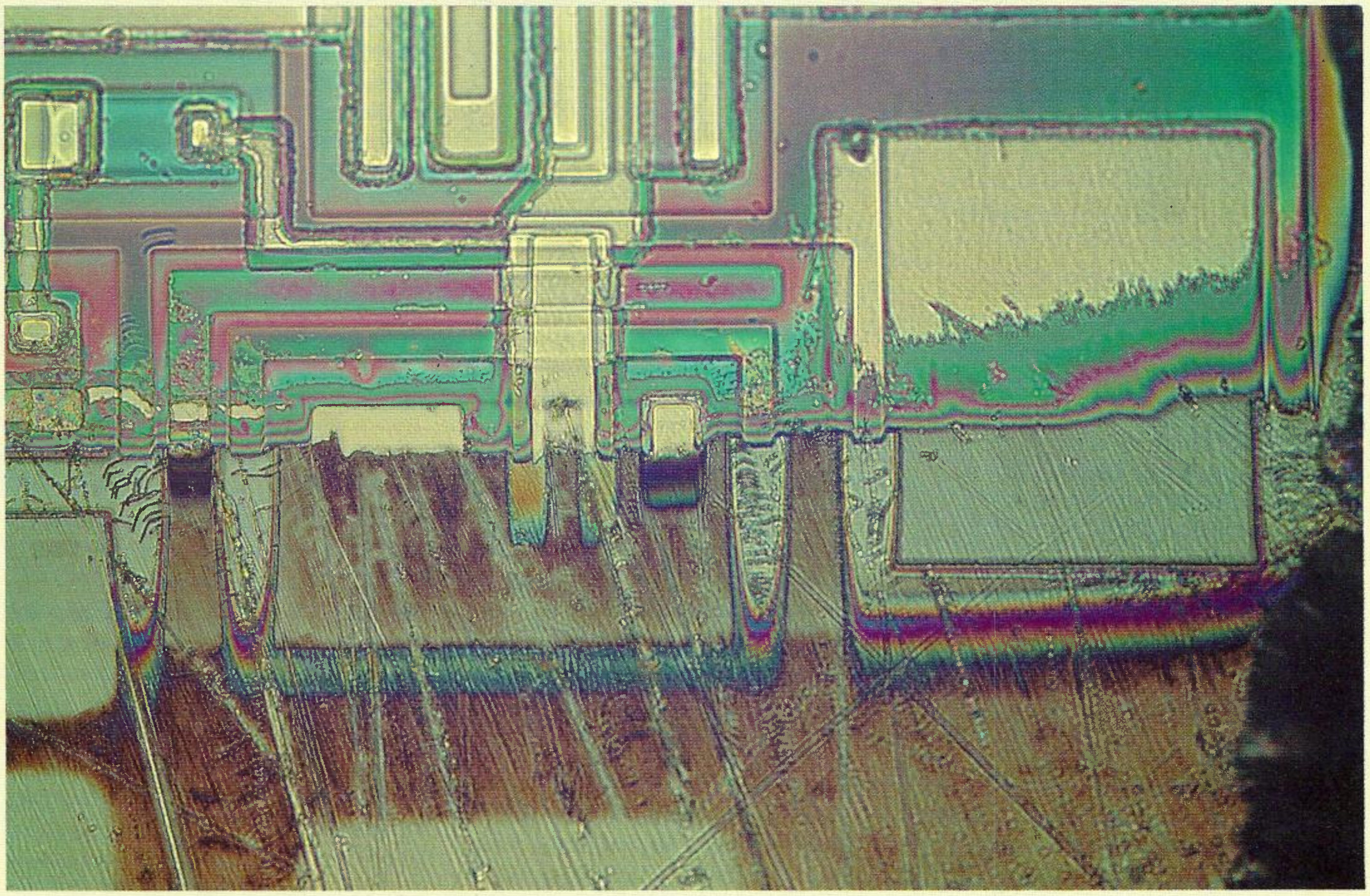
During laboratory tests using simulated exchange noise pulses, output glitches were observed in coincidence with the falling edge of the noise pulses. A strong dependence upon the fall time of the noise signal was evident, with output glitches only occurring with fall times less than 20 nanoseconds.

Normal electrical measurements followed by decapsulation and visual inspection failed to reveal the reason for this behaviour, necessitating the use of the more sophisticated stroboscopic voltage contrast electron microscopy technique. In this method, an electron beam is scanned over the surface of the working circuit, in such a way as to provide infor-

Discoloration of encapsulant at the edge of a solar photovoltaic module after 3 years' exposure at Cloncurry







Cross-sections of IC structures
a. noise-susceptible IC
b. noise-tolerant IC

mation about the voltages present at any point on the circuit. It is also possible to display, in a similar fashion as with a conventional oscilloscope, how these voltages change with time.

Using the Laboratories' electron beam probe system to observe the operation of the ICs under both normal and simulated conditions, it was possible to compare directly the voltages on specific circuit elements in each case and thence pinpoint the location where changes occurred. These measurements revealed that unexpected coupling of the input noise pulse was occurring between the input Schottky diodes and transistor within the IC. This resulted from the presence of a parasitic transistor between the two circuit elements. Such parasitic transistors are recognised as being a problem in junction-isolated circuits such as those examined. However, when tested under identical conditions, similar devices from other vendors did not show this effect.

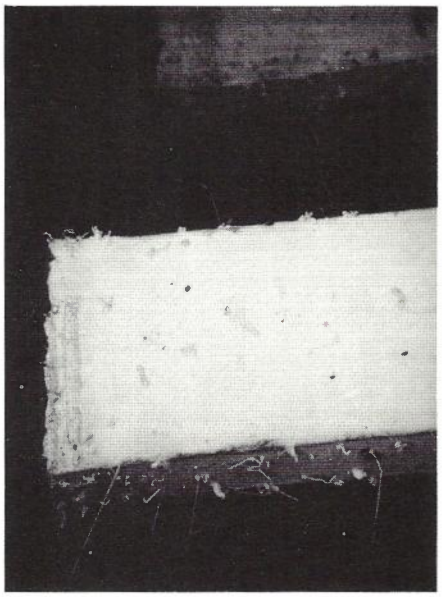
To determine the physical basis for this behaviour, ICs from a number of vendors were cross-sectioned. This process involved grinding and polishing the IC die through a region of interest, and after staining, it revealed the vertical structure of the individual transistors, diodes and resistors fabricated in the silicon. Examination of the stained cross-sections revealed that the noise-tolerant devices had a double isolation barrier around the input diodes, whereas only a single isolation was used in the faulty devices.

Since the operation of the ICs examined was adversely affected by high levels of electrical noise, they performed satisfactorily under conditions where only normal noise levels were present. Consequently, their replacement was recommended only for the one specific application which had produced the intermittent faulty operation.

PROBLEMS WITH METALLURGICAL SOLUTIONS

Telecom is a large purchaser of engineering and electronic equipment containing a wide variety of metals and alloys. The scientists of the Research Laboratories regularly provide other Departments of Telecom with advice on and assistance with problems of a materials science nature which arise in the day-to-day operations of Telecom. The consequent diagnosis and solution of problems often leads to direct advice and assistance to Telecom's equipment manufacturers, resulting in the production of improved, more efficient or safer equipment. This is perceived to be in the interests of both Telecom and the manufacturers. Some recent metallurgical investigations are described in the following paragraphs, to illustrate how this process of technology transfer led to the modification of existing materials or products.

Stress corrosion cracking in a waveguide connector casting



Tin whisker growth on an electroplated wire wrap pin of a connector block

In one Laboratories' investigation, the cause of a series of electrical faults found in digital data network equipment was traced to the presence of tin whiskers growing from electroplated wire wrap pins in the backplane connector blocks. The length of the whiskers was sufficient to short circuit adjacent pins by bridging between them. Some 60,000 connectors installed in Telecom's network were believed to be affected. Although the growth of metallic whiskers is not a new phenomenon, the manufacturer of the connector blocks and the equipment supplier to Telecom had overlooked or were unaware of the dangers of whisker growth and the appropriate preventative measures. They, and other suppliers of similar blocks to Telecom, were subsequently advised that the co-deposition of a small percentage of lead during the electro-deposition of tin or the use of tin-lead as an alternative to unalloyed tin would have prevented this costly fault. Fortunately, in this case, it was not essential to replace the blocks since the whisker growth can be removed periodically by brush and vacuum, as in due course, growth will cease when the stress in the plating is relieved with time.

In another Laboratories' investigation, the failure investigated had the potential to disrupt trunk transmission services seriously. Stress corrosion cracking was discovered in waveguide connectors of 4 GHz microwave systems in Queensland. The stress corrosion cracks occurred in several of the high strength alloy brass connector castings, and their discovery followed investigation of leaks found to be present in the pressurised connector system. The failure was serious, since, once the pressurisation fails, entry of moisture into the system can cause serious attentuation of the microwave signal. Laboratory tests concluded that ammonia generated from bird droppings interacted with the stressed brass, initiating the stress corrosion failures. As a result of this investigation, all new systems are now being fitted with castings made from a silicon brass, which is known to have a very low susceptibility to stress corrosion cracking. An inspection and replacement program is underway to remove the likelihood of further problems arising from stress corrosion cracking of the earlier type waveguide connectors.

Another recent investigation concerned the safety of practices of towing heavy mobile equipment with Telecom vehicles. The case was significant because Telecom spends many millions of dollars on automotive plant and failures in this type of equipment can often involve staff safety. Recently, whilst being towed, a large mobile air compressor unit broke away from its towing vehicle as a result of the failure of the bracket joining the towing drawbar to the compressor chassis. Investigation of the failure revealed that the breakage was the result of metal fatigue, a consequence of under-design and fabrication inefficiencies. As the particular compressor was one of many in use within Telecom, inspections of other similar units were performed and further brackets were found to have partly failed. Identification of the cause of the problem resulted in all compressors of this particular model being fitted with a re-designed bracket. Although the particular model of compressor is not in current production, the manufacturer was informed of the Laboratories' findings so that non-Telecom users could also be notified.

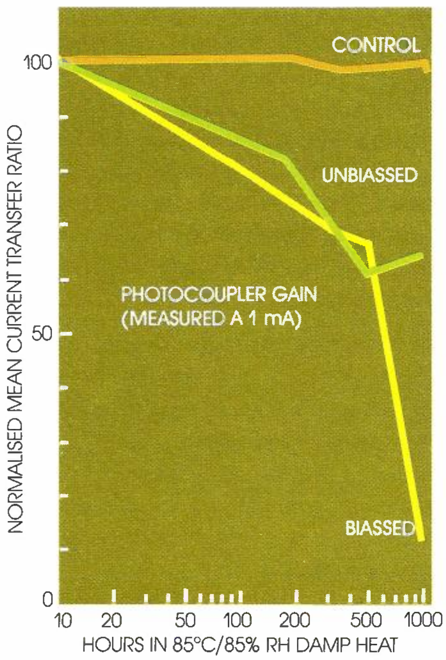
In another case following the failure of wheel studs on a caravan used in field operations by Telecom, metallurgical investigation revealed that the studs had been defectively heat-treated and were unsuitable for service. Subsequent referral of these findings to the caravan manufacturer identified a heat treatment problem, and a stud replacement program was initiated to replace all defective studs. The part played by the Research Laboratories in this investigation, as with that of the tow bar bracket failure, has contributed to safer working conditions within Telecom, and possibly prevented injury to personnel or even loss of life.

OPERATION OF PHOTOCOUPLERS IN HARSH ENVIRONMENTS

Photocouplers are being used increasingly to replace transformers, capacitors and relays in electrical circuits where signal transfer and voltage isolation are required together. The construction of a photocoupler typically consists of an infra-red light emitting diode (LED) and photodetector circuitry separated by an optically transparent dielectric medium, the whole being encapsulated in a DIL plastic package. Although the individual components of photocouplers are in common use and have good reliability as discrete devices, their plastic-encapsulated construction raises concerns about reliability, especially as they are being used to achieve electrical isolation for personnel safety as much as for their electrical function.

The plastic encapsulation process can result in residual stresses in the package and the resins used are often permeable to moisture. It is known that the light output of an infra-red LED may be seriously degraded by non-uniform die stress and by migration of impurities to the die. The optical transmitting medium, usually a transparent epoxy, and the plastic encapsulation could both be sources of ionic impurities and impose a significant physical stress on the die. Thus, the use of these materials in association with LEDs has been studied in the Research Laboratories

Performance degradation of a photocoupler under a laboratory-simulated damp heat environment



to determine possible effects on LED performance.

The Laboratories tested a number of photocouplers of four different types by monitoring their isolation resistance, dark current and current transfer ratio (CTR), while subjecting them to harsh test environments including 85°C/85% RH both with and without electrical bias. After 1000 hours of testing, all types showed reduced CTR, especially at low (less than 1 mA) diode currents. There was, however, little evidence of a corresponding increase in dark current, and the isolation resistance remained above 10^{12} ohm at all times.

Under biassed damp heat conditions, there were several failures. These are of concern as they may indicate a much reduced life for some of these devices if used in very humid environments. On the positive side, the failures did not cause any significant degradation of the isolation properties of the photocouplers. Thus, even if the equipment operation is impaired, there would appear to be little risk of a safety hazard developing due to the failure of a photocoupler in circuit.

SPECIFICATION FOR PLASTIC-ENCAPSULATED INTEGRATED CIRCUITS

For a number of years, the Laboratories have investigated the reliability of plastic-encapsulated integrated circuits (PEICs), monitoring the gradual development of better materials and processes. Improvements in plastics packaging technology and manufacturing processes have now resulted in PEIC reliability comparable with that of hermetically packaged devices. As a result, Telecom is now willing to accept good quality PEICs in its purchased equipment, provided that the equipment meets Telecom's product specifications and reliability requirements.

With the co-operation of other areas of Telecom and for the guidance of Telecom's suppliers, the Research Laboratories recently developed a specification for PEICs (No. 1485), which describes standard tests for assessing product reliability and sensitivity to various failure modes. Under the specification, the IC data may be based on tests performed by either the IC manufacturer or the equipment supplier. The data is generally supplied by the IC manufacturer, and so no cost or time penalty is generally imposed on the equipment supplier.

The acceptance of plastic-encapsulated devices under this new Telecom specification allows equipment manufacturers a wider choice of components, more flexibility of design, lower component costs, and improved availability and second sourcing than was possible when only ceramic-encapsulated devices were acceptable to Telecom.

RELIABLE ELECTRICAL INTERCONNECTION

Although the use of optical fibres is rapidly increasing within the network, reliable metallic interconnections will continue to be vital in the network for many more years. The components used to effect metallic interconnections in the network are numerous and the Laboratories undertake many investigations each year of the suitability of new connection devices, as well as detailed failure analyses of faulty interconnections arising in network operations. The following brief case studies give some idea of the variety and extent of these activities.

Termination of Jelly-filled Cable

The use of insulation displacement termination products is becoming widespread in Telecom's network operations. This type of connection offers significant labour savings, in that unstripped insulated conductors are pushed into a contact slot, which cuts through the insulation and indents the conductor surface to effect interconnection. As with any change to established techniques, the Laboratories were asked to assess the implications of the use of these products for network reliability.

One particular application of the insulation displacement technique, which has been of concern, is its use with jelly-filled (JF) cellular polyethylene-insulated cable, which is currently being introduced into the network as a replacement for solid polyethylene-insulated gas-pressurised cable. Tests were performed in the Laboratories to determine whether JF cable can be reliably terminated onto terminating modules, following concern that jelly contamination from the cable would inevitably penetrate to the insulation displacement contact slots and produce increased contact resistance or even isolation of some contact pairs. It was of further concern that the jelly would also pick up and retain particles of dust and other contaminants in these circumstances.

Fortunately, the results of the investigation showed that jelly and dust do not adversely affect the contact resistance of the connections or the operation of associated over-voltage protectors to any significant degree. Although the force required to remove conductors from the termination slots is reduced with JF cable, accidental conductor removal is considered unlikely, and it has been concluded from the experimental work that, although somewhat messy, JF cable may be reliably terminated onto insulation displacement terminating modules. Hence, the inconvenience and expense of using non-jelly filled tails for termination of JF cables have been shown to be unwarranted.

Grease-filled Cable Connectors

The grease-filled connectors currently used to joint small size distribution cables in the network are damaged by large pulse currents flowing in the cables as a result of nearby lightning activity. The annual maintenance cost associated with this problem is about $1M. The damage arises when lightning causes electrical arcs to occur inside the connectors. These arcs vapourise the grease filling, and the resulting gas under pressure ejects the connector cap which holds the connector elements, leaving the conductor joint exposed and subject to external fault inducing influences.

The 0.4 mm diameter wire commonly used in small size cables fuses at about 10 kA when a simulated lightning-induced pulse (with 8 microsecond risetime and 20 microsecond decay time to half peak voltage) is applied. Telecom Australia expects that grease-filled cable connectors should reliably conduct a minimum current of 8 kA in such circumstances. However, laboratory tests of samples of these connectors from various manufacturers showed that damage occurred over current magnitudes ranging from 4 kA to about 18 kA. The tests also showed that the majority of grease-filled connector types purchased by Telecom failed to meed the 8 kA criterion.

As a result of these tests, Telecom's grease-filled cable connector specification has been amended to include an 8 kA pulse test current requirement. It is confidently expected that the purchase of connectors complying with the new specification will markedly reduce the maintenance cost due to lightning damage.

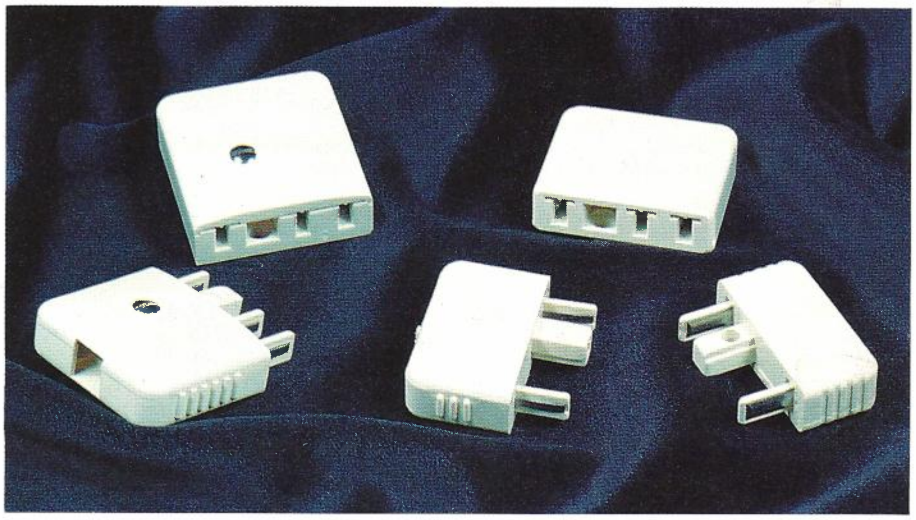
Termination of Aluminium Cable Conductors

Each year, Telecom Australia uses approximately twenty two million cable conductor jointing connectors with underground cable. Historically, copper has been used as the conductor, but aluminium was used some years ago on a limited trial basis to determine its suitability as a possible alternative for copper. Aluminium is mechanically inferior to copper and a tenacious resistive oxide film also forms rapidly on its surface. Lately, the increasing demand for digital services has necessitated the use some of these aluminium cables for this mode of transmission. The low voltages and currents associated with digital transmission provided problems because of poor continuity in some cable terminations. Two termination methods were investigated, namely, insulation piercing (IP) and insulation displacement (ID). The former method provided reliable electrical connection with paper insulated conductors, but the latter method produced unreliable terminations of aluminium conductors with certain types of connectors. In the latter method, the insulated conductor is forced between the tines of a forked contact, so displacing the insulation and indenting the conductor. Laboratory tests showed that, if the conductor is mechanically weak and/or inadequately supported during termination, the insulation may not be fully displaced and unreliable electrical connection is made with the conductor. In the case under examination, the mechanical integrity of the ID terminations required redesigned connectors, which support the aluminium conductor on either side of the tines during termination.

Separable Connectors for Underground Repeaters

In Telecom's external plant operations, maintenance visits to remote underground repeater sites are generally costly and long term reliability of the separable connectors used in equipment in such applications is essential. A critical factor in producing reliable connectors for such applications is the use of gold plating which has low porosity and an even thickness. Otherwise, the corrosive environment often found in such underground enclosures will attack and corrode the nickel underlay or base material of the contacts. A series of prototype connectors for such applications were made by a local manufacturer and submitted to laboratory examination.

Telecom's new standard telephone plug and socket provided an important electrical interconnection study because of their widespread use



They were initially rejected because the contact surface was rough, causing porosity and premature wear of the gold plating. With the co-operation of the manufacturer, the production process was revised. The contact surfaces were electro-polished prior to plating and selective gold plating was used to reduce the amount of gold required. These modifications provided a cost effective means of achieving the necessary reliability.

Reduced Gold-content Materials for Low Force Separable Connectors

The most desirable contact material for separable connectors is gold because of its inherent resistance to corrosion and its low electrical resistance. However, the high price of gold motivates a continuing search by the Research Laboratories for less costly alternatives. Amongst various possibilities examined, palladium has been a subject of major interest, because it is considerably cheaper than gold, yet has relatively noble chemical characteristics. It has one major drawback compared to gold in that it acts as a catalyst for organic polymer formation, especially in the presence of friction, but this can be minimised by alloying it with nickel and/or plating it with a very thin layer of gold. This approach has been taken by several connector manufacturers, with claims of high reliability for contacts with around 20% of the amount of gold previously used. The potential for economic savings is significant as Telecom buys hundreds of thousands of connectors each year.

Environmental tests conducted by the Laboratories have shown that connector contacts finished with 0.2 microns of gold over palladium or palladium-nickel alloy can achieve reliable performance equal or superior to gold over nickel in hostile environments such as humid and sulphur dioxide polluted test atmospheres.

Telecom's Standard Telephone Plug and Socket

Another interconnection study concerned Telecom's standard telephone plug and socket, which have been modified recently. Insulation displacement terminals have been provided in the socket to enable faster and easier termination of the cable, and the plug body has been changed to a moulded design. Although laboratory tests showed that the new sockets were satisfactory, the prototype plugs did not meet Telecom's requirements because of tracking between pins in humid environments and the delamination of plastics used in the plug. After consultation with the manufacturer, the polymers used and the processing conditions employed were modified successfully, rendering the plugs suitable for use in the network.

The above examples demonstrate how the Laboratories share knowledge and expertise with local industry to solve problems associated with electrical interconnection components, thereby contributing significantly to the reliability of Telecom's network.

THE EFFECTS OF ION IMPLANTATION ON ELECTRICAL CONTACT PROPERTIES

Trends in interconnection technology applied in telecommunications equipment, such as the miniaturisation of connector systems and efforts to conserve gold on contact surfaces, are placing increasing demands on interconnection component quality. The optimisation of contact properties such as electrical conductivity, durability in sliding applications and stability of contact resistance is therefore of continuing importance to the reliability of Telecom's networks.

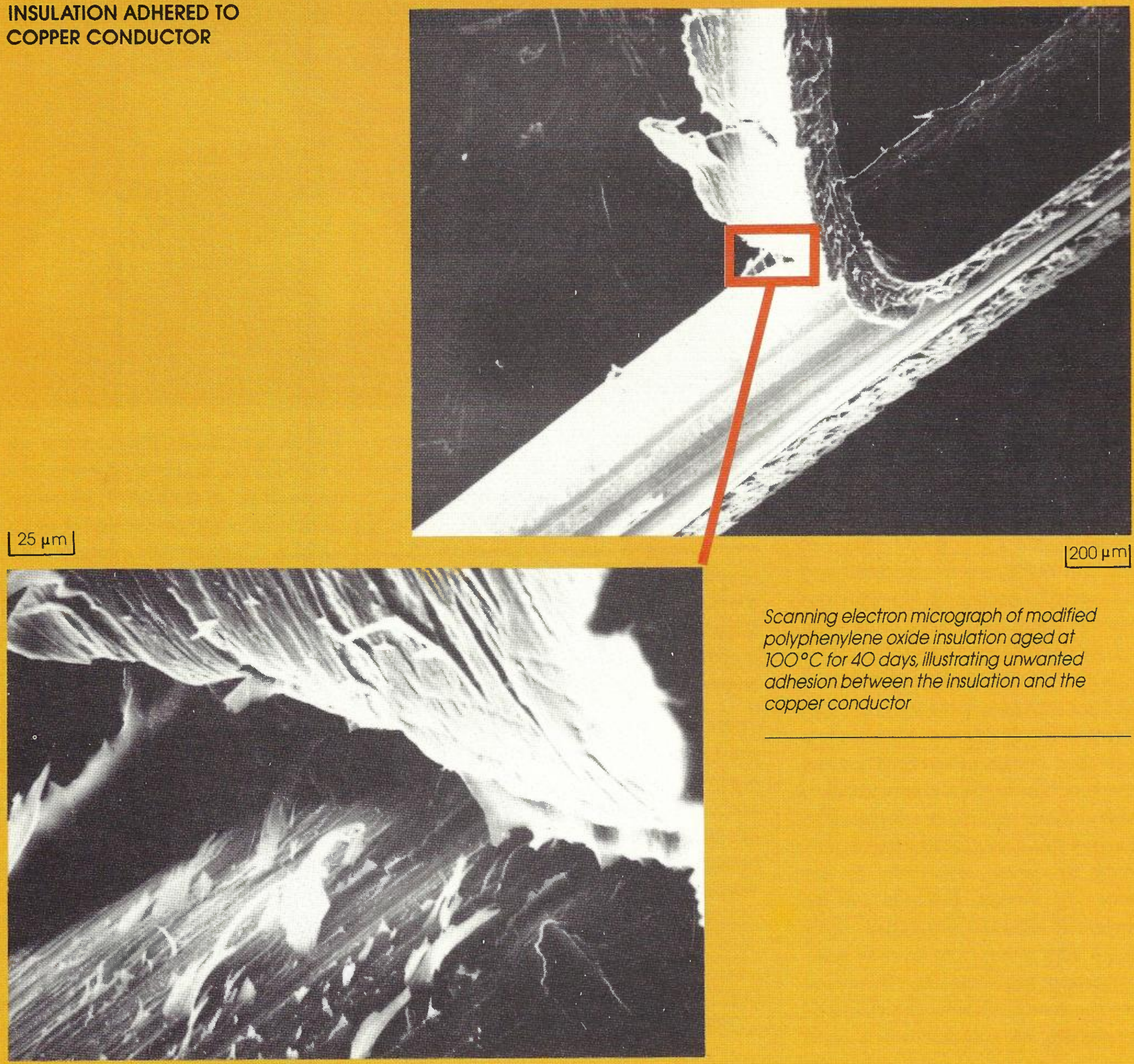
A recent Laboratories' programme investigated the possible enhancement of contact properties in connectors by means of ion implantation. This method of surface modification has shown considerable commercial promise in the treatment of metal components in which high reliability is required. Reduction in oxidation, corrosion or frictional coefficient of implanted surfaces has been widely reported to extend life and improve performance.

The basis of the treatment is the use of a high energy beam of accelerated ions to produce a controlled alteration in composition and properties of the near surface. Characteristic features of the process include the capability of implantation of a wide variety of elements over a continuous range of compositions without changing the appearance or dimensions of the implanted surface.

The Laboratories' investigation of such electrical contacts was undertaken using the 100 keV ion implantation facility of the Microelectronics Technology Centre at the Royal Melbourne Institute of Technology (RMIT). Initially, the investigation concerned switching contacts typical of miniature relays, for which the occurrence of material transfer or erosion between the surfaces during operation results in cumulative damage of the electrodes. High dose implantation of the contact surfaces with nitrogen ions produced a subsequent reduction in erosion rate of a considerable magnitude, the beneficial effect of which continued throughout the extended testing of the relay. The N^+ implantation effects on erosion rate were of equivalent magnitude in a number of different contact materials which were examined. At the same time, the implantation did not cause any alteration in contact resistance, an essential characteristic in applications with low level currents.

The effect of ion implantation treatment on the contact surfaces of other devices, such as separable connectors, was also investigated. Sliding wear is a major determinant of the reliability of these contacts due to their function of disconnection and engagement. Emphasis was placed on the ion implantation of noble metals which are economic alternatives to gold electroplating. In several combinations of these materials, implantation with nitrogen ions

INSULATION ADHERED TO COPPER CONDUCTOR



Scanning electron micrograph of modified polyphenylene oxide insulation aged at 100 °C for 40 days, illustrating unwanted adhesion between the insulation and the copper conductor

produced a significant reduction in the frictional coefficient and the extent of metal transfer between the contact surfaces.

These improvements in contact properties represent a novel and potentially useful application of ion implantation. The results also suggest that an associated technique, that of ion beam mixing of a thin pre-deposited film, offers further potential for alteration of noble metal contacts.

POLYMERS FOR THE INSULATION OF EXCHANGE WIRE AND CABLE

Disastrous fires in Europe, UK, Australia and Japan have generated increasing concern worldwide over the flammability of plastic-insulated cables installed in tunnels or telephone exchanges. The cost due to long term damage caused by a PVC fire can be substantial and the ability to provide a reliable telecommunications service to the community can be severely affected. As with other telecommunications organisations, Telecom Australia's concern arises from the long term, pervasive and deleterious effects of the corrosive and toxic gases and dense smoke given off by PVC when it is involved in a fire.

In the Research Laboratories, this concern is visible in continuing studies and investigations aimed at finding alternative polymers to PVC for the insulation of exchange cables.

A modified polyphenylene oxide (PPO) used in Scandanavia for the insulation of exchange wire and cable has recently been investigated. Claims for the compound are that it exhibits good physical and electrical properties, is reasonably priced and can be extruded down to the 0.1 mm radial thickness required for AXE exchange equipment installations. However, the compound was found to have a narrow processing window, resulting in an inconsistent product that exhibited poor thermal ageing characteristics, high shrinkage behaviour on heating and poor electrical properties.

The poor electrical properties were related to the presence of numerous carbonaceous particles in the compound, presumably caused by thermal degradation of the polymer during the compounding and/or pelletising stages of manufacture.

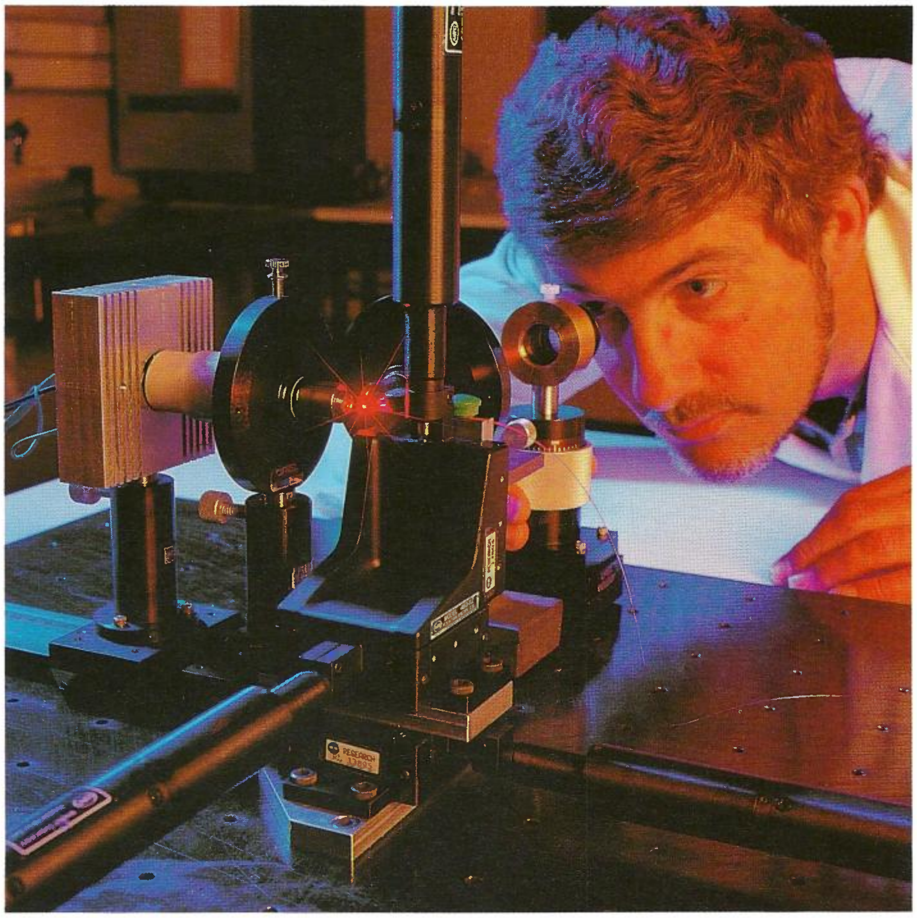
The extruded compound was also found to be oxidatively unstable. Oxidation was catalysed by the presence of metals, particularly copper. This caused an adherence problem between the insulation and copper conductor wire which was investigated by using a scanning electron microscope equipped with Energy Dispersive X-Ray analysis facilities. This clearly established that a chemical interaction occurred at the metal/polymer interface resulting in adherence of the insulation to the copper wire.

The Laboratories' investigations concluded that some improvement in the properties of the compound could be obtained by the addition of an improved stabilisation system, but because of the number of deficiencies in the modified PPO, the search for low aggressivity polymers is continuing. The answer might possibly be found in cross-linked, flame-retarded polyethylene, which will be the centre of the next round of research investigations.

EFFECTS OF MOISTURE ON THE COATING OF THE DARWIN-KATHERINE OPTICAL FIBRE CABLE

Telecom's new 333 km Darwin-Katherine optical fibre link comprises an early stage of a much larger project to construct an extensive long distance optical fibre trunk network throughout Australia by the early 1990s. The cable used in the Darwin-Katherine project uses single-mode, silica fibres with UV-cured, epoxy/acrylate coatings. At repeater stations, the fibre coatings are removed with a stripping tool to allow alignment of the bare fibre ends to facilitate fusion welding. On one section of cable, en route, field installation staff noticed that the coatings were soft and could be easily removed with thumb and forefinger, without the usual need for a stripping tool. This phenomenon was referred to the Laboratories for investigation.

Laboratory investigations revealed that water had entered the cable and penetrated to the surface of the fibres. Chemical analysis of the water trapped between the coating and the fibre indicated the presence of ground-water rather than condensed water from permeation of water vapour. It was also demonstrated that the coatings could be softened by moisture and then re-hardened by evaporation of the moisture. A literature study confirmed the role of moisture in reducing the bond strength between epoxy/acrylate coatings and silica fibres.



Repeatably precise alignment of fibres is central to laboratory assessments of fibre performance and service lifetimes

This experience highlighted deficiencies of the epoxy/acrylate coatings presently used on optical fibres, and it reinforced previous Laboratories' advice of the need to keep the core of an optical fibre cable free of water. The experience has also led to further Laboratories' investigations of more suitable coating materials.

ACCELERATED AGEING OF OPTICAL FIBRE CABLE

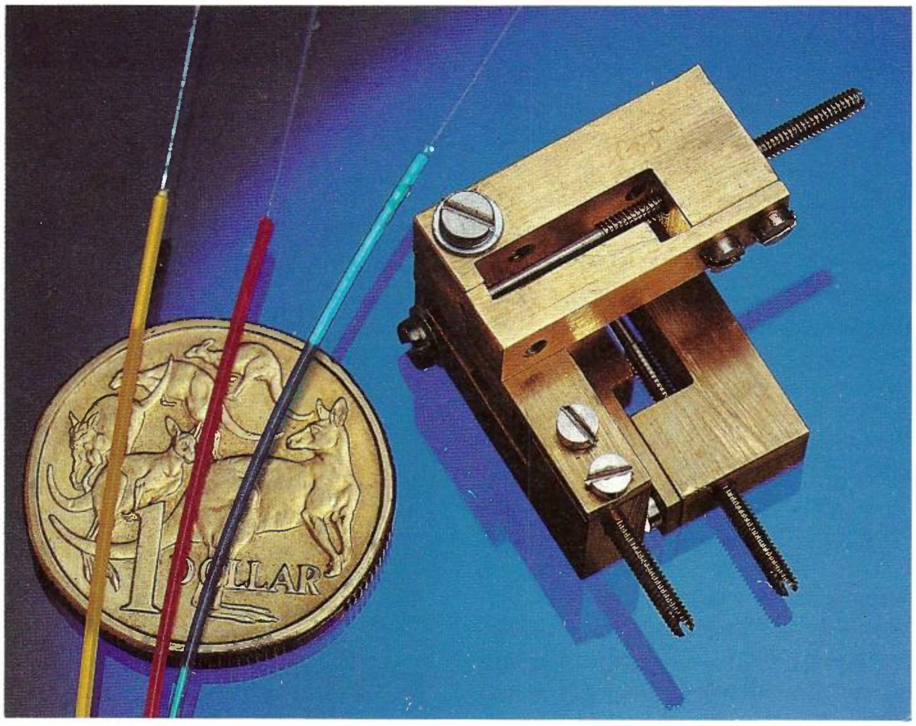
Telecom has now commenced projects which, over the next few years, will plough in thousands of kilometres of optical fibre cable across Australia, to extend the national trunk transmission network. In order to ensure long system lifetimes, repeater stations are being spaced conservatively to allow for some deterioration of cable transmission performance. However, if the long term performance stability of locally made optical fibre cables could be better guaranteed under the range of environmental conditions encountered in Australian operations, fewer repeaters could be used.

The Laboratories have therefore commenced a programme of mildly accelerated environmental ageing tests to assess the extent of change of physical properties which might be expected in long operational service and their effects on transmission performance and cable reliability. Stresses which might cause fibre deterioration are being applied to both cables and fibres. They include thermal ageing, water immersion and exposure to traces of hydrogen gas.

To permit the programme to be commenced, new test equipment was first developed to measure the spectral loss of optical fibres with very high repeatability, so that changes in fibre transmission loss can be detected as early as possible and monitored. One particularly challenging and important part of this task was the development of an automated micro-positioning system which accurately and reproducibly positions the end of a fibre for optimum imaging onto a small-area cooled detector.

The test programme is now underway, and in several years time, it should provide valuable insights into key environmental and materials science parameters which affect the long term service lifetimes of optical fibres in the Australian environment.

A 3-tier stack of micro-manipulators for precise positioning of optical sources and detectors



MICRO-MANIPULATORS FOR POSITIONING OF OPTICAL COMPONENTS

Some telecommunications components, especially in optical systems, are now so small that it is very difficult to assemble them accurately in position by hand or with standard tools. However, accurate positioning is readily achieved by using micro-manipulators, several of which have recently been made in the Laboratories. Precisely machined from phosphor bronze and stainless steel, these tiny manipulators are based on data published by the RCA Laboratories, USA. The manipulators are assembled as a stack of three separate modules to give smooth movement along three orthogonal axes with negligible backlash. Such a stack enables repeatable spatial positioning of optical sources and detectors for single mode fibres with an accuracy better than 1 micrometre.

Although their range of movement is limited, typically 70 micrometres, their size allows them to be built into most existing laboratory equipment. Before being assembled, three manipulator modules would easily fit into a standard matchbox.

In each manipulator module, a shallow tapered rod is screwed into or out of a Vee groove beneath the free end of a cantilevered beam, causing the beam end to rise or fall through an arc. By restricting the range of movement to 40 micrometres per axis, radial movement is negligible. The device to be positioned is fixed to the free end of the outermost module, and the manipulator itself is mounted at the fixed end of the innermost module. Each of the three module beams acts as its own spring.

All materials used were chosen with matching thermal expansion properties. As a result, the deviation from the set position is less than 0.5 micrometre for each degree Celsius change in ambient temperature. Despite their small size, the manipulator modules are robust and deflect minimally under normal loading forces.

Although the micromanipulators were initially built for optical applications, they are also suitable for other applications which require precise positioning of small objects over small ranges of movement.

PERFORMANCE OF STATIONARY LEAD-ACID BATTERIES

Telecom Australia has a large investment in stationary lead-acid batteries. They form the basis of standby and emergency power supplies of telephone exchanges and other equipment installations throughout the national telecommunications network. The size of this investment, the need for maximum reliability of these power supplies (particularly those in the more remote parts of Australia) and the vagaries of battery technology have been driving forces behind ongoing Laboratories' studies of performance parameters which influence reliability and service life of these batteries. A fully automated battery test facility, developed and constructed in the Laboratories, is used for this work.

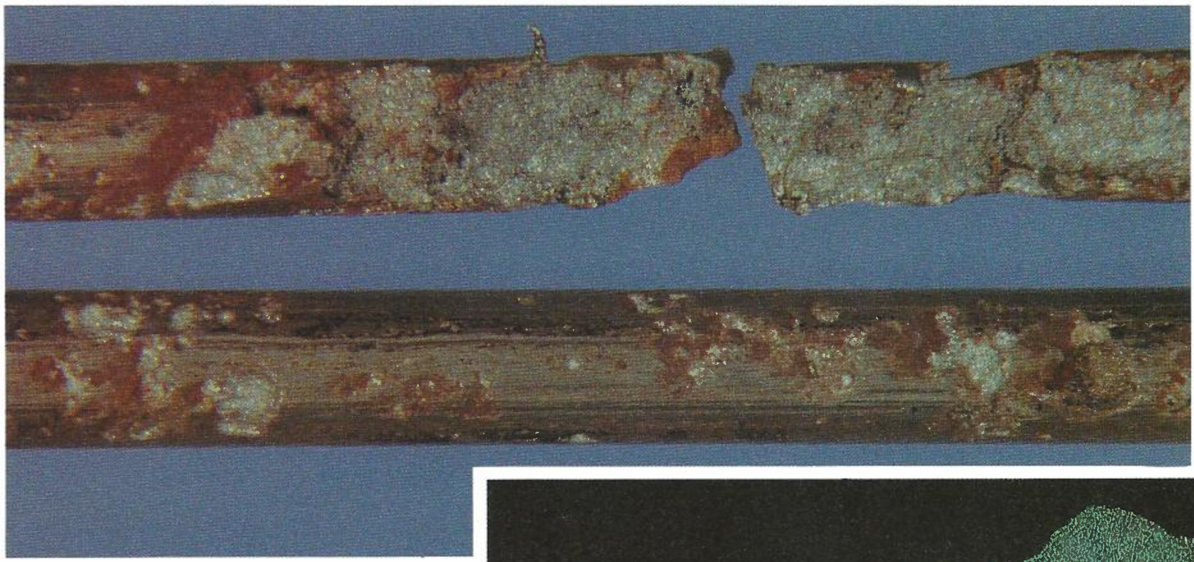
Using these facilities, test programmes have been in progress for some years to evaluate the performance of the different battery types purchased by Telecom. These cells are of capacities ranging from 25 Ah to over 3000 Ah, as required for the variety of Telecom applications. The test programme includes not only standard capacity tests but also measurements and examination of cell and half-cell potentials on charge and discharge, polarisation, float currents at different float voltages, electrolyte composition and structural and electrode components. The tests give comprehensive information for predicting the electrical performance and service characteristics of cells, which would not be possible from simple discharge capacity tests.

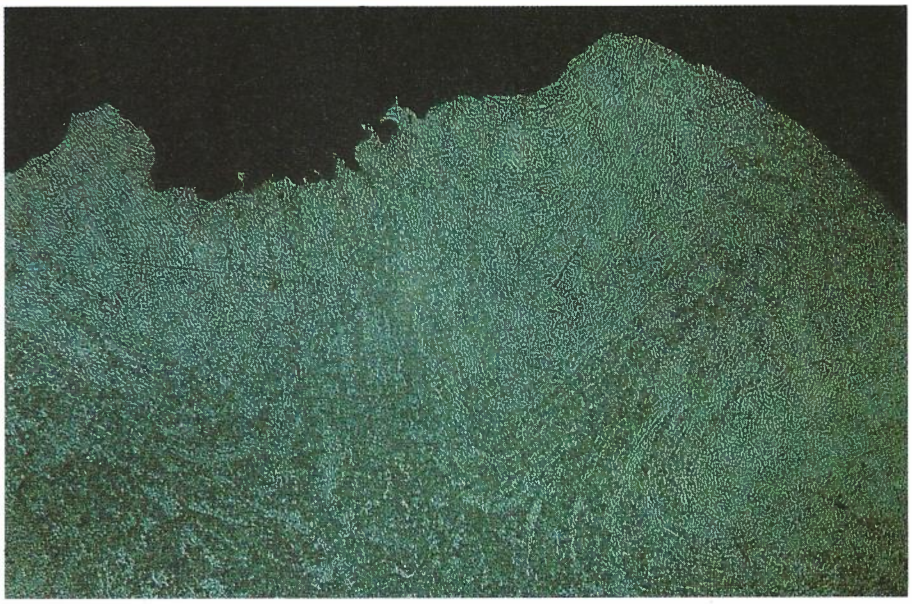
Over the period of the test programme, much of this information has been fed back to the battery manufacturers. In collaboration with Telecom, the manufacturers have been assisted to modify the designs of cells and materials selection and manufacturing processes to achieve improvements in the performance and reliability of their products.

The value of undertaking such a comprehensive testing programme was demonstrated in the conclusions drawn from a recent examination of current prototypes from different manufacturers. The Laboratories were able to show conclusively that the cells with the lowest capacities supplied by one manufacturer displayed superior electrical performance and would be expected to achieve better lifetime characteristics in the field than cells with higher capacities. If only conventional capacity measurements had been undertaken, it would have been incorrectly concluded that the latter cells were superior.

THE USE OF STAINLESS STEEL IN UNDERGROUND ENVIRONMENTS

A very limited range of suitable metals and alloys is available for underground applications where the requirements are for the material to be directly buried in saline soils, yet to provide a long service life. Stainless steel, nominally of 4 millimetres diameter, has been used successfully by Telecom as a guard wire





Severe pitting corrosion of type 316 stainless steel wire caused by electrolysis

(Inset) Cross-section of a pitted area of the wire showing typical etched microstructure of stainless steel

to protect buried telecommunications cable from lightning strikes. It is also used to provide suitable, long life earthing planes for radio transmission antennae at sites where the more traditional material, copper, has proved unsuitable.

Telecom's research studies and field experience have shown that the selection of the appropriate stainless steel alloy for a particular application is based predominantly on the corrosion resistance requirement. For small installations in low corrosivity soils, alloy types 302 and 304 are acceptable, but alloy type 316 should be used for large or remote installations, particularly in corrosive saline soil environments. Where the installation involves heating of the alloy, such as by welding or brazing, a stabilised version of the alloys may have to be considered (for example, alloy type 321 instead of 304, or type 316L instead of 316). The appropriate choice depends on the method of fabrication and the thickness (that is, thermal mass) of the material.

A recent Laboratories' investigation of a corrosion problem detected with a recently buried stainless steel wire highlighted the need to consider not only the type of material chosen but also its quality and many other environmental factors which could influence its service life. This particular corrosion problem involved severe pitting and some surface oxidation. Chemical analysis confirmed that the basic composition was that of type 316 stainless steel as specified. Corrosion rates were determined under standard conditions for new and exposed samples, and the results were compared with those obtained for both thermally sensitised and thermally stabilised materials. Consequently, the corrosion behaviour of the metals used in service was considered to be satisfactory. A metallurgical examination of the cross-sectioned samples showed no microstructural abnormalities to account for the observed corrosion of the field samples.

Further study revealed that the pitting corrosion was due to anodic electrolysis, which is to be expected if an external impressed cathodic protection system interferes. The surface corrosion was the result of incomplete removal of mill scale after completion of the manufacturing process.

However, following these comprehensive investigations, it was concluded that the effect of the mill scale should only marginally reduce the service lifetime of the stainless steel wire below that which might have been expected if clean, bright surfaced wire was exposed to identical environmental conditions.

A TEST CELL FOR RADIO FREQUENCY RADIATION MONITORS

Within Telecom, increased attention is being given to the investigation and elimination of bio-electromagnetic hazards which might arise if systems and equipment operated by Telecom emit excessive levels of radio frequency electromagnetic radiation (EMR). Telecom's first level of defence against such hazards is to define and implement safe working practices at likely EMR sources, such as radio broadcasting and radiocommunications sites. Telecom's trained survey teams are employed in identifying safe and unsafe areas at such sites, and devising and implementing work practices or equipment modifications to ensure that no person is exposed to EMR levels above the maximum exposure levels specified in Australian standards.

Survey teams use a range of commercial electromagnetic radiation monitors to establish the radio frequency radiation levels. Unfortunately, Telecom's experience has indicated that the fragile sensing

The tripod-mounted portable test cell used in electromagnetic field measurements

elements employed in some currently available instruments can fail in the rugged conditions sometimes encountered in field survey work. As instrument faults are not always immediately obvious to the operator, it is possible that a survey could be performed with a faulty monitor, resulting in incorrect radiation level measurements.

To overcome this problem, the Laboratories have developed a portable testing cell which provides a known enclosed electromagnetic field. By placing the radiation monitor probe inside the cell and rotating it by hand, the operator is able to check the instrument's sensitivity and isotropic response. Isotropicity is a measure of the probe's ability to respond evenly to radiation of all polarisations and directions of propagation.

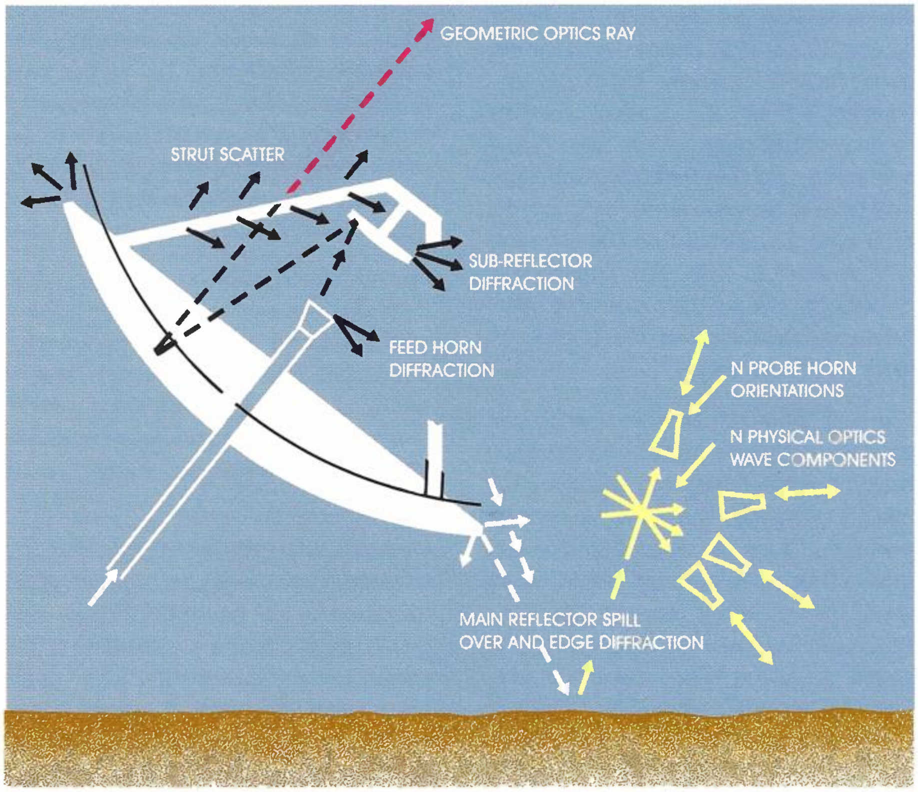
A number of these cells will be located at Telecom depots or carried by radiation survey teams. By using the cell to test the radiation monitors before and after each radiation survey, the operator will be quickly able to detect faulty monitors and remove them from service, considerably improving the reliability of the data obtained during field surveys.

ELECTROMAGNETIC FIELD LEVELS IN THE VICINITY OF SATELLITE EARTH STATIONS

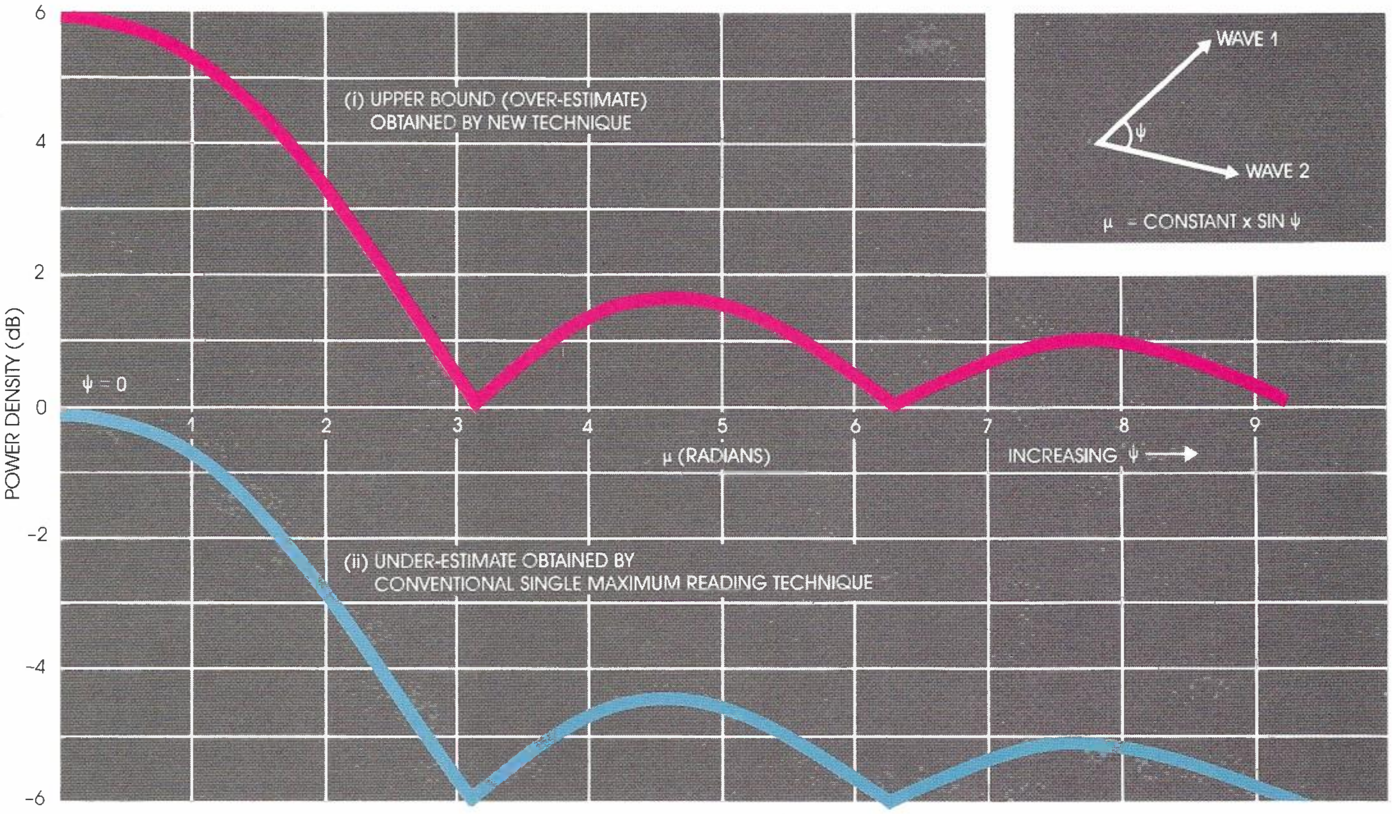
Recent media coverage of claimed possible adverse health effects arising from exposure to environmental levels of microwave radiation around satellite earth stations has sparked considerable public concern. There is, however, a national exposure standard (AS2772-1985) applicable to members of the general public, and satellite earth stations and all transmitting stations operated by Telecom are required to comply with that standard.

The conduct of surveys of microwave radiation levels in the vicinity of large aperture antennas for the purposes of assessing maximum potential exposure levels to members of the general public presents a task of some complexity. For instance, the environmental fields close to the antenna are complex in nature and originate from a number of different sources. The fields are produced by phenomena such as sub-reflector and feed horn diffraction and main reflector spillover and edge diffraction. At larger distances from the antenna, reflections from nearby objects, possible field enhancements due to phase variations across the aperture and strut scatter become increasingly important.

In the past year, two such surveys have been carried out by Laboratories' staff.



An illustration of the complexity of wave components near a satellite earth station antenna



Power density estimates for two waves co-polarised in the common plane of propagation
a. upper bound (over-estimate) obtained using the new technique
b. under-estimate obtained using the conventional technique

In one survey, field measurements were made using a 32 m diameter antenna, transmitting 300 W at 6 GHz. The following radiation levels were recorded at the distances and orientations indicated:

- at two points 10 m from the edge of the antenna, 4.1×10^{-6} and 9.0×10^{-6} mW/cm^2
- 250 m from and to the side of the antenna, 8.4×10^{-7} mW/cm^2
- 220 m in front of the antenna, 1.3×10^{-6}, 8.1×10^{-7} and 7.5×10^{-7} mW/cm^2
- 430 m in front of the antenna, 5.2×10^{-7} and 4.6×10^{-7} mW/cm^2.

In the second survey, a 6.4 m diameter antenna was used, transmitting 300 W at 14 GHz. The following radiation levels were recorded:

- at two points 2 m from the edge of the antenna, 4.5×10^{-4} and 6.8×10^{-3} mW/cm^2
- 60 m from and to the side of the antenna, 6.8×10^{-7} mW/cm^2
- 250 m in front of the antenna, 4.3×10^{-7} mW/cm^2
- 600 m in front of the antenna, 2.7×10^{-8} mW/cm^2.

These measured radiation levels can be compared with the limit of 0.2 mW/cm^2 recommended in AS2772 as the maximum exposure level above 30 MHz for members of the general public. The typical radiation levels of FM/TV signals received in two Melbourne suburbs, namely, 3.2×10^{-6} and 7.3×10^{-6} mW/cm^2, provide an interesting comparison.

From the survey measurements, it was concluded that the environmental levels of microwave radiation are many orders of magnitude below currently accepted exposure standards for members of the general public.

UPPER BOUNDS FOR ELECTROMAGNETIC RADIATION EXPOSURE IN A COMPLEX NEAR FIELD

The power density distribution due to a set of electromagnetic plane waves travelling in different directions through a common region of space generally exhibits a complex interference pattern containing various local maxima and minima. A specific situation of this type occurs with the electromagnetic wave fields generated in the vicinity of large aperture microwave antennas. In such situations, environmental surveys can be conducted using a directive microwave probe antenna connected to a field strength measuring receiver. Although measuring systems of this type have good sensitivity when used conventionally, they are prone to give indications of the power density maxima which are almost invariably significantly below the true values. This disadvantage is a considerable handicap for environmental survey work, where it is preferable to have a moderate over-estimate, or upper bound, of the maxima. Consequently, the Laboratories have devised a new technique to permit upper bound estimates to be obtained with such a directive probe antenna measurement system.

Instead of making a conventional single maximum level observation in the region of measurement, the technique requires that the directive probe is traversed along the directions of propagation of each component wave, so that the maximum observations of each may be recorded. By squaring the sum of these individual maximum field intensities, and allowing if necessary for arbitrary polarisation, it is possible to obtain the required upper bound for the power density.

In the simplest case of two waves co-polarised in the common plane of propagation, the amount of over-estimation is inversely related to the angle between the respective directions of travel, but is independent of the relative wave amplitudes. When the angle is zero, the over-estimate is 6 dB (that is, 4 times in terms of power density). It is less at all other values of the angle. Conversely, the under-estimate caused by the conventional

The RF protective suit, showing its open face

single maximum reading method is zero when the angle is zero, but can reach −6 dB (that is, one quarter in terms of power density) at various other values of the angle between the directions of travel.

Statistical results for a more complex four wave case show a similar inverse correlation between the respective upper bound over-estimation, the conventional single maximum reading under-estimation and the maximum single reading under-estimation.

INVESTIGATION OF A RADIO FREQUENCY PROTECTIVE SUIT

A protective suit consisting of an overall with an integral hat, gloves and oversocks, and constructed of an electrically conductive fabric, has been recently examined in the Laboratories for electromagnetic shielding effectiveness at radio frequencies in the range from 200 kHz to 4 GHz. The suit had been originally developed to provide personnel protection in high electric field gradients near overhead high voltage 50 Hz transmission lines.

A life-size hollow fibreglass phantom was used to support the suit during measurements. Various receiving probes were inserted inside the phantom, and all leads from the probes exited between the oversock and the leg of the suit. No holes were cut in the suit and great care was taken to ensure the leads did not act as antennas.

It was apparent from the open nature of the face of the suit that it would provide little or no shielding to microwave radiation incident on the face. In fact, the dimensions of the opening were such that a resonance was likely between 3 and 4 GHz.

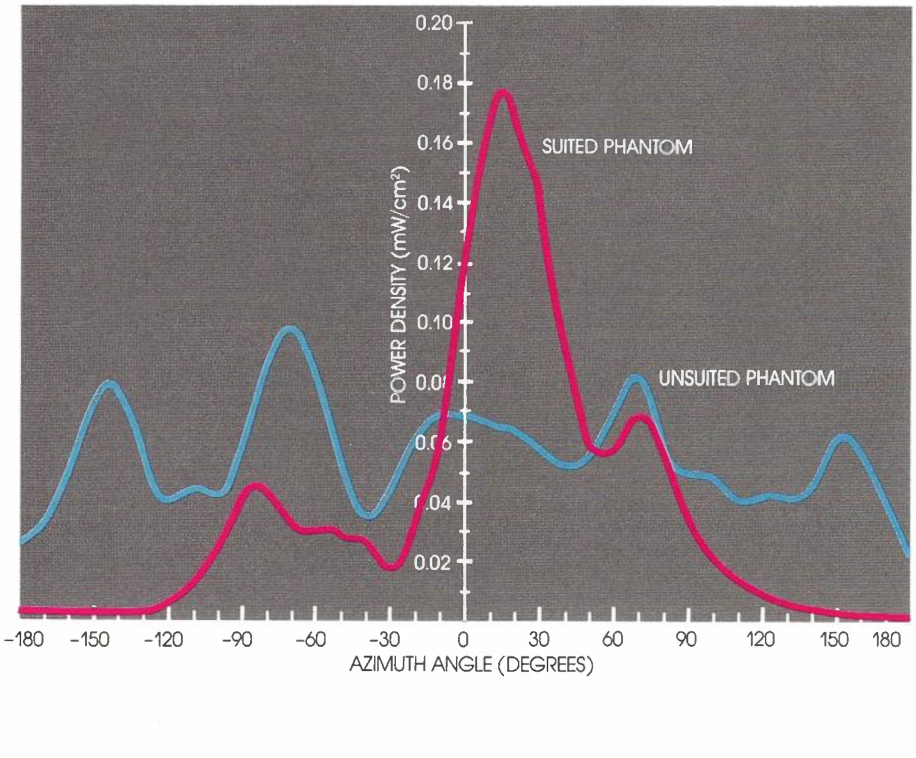
An isotropic electric field probe with a remote readout was placed on the head of the phantom. The phantom, with and without the suit, was exposed to frequencies between 3 and 4 GHz whilst being rotated. A definite resonance was found to occur at 3.5 GHz for radiation incident approximately 20° off axis.

The Laboratories' investigation concluded that:

- the suit provides little or no shielding effectiveness for microwave radiation directly incident on the face;
- at particular angles of incidence, the suit significantly enhances radiation in the head region.

The shielding effectiveness of the body of the suit to magnetic fields below 500 MHz was also investigated. Vertical loops were fixed to the inside surface of the phantom and coaxially aligned transmit loops were placed at various distances from the phantom. Measurements were then made of the relative signal strengths received inside the phantom, with and without the suit, over the frequency range 200 kHz to 20 MHz. These measurements showed that the suit provides no shielding effectiveness to magnetic fields below 4 MHz.

Power density, measured at an isotropic electric field probe on the head of the rotated phantom, showing a resonant enhancement caused by the suit



The investigation highlighted some essential suit design criteria which should be met, as follows:

- suits should be completely closed
- a minimum shielding effectiveness of 20 dB should be attained for all parts of the suit over the intended frequency range of use
- the fabric should be non-flammable
- normal ventilation should be assured.

The investigation also concluded that, even if an appropriate suit could be produced, its use should not be indiscriminate but confined to those occasions when other methods of ensuring compliance with current exposure standards are not possible.

THE TELECOM VOLT

A wide range of electrical measurements are made throughout Telecom on systems and equipment employed in, or undergoing evaluation for potential application in, Telecom's networks. To ensure the accuracy of these measurements so that equipment operates to specification, Telecom has a hierarchy of Calibration Centres which trace their calibration accuracy to precise reference standards of electrical (and other) quantities maintained in the Research Laboratories. In turn, the Laboratories provide accuracy traceable to the Australian and thence to international standards.

Probably the most basic reference electrical standard maintained by standards laboratories is the dc volt. Traditionally, this has been established by a group of electro-chemical saturated standard cells – the volt being defined in terms of the mean value of the electromotive force (emf) across each cell in the group. The mean is assumed to remain constant, or at least to have a low and constant drift rate. Having a high temperature coefficient, the cells must be kept in very precisely temperature-regulated baths. Such a cell is very sensitive to shock and vibration, and its emf is affected by minute electrical loading, making precise measurements to the required accuracy difficult.

The present "Telecom volt" is determined by the emfs of a group of six cells (whose mean value defines the actual volt) and a secondary group of ten cells whose emfs are continually monitored and which can be used to replace a faulty cell in the primary group, if and when necessary.

Until recently, traceability of the Telecom volt to the Australian national standard was achieved by hand-carrying a group of four cells in a temperature-controlled enclosure to CSIRO's National Measurements Laboratory in Sydney for calibration. However, the shock of travelling and the subsequent time required for re-calibration, after both the go and return journeys, to ensure repeatability of results resulted in a period of about three months to effect a voltage transfer.

In recent years, solid state devices have been developed to replace electrochemical standard cells. Their advantages are resistance to shock and vibration, low temperature coefficients and ability to withstand electrical loading without damage. Initially, their main disadvantages were long term drift and low frequency noise in their output, making measurements to the desired accuracy difficult. However, these devices have now been significantly improved in these respects, to the extent where they are now comparable with standard electro-chemical cells, without the inherent disadvantages of the latter.

The Laboratories are currently using one of these devices as a transfer standard to the national standards in Sydney. Experience has shown that it is possible to effect a voltage transfer within a fortnight, with precision nearly an order better than that obtained with standard electro-chemical cells. Tests are proceeding to determine the long term stability of these devices and it is anticipated that they will ultimately replace electro-chemical cells as the standard "Telecom volt".

A TERMINATING LEVEL TRANSFER STANDARD

In the course of disseminating electrical standards throughout Telecom with the view of improving calibration facilities and traceability to the national standards, the Laboratories develop standards specifically for use by the Calibration Centres in each of Telecom's State Administrations to assist them in their calibration work.

Following a request from one of these Centres, a 1 milliwatt terminating level transfer standard was recently developed by the Laboratories to aid in the calibration of 'Radiometer' type sending level standards used throughout Telecom. The device enables the 1 mW power level from a sending level standard to be measured in terms of substituted dc power over the range of frequencies from dc to 20 MHz. It consists of a 5 milliampere thermal converter shunted by an appropriate impedance network to give a characteristic impedance of 75 ohms with a reflection coefficient less than 0.01. A calibration report supplied with the unit gives the ac-dc transfer corrections which are typically less than 0.01 dB over the frequency range.

The standard has been sent to the requesting State Calibration Centre and further units will be provided to all other Centres. Their use of the standard will enable the precise calibration of sending level as well as terminating level standards throughout Telecom.

TIME TRANSFER BY SATELLITE

Considerations of uniformity and traceability within the national and international reference standards communities have been the force behind the Laboratories' recent adoption of satellite time transfer for inter-comparison of Telecom's time and frequency standard with similar standards elsewhere in Australia and overseas.

From 1967 until early 1986, Australian time and frequency standards laboratories inter-compared the performance of their Caesium clocks by using regular simultaneous measurements of the synchronising pulses of a pre-determined frame of a TV signal broadcast nationally by the Australian Broadcasting Commission (ABC) at the introduction of its national midday news service. The TV programme was relayed nationally via Telecom's terrestrial trunk network with precisely known differential transmission delays to receivers at the standards laboratories. All standards laboratories were able to obtain a common view of the TV signal frame synchronising pulse, which thus provided a national timing "instant" for precise time comparisons. However, in 1986, the ABC began using the national AUSSAT communications satellite for interstate relays of its programmes, thereby depriving the standards laboratories of this convenient means of obtaining a common-view timing instant.

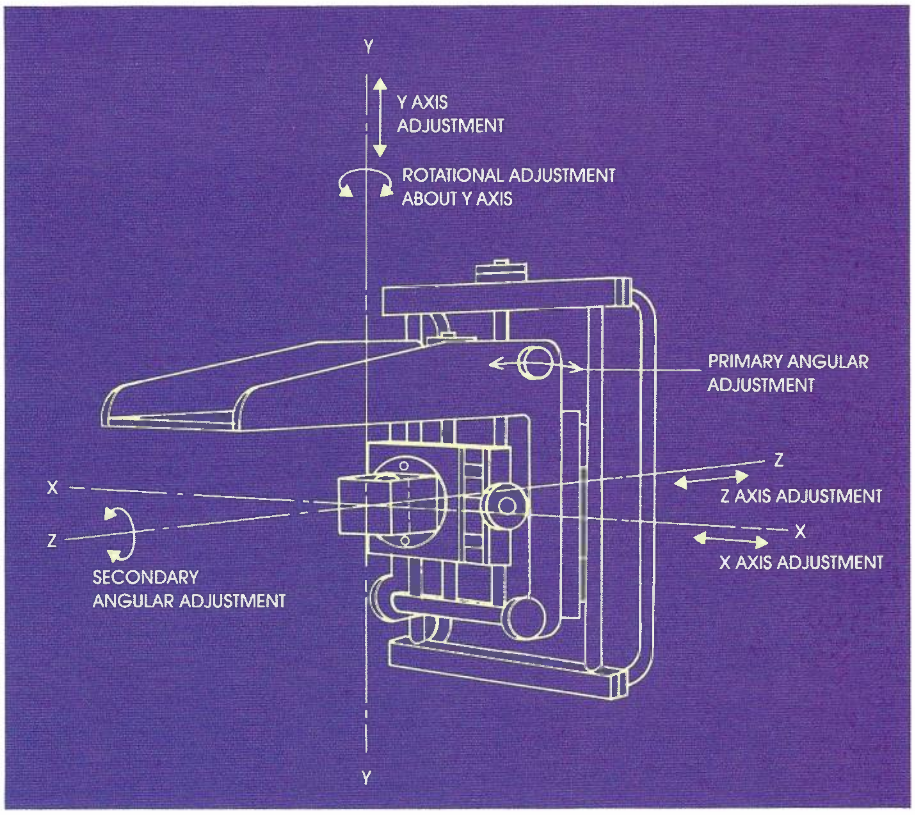
This motivated the Research Laboratories to develop a new technique for intercomparison of its time and frequency standards. In the new technique, two satellite systems are used for time transfer.

The USA-operated GPS-NAVSTAR system is a high precision navigation and time transfer system, which enables local or intercontinental time comparison against any other GPS user. The comparisons are traceable to the Bureau International de l'Heure in Paris, which co-ordinates world time under international agreement. Comparison accuracies of the order of 0.2 microseconds can be achieved.

Australia's national communications satellite, AUSSAT, has no inherent time transfer capability, but it is used as a transmission vehicle in the new time comparison technique. Utilisation of AUSSAT is complex for high accuracy applications due to its imprecise station keeping. The satellite's orbital adjustments cause minor variations in apparent path length between measurement sites. This makes direct timing comparisons by the old technique impossible because the required precision cannot be achieved. However, using AUSSAT, systematic error can be reduced by calculation of orbit by a common reference GPS measurement at three or more "key" standards laboratories. This technique gives lower standard errors in time comparison than those obtained previously using terrestrial communications links.

The use of the AUSSAT satellite has introduced a new dimension to national time comparison. AUSSAT's Homestead and Community Broadcasting Satellite Service (HACBSS) relays programmes to the whole of Australia (including the remote outback). This provides a vehicle for time comparisons via HACBSS earth stations for users who do not have GPS receivers or who are not able to receive a common TV programme transmission.

The mobile cryostat mounting in use



Modes of adjustment in the cryostat mounting

MOBILE CRYOSTAT MOUNTING

In the experimental growth of semiconductor materials, the Laboratories employ photoluminescence spectroscopy as one means of characterising the materials as a feedback process to ensure control of material quality and composition. In applying this technique, it is essential that the semiconductor material to be characterised is accurately positioned in the path of an excitation laser, thereby producing a spectrum of emitted light which identifies the composition of the material. This positioning function is accomplished by means of a mobile cryostat mounting.

To match the Laboratories' facilities and purposes, a cryostat mounting incorporating the following design features was required:

- portability
- incorporating means for specimen adjustment in several modes
- convenient placement of multi-purpose operator controls for accurate specimen location
- access to all vacuum lines and electrical monitoring cables leading to and from the cryostat
- ease of component assembly and fabrication
- mechanical stability combined with lightweight construction for maximised mobility.

Since it was not possible to purchase such a cryostat mounting, its design and fabrication was undertaken in the Laboratories. After consideration of several design concepts, a final design evolved. It comprised two major components, namely:

- a mobile cradle carriage
- the cradle assembly, incorporating the cryostat housing and the cradle itself.

The design is such that the mobile cradle carriage is transportable to different locations without dismantling the optics associated with the test specimen. It provides a mounting for the cradle assembly which can be easily and quickly attached or detached via over-centre locking clamps. A special primary vertical adjustment control enables the operator to position the cradle assembly precisely to suit varying bench heights encountered. This mechanism eliminates the need to lift the stainless steel cryostat manually, providing a safety feature since the cryostat is relatively heavy and awkward to handle.

The cradle assembly, comprising the cradle and cryostat housing, serves as the main mechanical adjustment means. By employing linear shafting, bearings and zero backlash screw threads, adjustments in the X (horizontal) and Y (vertical) axes can be achieved. Primary angular adjustment about the Y and Z axes is obtained by pivoting the combined vertical and horizontal stages and clamping them to the cradle arms in the desired position.

The cryostat housing provides a means to attach the cryostat. By using a split ring housing and clamping screws, rotational adjustment has been easily achieved. The whole housing mounts and pivots on the horizontal axis and is secured in position via two locking nuts once the correct secondary angular adjustment relative to the X and Y axes is obtained.

To satisfy the design specifications, the following points were addressed:

- To minimise cost, the design sought to employ, where possible, commercially available materials and components. Individual parts which did need manufacture were designed to keep machining operations simple and minimal.
- Easy access was provided to all fastening points, to permit quick component and parts assembly, while the extensive use of aluminium ensured a lightweight design.
- Stability and mobility were enhanced by ensuring that the centre of gravity of the whole system was located above the mid-point of the mobile cradle carriage wheelbase.

The mobile cryostat mounting was designed, fabricated and commissioned in 1986. It is now providing a purpose-designed facility for semiconductor materials research in the Laboratories.

PROTECTION OF MAINS-POWERED TERMINAL EQUIPMENT

Telecommunications terminals such as telephones, PABX and facsimile equipment may have to operate in environments where they can be subjected to lightning impulses, mains power surges and high frequency disturbances which are imposed on the telecommunications network. Mains-powered terminal equipment can be further subjected to over-voltages derived directly from the power distribution system. In extreme circumstances, these high voltages cannot only cause equipment malfunction or damage, but they can also present hazards to the user of the equipment or to Telecom's service personnel.

Since mains-powered telecommunications equipment, such as small business systems, are being increasingly connected to Telecom's networks, the Laboratories have been investigating particular instances where damage has occurred and studying general approaches for removing or protecting against the effects of such hazards.

The Laboratories' case studies have found that a number of factors are often involved. In addition to the underlying source of the imposed high voltage, they include the use of double-insulated power supplies, the ineffective equalisation of potentials in the customer premises environment and the mismatching of protective components.

The transformers used in double-insulated power supplies are designed to withstand a minimum of 3.5 kV rms between primary and secondary windings. While the use of these transformers in a telecommunications terminal provides a degree of isolation between the mains power supply and the telecommunications circuitry for steady state potentials, it does not necessarily provide protection for the terminal from impulse voltages, nor does it protect against over-voltages applied between the terminals of the primary winding. If energy impulses pass through the transformer to the telecommunications circuitry, a great deal of damage can occur both in the power supply and the Telecom line circuits. A recent example of this type of damage occurred near Darwin where the power supply of a small business system was totally destroyed when a nearby lightning strike created a high potential difference between the mains power supply and Telecom earths at the customer's premises.

In such circumstances, the use of an earthed power supply, with the active and neutral inputs protected by metal oxide varistors connected to the chassis of the equipment, should eliminate this problem. Alternatively, the use of a power line filter with double-insulated equipment would reduce the chance of damage. However, this protection is mainly dependent on the inductance of the power line filter.

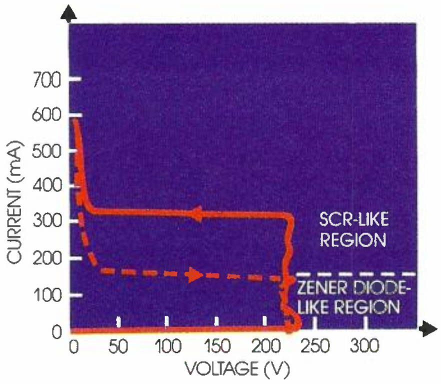
The best and fundamental method used to protect telecommunications equipment and its users from high voltage hazards relies on minimising the potential differences which can occur within the environment in which the equipment is to operate. This is normally achieved by providing an electrical connection between the mains power system, the Telecom network and the local earth. In practice, a conductor (bond wire) is connected between the equipment chassis, the Telecom earth and the mains power supply earth. Care must be taken to minimise the impedance of these bond wires, since when conducting lightning currents, a high impedance can itself produce hazardous voltage differentials. Laboratory measurements have shown that when a 5 kA, 8/20 microsecond current pulse is passed through a 10 m length of copper conductor comprising 7 strands of 0.67 mm diameter wire, 6 kV is developed along its length.

In Telecom's normal operational practices, gas-filled protectors are fitted to the telephone line at the customer's premises in lightning prone areas to provide primary protection of the equipment's line input circuitry. However, laboratory tests have shown that, if the external gas-filled protectors and the equipment's internal protection (normally metal oxide varistors) are not matched and/or separated by a suitable buffer impedance, the gas-filled protector may not operate, due to the clamping action of the internal protection. If the gas-filled protector is prevented from operating in this way, the internal protection will dissipate the surge energy and can fail prematurely.

As a result of these investigations, the Laboratories have identified problem areas and solutions which will reduce the amount of damage which can occur with mains-powered telecommunications equipment in some field environments due to voltage surges. To provide adequate protection for a system, the voltage between various parts must be kept to a safe level. This can be achieved by keeping earthing wires short, providing line to ground protection for the mains power input and the correct installation of gas-filled protectors where necessary. Most importantly, the Telecom and mains power earths must be connected together with a low impedance bond wire.

THYRISTOR FAILURE IN EXCHANGE POWER SUPPLIES

Power thyristors provide an effective means of controlling the output of exchange power supplies. However, device failure can have drastic consequences. One such failure occurred recently in a newly installed telephone exchange when several



Measured V-I characteristic of a current-limited fold-back diode

thyristors failed, causing loss of exchange power, costly equipment damage and inconvenience to Telecom's customers. Consequently, the Laboratories were asked to investigate why these devices had failed.

A common cause of thyristor failure is electrical overstress. This usually results in thermal runaway, when a spot on the silicon reaches the intrinsic temperature producing a negative temperature co-efficient and melt-through occurs in the material of the device. The subsequent damage to the thyristor is usually massive and detailed failure analysis requires a careful step-by-step dismantling of the device in the search for evidence of the cause of the failure.

In the particular investigation cited above, microscopic examination established that the failures had occurred in the centre of the cathode metallisation. This indicated that the devices were conducting when the failure occurred, since the damage would otherwise have occurred near the gate region. It was therefore concluded that the breakdown was caused by a high current surge while the device was conducting. Since the breakdown was attributed to an isolated set of circumstances rather than to faulty manufacture, no further remedial action other than repair of the faulty equipment was indicated.

FOLD-BACK PROTECTIVE DIODES

The extensive use of digital technology in telecommunications equipment has generated a demand for protective devices which can operate at speeds and voltage levels comparable with those of the circuitry they are protecting. One protective device which has been developed specifically for this purpose is the fold-back diode, and claims have been made that it will operate in nanoseconds, limit voltages to approximately 300 volts and carry currents of up to 150 amperes. The Research Laboratories therefore investigated these claims, to assess the potential usefulness of these new devices in Telecom's network.

For analysis purposes, the fold-back diode can be modelled as a silicon controlled rectifier (SCR) which is gated via a zener diode. The device thus acts like a conventional zener diode at currents below the device breakover current, typically 100 mA. Once the breakover current is exceeded, the SCR element is activated and the device's characteristics revert to those of an SCR, characterised as low voltage drop and large current carrying capacity.

To be effective in protecting telecommunications equipment, these diodes must be able to withstand the whole range of disturbances that can appear on telephone lines. The two major sources of these disturbances are lightning strikes and the mains power reticulation system.

In the Laboratories' assessment of these diodes, their response to lightning-induced current impulses was simulated using 8/20 microsecond impulses. Tests showed that the nominal 150 A devices failed at a mean current of 143 A, and the 400 A devices failed at a mean current of 240 A. In addition, the latter devices were found to have a turn-on voltage which was too low for practical applications in telecommunications networks.

Faults in the mains power reticulation system can induce a range of low frequency voltage surges within the telecommunications network. The duration of these surges is related to the fault detection procedures used in the power reticulation system. The diodes failed in two of the three tests which were used to reproduce the effect of these surges. However, it was noted that all of the failures occurred when the device was put into reverse bias. When the tests were repeated using a conventional diode bridge in series with the fold-back diode to ensure that no reverse bias was applied to the fold-back diodes, they successfully passed the tests.

This investigation thus showed that fold-back protection diodes cannot be used by themselves as protective devices for telecommunications equipment because of their low current carrying capacity and their low failure voltage under reverse bias conditions. However, when used in conjunction with a diode bridge and buffer resistors, they can provide onboard protection for digital circuitry, as a useful supplement to that already provided by either gas-filled protectors or metal oxide varistors, because of their lower turn-on voltage.

HAZARD ASSESSMENT IN THE WORK ENVIRONMENT

The analytical skills and facilities of the Applied Science Branch of the Laboratories provide scientific support to Telecom's efforts to reduce hazards in the working environment which might affect the occupational safety and health of Telecom's personnel. The following items illustrate several investigations of this nature which have been performed during 1986/87.

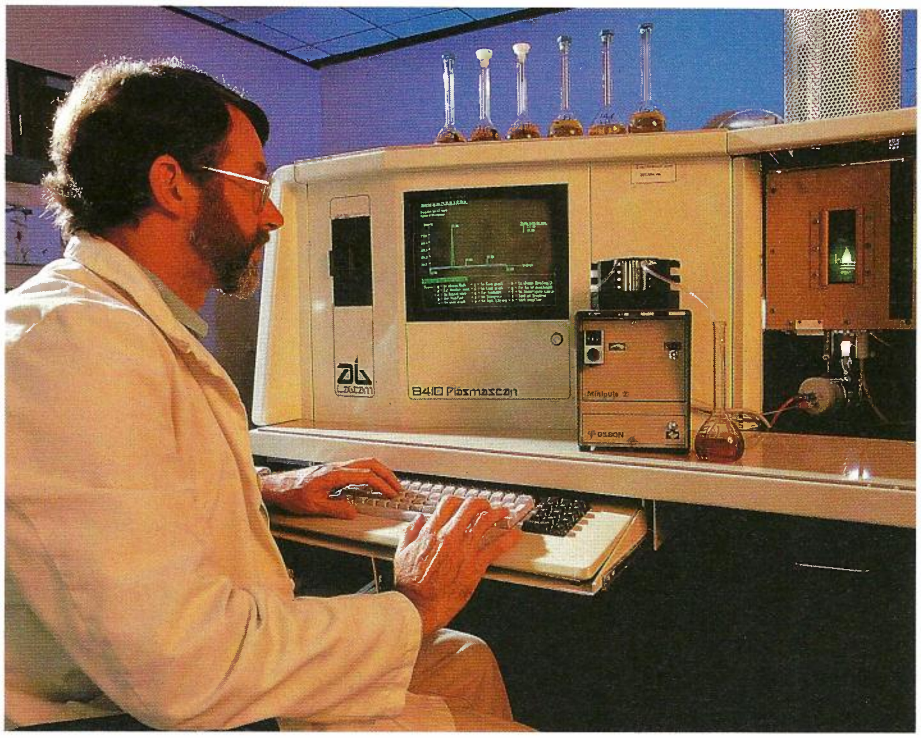
Effects of Heating Materials in Confined Work Environments

Many work practices, particularly in external plant operations, require Telecom staff to apply moderate heat to a variety of materials. The lead wiping process for large size cable joints and the use of shrink-down thermo-plastic sleeves in general cable jointing practice are typical examples. The work practice involving the particular material and the application of heat to it have been developed to ensure that tasks are readily and adequately accomplished to achieve operational reliability and network integrity. However, many of these practices are performed in confined spaces, such as cable pits, where the use of excess heat or its accidental application to other nearby materials could lead to a significant level of decomposition products in the working environment. In turn, this could present a hazard to staff or plant.

During the past year, the Laboratories pursued two investigations to identify the chemical species which might be produced in the confined working environment of a cable jointing pit, as a result of:

- the decomposition of stearine soldering flux during the lead wiping process
- accidental thermal decomposition of polyurethane duct sealant during general heating torch usage.

The study involved the rapid heating of these materials to approximately 600°C, collection of the released decomposition products by use of a cryogenic trap and analysis using the combined techniques of gas chromatography and mass spectrometry.



The Laboratories' inductively coupled plasma atomic emission spectrometer

This work has identified the chemical species which might be produced in such circumstances. When coupled to quantitative data relating to the volume of materials involved and the size of the confined working environment in a particular working situation, a comprehensive assessment of exposure levels and the possible hazards to personnel or plant can now be quickly made.

The Kinetics of Vapour Capture in Work Site Monitoring

The broadening use of chemical products in general, and of polyurethanes (PUR) in particular, combined with the extremely low safe exposure levels specified by Worksafe Australia, has required the Laboratories to confirm the speed and stoichiometry of relevant vapour capture reactions. The Worksafe Australia specifications give Threshold Limit Values (TLVs) for safe working. In many cases, TLVs of 0.02 parts per million are specified. These call for new and more accurate techniques for monitoring workplace atmospheres and for ensuring that any minute quantities of potentially harmful substances are detected and subsequently analysed comprehensively in the Laboratories.

The increasing availability and diversity of commercially packaged PUR-based jointing, splicing and filling kits for external plant applications has focussed the Laboratories' attention to this family of products in recent times.

The most recent study involved the conventional capture system for air-borne materials above the curing product, except that the absorbing species was a substituted piperazine, a compound whose capture activity can be stopped by the addition of acetic anhydride. By varying the allowed reaction period and subsequent analysis of the products present by high pressure liquid chromatographic techniques, the Laboratories confirmed the total capture efficiency of the substituted absorbing solution.

The application of this new technique will enable the Laboratories to perform reproducable, accurate examinations of candidate PUR materials for the external plant network.

Plasma Emission Spectrometry in Occupational Health Hazard Assessment

The Laboratories recently commissioned an Inductively Coupled Plasma Atomic Emission Spectrometer (ICPAES) for use in the analysis of elements at very low parts per million (ppm) concentration levels. This facility has proved valuable in the precise chemical analyses required to assess potential hazards in the work environment which might affect the health of Telecom personnel.

In the application of the ICPAES, inductively coupled argon gas and radio frequency energy produce a plasma which has a core temperature of approximately 9000 degrees Kelvin. Sample solutions are pumped into the plasma, where molecules containing analyte elements are dissociated into their atomic species. Sufficient energy is available in the plasma to ionize the analyte atoms, which then emit energy in the form of light as they return to their normal atomic state. The wavelength of this emitted light provides a fingerprint for the analyte element, and the intensity of emitted light is proportional to analyte concentration in the pumped solution.

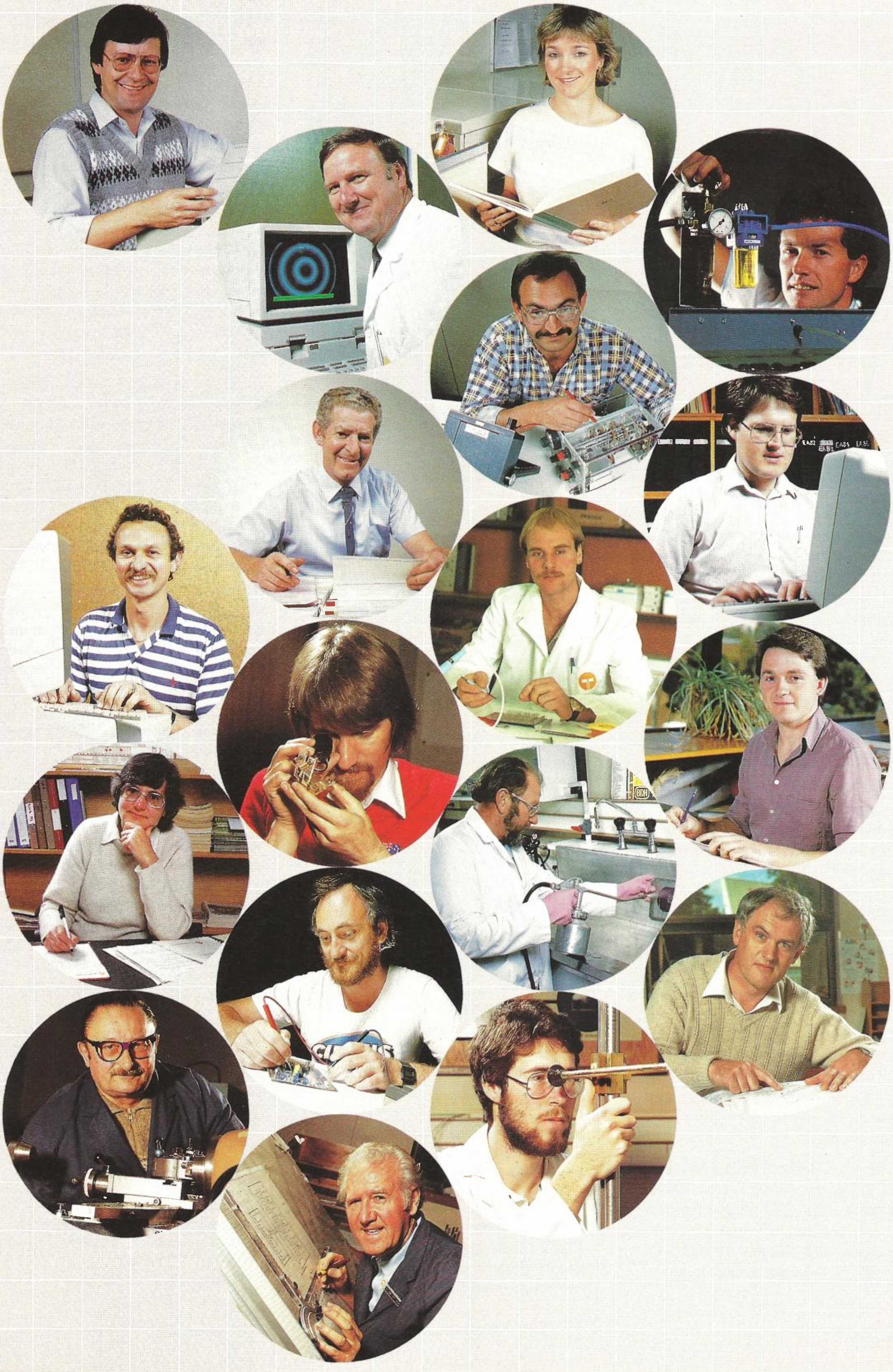
Several occupational health hazard assessments have been undertaken using this highly sensitive, ultra-low trace element detection facility. The most significant has been the application of ICPAES to the determination of copper, chromium and arsenic levels upon the surface of preservative-treated hardwood. This investigation was triggered by the fact that, in northern Australia, a treated pole manufacturer covered the preservative-treated hardwood product with a pressure-applied polymer sealant. Its purpose was to minimise cracks caused by moisture loss. It was considered possible that this process might also reduce worker exposure to preservative chemicals, and the Laboratories' investigation concentrated on this latter aspect.

In the laboratory investigations, a surface wash of sealed and unsealed pole products was performed. The concentrations of preservative residue upon the surface were then quantified. The results showed that the application of the polymer sealant produced a positive beneficial effect in reducing the exposure of personnel handling preservative-treated pole products.

Whereas the unsealed products presented little occupational hazard, the sealed products have reduced any hazard by a further order of magnitude.

HARDWOOD	mg of element/m^2		
	Copper	Chromium	Arsenic
Unsealed	12.7	14.1	17.2
Sealed	2.9	2.6	2.2

Table showing concentrations of residues on the surfaces of sealed and unsealed preservative-treated poles



Technology and 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 large number of small to large R&D projects which generally seek to develop technical knowhow across the spectrum of telecommunications science and technology and to transfer the knowhow to a wide range of Telecom "client" Departments, 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 informal day-to-day working interactions between Laboratories' staff and those of the client Department and through formal 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 external publishers. 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 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 which have taken place over the past year.

PROTOCOL ENGINEERING WITH PROTEAN

PROTEAN is a software tool which aids the comprehensive verification of communications protocols, the sets of rules which are needed to establish and manage connections between terminals communicating over modern complex switched networks. PROTEAN was developed in the Research Laboratories about six years ago and has since undergone a number of enhancements. It is based on Numerical Petri Net techniques and has been used extensively in the Laboratories to verify a number of protocols. This work has not only been to Telecom's benefit but it has also provided a basis for Telecom's contributions to the processes of developing international standards for protocols in the relevant study groups of the CCITT and ISO.

Telecom has licensed PROTEAN to a number of Australian Universities and Institutes of Technology and to CSIRO's Division of Information Technology. These licences have protocol engineering research as their basic objective and have provided a valuable vehicle for collaboration and co-ordination of this Australian R&D effort. They have also led to some enhancement of the PROTEAN package, thereby increasing its usefulness.

In June 1986, the Jutland Telephone Company of Denmark was licensed to use PROTEAN. Jutland Telephone, which provides all telecommunications services in the mainland part of Denmark, is now using PROTEAN for verification of interworking protocols. As part of the licence arrangements, three members of the Research Laboratories visited Denmark to give five days of consultancy lectures, install PROTEAN and conduct some test suites. The lectures covered the fields of general protocol engineering, Petri Nets and Numerical Petri Nets, PROTEAN and how to use it, and the protocol verification methodology developed by the Laboratories. A major case study was also presented on the modelling and verification of the Open Systems Interconnection Class O Transport Protocol.

In March 1987, a firm order for PROTEAN, a maintenance contract and a five day consultancy course was received from Philips in Germany. Two Research Laboratories' staff provided the consultancy in April 1987.

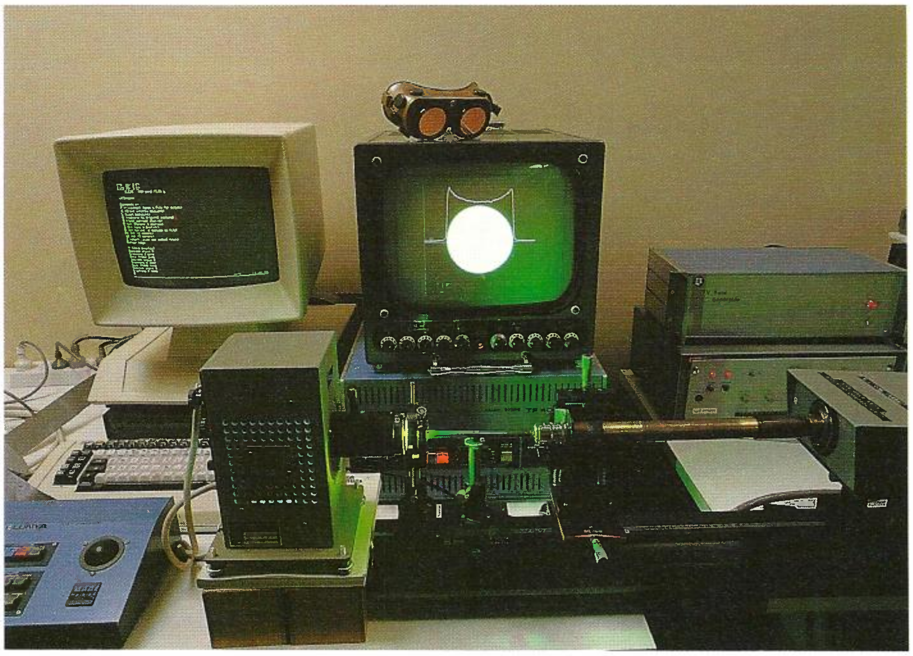
Since October 1986, UNICO Computer Systems Limited, an Australian software company, has been maintaining and extending PROTEAN under contract to Telecom, in close collaboration with the Switching and Signalling Branch of the Laboratories. UNICO had previously successfully completed another Telecom R&D contract, let in 1985, to develop software that implements the OSI Transport Layer protocols. This contract resulted in an implementation of transport protocol classes 0 to 3 and supporting software. The implementation was also based on Numerical Petri Net techniques.

The expertise gained by UNICO in this specialised area of communications protocols has demonstrated that Telecom's R&D contracts successfully assist the processes of technology transfer. As a result of its work in the protocol engineering field, UNICO now proposes to write generic software that can be used to implement any Numerical Petri Net specification of a protocol, as a proposed tool which could be used to produce test suites from the specifications that are suitable for testing implemented protocols.

THE MELBA SDL GRAPHICS TOOL

The software required to control modern, computer-based switching systems is extremely complex. The International Consultative Committee for Telegraphy and Telephony (CCITT) has developed Recommendations for a Specification and Description Language (SDL) and a high-level programming language (CHILL), to assist in the specification, design and implementation of such communications systems.

To support its own R&D in this field, Telecom, through its Research Laboratories, issued an R&D contract to the Royal Melbourne Institute of Technology (RMIT) for the investigation and development of methods of converting SDL diagrams directly into CHILL code. This led to the development of a computer-based system called MELBA. SDL diagrams are drawn on an IBM PC/AT desktop computer and the resulting files are transferred to a VAX minicomputer for definition of data and CHILL code generation.



A PROTEAN terminal

It is expected that the SDL graphics tool will be used extensively within Telecom Australia, since SDL is now widely used as a specification and design technique.

The development of MELBA has enabled a considerable number of RMIT's undergraduate students to learn about SDL and CHILL and their application to communications systems. Several postgraduate students have become experts in the methodologies. One of them, Mr C.J. Fidge, together with RMIT staff member, Mr R.S.V. Pascoe, have made significant contributions to CCITT on the development of SDL.

RMIT is also using MELBA to support another Telecom R&D contract for investigations of design techniques for very large scale integrated (VLSI) circuit devices. The desired VLSI system design is specified using SDL on MELBA. The resulting CHILL code is used as an intermediate language and is converted to another language called ZEUS, from which the plans for the silicon layouts are developed.

As a result of Telecom's R&D contracts, RMIT has developed a tool which is not only of great interest to Telecom Australia but which is also used in RMIT's own teaching and research programmes. At the same time, RMIT is training students in techniques which Telecom uses and will continue to use for some time to come, adding relevance to their future employment prospects in the telecommunications sector.

MOBILE/PORTABLE EARTH STATION FOR SATELLITE COMMUNICATIONS

To assist its intramural investigations of the transmission aspects of using communications satellites to provide new services, Telecom recently issued a contract to the Microwave Technology Development Centre (MITEC) at the University of Queensland. The purpose of the contract is to conduct design studies and to develop the radio transmission/reception components of a mobile/portable earth station. MITEC is sub-contracting some of the system design studies and development work to two Australian companies, Codan Pty Ltd and Trippett Allan and Associates.

Under the contract, MITEC will use a modular approach to the design and development of an experimental terminal which will be used by the Research Laboratories to establish a "test bed" operating through the AUSSAT satellite system. The terminal will comprise a small, hemispherical pattern antenna (less than one metre diameter), a low noise amplifier sub-system and separate tranmitter/up converter and receiver/down converter modules. The test bed will enable the Research Laboratories to undertake an experimental programme of research into modulation, coding and multiple access schemes for future voice, data and text services offered via satellite.

The antenna system to be developed under the contract will provide receive-only facilities for mobile studies using land vehicles. Concurrently, the Research Laboratories are developing a smaller antenna system for portable transmit/

receive applications. The modular design approach will allow small earth stations to be configured in experimental test beds to work via the AUSSAT satellite system to a larger earth station at the Research Laboratories. This latter terminal utilises a 6.4 metre antenna to ease transmit power and receiver sensitivity requirements of the smaller terminals. The test bed will provide Telecom with a research facility which can be adapted to transmission tests between either a small fixed earth station or a mobile earth station located anywhere in Australia.

The contract with MITEC involves the application of state-of-the-art microwave technology in the development of the transmission elements of a small earth terminal, which will be low cost, rugged yet small in size and lightweight, reliable and consume little power. The work could lead to the further development of a complete portable/transportable terminal.

Established in 1980 as a national Centre of Excellence in microwave technology, MITEC now provides a significant resource in advanced microwave technology in Australia. The potential importance of this technology for Australia is now well understood and MITEC is well placed to participate in the growth of this new industry. Telecom's contract will allow MITEC to expand its knowledge and facilities for providing total integrated system designs for satellite communications. Hopefully, this will lead to technology transfer which will benefit Australia in the large quantity manufacture of local microwave system designs, such as small mobile/portable satellite terminals, thus easing Australia's dependence on overseas manufacturers for this technology.

DIGITAL RADIO TEST SET

Over the last six years, the Laboratories have investigated a number of parameters potentially affecting the performance of high capacity 140 Mbit/s digital microwave radio systems in the long distance trunk network. One such investigation concerned the degradation of performance due to propagation effects. To develop route design techniques, the Laboratories undertook a highly instrumented field experiment between 1982 and 1984, and the detailed analysis of propagation effects on system performance led to the development of a robust route design technique which is the basis of Telecom Australia's current technique.

A novel method of equipment and system testing was conceived out of this work, whereby the concept of a "dispersion signature" enabled practical field measurements to indicate the performance of working systems carrying traffic. The concept was subsequently the subject of patent applications filed by Telecom Australia in Australia and overseas countries. The realisation of a "digital radio test set" employing the dispersion signature concept was considered important to Telecom Australia's implementation of digital microwave systems and also an opportunity for local industry to develop a new product for a narrow but significant overseas market niche.

In order to obtain production prototypes of the digital radio test set for field evaluation, Telecom let a research and development contract to Mintec Telecommunications Pty. Ltd. in 1986. Mintec Telecommunications has also been licensed by Telecom Australia to commercialise the invention, and the licence arrangements encompass a technology exchange agreement between Mintec Telecommunications and Hewlett Packard Australia Ltd, who will also market the final product.

Under Telecom's contract, Mintec Telecommunications is developing two versions of the test set, a laboratory version and a field version. The laboratory version will incorporate a multipath simulator to create an electrical model of multipath characteristics which affect digital microwave systems. This version can be applied to tune and test a system to its correct dispersion signature in the laboratory, prior to putting the system into service. It will also enable design testing of new equipment or laboratory comparisons of the performance of different types of equipment.

The more robust field unit will not incorporate the multipath simulator since it will be used to test digital radio systems which are in service. This version of the digital radio test set will emphasise portability and ease of operation.

OPTICAL LOCAL DISTRIBUTION NETWORK

The concepts of a novel passive digital optical local distribution network arose out of recent Laboratories' investigations of customer access networks. The network concepts are the subject of patent applications lodged by Telecom Australia.

During 1986/87, a contract for the further research and development of a prototype network was let to Standard Telephones and Cables Pty Ltd (STC), with Australian Optical Fibre Research Pty Ltd (AOFR) as the sub-contractor for the optical portion of the network.

The successful performance of the contract requires research and development in two main fields. The multiplexing of the individual streams of information to and from sixteen customer ends in a single distribution network is STC's responsibility, along with the development of suitable electronics for the optical transmitters and receivers. In the field of optical technology, AOFR will develop advanced single-mode optical couplers to ensure that sufficient optical bandwidth is available to support both-way transmission. In the future, the bandwidth requirement may increase, and some preliminary work will be commenced under the contract to establish the feasibility of providing additional broadcast capacity in this type of network.

STC is one of Australia's largest telecommunications manufacturing companies, and has recently won contracts for the design, development and supply of low capacity single-mode optical fibre systems. This contract is sufficiently different from the previous contracts to provide a number of challenges, and the exchange of ideas during the performance of the contract will benefit both STC and the Research Laboratories.

AOFR has an agreement with the Australian National University and the Australian Defence Force Academy for theoretical support of the development of couplers and other optical components. Telecom's contract is providing AOFR with additional resources to help maintain its position as a world leader in the field of fused tapered coupler research and development.

DIGITAL CELLULAR MOBILE TELEPHONE SYSTEMS

During 1986/87, Philips Communication Systems Ltd commenced a study of the significant parameters and techniques for increasing the capacity of future digital cellular mobile radio telephone systems. A major objective of the study will be to fit the maximum economically feasible number of customers into the limited available radio band. The study is being supported by a Telecom Australia R&D

contract and will extend over a period of two and a half years.

To assist the study, Philips will enlist the expertise of its research centre for digital mobile telephony in Nuremberg, West Germany. The three-way involvement of Telecom and the two Philips companies will provide a significant vehicle for technology transfer to Australian industry.

Telecom expects to use the outputs of the contract to assist the planning and specification of its next generation digital mobile radio systems. Expected to be introduced in the mid-1990s, these systems will provide digital telephone and data communications in the 900 MHz or 1.5 GHz bands. Terminals are expected to include pocket-style, in-car and book-size keyboard/screen versions.

EXPERIMENTAL ISDN NETWORK

During 1985, Telecom, through the Research Laboratories, commenced a contractual partnership with Standard Telephones and Cables Pty Ltd (STC) to establish and operate, within the Laboratories, an experimental network comprising Integrated Services Digital Network (ISDN) exchanges and terminals. The prototype exchanges used in the network were developed by BTM in Belgium, with involvement of STC engineers to ensure that the new technology involved was well understood and could be further developed in Australia. The experimental network is being used as a test bed for a variety of ISDN-related studies.

During the experimental period, the network has been operated in a series of interworking trials by a joint team of STC and Telecom engineers and technical staff. This has provided technology transfer in two directions. Telecom's staff have gained an increased understanding of ISDN switching technology, and STC's staff have gained a deeper understanding of the possibilities of interworking ISDN, voice and packet networks.

THE QPSX DISTRIBUTED COMMUNICATIONS NETWORK

QPSX is a distributed communications network which is categorised as being a Metropolitan Area Network. The concepts of QPSX were developed by the University of Western Australia following research into techniques applied in Local Area Networks. The QPSX concept has since been developed to prototype model status by the University, which has been assisted in this work by R&D collaboration with staff of the Laboratories and the issue of a Telecom R&D contract.

A key feature of the QPSX network is its ability to provide integrated switching of both voice and data services through a common fabric for both circuit and packet modes of switching. Circuit switching is primarily used for voice and other signals having real time constraints. Packet switching is used for data communications, an application environment in which real time constraints are far less critical. QPSX accommodates circuit and packet switching within a common structure and both share the available capacity of the switch.

Telecom's contract placed emphasis on two aspects of the QPSX project. Firstly, the development of the original QPSX concepts was undertaken to derive an integrated voice and data communications network design outline. Then through the development of laboratory prototypes, it was demonstrated that such a network was feasible for development by industry. Another key aspect of the work was to ensure, through appropriate contributions to the IEEE developments of international technical standards for Metropolitan Area Networks, that QPSX complied with evolving international standards.

The output of the QPSX contract has been the rapid development and successful demonstration of a prototype distributed switch which offers integrated voice and data facilities and which has demonstrated ability to interwork with existing public networks. In its present form, QPSX is capable of satisfying a number of multiservice applications within both private and public networks. Possible private network applications include distributed PABXs and LANs.

Telecom, together with the University of Western Australia, has recently stimulated international awareness of QPSX capabilities through promotion in the international standards arena. QPSX is now under active consideration within IEEE 802.6 as a candidate for standardisation as a metropolitan area network (MAN).

Confidence in the future of QPSX as a commercial product has developed over the two and a half year period of Telecom's R&D contract, which will be completed in July 1987. This confidence has led to the recent formation of a company to carry QPSX into commercial production, as a joint venture by the University, Telecom and Australian industry.

FAST PACKET SWITCHING RESEARCH PLANNING WORKSHOP

A Fast Packet Switching Research Planning Workshop was held at Telecom's Research Laboratories on 24 November 1986. It was attended by 70 people from 25 organisations and 14 papers were presented. The Workshop was sponsored by the Australian Telecommunications and Electronics Research Board (ATERB) and Telecom Australia.

One of the motives for the Workshop was the wish shared by ATERB and Telecom to support a co-ordinated programme of complementary investigations relating to fast packet switching and its application to integrated information services. The Workshop was a first step. Its aim was to identify research topics and institutions interested in the field of fast packet switching and its applications, and to plan future complementary activities. The Workshop was very successful in achieving its aim and has stimulated a number of new research initiatives.

Fast packet switching (FPS) involves much more than a switching mechanism. It encompasses a new generation of communications networks that will be able to support a new range of services. In the near future, FPS will permit voice, data and video services to be provided on a single integrated network. This will provide economic advantages to customers and network providers, but more importantly, it will increase the flexibility of networks to handle new and changing services.

The papers and discussions of the Workshop concluded that the development of FPS will require many new studies and developments to be commenced, covering terminal equipment, variable rate encoding for voice, video and images, customer access and network protocols, switching architectures, performance analysis and network management techniques. It was agreed that, in order for Australia to be able to produce and effectively use information products using fast packet switching, a complementary range of research topics needs to be investigated in a planned and co-ordinated manner.

As a result of the Workshop, a matrix of research topics and interested institutions has been determined. The Research Laboratories will continue to play an active role in helping to co-ordinate these research activities.

The Siemens K1195 Protocol Tester

ISDN PROTOCOL TESTING

In December 1986, Telecom Australia, Siemens (Germany) and Siemens (Australia) established a joint project team within the Laboratories to develop an ISDN Access Protocol Tester based on extending the functionality of the Siemens K1195 Protocol Tester. The ISDN Tester will be designed to test both internationally standardised CCITT D-channel protocols and Australian- specific realisations of these protocols. The tester will permit the monitoring of D-channel traffic and the emulation of either user or network equipment at the Primary Rate or Basic Access points. It is anticipated that the tester will fill both Australian and world market niches.

The project team is responsible for the development of the Layer 3 software, specifying some of the Layer 1 testing facilities and upgrading the existing Layer 2 software. The Layer 1 hardware and most of the Layer 1 and Layer 2 software is being developed by Idacom (Canada), an affiliate company of Siemens. Nearly all of the software is being coded using the powerful and readily extendable programming language and environment, FORTH, from functional specifications written using the CCITT Specification and Description Language, SDL.

On completion, these new ISDN Access testing capabilities will play a critical role in testing and commissioning the Australian Integrated Services Digital Network (ISDN) and associated Private Automatic Branch Exchanges (PABXs), Local Area Networks (LANs), ISDN customer terminals and terminal adaptors.

Another pleasing aspect of this joint development is the technology transfer that is taking place. Information and skills relating to the K1195 Protocol Tester are being transferred from Siemens (Germany) to Siemens (Australia) and Telecom Australia, while knowledge of protocol engineering and ISDN developments are being transferred from Telecom to both local and overseas industry.

FIRST AUSTRALIAN TELETRAFFIC RESEARCH SEMINAR

The first Australia-wide teletraffic research seminar was held at the Laboratories on 25-26 November 1986. The seminar attracted almost 100 engineers and mathematicians from universities, colleges of advanced education, OTC (Australia), telecommunications equipment manufacturers and Telecom Australia. The objective of the seminar was to explore new directions for research in teletraffic engineering and to stimulate interest in this discipline among Australian academics. To reflect the emphasis being given to new techniques that are required for the analysis, dimensioning and management of new telecommunication networks and services to be provided by Telecom, the theme chosen for the seminar was "The New Teletraffic Engineering".

A total of 23 papers were presented at the seminar, of which 13 were contributed by staff of the Laboratories. The keynote address was given by an invited speaker, Professor Dr-Ing Paul Kuehn of Stuttgart University, a world authority on teletraffic engineering and data switching. The majority of the papers concentrated on the problems presented to teletraffic engineers by new telecommunications networks and services, which are considerably more complex than the familiar telephone network and require the application of new mathematical and simulation techniques for their analysis. In addition to the papers which created considerable interest among the participants, the seminar programme also included two panel discussions. The first panel dealt with the question of what do customers expect from the "new" teletraffic engineering, while the second reviewed what has already been achieved and attempted to chart future directions for teletraffic research.

It was gratifying to see strong participation by academic staff of Australian universities. Until recently, apart from one or two notable exceptions, universities have not been greatly interested in teletraffic engineering problems. The seminar showed that there is a great deal of as yet untapped expertise in this subject in the universities, which could be harnessed to carry out studies complementary to those already being pursued in the Laboratories. This is already happening in the newly established Teletraffic Research Centre at the University of Adelaide, which, as reported in an adjoining item, is being funded by Telecom Australia under a research and development contract.

WORKSHOP ON STOCHASTIC MODELLING FOR DIGITAL COMMUNICATIONS SYSTEMS

Stochastic processes are essential tools in the modelling of digital transmission systems. The modelling must encompass the digital signals, the variety of channels over which the signals are transmitted and various operations in the transmitters and receivers. Important areas for the application of stochastic processes include calculating the power spectral density of digital signals, determining the performance of adaptive equalisers and echo cancellers, modelling radio propagation channels and characterising the large number of noise processes that occur in optical fibre systems.

Recognising the importance of modelling techniques and the benefits of cross-fertilising ideas among research personnel working on different transmission media (such as radio, satellite, metallic and optical fibre cables), the Australian Telecommunications and Electronics Research Board (ATERB) sponsored a 2-day Workshop on Stochastic Modelling in Melbourne in August 1986. Staff of the Laboratories assisted in organising the Workshop and presented papers.

The Workshop was organised by a committee comprising Dr B.R. Davis (University of Adelaide), Dr D.B. Keogh (Monash University) and Dr P.G. Potter and Dr B.M. Smith of Telecom's Laboratories. The workshop was restricted to 25 participants, all of whom were active researchers in the field. About half were from academia. Dr David Falconer of Carleton University, Ottawa, was invited to attend and brought his wide experience in digital communications research, especially adaptive equalisation and echo cancellation, to the Workshop. He also visited various research organisations in Melbourne, Adelaide, Canberra and Sydney after the Workshop.

Fifteen papers were presented at the Workshop and generated lively discussion. Several papers emphasised the richness of stochastic processes in optical fibre system modelling. With the emergence of these systems as a major medium of transmission, the importance of stochastic modelling in digital communications theory was reinforced. The Workshop provided a good opportunity for educators to hear at first hand which areas of stochastic processes are useful in the modelling of current communications systems. Several papers highlighted the necessity of using cyclo-stationary statistics in the modelling of digital signals. A session on the teaching of stochastic communications theory allowed the educators to discuss their different approaches to teaching in this topic field and to emphasise to the non-educators the realities of teaching, especially to undergraduates.

THE FIRST AUSTRALIAN CONFERENCE ON SPEECH SCIENCE AND TECHNOLOGY

The first Australian Conference on Speech Science and Technology was held in Canberra on the campus of the Australian National University between 24-27 November 1986. The Conference was sponsored by the Department of Industry, Technology and Commerce, the Department of Science, OTC (Australia) and Telecom Australia. The Conference was initiated by the Australian Speech Research Association and provided a national focus for recent advances in the rapidly developing field of speech science and technology. An organising committee representing government agencies (including Telecom), industry and academia put together a conference agenda covering the interests of each of these three sectors and was rewarded by substantial attendance from each sector. In all, 127 delegates attended the whole or part of the one-day tutorial, two-day conference and one-day workshop sessions. A stimulating exhibition of current speech technology products and tools accompanied the conference.

The tutorial session attracted about 50 people to lectures on the basics of speech technology, covering speech production, perception, analysis, synthesis and automatic recognition. The lectures were given by five researchers in the field. A final panel presentation of current applications was followed by a lively question and answer session.

The two-day conference was opened by Senator, the Honorable John N. Button, Minister for Industry, Technology and Commerce. Keynote speakers were Professor John Laver of the Centre for Speech Technology Research, University of Edinburgh, and Professor Louis Pols of the Institute of Phonetic Sciences, University of Amsterdam. Both speakers gave complementary overviews of the world scene in speech science and technology. Professor Laver also highlighted the social implications of two-way speech communication with machines, while Professor Pols emphasised the need for very careful objective assessment of the performance of speech devices or systems.

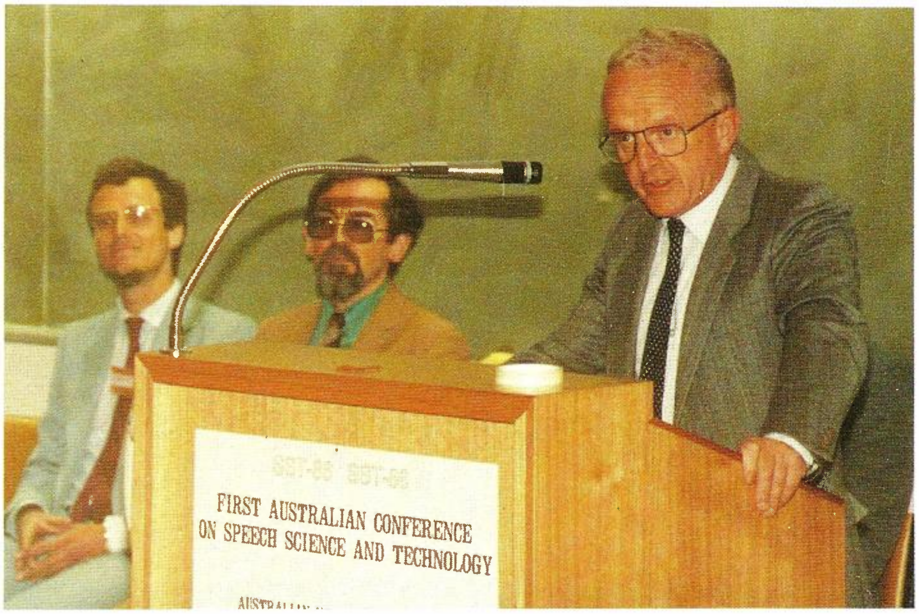
There were 62 contributed papers presented in two parallel streams of seven sessions. The session themes comprised text-to-speech synthesis, speech disorders, speech perception, speech technology in communications, speech analysis, assessment of speech technology applications, speech aids for the disabled, speech signal processing, speech research hardware and software, speaker characteristics, speech technology applications and automatic speech recognition.

Six papers, one for the tutorial day and five for the conference, were presented by staff of Telecom's Research Laboratories, as follows:

- "Speech Technology Applications for Telecommunications" (tutorial paper)
- "Algorithmic Issues of Adaptive Differential Pulse Code Mudulation with Reference to CCITT Recommendation G.721"
- "An Experimental Study of Residual Excited Linear Predictive Coders for Telecommunications Purposes"
- "The Assessment of Isolated Word Speech Recognisers"
- "A Perspective on Telecommunications Services with Relevance to Speech Processing"
- "Voice Response Techniques for Telecommunications Applications"

The final day comprised three informal workshops for researchers active in the fields of speech normalisation, quantitative assessment of speech devices and speech chip technology. These workshops attracted some 55 people.

The very positive reaction to all sessions has encouraged the organisers to plan for a further conference in Sydney in November 1988.



Senator the Honorable John N. Button, Minister for Industry, Technology and Commerce, opens the first Australian Conference on Speech Science and Technology

ADVANCED TELETRAFFIC ENGINEERING COURSE

Staff of the Laboratories joined with staff of the Network Engineering Department to present the tenth course on advanced traffic engineering techniques between 7-19 September 1986. The course is a regular specialist course encompassed by Telecom's Engineer Development Programme. It is presented, on average, every second year. Course participants are primarily Telecom engineers, but some course places are usually offered to non-Telecom personnel.

A total of 31 participants attended this latest course. Of these, 28 were from Telecom, two from Hong Kong and one from the People's Republic of China.

The first of these teletraffic engineering courses was held almost 20 years ago, in 1967, when the need for training in teletraffic engineering theory and methods was first recognised. The original course syllabus and the lecture notes were prepared by Dr C.W. Pratt, who also did most of the lecturing. In 1976, the course syllabus and the lecture notes were extensively revised and expanded by the senior professional staff of what is now the Teletraffic Research Section of the Laboratories. Further updating of the lecture material and project work has been done before each subsequent course. To refresh the relevant mathematical skills of the older participants, a 3-day Maths Workshop is also now presented prior to the main course.

SDL COURSE FOR AUSTRALIA POST

The CCITT Specification and Description Language, known as SDL, has been designed to suit the specification and description of the behaviour of telecommunications switching systems. It was first standardised in 1976. Extended and revised versions of SDL were published in 1980 and 1984, and the 1988 version was approved using the CCITT accelerated procedures in 1987. SDL has gained widespread application in the telecommunications industry and is now used in over 23 countries.

A two-day course has been developed by the Research Laboratories to introduce engineers to this important technique. It includes a case study which examines part of the X.25 protocol. The course has been presented to Telecom Australia staff many times as part of Telecom's Engineer Development Programme.

In September, 1986, the course was presented for Australia Post as a consultancy service. As well as Australia Post staff, the course was attended by personnel from the private companies, Burroughs Cyberware, Fortronic Technology and Computer Power.

The course was very successful, demonstrating that SDL fulfils a real need to be able to specify communications protocols formally. Australia will benefit from the increased understanding of SDL by engineers outside Telecom Australia, and this is likely to be of advantage to Telecom as well as to Australia Post.

The Laboratories – Summary Information

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.

THE RESEARCH LABORATORIES' ORGANISATION

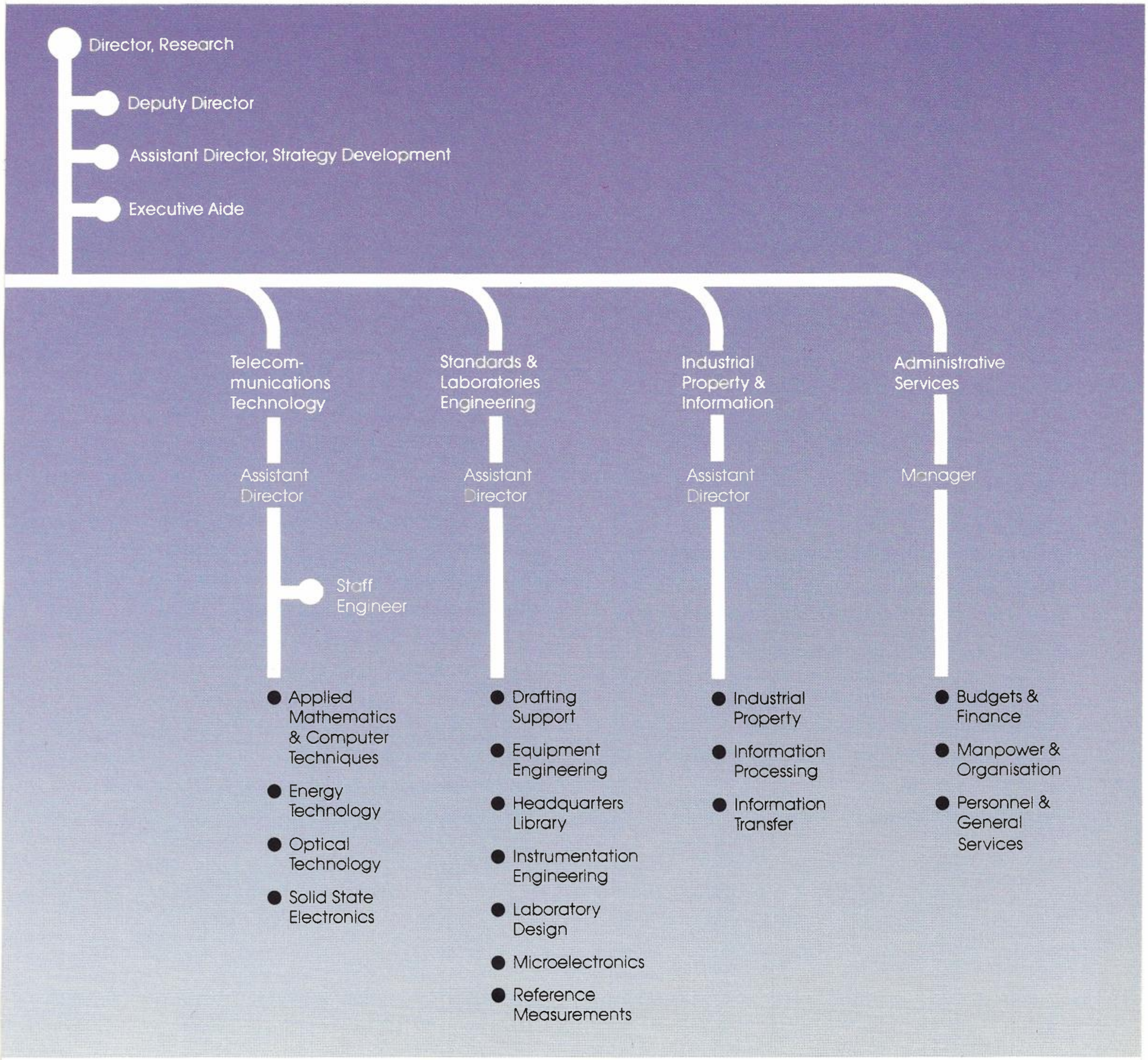
BRANCHES	Customer Services & Systems	Switching & Signalling	Transmission Systems	Applied Science
	Assistant Director	Assistant Director	Assistant Director	Assistant Director
SECTIONS	• Access Control & Authentication • Customer Access • Human Communication • Telematic & Message Services • Voice Services	• Computing Facilities • Distributed Computing • Networks & Signalling • Switching • Teletraffic Research	• Electromagnetic Compatibility • Local Access Systems • Optical Systems • Radio Systems • Satellite Systems	• Chemistry • Device Technology • Electrochemistry • Polymer • Solar & Environment • Surface Characterisation

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 Research Laboratories constitute a Department of the Headquarters Administration of Telecom Australia. The Director, 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 Director's Office, an Administrative Services Group, and thirty five scientific and engineering Sections arranged in seven Branches. The scientific and engineering Sections each possess expertise in particular areas of telecommunications engineering or science.



Professional and Senior Staff

EXECUTIVE

Director: H.S. Wragge, BEE(Hons), MEngSc(Hons), FIEAust

Deputy Director: R. Smith, BE(Hons), ME, MIEE, SMIREE

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

Executive Aide: B.F. Donovan

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.

Assistant Director: R.J. Morgan, BSc(Hons), PhD

Branch Administrative Officer: H. Merrick

Access Control and Authentication 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, databases, etc.
- Contribute to and evaluate international standards relating to secure telecommunications.

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

Principal Engineer: N. Demytko, BSc, BE(Hons), MAdmin

Engineer: E.A. Zuk, BE, ME

Senior Technical Officer: R.I. Webster

Customer Access Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Conduct theoretical and experimental research into the techniques of providing customer access to Telecom's value added services
- Evaluate emerging international standards on customer access and related service issues, including terminal developments, database access, graphics and ISDN
- Conduct studies into the interworking of Telecom Australia's services and networks with customer systems and networks.

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

Principal Engineer: P.I. Mikelaitis, BE, MEngSc, MIEEE

Senior Engineer: B.J. McGlade, BE(Hons)

Engineer: A.J. Hopson, BE(Hons)

Senior Technical Officers:
D.A. Drummond
P.D. Jackson

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 communication 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 efficiently
- 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

Principal Engineer: J.K. Craick, BE(Hons), BSc

Principal Scientist: J.B. Guy, BSc, PhD

Senior Engineer: A.R. Jenkins, Dip Comm Eng, ARMIT

Senior Psychologist: G. Lindgaard, BSc(Hons), SRN, MAPS, AFMAPA

Psychologists:
J. Chessari, BSc(Hons)
M. Papasava, BSc(Hons), PhD

Senior Research Officer: M.E. Cavill, BA(Hons), Dip TRP, MRAPI

Senior Technical Officers:
A.H. Borg
D.R. Potter

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: E.K. Chew, BE, MEngSc, PhD, MIEEE, MACM

Technical Specialist: R. Exner, BSc, BE(Hons), MAppSc, MIEEE

Principal Engineers:
P.C. Craig, BE(Hons), PhD, MIEAust
M.J.T. Ng, BSc(Hons), PhD
D.Q. Phiet, BE(Hons), PhD

Senior Engineer: M. Blakey, BE(Hons), MEngSc

Senior Scientist: B.P. Smetaniuk, BSc(Hons), Dip CompSc, PhD

Engineers:
M. Andrews, BE(Hons), BSc
A. Loch, BE(Hons)
J.B. Nakulski, BE(Hons)
P. Nguyen, BE(Hons)
S. Pungsornruk, BE, MSCS

Scientist: S. Legg, BSc(Hons)

Principal Technical Officer: I.J. Moran

Senior Technical Officers:
B.W. Booth
I.C. Meggs

Voice Services Section

Functions

- Provide information, advice and consultancy as defined in Branch objectives
- Conduct theoretical and experimental research into techniques relating to the generation, synthesis, transmission, reception, recognition, measurement and characterisation of speech signals for telecommunication services
- Develop quality assessment techniques and associated reference standards for services incorporating speech processing, and make recommendations on their performance criteria
- Conduct investigations into audio frequency acoustic signal propagation and noise in relation to the provision of voice communications services.

Section Head: E.J.Koop, Dip Elec Eng, BE, MAAS

Principal Engineers:
P.F. Duke, Dip Maths, BTech
R.A. Seidl, BE(Hons), PhD

Senior Engineers:
N.H. Duong, BE(Hons), MEngSc
M.J. Flaherty, BE(Hons), PhD

Engineers:
J.P. Goldman, Dip Rad Eng, Dip Comm Eng, GradIEAust
J.S. Spicer, BE(Hons)

Senior Technical Officers:
J.B. Carroll
G.R. Leadbeater
T.R. Long

SWITCHING AND SIGNALLING 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.

Assistant Director: P.H. Gerrand, BE(Hons), MEngSc, MIEAust

Branch Administrative Officer: S.J. Chalk

Computing Facilities Unit

Functions

- Provide co-ordination and support, conjointly with available expert disciplines within the Branch, for the hardware, software and communications facilities associated with the Branch processor complex
- Develop the complex in such a way as to anticipate the directions of the Branch's endeavours and future requirements
- Advise the Branch of new developments in hardware and software, for possible application in the processor complex, other processing equipment, and peripherals.

Technical Co-ordinator: F.R. Wylie, BE

Senior Technical Officers:
P.C. Murrell
S. Dovile

Distributed Computing Section

Functions

- Study and develop new techniques in the application of computer systems to telecommunications networks
- Study and develop new methods for specifying and describing telecommunications systems and facilities and contribute to improvements to Telecom's standards of system specification and description
- Investigate and develop new methods for the application of distributed database techniques in telecommunication networks
- Investigate and develop techniques for the specification and analysis of telecommunication protocols
- Study and contribute to the development of standards for new protocols in ISO, CCITT and for Telecom Australia
- Provide specialist advice in matters pertaining to computer techniques and protocol engineering.

Section Head: E.M. Swenson, MSc, Grad Dip Data Proc, MAIP, MACS, MIEEE, MIE Aust

Principal Engineer: M.C. Wilbur-Ham, BE(Hons)

Principal Computer Systems Officer: R.H. Haylock, MACS

Senior Scientist: G.R. Wheeler, BSc(Hons), MSc, Grad Dip Comp Sc

Senior Computer Systems Officers:
R. Liu, BSc(Hons), Dip Comp Sc, MACS
G.P. Rochlin, BSc, MACS

Engineer: R.J. Fone, BE(Hons), MEngSc, MIEEE

Scientist: H.J. Everitt, BSc(Hons), MSc

Computer Systems Officer: J.A. Gilmour, BAppSc, MIEEE

Networks & 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

Principal Engineers:
R.A. Court, BE(Hons), BSc, MEngSc, SMIEEE, SMIREE
B.T. Dingle, Dip Elec Eng, Be(Hons)
D.R. Manfield, BE, PhD
M. Subocz, BE(Hons), MEngSc, MIEAust

Senior Engineers:
H.K. Cheong, BE(Hons) PhD
D.M. Harsant, BE(Hons)

Engineers:
S.M. Jong, BE
S.A. Leask, BE(Hons)
P. Richardson, BE(Hons)

Scientist: P. Lambrineas, BSc(Hons), Grad AIP, Grad AXAA

Principal Technical Officer: W. McEvoy

Senior Technical Officers:
R.L. Backway
H.G. Fegent

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
- Study interworking between different switched networks and develop interworking units where appropriate to meet future network needs
- Develop network performance analysis and monitoring techniques and apply them to switched networks
- Contribute to the development of standards for packet switched networks and participate in their application.

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

Principal Engineers:
P.V. Bysouth, BE(Hons)
P.R. Hicks, BE, BSc, MEngSc
P.A. Kirton, BE(Hons), PhD, MIEEE
S.L. Sutherland, BE(Hons)
E. Tirtaatmadja, BE, MIEEE

Senior Engineers:
G.A. Foers, BE(Hons), MIEEE
C.J. O'Neill, BE(Hons), PhD
R.A. Palmer, BE, PhD
C.J. Scott, BAppSc, Grad AIP

Engineers:
D. Beard, BE
J.L. Burgin, BE(Hons), MIEEE
B.W. Keck, BSc(Hons), BE(Hons), PhD
I. Lewis, BE(Hons)
M. Littlewood, BE(Hons)

Senior Technical Officers:
P. Ellis
L.D. Lucas
S.G. Ratten
M. Schulze

Teletraffic Research 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: J. Rubas, Dip Rad Eng, ARMTC, MIEAust

Principal Engineers:
R.J. Harris, BSc(Hons), PhD
R.E. Warfield, BE(Hons), PhD

Principal Scientists:
R.G. Addie, BSc(Hons), PhD
L.H. Campbell, BSc(Hons), PhD

Senior Engineer: D.E. Everitt, BE(Hons), PhD

Senior Scientist: R.H. Rossiter, BSc(Hons)

Engineers:
M.Zukerman, BE, PhD
D.W. McMillan, BE, BSc(Hons)

TRANSMISSION SYSTEMS BRANCH

Objectives

- In the field of transmission, 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 signal transmission within the Telecom Australia network
  - new transmission systems, and systems which are extensions of present techniques, with particular reference to their integration into the existing network
  - mutual compatibility of the various services and systems within the network
  - sensitivity studies.

Assistant Director: A.J. Gibbs, BE(Hons), ME, PhD, SMIEEE, SMIREE

Branch Administrative Officer: K.J. Sexton

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

Principal Engineers:
W.S. Davies, BE, MEngSc(Hons), PhD
S. Sastradipradja, BE, SMIREE, MIEEE, MARPS

Principal Scientist: K.H. Joyner, BSc(Hons), PhD, Dip Ed, MARPS, MIEAust

Senior Engineers:
S. Iskra, BE(Hons), MIEEE
E. Vinnal, BE(Hons),MIEEE

Engineer: S. Hamilton, BE(Hons)

Senior Technical Officers:
G.J. Bail
A.J. Cole
P.R. Copeland
D.M. Farr
R.J. Francis
B.C. Gilbert
S.J. Hurren

Local Access Systems Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into both narrowband and wideband customer access transmission systems and networks which utilise various transmission media and possible combinations of these media, with emphasis on the use of optical bearers:
  - for local distribution between the customer and the local exchange involving:

    (i) multiple access techniques and methods for shared utilisation of the transmission medium and the dynamic allocation of bearer capacity

    (ii) provision of wideband services on a widespread basis
  - 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 telecommunication services, and

    (ii) network maintenance, reliability and security protection to provide customer service integrity
- Investigate and develop appropriate performance evaluation methods and design criteria for new local access systems and networks
- Conduct experiments and participate in field trials designed to demonstrate the feasibility of new local access systems and networks.

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

Principal Engineers:
I.M. McGregor, BE(Hons), MEngSc,PhD
P.G. Potter, BE(Hons), PhD, MIEEE
G.J. Semple, BE(Hons), MEngSc

Senior Engineers:
B.R. Clarke, BE(Hons), PhD
P.A. Evans, BE(Hons), MIEEE
M.D. Hayes, BE(Hons)

Engineers:
T. Batten, BE(Hons), MIEEE
C. Desem, BSc(Hons), MSc

Senior Technical Officers:
L.W. Bourchier
G. Dhosi
J.L. Kelly
R. Owers
G. Prete
R.C. Witham
N. Wolstencroft

Optical Systems 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
- Conduct research into transmission systems which utilise optical media
- Evaluate the potential applications and utilisation of systems using such media for the tranmission 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
- Develop and advise on new techniques for the measurement of transmission properties and characterisation of optical systems
- Maintain an awareness of, and evaluate and advise on, emerging techniques relating to optical systems transmission.

Section Head: R.W.A. Ayre, BE(Hons), BSc(Hons), MEngSc, MIEEE

Principal Engineers:
G. Nicholson, BE(Hons), MEngSc, MIEEE
T.D. Stephens, BE(Hons), MEngSc, MIEEE

Senior Engineer: K. Hinton, BE(Hons), BSc, PhD

Senior Scientist: J.L. Adams, BSc(Hons), PhD

Engineers:
D.J. Bakewell, BEE(Hons)
G. Cowle, BSc, BE(Hons)

Senior Technical Officers:
E.A. Dodge
J.H. Gillies
R.G. Hand
D.J. Temple

Radio Systems Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into transmission systems which utilise radio bearers
- Investigate the interworking of such systems with other parts of the transmission and switching network
- Investigate and develop appropriate bearer and system testing methods
- Develop appropriate systems and testing apparatus which are not otherwise available.

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

Principal Engineers:
F.G. Bullock, BE(Hons), GradIEAust, MIEEE
J.C. Campbell, BE(Hons), MEngSc, MIEEE
J.G. Hollow, BE(Hons), PhD, MIEEE
L.J. Millott, BE(Hons), MEngSc, SMIEEE

Senior Engineer: I.C. Lawson, BEE

Senior Scientist: G. Bharatula, BSc, MSc, MTech

Engineers:
A.B. Johnson, BE(Hons), MIEEE
A. Urie, BE(Hons), MIEEE

Principal Technical Officer: R.L. Reid

Senior Technical Officers:
M.J. Durrant
D.A. Jewell
R.N. Swinton
D.J. Thompson

Satellite Systems Section

Functions

- Provide information, advice, consultancy and recommendations as defined in the Branch objectives
- Conduct research into communications satellite technology, systems and networks
- Conduct theoretical studies, hardware development and field investigations to demonstrate the feasibility of new satellite system concepts and related networks
- Evaluate the potential applications and utilisation of such systems and networks for the transmission of existing and emerging telecommunications services
- Maintain and promote an awareness of developments in satellite communications services and networks, and provide consultancy and technical advice of strategic value
- Investigate the interworking of satellite systems and networks with other communications systems and networks.

Section Head: G.F. Jenkinson, BSc, SMIREE

Principal Engineers:
A.J. Bundrock, BE(Hons)
R.K. Flavin, BSc, MSc

Senior Engineer: R.A. Harvey, Dip Rad Eng, BSc, MIREE

Senior Technical Officers:
D.K. Cerchi
A.D Martinus
J.J. Sekfy

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

Assistant Director: G. Flatau, Dip App Sc, FRMIT

Branch Administrative Officer: L. Roberts

Chemistry Section

Functions

- Conduct exploratory research into the chemical properties, composition and behaviour of materials
- Conduct scientific studies into the chemical phenomena and hazards encountered by materials, devices and equipment and advise on protective or remedial measures
- Devise or develop specialised test methods and analytical techniques
- Establish and provide specialised scientific facilities for the assessment of hazardous materials or conditions
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: F.C. Baker, Dip App Chem, Dip Chem Eng, MAppSc, FRACI, AAIST, CChem, MRSC

Principal Scientist: R.N.M. Barrett, BSc(Hons), CChem, FRSC

Senior Scientists:
T.J. Elms, Dip App Sc, Grad Dip Anal Chem, Grad RACI
G.N. Pain, BSc(Hons), PhD, ARACI, CChem

Scientist: G.I. Christiansz, BSc(Hons), PhD, Dip Ed

Senior Technical Officers:
D.A. Holding
R.R. Pierson, Dip Res Cons Stud, ARACI, CChem, MAIST

Device Technology Section

Functions

- Conduct exploratory research into the reliability of electronic components and devices
- Undertake exploratory research into the properties of metals and alloys
- 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 behaviour of metal products and investigate electrical contact or interconnection systems
- Devise and develop specialised test or measurement equipment and techniques
- Research novel testing methodologies 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

Principal Scientists:
J. Thompson, BA(Hons)
T.J. Keogh, Dip Sec Met

Senior Scientists:
S.J. Charles, BAppSc
J.R. Godfrey, Dip Met
P.W. Leech, FRMIT, MAppSc, PhD
T.P. Rogers, BAppSc

Scientists:
P.A. Galvin, Dip Sec Met
E.E. Gibbs, BSc(Hons), PhD

Senior Technical Officers:
S.G. Harper
M. Jorgensen, Dip Sec Met
I.E. Long

Electrochemistry Section

Functions

- Conduct exploratory research in electrochemistry including the study of corrosion and electrochemical power sources
- Conduct scientific studies related to the protection of telecommunications materials, devices and equipment against the effects of corrosion and electrochemical phenomena and develop appropriate protection methods
- Devise and develop specialised test methods and analytical techniques
- Conduct scientific investigations into the behaviour of electrochemical power sources; investigate failure modes to establish whether the faults are due to materials, construction or maintenance procedures and thereby improve operational reliability develop test facilities and methods
- Undertake fundamental investigations into surface phenomena and electro-deposition
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: J. Der, BSc, ARACI

Senior Scientist: S. Hinckley, BSc(Hons), PhD, MIEE, Grad AIP

Scientist: P.J. Gwynn, Dip App Chem

Senior Technical Officer: F.M. Hamilton

Polymer Section

Functions

- Conduct exploratory research in the field of polymer science and technology
- Conduct scientific studies into the behaviour and interaction of polymer materials and additives and develop polymer systems specifically suited to the Australian environment and Telecom Australia's network
- Conduct studies into new polymeric materials or develop alternatives for existing polymers
- Devise or develop specialised test methods and analytical techniques to characterise, evaluate, and establish life expectancy and performance parameters of polymeric components
- Provide information, advice and consultancy as defined in the Branch objectives.

Section Head: H.J. Ruddell, Dip App Chem, FPIA, FRACI, CChem

Principal Scientist: B.A. Chisholm, Dip App Chem, MSc, GradRACI, GradPRI

Senior Scientists:
D.J. Adams, Dip App Chem, GradRACI
R.J. Boast, Dip App Chem, Dip Pol Sc, GradRACI
P.R. Latoszynski, Dip App Sc, Dip Anal Chem, GradRACI

Scientists:
S. Georgiou, BAppSc, Dip Anal Chem
R.C. Wallis, BSc, PhD

Senior Technical Officers:
S.D. Barnett
D. Coulson

Solar and Environment Section

Functions

- Conduct exploratory research into the physical properties of materials and components and their performance under environmental and high potential stresses
- Conduct scientific studies into the properties of photovoltaic solar cells and modules and their performance under various climatic conditions
- 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 environmental factors and their effects on materials, components and equipment; measure the incidence and distribution of climatic factors
- Devise or develop specialised test methods and equipment
- Provide and maintain data acquisition and analysis facilities for the Branch
- 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: D. McKelvie, BSc(Hons)

Principal Scientists:
E.J. Bondarenko, Dip App Phys, BAppSc, MAIP, MIEAust, SMIREE, FRAS
A. Kruijshoop, NatIr(Delft)

Principal Engineers:
A.M. Fowler, MIEAust
I.K. Stevenson, BAppSc, Dip Elec Eng, GradAIP, GradIEAust

Senior Engineer: P. W. Day, BE

Senior Scientists:
G.W.G. Goode, BSc
A.J. Murfett, BSc(Hons)

Scientist: D.E. Thom, BSc, Dip Ed, Dip Proc Comp Systems

Senior Technical Officers:
G.C. Healey
M.C. Hooper
R.R. Leschinski
S.F. Molnar
I.M. Tippett

Surface Characterisation Section

Functions

- Conduct exploratory research into fundamental surface-related phenomena
- Conduct scientific studies into the influence of surface characteristics on the behaviour of materials and devices
- Develop and maintain expertise in surface analysis techniques, and devise specialised facilities and novel analytical techniques
- Provide information, advice and consultancy as defined in the Branch objectives.

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

Senior Scientist: C.G. Kelly, BAppSc, AAIP, MAXAA, MAVS

Scientists:
S.J. Faulks, BSc(Hons), PhD
M.H. Kibel, BSc(Hons), PhD, MAVS, ARACI, CChem, AH

Senior Technical Officers:
C.J. Ellery
L.O. Barling

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.

Assistant Director: P.V.H. Sabine, BSc, BE(Hons), PhD

Branch Administrative Officer: C.J. Chippindall

Applied Mathematics & Computer Techniques Section

Functions

- Provide information, advice and consultancy as defined in the Branch objectives
- Investigate and make recommendations on methods of mathematical analysis and their application to problem solving in telecommunications engineering
- Conduct fundamental studies of, and recommend or implement as appropriate, modelling and simulation methods applicable to telecommunications systems and techniques and related activities
- Investigate and recommend or implement computing techniques and facilities including hardware and software to meet special needs within Telecom Australia.

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

Principal Engineer: C.D. Rowles, BSc, BCommE, MIEEE

Senior Engineer: P.L. Nicholson, BE, MIEEE

Scientists:
A. Kowalczyk, MAppSc, PhD
J. Szymanski, MSc, PhD

Engineer: L.A.R. Denger, ENSEMN, MIEEE, MSocFrElec

Senior Technical Officers:
R.B. Coxhill
A. Thomas

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

Principal Engineer: D.J. Kuhn, BE(Hons), MEngSc

Scientists:
S. Goh, BSc, MSc, PhD
I. Muirhead, BSc(Hons), MEnvStud
T. Robbins, BSc(Hons), MSc, MIREE

Senior Technical Officer: E.D.S. Fall

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

Principal Engineers:
Y.H. Ja, BE, PhD, MAOS
G.E. Rosman, BEE, ME

Senior Engineer: M.S. Kwietniak, BSc, MEngSc, PhD, MIEEE, MAPS, MAVS

Senior Scientist: T. Warminski, MSc, PhD, DSc

Scientists:
P.M. McNamara, BSc(Hons), MSc, PhD
Y. Ito, BE(Hons), ME

Engineer: A.M. Duncan, BSc, BE(Hons)

Principal Technical Officer: B.P. Cranston

Senior Technical Officer: P.F. Elliott

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

Principal Scientist: P.C. Kemeny, BSc(Hons), PhD, GradAPS

Senior Engineer: J. Hubregtse, Dip Comm Eng, MIREE

Senior Scientist: B.F. Usher, BSc(Hons), PhD, Dip Ed, MAIP

Engineer: J.Dell, BEE(Hons)

Scientist: P. Orders, BSc(Hons), PhD, MAPS, GradAIP

Senior Technical Officers:
R. Garner
F. Gigliotti
R. Tarran

STANDARDS AND LABORATORIES ENGINEERING BRANCH

Objectives

- Ensure 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
- Conduct studies, exploratory development and field experiments, contribute to specifications and provide advice and recommendations as appropriate relating to:
  - development and application of standards of electrical quantity, time and frequency within the field of telecommunications
  - telecommunication instrumentation and equipment engineering practices
  - development and application of microelectronics components
- Provide a mechanical, electrical and/or electronic equipment development facility for Telecom Australia
- Provide a laboratory design and instrumentation facility for the Research Department
- Provide a comprehensive library service to all Departments and Directorates at Headquarters
- Provide design drafting, engineering documentation and consultative drafting services for the Research Department.

Assistant Director: G.M. Willis, FRMIT, MIEAust, SMIREE

Staff Engineer: A.J. Stevens, BE, MIEE, MIEEE

Branch Administrative Officer: P. Rodoni

Drafting Support Section

Functions:

- 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: M.K. Brown

Supervising Draftsmen:
A. Carratelli
A. Craig
A. Davenport

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 Department 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 Department.

Section Head: F. Wolstencroft, C Eng, MIMechE

Principal Engineer: P.F.J. Meggs, Dip Mech Eng, ARMIT, Grad Dip Ind Mgt, MIEAust, SMSME

Senior Engineers:
W.F. Hancock, Dip Elec Eng, MIEAust
V. Lee, BSc(ME), MSc(ME)

Engineers:
A.R. Gilchrist, Dip Mech Eng, BE(Hons), GradIEAust
R.E. Proudlock, BE

Senior Technical Officers:
J.D. Kisby
D.J. McMillan
W.L. Reiners

Headquarters Library

Functions

- Provide a comprehensive library service to all Departments and Directorates at Headquarters, including translation of foreign languages
- Co-operate with State Administrations and provide consultative services in regard to common standards and systems.

Principal Librarian: H.V. Rodd, BA, Dip Lib

Senior Librarians:
D.J. Richards, BA, Dip Lib
J.A. Smith, BA, Dip Lib, Dip Ed, ALAA

Librarians:
Y.B. Chen, BA, Dip Lib
J.L. McLelland, BSc, Dip Lib
P. Millist, Dip Lib, ALAA
E.M. Spicer, BA, Dip Lib
K. Sridhar, MA, Dip Lib
E.M. Tunaley, Dip Lib
G. Woods, Dip Lib

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 Department's instrumentation
- Conduct the procurement programme for all new equipment for the Department, including preparation of technical specifications, tender evaluations and technical reports; perform acceptance testing of new equipment.

Section Head: A.M. Collins, BSc

Principal Engineer: G.C. Heinze, Dip Elec Eng, BE

Senior Engineers:
I. Dresser, BE
N.A. Leister, BE, MIREE

Engineer: P. Standaert, BE(Hons)

Computer Systems Officer: B.R. Nigli, BSc, AACS

Senior Technical Officers:
B.J. Churchill
P.J. Dalliston
D.R. Daws
D.C. Diamond
S.J. Heath
K.L. Rogers
D. Wilson

Laboratory Design Section

Functions

- Plan and specify, in conjunction with other Telecom Australia staff, accommodation requirements of the Department 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 Division to arrange all buildings and building services, repairs and maintenance required within the Department
- Co-ordinate all safety, security, and fire protection matters within the Department.

Section Head: D.S. Geldard, MIEE, MIEAust

Engineer: R.J. Day, Dip Elec Eng, Dip Mech Eng, MIEAust

Senior Technical Officer: T.W. Crichton

Microelectronics Section

Functions

- Conduct research studies into the design and physical realisation of electronic circuitry, in particular that involving miniature and microminiature techniques and components, and into interconnection and mounting of these circuits
- Provide in-house facilities for the production of prototype microelectronic circuits in experimental quantities; specify and develop test criteria and techniques for the control of quality and reliability of these circuits.

Section Head: D.E. Sheridan, Dip Elec Eng, Dip Mech Eng, MISHM

Principal Engineers:
G.J. Barker, Dip Mech Eng, MIEAust
G.K. Reeves, BSc(Hons), PhD, MIEAust
H.S. Tjio, Dip Elec Eng, BE

Senior Technical Officers:
G. Brinson
M. Crarey
G. Longridge

Reference Measurements Section

Functions

- Plan and oversight the implementation, operation and further development of a system of engineering references and calibration facilities for Headquarters and all State Administrations
- 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

Principal Engineer: E. Pinczower, Dip Elec Eng, MIEAust

Senior Engineers:
R.W. Pyke, Dip Elec Eng, BE(Hons), MIEAust
B.R. Ratcliff, Dip Comm Eng, ARMIT

Engineers:
J.P. Colvin, Dip Elec Eng, BE
D.A. Latin, BE

Principal Technical Officers:
J.B. Erwin
R.H. Yates

Senior Technical Officers:
K.J. Bassett
C.R. Flood
J. Freeman
T.W. Pearson

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 Department's programme of R&D contracts and related processes for R&D collaboration with external organisations
  - technology and information transfer from the Research Department to other Departments of Telecom Australia, industry, academia and other external organisations
  - co-ordination of the participation of staff of the Department in the activities of external organisations
  - recruitment and development of professional and technical grade staff of the Research Department
  - the investigation development and operation of centralised, integrated networking computer-based facilities – in support of the Research Department's management, administration and investigatory functions
  - the formulation of the Department's work programme.

Assistant Director: F.W. Arter, BEE, MEngSc

Branch Administrative Officer: T.M. Walsh

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 Department's 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 Department, to industry.

Section Head: O.J. Malone, BEE

Senior Engineer: P. Gretton, Dip Elec Eng

Engineer: A.P. Mizzi, BEE

Information Processing Section

Functions

- Conduct relevant research, develop and operate integrated, networking computer-based information processing facilities for the Research Department, 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 Department's management, administrative and investigatory functions
- Prepare software and hardware specifications for and co-ordinate the acquisition and commissioning of such facilities, liaising with other Departments of Telecom Australia and industry as required
- Provide consultant advice and assistance to staff of the Research Department 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

Principal Computer Systems Officer: P.Y.F. Hui, BSc

Management Information Systems Officer: G.A. Lawson, BA, Dip Lib, ALAA

Senior Technical Officers:
S.R. McAllister
W.W. Staley

Senior Computer Operator: B.L.P. Stone

Information Transfer Section

Functions

- Develop and implement methods and programmes for the effective transfer of technical information generated within the Research Department to other Departments 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 Department, 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 Department
- Provide a focus for technical liaison with, and representation of Departmental 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 Department, and develop, co-ordinate and execute programmes for their technical development.

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

Senior Technical Officers:
C.A. Block
G.C. Galey
A.M. Johnson
K.M. Lowe
A.K. Mitchell

ADMINISTRATIVE SERVICES GROUP

Functions

- Provide administrative and clerical support to the Laboratories,including information and assistance on matters relating to:
  - manpower, organisation establishment and recruitment
  - budgets, finance and procurement of supplies and services
  - staff and general personnel services, e.g. assessment of entitlements, staff pay and allowances
  - administrative support services, e.g. registry, typing.

Manager, Administration: B.M. Douglas

Manager, Budgets and Finance: M.A. Chirgwin

Manager, Manpower and Organisation: T.W. Dillon

Budgets Officer: R.J. Beveridge

External Liaison Officer: T.H. Brown

Clerk, Management Information: M.J. Holmes

Project Officer: P.S. Dawson, BBus.

Supply Officer: J. Utan

Staff Services Co-ordinator: P.I. McGibbony

Papers, Lectures, Talks and Reports

Research Laboratories Reports 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. The 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 papers, lectures, talks and reports presented or published during the last 12 months.

PAPERS

Author(s)	Title
Adams, D.J.	"Development of Australian Colour Concentrates for Insulation", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Adams, J.L.	"Optical Sources for Coherent Optical Fibre Communications Systems", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Addie, R.G.	"Design of New Networks – a Case Study", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Andrews, M.D. & Smetaniuk, B.P.	"Towards the Development of a Multi-mode Document Workstation", 2nd Australian Computer Engineering Conference, Sydney, August 1986
Ayre, R.W.A	"Measurement of Longitudinal Strain in Optical Fibre Cables During Installation by Cable Ploughing", IEEE Journal of Lightwave Technology, Issue LT-4, January 1986
Ayre, R.W.A. de Boer, B.T. Schuster, R.B.,	"Cable Design and Installation Techniques for Direct Buried Non-Metallic Optical Cables", Telecommunication Journal of Australia, Vol. 35, No. 3, 1985
Bakewell, D.J.	"Semiconductor Optical Amplifiers for Coherent Systems", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Batten, T.J. Gibbs, A.J. Hawkins, S. & Nicholson, G.	"Statistical Design of Long Optical Fibre Routes", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Bharatula, G.	"Mobile Packet Radio", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Boast, R.J.	"Materials Selection for Telecommunications Applications", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Bullock, F.G.	"Sydney Rain Storm Details from Radio Experiment", Telecom News, No. 123, October 1986
Bullock, F.G.	"Rain Attenuation Measurements on Local Radio Links in Sydney", European Conference on Radio Relay Systems, Munchen, Federal Republic of Germany, November 1986

Author(s)	Title
Burgin, J.L.	"Protocol Design Studies and Route Determination Aspects of Fast Packet Switching Networks", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Charles, S.J.	"The Reliability of Plastic Encapsulated Integrated Circuits in Humid Environments", Australian Telecommunication Research, Vol. 20, No. 2, 1986
Charles, S.J.	"Moisture Related Failures in Plastic Encapsulated Integrated Circuits", 5th Australian and Pacific Region Microelectronics Conference, Technology for Industry, Adelaide, May 1986
Cheong, H.K.	"Signalling System No. 7 Link Capacity Estimation", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Chisholm, B.A.	"Review of Materials for Australian Optical Fibre Cables", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Clarke, B.R.	"The Complexity of Echo Cancellers and Decision Feedback Equalisers for Digital Customer Access", Australian Telecommunication Research, Vol.20, No. 2, 1986
Clarke, B.R.	"An Index of Phase Distortion", International Journal of Circuit Theory and Applications, Vol. 14, No. 3, July 1986
Clarke, B.R.	"The Use of RMS Eye Closure to Approximate the Effect of Interference on Probability of Error", Australian Telecommunication Research, Vol. 20, No. 1, 1986
Cook, J.B.	"Experience with Using SDL for Software Description and Implementation", 1st Australian Software Engineering Conference, Canberra, May 1986
Coutts, R.P. Rummler, W.D. (AT&T Bell Labs) Liniger, M. (Swiss PTT)	"Multipath Fading Channel Models for Microwave Digital Radio", IEEE Communications Magazine, Vol. 24, No. 11, November 1986
Coutts, R.P. & Boland, J.E.	"Mobile Communication – a Matter of Spectrum?", IEAust/IREE, Radio Communications Workshop, Melbourne, November 1986
Craick, J.K. & Cavill, M.	"New Times, New Traffic, New Methods?", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Cranston, B.P.	"Development of an Effective Polishing Technique for the Preparation of BGO Crystals for Four-Wave Mixing", 4th Optical Society Conference, Melbourne, December 1986
Davies, W.S. & Lang, R.J. (Monash University)	"Special Efficiency Advantage of Adaptive Multiple Beam Base Station Antennas for Cellular Mobile Radio Systems", IEAust/IREE, Radio Communication Workshop, Melbourne, November 1986
Duc, N.Q.	"An Introduction to Integrated Services Digital Networks (ISDNs)", Telecommunication Journal of Australia, Volume 34, No. 1, 1984
Duke, P.F. & Spicer, J.S.	"The Assessment of Isolated Word Speech Recognisers", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
Duong, N.H.	"An Experimental Study of Residual Excited Linear Predictive Coders (RELP) for Telecommunications Purposes", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
Duong, N.H.	"An Experimental Study of Residual Excited Linear Predictive Coders for Telecommunication Purposes", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
Elms, T.J. & Pierson, R.R.	"The Use of ICPAES in Occupational Hygiene – A Case Study: Timber Preservatives", Chemistry in Occupational Hygiene and the Environment, a Specialist International Conference, Darwin, July 1986
Elms, T.J. & Pain, G.N.	"The Use of ICPAES in Occupational Hygiene – A Case Study: Metals in Carbonless Copy Paper", Chemistry in Occupational Hygiene and the Environment, a Specialist International Conference, Darwin, July 1986
Elms, T.J. Baker, F.C. & Eva, B.C.	"Foam-in-place Urethanes – Measurement of MDI Monomer During Curing", Chemistry in Occupational Hygiene and the Environment, a Specialist International Conference, Darwin, July 1986
Flaherty, M.J.	"Algorithmic Issues of Adaptive Differential Pulse Code Modulation with Reference to CCITT Recommendation G721", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
Flavin, R.K.	"Small Earth Terminals for Satellite Links," IREECON 85, Melbourne, September 1985
Georgiou, S.	"Polyurea Greases for the Filling of Telecommunications Cables", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Gerrand, P.H.	"The New Teletraffic Engineering", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986

Author(s)	Title
Gerrand, P.H.	"Opportunities for Indigenous Developments of Telecommunications Systems for the early 1990s and the Curriculum Development Needed to Support It", Pacific Region Electrical Engineering Conference, Queenscliff, December 1986
Gerrand, P.H.	"Experience Gained in Creating and Applying Formal Description Techniques to the Design of Complex Real-time Systems", IEAust 1st National Conference on Software Engineering, Canberra, May 1986
Gerrand, P.H. & Darling, P.	"ISDN Numbering and Addressing – Issues Techniques and an Integrated National Solution", 8th ICCC'86, Munich, Federal Republic of Germany, September 1986
Godfrey, J.R.	"Assessment of Connector Contacts Comprising a Thin Layer over Palladium", Asia Pacific Interfinish Congress and Exhibition '86, Hobart, Tasmania, October 1986
Godfrey, J.R.	"Industrial Atmosphere Corrosion Testing of Connector Contacts Plated with Precious and Semi-precious Metal Coating", Asia Pacific Interfinish Congress and Exhibition '86, Hobart, October 1986
Godfrey, J.R.	"Performance Testing of Connector Contacts Made from Gold Coatings", Materials Technology Congress, Adelaide, May 1986
Harper, S. Galey, R.A. & Thompson, J.	"Reprogrammability Endurance of Electrically Erasable Programmable Read Only Memory Devices", 5th Australian and Pacific Region Microelectronics Conference, Technology for Industry, Adelaide, May 1986
Harris, R.J.	"Applied Mathematics for Communications of the Future", Applied Mathematics Conference, Wirrina, Adelaide, February 1986
Harris, R.J.	"Operations Research Methods for Network Planners and Network Managers", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Harris, R.J. & Berry L.W. (University of Adelaide)	"Modular Design of a Large Metropolitan Telephone Network: A Case Study", Australian Telecommunication Research, Vol. 20, No. 1, 1986
Hicks, P.R.	"Performance Measurements of Packet Switched Data Networks", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Hinton, K.J. & Nicholson G.	"The Effect of Gain Suppression on Frequency Noise in Laser Diodes", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986

Author(s)	Title
Hinckley, S., McCann, J.F. & Haneman, D. (Melbourne University)	"A Flux Analysis of Multiple Junction Solar Cells, the General Equations with Computations for a n-CdS/n-GaAs Solar Cell", Solar Cells, Vol.17, April/May 1986
Hinton, K.J. & Nicholson, G.	"Probability Density Function for the Phase and Frequency Noise in a Semiconductor Laser", IEEE Journal of Quantum Electronics, Vol. QE-22, November 1986
Ito, M.Y. & Warminski, T.	"Preparation of Multi-Element Mid-infra-red Fibre Samples for Detailed Element Profile Analysis", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Ja, Y.H.	"Real-Time Image Translation and Differentiation by Degenerate Four-wave Mixing", 4th Australian Optical Society Conference, Melbourne, December 1986
Ja, Y.H.	"Degenerate Four-wave Mixing in $Bi_{12}GeO_{20}$ Crystals involving Internal Reflections", Applied Physics B, Vol. 41, December 1986
Ja, Y.H.	"Finite Element Method to Solve the Non-linear Coupled-wave Equations for Degenerate Two-wave and Four-wave Mixing", Applied Optics (USA), Vol. 25, No. 23, December 1986
Ja, Y.H.	"Phase Conjunction With Two Object Beams in Photorefractive $Bi_{12}GeO_{20}$ Crystals", Optics Communication, Vol. 57, No. 2, February 1986
Jennings, A.J.	"Teletraffic Engineering Artificial Intelligence", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Jennings, A.J.	"An Artificial Intelligence System for Capacity Assignment in Networks", 1st Australian Conference on Artificial Intelligence, Deakin University, November 1986
Johnson, A.B.	"Mutually Coupled Micro-strip Antenna Arrays", CSIRO/ATERB Symposium on Antennas, Sydney, February 1987
Joyce, M.J.	"Effect of Amplitude Modulation on Stimulation Brillouin Scattering", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Joyner, K.H. Davies, W.A. Sastradipradja, S. Copeland, P.R. & Gilbert, B.C.	"Environmental Levels of Microwave Radiation around Satellite Earth Stations", CSIRO/ATERB Symposium on Antennas, Sydney, February 1987
Kemeny, P.C.	"Composition of AlGaAs Films Grown by Molecular Beam Epitaxy", Journal of Vacuum Science & Technology, March/April, 1986
Keogh, T.J.	"Metal Teeth for Trenching Operations", Materials Technology Congress, Adelaide, May 1986

Author(s)	Title
Kirton, P.A.	"Some Trends and Developments in Information Networks", Telecommunication Journal of Australia, Vol. 35, No. 3, 1985
Kirton, P.A.	"Teletraffic Issues in Fast Packet Switched Networks", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Kirton, P.A. & Park, J.L.	"Fast Packet Switching for Integrated Services", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Kuhn, D.J. Dowel, B. Muirhead, I. & Teede, N.F.	"Small Generation Systems for Remote Areas", Electrical Energy Conference, Brisbane, October 1986
Kuhn, D.J., Muirhead, I. & Teede, N.F.	"Small Remote Area Power Systems", Solar '86 Conference, Australian and New Zealand Energy Society, Adelaide, November 1986
Kuhn, D.J., Muirhead, I.J. & Teede, N.F.	"Power Sources for Remote Telecommunications Equipment", Australian Telecommunication Research, Vol. 20, No. 2, 1986
Kwietniak, M.S.	"Optical Properties of a-Si:H", 4th Australian Conference of Optical Society, Melbourne,December 1986
Kwietniak, M.S. & Ito, Y.	"Narrow-Gap Semiconductors for Optoelectronics", IREECON 85, Melbourne, September 1985
Latoszynski, P.R.	"Evaluation of Stabiliser Performance in Cellular Polyethlene Insulation", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Lawson, I.C. & Ellershaw, J.C.	"Co-Channel Interference in a Cellular Rural Radio Telephone System", ICC'86, Toronto, Canada, June 1986
Leech, P.W.	"Comparison of the Sliding Wear Process of Various Cast Irons in Laser Surface Melted and As-cast Forms", Wear International, Vol. 113, No. 2, November 1986
Leech, P.W.	"Nitrogen N^+ Ion Beam Treatment of Noble Metal Contacts", Asia Pacific Interfinish Conference 1986, Hobart, Tasmania, October 1986
Leech, P.W. & Parkinson, S.L.	"The Influence of Ion Beam Treatment on the Contact Erosion of Au/8% Ag and Ag"., Materials Technology Congress, Adelaide, May 1986
Lindgaard, G.	"Performance in Interactive Computing; Metaphors Versus the Real Thing", 13th Experimental Psychology Conference, Lorne, May 1986
Lindgaard, G.	"Cognitive Processes in Interactive Computing: A Multi-Disciplinary Approach to Practical and Theoretical Understanding", Australian Psychological Society Conference, Townsville, August 1986
Martin, A.L.	"Digital Microwave Radio – A New System Measurement Technique", ICC'86, Toronto, Canada, June 1986
Martin, A.L.	"Dynamic Dispersion Signatures – Some Results of Laboratory and Field Measurements", European Conference on Radio Relay Systems, Munich, Federal Republic of Germany, November 1986
Mikelaitis, P.I. & Ng, M.J.T.	"Design Architecture of an ISDN Access Unit", ICC'86, Toronto, Canada, June 1986
Millot, L.J.	"Co-intensity Spectra of QAM Signals after Bandpass Non-linearities", Workshop on Stochastic Modelling, ATERB, Melbourne 1986
Mitchell, G.G.	"The Use of Metals in Integrated Circuits", Materials Technology Congress, Adelaide, May 1986
Mottram, K.G. & Petchell, F.M.	"Surface Preparation for Painting New Galvanized Structural Steel", Journal of Oil and Colour Chemists' Association, Vol. 69, No. 4, April 1986
Muirhead, I.	"Solar Energy Design Using Real Meteorological Data", Australian and New Zealand Solar Energy Society, Adelaide, November 1986
McNamara, P. & MacFarlane, D.R. Conway, J.F. & Moore, L.J. (Monash University)	"Extrinsic Scattering Losses in Heavy Metal Fluoride Glasses: Vacuum Bubble Occlusions", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
McGregor, I.M. Clarke, B.R. Smith, B.M. & Semple, G.J.	"Optical Fibre Systems for the Customer Access Network", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Ng, M.J.T. & Hoang, D.B.	"Joint Optimisation of Capacity and Flow Assignment in a Packet Switched Communications Network", IEEE Transactions on Communications, Vol. 35, Issue 2, 1986
Nicholson, G.	"ASK Coherent System with a 6-Port Fibre Coupler at the Receivers", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Nicholson, G.	"Optical Source Linewidth Criteria for Heterodyne Communication Systems for PSK Modulation", Optical and Quantum Electronics 17, 1985
Nicholson, G.	"Determination of the Error Probability in Coherent Optical Communication Systems", Workshop on Stochastic Modelling, ATERB, Melbourne 1986
Nicholson, P.L.	"'VLSI Technologies for Telecommunications", IREECON 85, Melbourne, September 1985
O'Neill, C.J.	"Performance Based Design Issues", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Palmer, R.A.	"Fast Packet Switch Architectures", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986

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Potter, P.G.	"Metropolitan Area Networks", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Price, G.L.	"Application of Very Thin Films in Semiconductor Devices", Australian Institute of Physics National Conference, Adelaide, August 1986
Reeves, G.K. & Harrison, H.B. (RMIT)	"Determination of Contact Parameters of Interconnecting Layers in VLSI Circuits", IEEE Transactions on Electron Devices, Vol. ED-33, March 1986
Reeves, G.K. Harrison, H.B. (RMIT) & Walton, A.J. (Edinburgh University)	"An Experimental Technique to Acquire the Specific Contact Resistance of Multilayer Interconnections", Materials Research Society Symposium Proceedings, Volume 54, 1986
Reeves, G.K. & Kemeny, P.C.	"Opto-electronic Devices", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Richardson, P.	"The Design of a Fault Tolerant Signal Transfer Point within a Telecommunications Network", 2nd Australian Computer Engineering Conference, Sydney August 1986
Rogers, T.P.	"Internal Timing and Voltage Measurements in Integrated Circuits Using Stroboscopic Voltage Contrast Techniques", 5th Australian and Pacific Region Microelectronics Conference, Technology and Industry, Adelaide, May 1986
Rosman, G.E.	"Searching for Low-loss Fibre Materials Overseas and in Australia", Optoelectronics Newpaper, July 1986
Rosman, G.E.	"Communications and Sensor Applications in Australia of Glasses Based on Zirconium Tetra Fluoride", Bilateral Australia/Japan Ceramics Workshop, Tsukuba, Japan, September 1986
Rossiter, M.H.	"A Proposed Model for Data Traffic", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Rowles, C.D.	"Architectural – level Simulation of VLSI Systems", 5th Australian and Pacific Microelectronics Conference, Technology and Industry, Adelaide, May 1986
Rubas, J.	"Role of Simulation in the New Teletraffic Engineering", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Ruddell, H.J. & Wallis, R.C.	"Polymers for the Insulation of Exchange Wire and Cable", RACI, 16th Australian Polymer Division Symposium, Cowes, Victoria, February 1987
Ruhl, F.F.	"Limitations due to Self-phase Modulation on Future Optical Fibre Transmission Systems", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Ruhl, F.F.	"Cutoff Decomposition on Multiply Clad Fibres", IEEE Journal Lightwave Technology, Vol. LT-4, No. 11, November 1986
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Rowles, C.D. Foster, G.	"An Artificial Intelligence Approach to Automated Hardware Synthesis", 1st Australian Artificial Intelligence Congress, Deakin University, Geelong, November 1986
Sabine, P.V.H.	"Telecom Research in Microelectronics", 5th Australian and Pacific Region Microelectronics Conference, Technology and Industry, Adelaide, May 1986
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Sastradipradja, S.	"Far-field Antenna Measurement Methods", CSIRO/ATERB Symposium on Antennas, Sydney, February 1987
Seidl, R.A.	"Speech Technology Applications for Telecommunications", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
Seidl, R.A.	"A Perspective on Telecommunication Services with Relevance to Speech Processing", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986
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Smith, B.M. & Potter, P.G.	"Design Criteria for Crosstalk Interference Between Digital Signals in Multipair Cable", IEEE Transactions on Communications, COM6-12, June 1986
Smith, B.M. & Potter, P.G.	"Crosstalk Design Criteria – an Instructive Example of Modelling of a System with Multiple Random Processes", ATERB Workshop on Stochiastic Modelling for Digital Communications Systems, Melbourne, August 1986
Snare, J.L. Frueh, P.F. & Lockwood, J.A.	"Security Considerations for EFT in Australia", 8th ICCC '86, Munich, Federal Republic of Germany, November 1986
Spicer, J.S. & Duke, P.F.	"The Assessment of Isolated Word Speech Recognisers", 1st Australian Conference on Speech Science and Technology, Canberra, November 1986

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Stevens, A.J.	"Increasing the Speed of Loading String Arrays on 86A", Crosstalk : Journal of the Hewlett Packard Desktop Users Group of Victoria, May/June 1985
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Stephens, T.D.	"Coherent Optical Communications Systems Experiments", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Sutherland, S.L.	"Network Structure", ATERB Fast Packet Switching Research Planning Workshop, Melbourne, November 1986
Szymanski, J.	"Energy Loss Mechanism for Hot Electrons in GaAs", 11th Annual Condensed Matter Physics Meeting, NZIP and AIP, Pakatoa, New Zealand, February 1987
Szymanski, J.	"Multipair Exitations and the Dynamic Response of the Metallic Electron Gas in Two and Three Dimensions", Many Boxy Physics Workshop, Argonne National Laboratories, Argonne, Illinois, USA, July 1986; published in Condensed Matter Theories, Vol. 2, 1986
Teede, N.F.	"Telecommunication Systems Solar Power System, Design", UNESCO Seminar on Solar Photovoltaic Power Systems, Yogyakarta, Indonesia, January 1987
Teede, N.F.	"Small Stand Alone Power System Sizing and Cost Optimisation", UNESCO Seminar on Solar Photovoltaic Power Systems, Yogyakarta, Indonesia, January 1987
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Thompson, J.	"Case Studies Spotlight Failures", Australian Electronics Engineering, Vol.19, No. 10, October 1986
Thompson, J.	"Metal Related Failures in Integrated Circuits", Materials Technology Congress, Adelaide, May 1986
Thompson, J.	"Failure of Integrated Circuits in Telecommunications Equipment – Case Studies", 5th Australian and Pacific Microelectronics Conference, Technology for Industry, Adelaide, May 1986
Thompson, J. Rogers, T.P. & Rydz, R.W.	"A Non-destructive Chip Temperature Measurement Technique for VLSI Devices", 5th Australian and Pacific Microelectronics Conference, Technology for Industry, Adelaide, May 1986
Tirtaatmadja, E.	"A Tool for Digital System Experiments", IREECON 85, Melbourne, September 1985
Wallis, R.C.	"Polymers for the Insulation of Exchange Wire and Cables", 16th Australian Polymer Symposium, Cowes, Victoria, February 1987
Warfield, R.E. & Cowle, G.J.	"Network Traffic Management and Customer Traffic Management", 1st Australian Teletraffic Research Seminar, Melbourne, November 1986
Warfield, R.E. & Foers, G.A.	"Application of Bayesian Teletraffic Measurement to Systems with Queueing or Repeated Attempts", Australian Telecommunication Research, Vol. 20, No. 1, 1986
Warminski, T.	"Fluoride Glass Compositions as given by the EPMA Technique", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Warminski, T. Kwietniak, M. et al	"Structural Properties of Some Copper Ternary Compounds", 7th International Conference on Ternary and Multiternary Compounds, Snowmass, Colorado, USA, September 1986
Wheeler, G.R. Batten, T.J. Billington, J. & Wilbur-Ham, M.C.	"A Methodology for Protocol Engineering", 8th ICCC '86, Munich, Federal Republic of Germany, September 1986
Wragge, H.S.	"The Strategic Importance of Optical Fibre Communications Research", 11th Australian Conference on Optical Fibre Technology, Geelong, Victoria, December 1986
Wragge, H.S.	"The Future Role of the Telecom Australian Research Laboratories", Australian Telecommunication Research, Vol. 20, No. 1, 1986
Zukerman, M.	"On Markovian Type Queueing Systems", 1st Australian Teletraffic Research Seminar, November 1986

LECTURES AND TALKS

Author(s)	Title
Burgin, J.L.	"Fast Packet Switching for Integrated Services", Computer Science Department, La Trobe University, September 1986
Coutts, R.P.	"Directions for Next Generation Land Mobile Radio Systems", Telecommunications Advisory Committee, Canberra, November 1986
Foers, G.A.	"Open Systems Interconnection", Computer Science Department, La Trobe University, September 1986
Goh S.C.	"Amorphous Silicon Solar Cells – Issues and Promises", Monash University, Department of Physics, July, 1986
Hicks, P.R.	"Data Switching Networks", Computer Science Department, La Trobe University, September 1986
Hicks, P.R.	"Data Network Performance", SAA Sub-committee on Electronic Funds Transfer, Melbourne, October 1986
Hinton, K.J.	"Particle Detectors in Non-Minkowski Spacetimes" & "Physics and Philosophy," Mathematics Department, Monash University, June 1986
Hinton, K.J.	"Optical Communications Research in Telecom Australia", Adelaide University, Adelaide, May 1986
Hinton, K.J.	"Laser Diodes – Physics and Applications", Flinders University, Adelaide, May 1986
Hinton, K.J.	"Quantum Physics in Modern Communications", Adelaide University, May 1986
Ito Y.	"Mid-infrared Fibre Communications Project in Telecom Australia", Furokawa Electric Co., NTT Ibaraki ECL, NTT Yokosuka ECL, Fujitsu Laboratories Ltd. Atsugi and Hitachi Cable Co. Cable Laboratory, Japan, March-April, 1986
Jennings, A.J.	"Artificial Intelligence in Communications Technology", Hitachi Research Laboratories; and NEC Research Laboratories, Kawasaki, Tokyo, Japan, September 1986
Jennings, A.J.	"Artificial Intelligence in Communications Technology", XEROX Parc, Palo Atlo; Computer Science Department, Rutgers University, New Jersey; University of Massachusetts, Amherst; Honewell Systems Development Laboratory, Minneapolis, Minnesota; Bolt, Beranek & Newman, Boston, Massachusetts, USA, September 1986
Kirton, P.A.	"OSI Connectionless Network Protocol Implementation", SAA Subcommittee on Electronic Funds Transfer, Melbourne, October 1986
Kirton, P.A.	"Teletraffic Aspects of Fast Packet Switched Networks", Teletraffic Engineering Course, Frankston, September 1986
Kirton, P.A. & Park, J.L.	"Fast Packet Switching for Integrated Services", OTC(A); Computer Science Department, University of Sydney, Electrical Engineering Department, University of Tasmania, Electrical Engineering Department, Monash University, Electrical Engineering Department, University of Queensland, Electrical Engineering Department, University of Adelaide, July 1986
Kirton, P.A. & Park J.L.	"Fast Packet Switching for Integrated Services", Melbourne Branch of IEEE, Melbourne, May 1986
Littlewood, M.	"Fast Packet Switching and Parallel Processing Applications", Seminar on Parallel Computing Architecture, Melbourne, February 1986
Nicholson, G.	"Optical Communication Systems Research at Telecom Research Laboratories", University of Western Australia, October 1986
O'Neill, C.J.	"OSI Network and Transport Layer Implementation", SAA Sub-committee on Electronic Funds Transfer, Melbourne, October 1986
Pain, G.N.	"MOCVD and Its Applications", University of New South Wales, December 1986
Palmer, R.A.	"Introduction to Digital Circuit Switching", Computer Science Department, La Trobe University, September 1986
Park, J.L.	"Introduction to Telecom Australia Research Laboratories", SAA Sub-committee on Electronic Funds Transfer, Melbourne, October 1986
Park, J.L.	"Integrated Packet Switching for ISDN", Telecommunications Society of Australia, Melbourne, February 1987
Park, J.L.	"Open Systems Interconnection", Australian Computer Society, Hobart, Tasmania, July 1986
Price, G.L.	"Recent Developments in the Molecular Beam Epitaxy of Semiconductor Devices", Computer Science Department, La Trobe University, July 1986
Rosman, G.E.	"Light Scattering in Glass", 4th Conference of the Australian Optical Society, Melbourne, December 1986
Rosman G.E.	"Choosing Fundamental Particles for Telecom", Australian Institute of Physics Meeting, University of NSW, May, 1986
Rosman G.E.	"Uncle Telecom Goes Optical", IEAust Campus Chapter Meeting, University of Melbourne, July, 1986
Sabine, P.V.H.	"Advanced Optical Materials Research in Australia", Sino-Australian Workshop on Advanced Materials, RMIT, Melbourne, December 1986
Sabine, P.V.H.	"Developments in Optical Fibres and Optoelectronics", Joint Telecom/Industry Meeting, Melbourne, October 1986.

Author(s)	Title
Sabine, P.V.H.	"Fibres, Photons & the Future", IREE, Melbourne, September 1986
Sabine, P.V.H.	"Optical Fibres – in Transit between Physics & Engineering", 7th National Congress of Australia Institute of Physics, Adelaide, August 1986
Sabine, P.V.H.	"Telecommunications Technology Towards 2000", Telecom Society of Australia and Melbourne Branch of IEEE, Melbourne, September 1986
Sabine, P.V.H.	"Developments in Mid-infrared Fibres and Associated Optoelectronics", IEEE Optoelectronics Group, Sydney, April 1986
Scott, C.J.	"The Wideband Switching Future", Melbourne Branch of IEEE, Melbourne, June, 1986
Scott, C.J.	"The Wideband Switching Future", Telecommunication Society of Australia, Victorian Division, Melbourne, June 1986
Snare, J. L.	"Access Control Security of Remote Computer Systems", IEEE Communications and Computer Society, Melbourne, May 1986
Snare, J. L.	"Communication Security in EFTPOS Networks", IEEE Victorian Division, Melbourne, August 1986

TECHNICAL CONTRIBUTIONS ON STANDARDISATION ISSUES

Author(s)	Title
Burgin, J.L.	"Future Development of ISDN Packet Mode Bearer Services" CCITT Group XVIII, June 1986
Burgin, J.L.	"Step 4 Packet Mode Bearer Service Architecture Issues", CCITT Study Group XVIII, February 1987
Burgin, J.L.	"Evaluation of Packet Mode Bearer Services", CCITT Study Group VII, July 1986
Craig, P.C.	"Access Control", Joint ISO/CCITT Meeting on Directories, London, September 1986
Craig, P.C.	"Need for a More Complete Protocol Specification", Joint ISO/CCITT Meeting on Directories, London, September 1986
Craig, P.C. & Exner, R.	"Transparency and Upward Compatibility in X.400", Q33/VII Rapporteur's Meeting, Geneva, September 1986
Craig, P.C. & Nakulski, J.P.	"Errors and Partial Results", Joint ISO/CCITT Meeting on Directories, London, September 1986
Duke, P.F.	"Algorithms for Calculation of Loudness Ratings", to Q.15 of CCITT Study Group XII, February 1987
Exner, R.	"Distributed Entries", Joint ISO/CCITT Meeting on Directories, London, September 1986
Exner, R.	"Problems with the Definition of Object-Set Descriptor", Joint ISO/CCITT Meeting on Directories, London, September 1986
Exner, R.	"Distributed Operation of Directory", Joint ISO/CCITT Meeting on Directories, London, September 1986.
Exner, R. & Smetaniuk, B.P.	"Distributed Name Validation", Joint ISO/CCITT Meeting on Directories, London, September 1986
Hicks, P.R.	Question 16/XVIII : "Call and Packet Processing Performance – Adoption of Study Group VII Recommendations", CCITT Study Group XVIII, July 1986
Hicks, P.R.	Question 29/VII : CCITT Study Group VII Meeting, September 1986:- "Measurement of Data Packet Transit Delay t3c – National Portion (Terrestrial Circuit)"; "Measurement of the International Portion of Data Packet Transit Delay t3c"; "Australian Position on Draft Recommendations X.134 and X.135"; "Measurement of Throughput Performance of 9600 bit/s X.25 Customer Access Link"; "Measurement of the Throughput Performance on an International Packet Switched Data Circuit between Australia and Singapore".
Nakulski, J.P. & Craig, P.C.	"Changes to the Directory Protocol Parameters", Joint ISO/CCITT Meeting on Directories, London, September 1986
Snare, J.L.	"An SDL Description of the SAA EFTPOS Transaction Key Management Scheme", SAA Subcommittee IS/S/4 (Electronic Funds Transfer Security), September 1986
Snare, J.L.	"An SDL Description of the SAA EFTPOS Session Key Management Scheme", SAA Sub-committee IS/5/4 (Electronic Funds Transfer Security), January 1987

REPORTS

Number	Author(s)	Title
7118 *	Day, R.J.	Production of Prototype Multilayer Printed Boards
7446	Stephens, T.D.	Computer Aided Design of Optical Fibre Digital Transmission Systems – Part II
7509	Barrett, R.N.M.	The Determination of Epichlorohydrin
7621	Cheong, H.K.	CCSS No. 7 Signalling Link Capacity Estimation
7669	Potter, P.G.	Models for Crosstalk in Multipair Cable in the Frequency Range 10 kHz to 1 MHz
7677 *	Stone, G.O.	Telecommunications Applications of the Finite Element Method for Nonlinear Analysis and Design

Report Number	Author(s)	Title
7686 *	Hollow, J.G.	The Use of the Passive Bus for Access to the ISDN
7687	Goode, G.W.G.	Correlation Between Outdoor and UV Chamber Ageing of UPVC
7690	Demytko, N.	Line Rate and Linear Code Dependent Crosstalk Source for the Evaluation of Crosstalk Noise Immunity of Local Digital Reticulation Systems
7724 *	Webster, R.I.	An Interface Program to Draw Eye Diagrams using Taconet Plot 10 Graphing Facilities
7729	McGlade, B.J.	Calculation of Error Performance of a Multimode Optical Fibre System
7737	Billington, J. Wilbur-Ham, M.C. & Bearman, M.Y.	Analysis of the OSI Class O Transport Protocol
7744 *	Jenkins, A.R.	Subjective Evaluation of a GEC 2 Mbit/s Codec
7768 *	Brunelli, A.	Process Specifications for the Manufacture of Production Masters on Glass Plates
7774	Hinton, K.	Quantum Analysis of Laser Diodes
7776	Stephens, T.D.	Characterisation and Multiplexing of Maximal Length Pseudo Random Sequences
7784	Barrett, R.N.M.	Detection and Identification of Polychlorinated Biphenyls
7785	Barrett, R.N.M.	Mass Spectrometric Identification of Polychlorinated Biphenyls
7787 *	Rochlin, G.P.	Overseas Visit Report, September/October 1984 : Software Engineering Trends in Europe and North America
7790 *	Bharatula, G. & Sekfy, J.J.	Simulation of Digital Satellite Communication Links
7794 *	Hicks, P.R.	X.25 Traffic Generation Programs for a VAX11/780 Computer
7799 *	Latoszynski, P.R.	Migration of Stabilisers in Insulation Grade Polyethylenes
7799 *	Latoszynski, P.R.	Addendum No. 1 : Migration of Stabilisers in Insulation Grade Polyethylene
7800	Christiansz, G.I.	Analysis of Organic Acids in Stationary Battery Electrolyte
7803	Galey, R.A. & Thompson, J.	The Characterisation of IC Defects Detected by Marginal Voltage Analysis
7807	Ruhl, F.F.	Cutoffs in Multiply Clad Optical Fibres

Report Number	Author(s)	Title
7808 *	Ruddell, H.J.	Overseas Visit Report, October/November 1984 : Telecommunication Cable Technology
7811 *	Stevenson, I.K.	Overseas Visit Report, May/June 1984 : Telecommunications Protection
7812 *	McNamara, P.	Reliability and Performance of Integrated Circuit Sockets
7813 *	Georgiou, S.	Detectable Optical Fibre Cable Markers
7814	Carroll, J.B. & Johansen, E.	Frequency Stabilisation of Helium-Neon Lasers
7816	Smetaniuk, B.	Survey of Defined Abstract Syntaxes
7817 *	Rogers, T.P.	Overseas Visit Report, March/April 1985 : Electron Beam Testing Techniques for Integrated Circuits
7818 *	Brunelli, A.	Introduction to Thick Film Hybrid Microcircuit Technology
7821 *	Kirton, P.A.	Some Trends and Developments in Computer Networking: Report on Telecom Development Award at the Information Sciences Institute
7824 *	Exner, R.	Overseas Visit Report, September 1985 : Developments in Electronic Messaging
7825	Perry, L. Lindgaard, G. & Wilshire, C.	Do Words Really Matter? Preferences and Performance with an Electronic Message Handling System (Part 1)
7826	Lindgaard, G. & Perry, L.	Do Words Really Matter? Preferences and Performance with an Electronic Message Handling System (Part 2)
7827	Burgin, J.L.	Spread Spectrum CDMA Techniques applied to Optical Fibre Local Area Networks
7828	Harris, R.W.	Time and Frequency Distribution in Australia
7829 *	Addie, R.G. Harris, R.J. & Warfield, R.E.	Review of Eleventh International Teletraffic Congress and the International Seminar on Computer Networking and Performance Evaluation
7830 *	Leech, P.W. & Godfrey, J.R.	The Environmental Stability of Various Geometries of Complaint Pins
7831	Hayes, M.D.	State of Polarisation Control for Coherent Optical Fibre Systems

Report Number	Author(s)	Title
7832	Dresser, I.	Sixteen Channel Fault Indicator for Air Conditioning Plant
7833 *	Cheong, H.K.	Australia-Japan Bilateral Field Trial of CCITT Signalling System No. 7
7834	Adams, J.L. & Stephens, T.D.	Calculation of the Error Probability in Optical Fibre Systems
7836 *	Jenkinson, G.F.	WARC ORB(1): World Administrative Radio Conference on the Geostationary Satellite Orbit – First Session – 1985
7837 *	Chew, E.K.	Overseas Visit Report, January/February 1986 : Electronic Directory Systems and Message Handling
7838 *	Chisholm, B.A. & Barry, W.	Evaluation of the Environmental Stress-Cracking Behaviour of Cable Leak Detection Solution
7840	Campbell, J.C.	Microbending Loss in Optical Fibres
7841 *	Latoszynski, P.R.	Migration of Antioxidants in Insulation Grade High Density Polyethylene
7844	Burgin, J.L.	Spread Spectrum Synchronization and Tracking Considerations
7845 *	Nakulski, J.P.	Key Management Techniques for a Secure Communications System
7846	Bondarenko, E.J. & Clark, R.A.	Electrical Stress on the Rural Cable Network
7847 *	Foster, G.	Application of 1984 SDL to the Q.931 Protocol
7848 *	Georgiou, S. & Keon, B.J.	Non-Detectable Marking Tapes for Use with Buried Optical Fibre Cables
7849 *	Duke, P.F.	Final Report: The Objective Measurement of Loudness Ratings
7853	Flaherty, M.J. et al	Algorithmic Issues of Adaptive Differential Pulse Code Modulation (ADPCM) with Reference to the CCITT Algorithm G.721
7854 *	Subocz, M.	Overseas Visit Report, May/June 1986 : CCITT WP X1/2 Meeting in Geneva and Related Investigatory Visits
7858	Joyner, K.H. Copeland, P.R. & Macfarlane, I.P.	Evaluation of a Radiofrequency Protective Suit
7859	Demytko, N.	Number Theory and Its Application to the RSA Cryptosystem
7866 *	Thompson, J.	Overseas Visit Report, April/May 1986 : Reliability of Plastic Encapsulated Integrated Circuits

Notes: The reports marked * are classified as 'Telecom Australia Use Only'. In addition, several "In Confidence" reports with restricted distribution were produced.

BRANCH PAPERS

Number	Author(s)	Title
ASO075 *	Murfett, A.J.	Laboratory Simulation of Hail Damage to an Elliptical Waveguide
ASO076 *	Mottram, K.G.	Excessive Wear of Crossbar Relays During Life Testing
ASO077 *	Godfrey, J.R.	Report of Overseas Visit to New Zealand, October 1985
ASO078 *	Wallis, R.C.	Evaluation of Lead-Acid Battery Separators
ASO079 *	Hamilton, F.M. & Der, J.J.	Performance Comparison Between a Gould 2V2900 Ah Lead-Calcium Cell and a Besco 2V2200 Ah Pure Lead Positive Cell
ASO080 *	Murfett, A.J.	Environmental Testing of ARCO G100 Amphorphous Silicon Solar Module
ASO081 *	Goode, G.W.G.	Optical Fibre Cable Locator Pegs – C9779
ASO082 *	Lambrineas, P.	Main Distribution Frame Overvoltage Protection
ASO083 *	Hamilton, F.M. & Gwynn, P.J.	Characterisation of Wave-Soldering Fluxes
ASO084 *	Murfett, A.J.	Long Term Dry and Damp Heat Tests on Solar Modules
ASO085 *	Eva, B.C.	Evaluation of Sealed Lead-Acid Automotive Batteries
ASO086 *	Powell, L.G.	The Measurement of Organic Acid Contamination in Lead-Acid Battery Electrolyte
ASO087 *	Day, P.W.	HV Evaluation of the Commander T210 Telephone System
ASO088	Keogh, T.J. Godfrey, J.R. Mitchell, G.G. Thompson, J. & Leech, P.W.	Telecom Papers presented to Materials Technology Congress – Adelaide, May 1986
ASO089 *	Galvin, P.A.	Mini Wrap Gold Plated Posts
ASO092 *	Keogh, T.J. & Jorgensen, M.	The Corrosion Resistance of "Zincalume"

Paper Number	Author(s)	Title
AS0093 *	Der, J.J. Hinckley, S. & Hamilton, F.M.	Performance Evaluation of 1984 Prototype Pasted-plate Lead-Acid Batteries for Stationary Applications
AS0094 *	Galvin, P.A.	The Termination of Conductors from Jelly-filled Cables onto Krone Terminating Modules
AS86/001 *	Keogh, T.J. & Godfrey, J.R.	Whisker Growth on Tin Plated Wire Wrap Connector Block
AS86/002 *	Charles, S.J.	MEMTECH Membrane Keypads
AS86/003 *	Galvin, P.A.	Evaluation of EEL Off-tool Type 612 Telephone Socket
AS86/004 *	Thompson, J.	NEC Hybrids for Loop Multiplex Signalling
AS86/005 *	Keogh, T.J.	Failure of Ditch Witch Trenching Machine Axles
AS86/006 *	Charles, S.J.	Antistatic Products
AS86/007 *	Rogers, T.P. & Hand, R.	Faulty 74LS08 Integrated Circuits from AXE Exchange Equipment
AS86/008 *	Galvin, P.A.	Addendum No 1: Evaluation of EEL Off-tool Type 606 Telephone Plug
AS86/009 *	Keogh, T.J.	Pinion Failure in Mercedes Benz Plough Tractor
AS86/010 *	Rydz, R.W.	Modified OKI MSM60521-17 Repertory Dialler IC
AS86/011 *	Rydz, R.W.	Hitachi HD63705 VOP Microprocessor IC
AS86/012 *	Keogh, T.J.	Compressor Drawbar Bracket Failure
AS86/013 *	Rydz, R.W.	Mitel ML8205 Tone Ringer ICs
AS86/014 *	Galvin, P.A. & Tzatzakis, C.	Evaluation of Re-designed ASC Type 606 Telephone Plug
AS86/015 *	Keogh, T.J.	Assessment of Pratco Trench Digging Teeth
AS86/017 *	Rydz, R.W.	Failed Semikron SKT 250/04C Thyristors
AS87/001 *	Keogh, T.J.	Preliminary Examination of a Cracked Rolled Steel Angle Transmission Mast Leg Section
CSS0094	Duong, N.H.	Linear Predictivity Coding and Its Application to a Commercial Synthesiser IC
CSS0095	Koop, E.J.	Voice Services on Packet Data Networks
CSS0100	Andrews, M.O. & Smetaniuk, B.P.	Towards the Development of a Multi-mode Document Workstation
CSS0103 *	Cavill, M.E. Craick, J.K. & Jenkins, A.R.	Mapping Telecom and its Customers : A Case Study of the Medical Industry
CSS0105	Koop, E.J.	Speech Processing Strategy
CSS0108	Lindgaard, G.	Cognitive Processes in Interactive Computing: A Multi-disciplinary Approach to Practical & Theoretical Understanding
CSS0109 *	Spicer, J.S.	Commercial Speech Recognisers Revisited: Performance Assessment and Template Clustering
CSS0110 *	Seidl, R.A.	Enhanced Services Using Voice Response
CSS0112 *	Craig, P.C.	Comparison of Telememo Facilities with the CCITT X.400 Recommendations
CSS0113	Flaherty, M.J. Duong, N.H. Duke, P.F. Spicer, J.S. & Seidl, R.A.	Speech Technology – Contributions to SST'86 by Voice Services Section
CSS0114 *	McGlade, B.J. & Smetaniuk, B.P.	CSS and Product Development
SLE0034 *	Colvin, J.P.	An Automated Supervisory System for a Speaking Clock Installation
SLE0039 *	Reiners, W.L.	Pressurisation System – Emergency Bypass to Stored Compressed Air
SLE0040 *	Reiners, W.L. & Beavis, D.J.	Pneumatic Rotary Indexing Device
SLE0042 *	McMullen, P.N.	A Contact Wear Measurement Unit
SLE0043 *	Lee, V. & McMillan, D.	Heating Block Design
SS0082	Addie, R.G. & Fegent, H.	Dial Tone Delay in ARK-M Exchanges Which Use Satellite Interworking
SS0084 *	Foster, G.	Interworking of the ISDN D-Channel Signalling and ISDN User Part Protocols
SS0085	Harris, R.J.	Optimisation of the Telephone Network
SS0086	English, K.S.	Development of a Traffic Model for ISDN Services
SS0087	Littlewood, M.	Fast Packet Switching: A Parallel Processing Application
SS0088	Park, J.L. & Kidd, G.P.	CCITT Study Group VII: Australian Delegates Report of Meeting in Geneva, February 1986

Paper Number	Author(s)	Title
SSO089 *	Warfield, R. & Addie, R.G.	Evaluation of Two Techniques for Network Traffic Management: Holding Time Minimisation and Code Blocking
SSO092 *	Warfield, R.	Overseas Visit Report, September 1985, Part 2 : Investigations of Network Management and Dynamic Routing
SSO094 *	Bysouth, P.V. & Lewis, I.R.	A Prototype X.32 Interworking Unit for the AUSTPAC Network
SSO095	Fidge, C. & Heagerty, D.	Everything You Ever Wanted to Know About Documentation (and should have asked)
SSO096 *	Harsant, D.M.	Photovideotex and Its Network Implications
SSO098 *	Tirtaatmadja, E. & Taylor, A.	The Analogue Subscriber Line Module of the Experimental Digital System
SSO099	Bysouth, P.V.	Telephony/Packet Network Interworking – CCITT X.32 Explained
SSO101 *	Fone, R.J. & Palmer, R.A.	The Application of a Token Passing LAN for Interprocessor Communication in an Experimental Switching System
SSO103 *	Rochlin, G.P.	Telecom Australia's Current and Likely Future Distributed Databases
SSO105	Cook, J.B.	An Introduction to LATEX
SSO108	Burgin, J.L.	Integrated Services Packet Network - Protocol Design Considerations
SSO109 *	Park, J.L. Lee, S. & Chew, E.K.	CCITT Study Group VII Meeting, Geneva, 29 September to 10 October 1986
TSO133 *	Copeland, P.R.	An Experimental 64 kbit/s Viterbi Decoder
TSO136 *	Adams, J.L.	Interference Study of Digital Point-to-Multipoint Microwave Urban Radio Systems
TSO137 *	McGregor, I.M.	Optimisation of the Local Distribution Area with Passive Coupler Optical Transmission Systems
TSO140 *	Stephens, T.D.	Chromatic Dispersion Measurement of Installed Single Mode Optical Fibre Cables
TSO143 *	Harvey, R.A.	Automatic Rain Compensation Methods with the AUSSAT Beacon

Paper Number	Author(s)	Title
TSO144 *	Hayes, M.D. & Potter, P.G.	Local Area Networks Issues
TSO145 *	Campbell, J.C.	Measurements of the Mode Partition Noise of Laser Diodes
TSO146	Coutts, R.P.	Report of the First Meeting of IWP8/13 on Future Public Land Mobile Systems
TSO147 *	Urie, A.	Minimum Model Capacity for a Wireless Office – a Traffic Study
TSO148 *	Bharatula, G.	Radio in the Customer Network – Bandwidth Requirements for ISDN Services
TSO149 *	Anderson, A.	UHF Propagation in the Vicinity of Isolated Buildings
TT86/006	Leask, S.A.	A CAD Package for VLSI Design
TT86/008	Robbins, T.	High Frequency Switching Losses in Switchmode Power Supplies
TT86/009	Andrews, W.C.	Further Refinements in the Surface Preparation of Mercury Cadmium Telluride
TT86/010	Jennings, A.J.	INET: A System using Simple Learning for Network Capacity Assignment
TT86/011	Kuhn, D.J.	Maximum Power Point Trackers – A Critical Evaluation
TT86/012	Rowles, C.D. & Foster, G.	An Artificial Intelligence Approach to Automated Hardware Synthesis
TT87/001 *	Kowalczyk, A. Szymanski, J. & Warminski, T.	Radiation Concentrator for Measurements of Cathodoluminescence
TT87/002 *	Kuhn, D.J.	Battery Options for Photovoltaic Systems

Notes: The Branch Papers marked * are classified as 'Telecom Australia Use Only'. In addition, several "In Confidence" reports with restricted distribution were produced.

Staff Affiliations with External Bodies

Some of the staff of the Laboratories are active members of the governing bodies of educational establishments, learned societies and professional bodies and institutions. Staff members also serve on a variety of national and international committees. These include:

NATIONAL EDUCATIONAL BODIES

Technical and Further Education Board, Victoria

- Science Laboratory Standing Committee — F.C. Baker
- Applied Science Joint Standing Committee — F.C. Baker

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

Footscray Institute of Technology

- Course Advisory Committee — D.E. Sheridan

Chisholm Institute of Technology

- Course Advisory Committee — R.J. Boast, R.J. Morgan, H.S. Wragge
- Advisory Board, Centre for Business Technology — H.S. Wragge

Royal Melbourne Institute of Technology

- Course Advisory Committee, Applied Physics Department — J.G. Hollow
- Course Advisory Committee, Communications Engineering Department — P.H. Gerrand, H.S Wragge

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 — P. Lambrineas

Institute of Electrical and Electronic Engineers

- Australian Council
  - Chairman — A.J. Gibbs
  - Committee Member — R.A. Court
- Victorian Section Committee
  - Chairman — R.A. Court
  - Secretary/Treasurer — P.A. Evans
  - Committee Members — J.C. Campbell, R.P. Coutts, A.J. Gibbs, L.J. Millott, C.D. Rowles
- Computer Society
  - Secretary/Treasurer — C.D. Rowles
- Communications Chapter
  - Committee Members — T. Batten, E. Vinnal
- Hewlett Packard Desk Top Computer User Group Victoria — A.J. Stevens

Telecommunications Society of Australia

- Council of Control — E.A. George, 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

- Task Force on Engineering Education
  - Chairman — H.S. Wragge
- National Committee on Computers and Information Technology — F.J.W. Symons

NATIONAL STANDARDISATION BODIES

Standards Association of Australia (SAA)

- Council — G. Flatau
- Australian Electrotechnical Committee
  - IEC Quality Assessment Scheme for Electronic Components — G. Flatau
- Co-ordinating Committee on Fire Tests — F.C. Baker
- Telecommunications and Electronics Standards Board and Executive — G. Flatau

SAA TECHNICAL COMMITTEES

- Acoustic Standards
  - Instrumentation and Techniques for Measurement of Sound — E.J Koop
- Battery Standards
  - Primary Batteries — J. Der
  - Secondary Batteries — J. Der
- Chemical Industry Standards
  - Adhesives — F.C. Baker
  - Examination of Workplace Atmospheres — F.C. Baker
  - Heavy Duty Paints — F.C. Baker
- Computers and Information Processing Standards
  - Data Communications — C.J. O'Neill, M.C. Wilbur-Ham
  - Data Cryptographic Techniques — J.L. Snare
  - Electronic Funds Transfer — C.J. O'Neill, J.L. Park, J.L. Snare
  - Information Systems — F.J.W. Symons
  - Open Systems Interconnection — E.K. Chew, J.L. Park
  - Programming Languages — G.P. Rochlin
  - Text and Office Systems — R. Exner, D.Q. Phiet

- Electrical Industry Standards
  - Control of Undesirable Static Charges — G.W.G. Goode
  - Electrical Accessories — E. Bondarenko
  - Electrolytes — F.C. Baker
  - Indicating and Recording Instruments — E. Pinczower
  - Lightning Protection — E. Bondarenko
  - Plastics — G.W.G. Goode
- Mechanical Engineering Industry Standards
  - Engineers Hand Tools — P.F.J. Meggs
  - Fasteners — F. Wolstencroft
- Metal Finishing Standards
  - Armouring Cable — T.J. Keogh
  - Electroplating & Precious Metals — J.R. Godfrey
  - Methods of Test — T.J. Keogh
  - Tin and Tin Alloys — J.R. Godfrey
  - Zinc and Cadmium Coatings — T.J. Keogh
  - Solder and Solder Fluxes — P.J. Gwynn
- 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, B.J. Adams
  - Mechanical Testing of Plastics — B.A. Chisholm
  - Outdoor Weathering of Plastics — G.W.G. Goode
  - Plastics for Telecommunications Cables — H.J. Ruddell, D.J. Adams
  - Safety Helmets — R.J. Boast
- Safety Standards
  - Electronic Equipment — E. Bondarenko
  - Industrial Safety Gloves — F.C. Baker
  - Laser Safety — R. Ayre, P.V.H. Sabine
- Telecommunications and Electronics Industry Standards
  - Capacitors and Resistors — S.J. Charles
  - Electro-Acoustics and Recording — E.J. Koop
  - Electromagnetic Interference — S. Iskra, I.P. Macfarlane
  - Environmental Testing — G. Flatau, M.C. Hooper
  - Hazards of Non-Ionizing Radiation — K.H. Joyner, S. Sastradipradja
  - Measurement Methods for RF Radiation — K.H. Joyner, I.P. Macfarlane
  - Photovoltaic Modules — D. McKelvie
  - Printed Boards — D.E. Sheridan
  - Radio Communications — R.K. Flavin, K.H. Joyner
  - Semiconductor Devices — E.A. George, G.G. Mitchell

National Association of Testing Authorities (NATA)
- Acoustic and Vibration Measurement Advisory Committee — E.J. Koop
- 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

Australian Radiation Protection Society — K.H. Joyner, S. Sastradipradja

CSIRO
- Division of Applied Organic Chemistry Advisory Committee — H.J. Ruddell
- Standards Advisory Committee — G.M. Willis

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

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

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. Ayre
- IEC Quality Assessment System for electronic Components, Certifications Management Committee, Treasurer — G. Flatau
- International Confederation for Thermal Analysis — F.C. Baker
- International Special Committee on Radio Interference (CISPR) Working Groups — I.P. Macfarlane
- Teletraffic Engineering Training Project TETAPRO, ITU/ITC — J. Rubas
- Special Rapporteur, CCITT SG VII/48 — J.L. Park
- Special Rapporteur, CCITT SG XI/14 — M. Subocz

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.

Invention Title (Inventor/s)	Provisional Specification	Complete Specification	Patent No. (if granted)	Country
Self Adaptive Filter and Control Circuit (L.K. Mackechnie)		98800	3732410	USA
Tip Welding Means (E.J. Bondarenko)		4714/71	3657512	USA
Analogue Multiplier (H. Bruggemann)		855543	3629567	USA
Apparatus for Monitoring Communications System and Detector (J.A. Lewis)	PA1474/70	29415/71	458997	Australia
Control of Operation of a System (N.W. McLeod)	PA2035/70	31550/71 166819 56442/71	466670 3745418 888597	Australia USA Japan
Smoke Detector (L. Gibson & D.R. Packham)		367260	3874795	USA
Method and Apparatus for Deteecting the Presence of Signal Components of Predetermined Frequency in a Multi-frequency Signal (A.D. Proudfoot)		387855 178402	3882283 984068	USA Canada
Optical Waveguides and Method of Manufacture (P.V.H. Sabine & P.S. Francis)	PC4499/76	21232/77	507723	Australia
Transversal Filter (K.S. English)	PD7273/79	54367/80 109589/80	532103 4340875	Australia USA
Fibre Optic Termination (P.V.H. Sabine)	PD6157/78	50841/79	521528	Australia
Noise Assessment of PCM Regenerators (A.J. Gibbs)	PD6790/78	52160/79 793025727 339841 148305/79 093228	525766 0012515 1134915 4300233	Australia Europe (designating France W. Germany UK Italy Holland Switzerland) Canada Japan USA
Tap Coupler for Optical Fibres (E. Johansen & E. Dodge)	PF0272/81	87251/82	544705	Australia
Apparatus and Method of Cable Hauling (J. Alcorn)	PF5293/82	17465/83	559320	Australia
Method and Apparatus for Testing Bells and Other Electrically Actuated Devices (B. Sneddon)	PF5557/82	17570/83		Australia

Invention Title (Inventor/s)	Provisional Specification	Complete Specification	Patent No. (if granted)	Country
Instant Speaker Algorithm for Digital Conference Bridge (D.Q. Phiet)	PG4037/84	39841/85		Australia
		85306496		Europe
				(designating
				Austria
				Belgium
				France
				W. Germany
				Luxembourg
				Netherlands
				Sweden
		8600304		UK
				Italy
				Switzerland)
		775549	4644530	USA
		490497		Canada
		201967/85		Japan
LAN for Mixed Traffic (P.F. Frueh)	PG5956/84	44818/85		Australia
Cable Laying Apparatus (R.A. Vidler)	PG7266/84	47460/85		Australia
		778453		USA
		8523098		UK
		213532		New Zealand
		491271		Canada
		905998		USA
Characterisation of Digital Radio Signals (A.L. Martin)	PG4999/84 PG8701/84	43227/85		Australia
		PCT/AU85/00107		PCT
				(designating
		85902515		Europe (all states)
		829150		USA
		8600304		UK
		61-502858		Japan
		175/85		Denmark
		860176		Finland
		860100		Norway)
		1211/85		Ireland
		543131	543131	Spain
		481293		Canada
Conforming the Frequency Spectrum of an Output Signal to a Desired Form (B.W. Sneddon & S.G. Beadle)	PG8284/84	49251/85		Australia
Optical Distribution Systems (I.M. McGregor)	PH2612/85			Australia
		PCT/Au86/00277		PCT
				(designating
				Europe (all states)
				Australia
				Denmark
				Japan
				Norway
				USA)
				Canada
		8602185		Spain
Mounting Device (B.T. Burland & D.C. Hoyune)	PH3372/85	65082/86		Australia
Method of Initial Synchronisation for Full Duplex Digital Transmission (A.J. Jennings & B.R. Clarke)	PH4020/85	66929/86		Australia
Switch Number Identifier (J. Coles, R. Nicholls & J. Keith)	PH5375/86			Australia
		PCT/AU87/0095		PCT
				(designating
				Australia, USA
				Japan
				Europe)
				Canada

REGISTERED DESIGN APPLICATIONS AND REGISTERED DESIGNS

Design Title (Author/s)	Application Number	Design Number	Country
Housing (B.T. Burland)		87777	Australia
Table (B.T. Burland)		87679	Australia
Communications Apparatus (Design & Development Group, Telecom Australia Workshops)	8087/84	96141	Australia
Telephone (B.T. Burland & N.E. Joseph)	1328/85		Australia
Telephone Plug (A.R. Pickering)	1327/85	96041	Australia
Base Plate for a Telephone (D. Atkins)	1765/85	95362	Australia
Telephone Handset (D. Atkins)	1766/86	95363	Australia
Telephone (D. Atkins)	1767/85	95364	Australia
Telephone (D. Atkins)	1768/85	95365	Australia
	934148		USA
	46854/86		Japan
	20868		New Zealand
	1038314	1038314	UK
	86301020		China
	URA1544/86	MR26842	Germany
	61624.00	15565.00	Netherlands
	157740	157740	India

Visitors to the Laboratories

The work of the Laboratories often calls for close liason 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 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:

- A party of ten members from the Association of PTT Engineers Finland, for discussions of a range of Laboratories activities, including time and frequency reference standards, next generation fluoride glass fibres and coherent optical systems, and electromagnetic compatibility studies
- The Standards Association of Australia Electronic Funds Transfer Committee, for discussions of OSI network and transport layer implementation, OSI connectionless network protocol implementation, protocol verification, data network performance, access control and authentication, and electronic directory services
- Mr B. Macfarlane, Industry Analyst (Electronics Industry), Department of Industrial Development, Western Australia, for discussions of optical fibre, technology materials and component testing, and the QPSX Metropolitan Area Network development
- Messrs J. Brodie, D. Lewis and P. Watt of the University of Tasmania, for discussions of projects in a number of topic fields, including radio, satellite and optical transmission for local and trunk applications, fast packet switching, communicationsprotocol verification and electro-magnetic compatibility of equipment
- Mr P.C. Wilson, Mr H.L. Spencer, Mr K. Willem and Mrs S. O'Neil, Executives of the Commonwealth Bank, for discussions of new telecommunications techniques/technologies and potential new services relevant to the development of banking networks
- Ms H. Godfrey, Secretary, Interdepartmental Committee on the Ross Report on Commonwealth Laboratories for discussions with senior staff and a broad overview of the Laboratories' work programme and internal/external work relationships
- Professor L. Pols, Institute of Phonetic Sciences, University of Amsterdam and Dr R. Linggard, British Telecom Research Laboratories, for technical discussions of speech signal processing techniques
- Dr Trommer, Siemens Research Laboratory, to present a talk and hold discussions with senior staff on avalanche photodiodes and other devices for optical fibre communications in the 1-1.6 micrometre wavelength range
- Professor Dai Xian-Da, Department of Electrical Engineering, Beijing Institute of Aeronautics and Astronautics, to contribute his knowledge and expertise to the study of non-linear effects in crystals

- Professor H. Hartnagel, Technische Hochschule, Darmstadt, to discuss with senior staff Gallium Arsenide and Indium Phosphide surface analytical studies and the development of long-life devices
- Professor J. Lamb, University of Glasgow, for discussions on applications and realisations of integrated optical circuits
- Mr J. Reid and Mr H. Luecke, Siemens, for discussions of a variety of transmission and switching topics
- Mr J. van Remartel, British Telecom, and Mr B. Jones and Mr R. McKay, STC, for discussions on longer term ISDN strategic issues and technology choices
- Mr Hoshikawa, Chief Research Associate, Sumitomo, Japan, delivered a talk titled "Optical Fibre Cables for Subscriber Distribution and Local Area Networks"
- Mr J. Andrews, previously of British Telecom Research Laboratories, for discussions of fast packet switching applied in an evolving ISDN environment, communications protocol specification and validation techniques, reliability investigations and quality assurance of materials and components, and advanced electronic and optoelectronic device technology
- Dr F. Thon, Chief of Research and Development, Siemens AG, Germany, accompanied by Mr A. Muller, Mr E. Mueller, Mr H. Luecke, Dr O. Von Zyl and Mr W. Trautwein of Siemens (Germany) and Siemens (Australia), for discussions relating to collaboration in the development of an ISDN communicationsprotocol test set
- Eight Commonwealth Bank executives for discussions of ISDN evolution, the specification/verification of communications protocols, fast packet switching techniques, access control and authentication in data communications, and advanced semiconductor and optical fibre technologies
- Ms G. Comer, Business Manager for Office Automation, Asia, Pacific and Americas Region, AT&T, for discussions of investigations being performed by the Laboratories in the broad field of potential new customer services and systems.

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. Ayre
A.J. Bundrock
E.K. Chew
P.C. Craig
N. Demytko
P.A. Evans
J.G. Hollow
A.J. Jennings
P.A. Kirton
I.P. Macfarlane
G.N. Pain
J.L. Park
P.G. Potter
R.W. Pyke
G.K. Reeves
T.P. Rogers
H.J. Ruddell
M. Subocz
N.F. Teede
R.J. Vizard
H.S. Wragge

Assistance with Studies

The Laboratories have a policy of encouraging staff to further their educational qualifications and technical expertise by study in fields relevant to the work of the Laboratories. Professional staff are selected to pursue postgraduate courses, often leading to higher degrees, at universities and colleges of advanced education, or to broaden their expertise by working outside the Laboratories for short periods. Non-professional staff are also encouraged to seek higher technical or professional qualifications through part or full-time study. Incentives are offered in the form of paid study leave and other concessions for part-time studies, or of extended leave without pay for full-time studies.

The following staff have been engaged in sponsored tertiary studies or development training programmes during the past year:

- M.J. Biggar, Postgraduate Scholarship leading to Doctorate of Philosophy, Imperial College of Science and Technology, London, UK
- A.J. Murfett, Development Training Programme Award, Japanese Government Electrotechnical Laboratory, Ibaraki, Japan
- Dr K.H. Joyner, World Health Organisation Fellowship, Canada and USA
- J. Billington, Postgraduate Scholarship leading to Doctorate of Philosophy, University of Cambridge, UK

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 contractsand agreements and through its participation in the activities of bodies such as the Australian Telecomunications and Electronics Research Board (ATERB).

The 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.

During 1986/87, the Research Laboratories have managed a portfolio of 20 R&D contracts with industry (total value $4 million) and 36 R&D contracts with other R&D institutions and academia (total value $1.7 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 1986/87 will be approximately $1.6 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.

Current R&D contracts administered by the Laboratories concern 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
- Organisational Cultures and Telecommunications Choice
- Interconnect Technology in Metal Oxide Semiconductor (MOS) Devices

Development of:

- A Gas Corrosion Test Facility
- A Large Weathering Chamber
- A Dual-module Digital Cross Connect Switch
- An Optical Regenerator Test Instrument
- An Announcing Machine for the Speaking Clock Service
- Software for Implementing Transport Layer Communications Protocols
- 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
- Transient Recorders
- An Optical Distribution System

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
- Adaptive Digital Hybrid Transmission Networks
- Effects of Bismuth Impurity Levels in Lead-Acid Batteries
- Stress Relaxation in Thermo-shrink Cable Jointing Sleeves
- Application of Control Theory in Dynamic Routing of Communications Links
- Computer-aided Graphics for the Specification and Description Language (SDL) for Communications Networks and Protocols
- Equalisers for Digital Subscribers Loops
- Capacity of Time Division Multiple Access (TDMA) Satellite Communications Systems
- Metal-Insulator Semiconductor Structures
- A Double-ring Local Area Network
- Computer-based Graphics for Computer-aided Specification and Validation of Communications Protocols
- Fluoride Glass Systems for Mid-Infra-Red Optical Fibres
- Packaging Techniques for VLSI Circuits
- Customer Access Principles for an Integrated Services Digital Network (ISDN) Environment
- On-line Computer-based Directory Database Structures
- Integrated Voice/Data Local Area Networks
- Computer-aided Specification and Design Techniques for VLSI Circuits
- Advanced Design and Testing Techniques for VLSI Circuits
- Rules for the Automated Production of Speech from Text
- A Long Wavelength (1.55 micron) Optical Time Domain Reflectometer
- Millimetre Wave Digital Radio Systems
- Optical Phase Modulators
- Circuit Design Techniques for Optical Communications Systems
- Techniques for the Thermal Modelling of Buildings
- Computer Tools Employing the Calculus of Communicating Systems for Protocol Specification and Analysis
- Optical Switch Technology
- Digital Switchblock Device Technology
- Wideband Switching in the Optical Domain.
- Algorithms for Directed Graphs
- Automation of Numerical Petri Nets (NPNs)
- Interconnect Technology in MOS Devices
- A Software Tool for Common Channel Signalling (CCS) Network Planning
- A Real-Time Fibre Tension Measuring Instrument
- Telecommunications Traffic Engineering
- Mid Infra-Red (IR) Objective Lens

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.