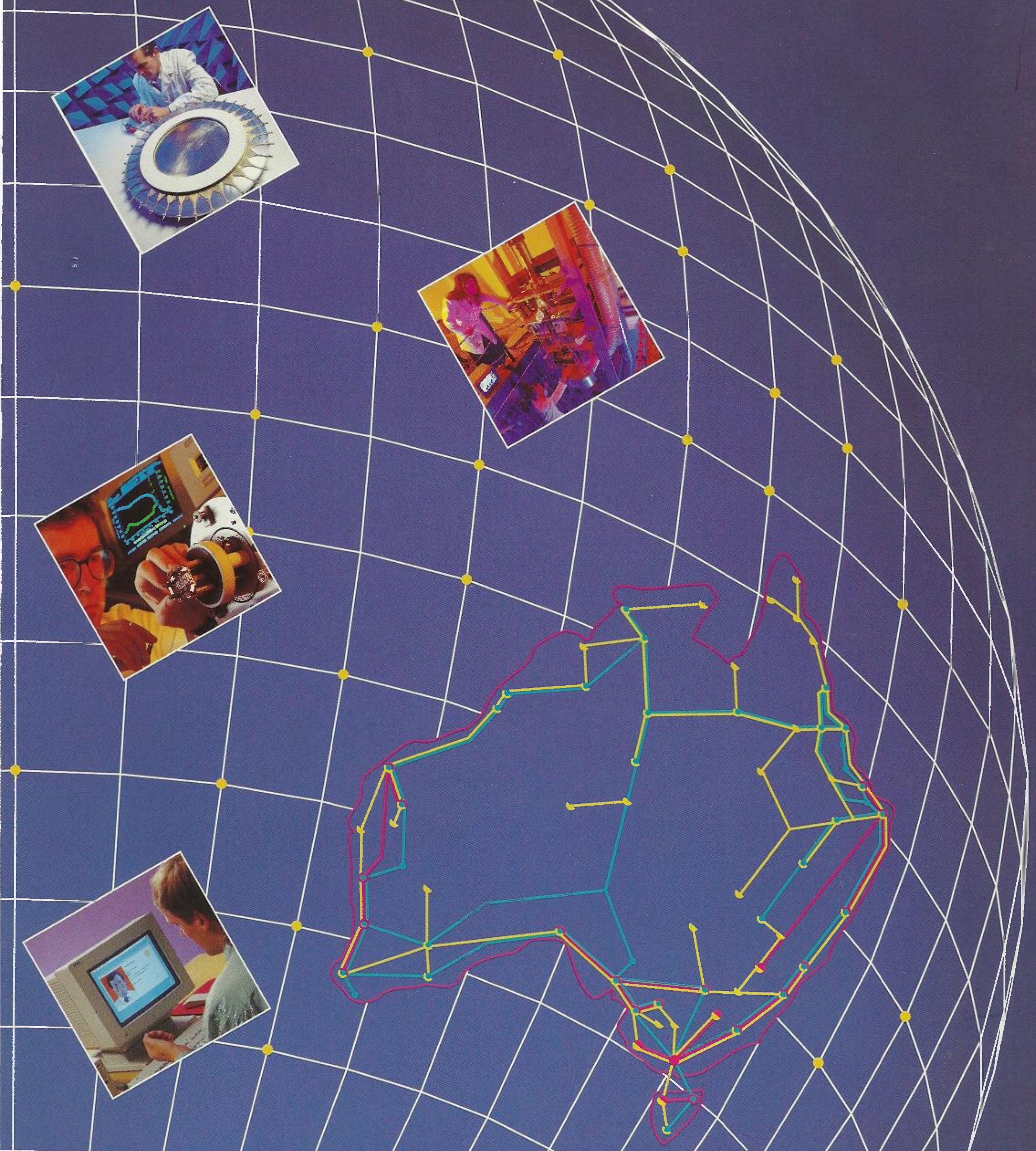
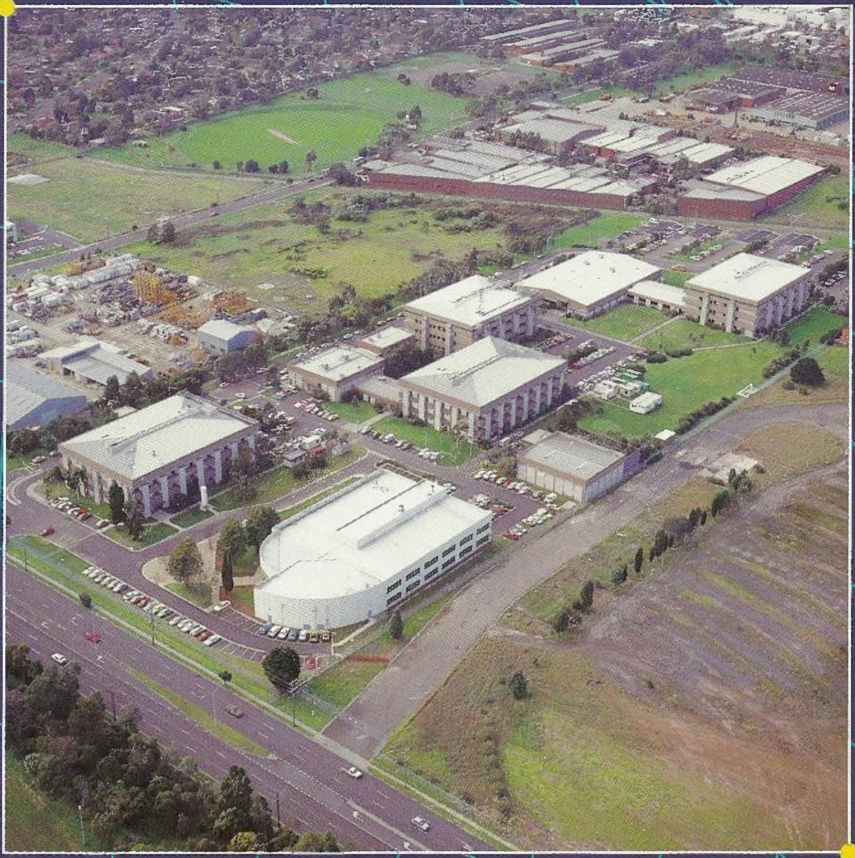
1991 REVIEW OF ACTIVITIES

TELECOM RESEARCH LABORATORIES



Telecom Australia
Research Laboratories



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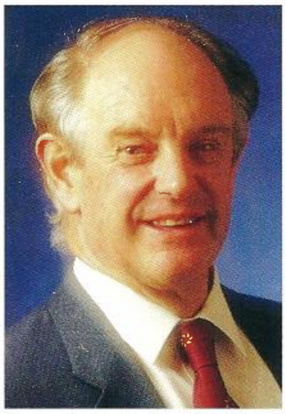
FOREWORD

Now that the new decade is well underway, Telecom Research Laboratories (TRL) is successfully facing what one might call the most challenging and exciting period of telecommunications in Australia's history.

Not only do we see rapid changes and developments in technology, but we also see rapid changes in the infrastructure of the Australian telecommunications industry with the merging of OTC and Telecom Australia to form the Australian and Overseas Telecommunications Corporation (AOTC). With this change comes the introduction of a competitor. Therefore, now more than ever we are forced to rethink our attitudes towards research and fully realise its value in providing a strategic advantage for AOTC's future.



The commercial support for 'blue sky' research is becoming less and less — research is now considered most valuable when it is directed to accomplish known goals. It must be firmly aligned with market direction and customer needs. We invest in research in the expectation of gaining real and tangible financial benefits. Long term and continued investment in Australia's scientists and engineers will secure such benefits and provide a business advantage for the future.

During 1991, TRL has served to provide Telecom Australia with the technical expertise and back-up that reinforces Telecom Australia's position as a world leader in the field of telecommunications. TRL has also continued to provide ongoing rapid technological advances needed by all Australians for their business success and private convenience.

Throughout 1991, TRL has become a more powerful force with the consolidation of research onto the one site. For the first time since 1942, all of TRL has been relocated onto the one site in Clayton on the outskirts of Melbourne. We commemorated this event with the opening of a new building which provided an opportunity to bring together people from industry, the political arena, academe, and other client areas of Telecom, to view the latest telecommunications technologies.

Important areas of research throughout 1991 have included customer service, artificial intelligence, signalling for personalised services, network management, reliability, advanced materials, safety, security, broadband packet switching, optical fibre, human, social and business needs, and personal communications. These areas aim at providing Telecom with faster, better, cheaper, and more reliable products and services — all of which you will taste throughout the following pages.

The chapters to follow will expand on what I have said, and will provide the viewer with a window to the decade of value-adding research and development that lies ahead. TRL will continue to research and develop services and products so that the new AOTC will keep Telecom Australia's reputation as the best provider of telecommunications for the Australian community.

H.S. Wragge

Executive General Manager

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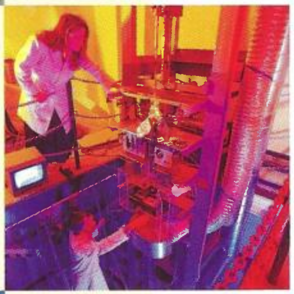

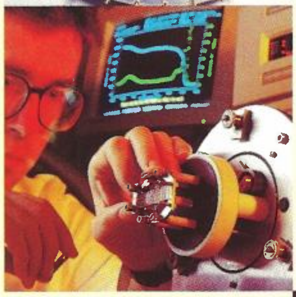

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middle row

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- Instrumentation Engineering

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.

Achieving the Mission

TRL seeks to provide expertise which will allow Telecom to be an intelligent and sophisticated procurer and operator of high level technology in meeting the telecommunications needs of it's customers.

TRL's mission is being achieved through seven key areas:

- provision of strategic advice and expert consultancy,
- value adding to Telecom Australia's products and services,
- cost reduction of Telecom Australia's equipment, systems and networks,
- technical support of Telecom Australia's existing plant and equipment.
- transfer of technology to other parts of Telecom Australia,
- increased ownership of Telecom's products through system and component design, and
- maintenance of a highly skilled, expert and motivated work force.

A Shared Resource Unit of Telecom Australia

TRL is a Shared Resource Unit within Telecom Australia. It is responsible for performing Telecom Australia's research needs. TRL conducts a Research Programme derived from a corporately endorsed and approved Business Plan. Complementing the Research Programme, TRL also provides a number of corporate facilities for the company. These include the Telecom intellectual property portfolio, the provision of a Telecom-wide information resource, and the conduct of a programme to support academe. The services that TRL provide are available to all other organisational units of Telecom Australia.

The annual formulation of the Business Plan requires the consideration of corporate priorities and performance needs of R&D projects and related activities. This is in terms of the required "deliverables" and the resources needed to ensure their timely delivery. A requirement is that 85% of the Research Programme is funded by other business units of Telecom. The other 15% is discretionary and contains more forward looking work that business divisions are not yet ready to fund.

The Role of TRL

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

Expert Advice

TRL's advice regarding the application of new and existing technologies ensures that Telecom Australia is best able to provide up-to-date services and a highly reliable network. It does this by providing strategic advice concerning opportunities for exploiting potential new technologies and new generic services, and by transferring technology to other parts of Telecom, Australian industry and academe. In addition, TRL supports existing network technologies by enhancing reliability, reducing operational costs and improving performance. Furthermore, TRL strives to increase ownership in Telecom Australia's products, both at system concept levels and through specialised device design.

Collaboration

Collaboration between TRL and industry ensures that systems and equipment are cost-effective and reliable. TRL's collaboration with universities helps tailor appropriate telecommunications skills for future graduates.

Standards

Participation in the development of technical standards ensures that they operate to the greatest advantage for Telecom's requirements. TRL provides delegates to participate in the development of national and international standards relating to telecommunications. In this way, TRL can represent both the interests of Telecom Australia and Australian industry in national and international fora. TRL's technical experts are able to debate complex issues from a position of in-depth knowledge and expertise, and can thus influence the development of standards to be in harmony with Australia's telecommunication needs. These fora are also a source of strategic information regarding future trends in service provision and system development. So then, TRL is able to advise Telecom Australia on the current status of technical standards and the probable directions of evolving standards. Telecom can then apply standards in a timely manner with assurance that they are the most up-to-date, therefore making the applications credible and viable. TRL can use this information to their advantage by developing tools that will optimise the application of new standards.

Corporate Facilities

As an adjunct to the performance of the Research Programme, TRL manages and provides several specialised Corporate Facilities for the whole of Telecom Australia. These include:

- the operation of the National Information Resource Centre (NIRC), which provides up-to-date library and information services covering a wide range of topics relevant to Telecom's operations,
- intellectual Property Consultancy, including the management of Telecom Australia's intellectual property portfolio,
- a programme of support to academe, principally via the establishment of Centres of Expertise in relevant areas of telecommunication study at appropriate universities, and
- maintaining Telecom's reference standards in relation to the measurement of physical, optical, and electrical quantities, to enable Telecom to meet its obligations under the Weights and Measures Act.

Corporate External R&D Programmes

TRL is responsible for the management and conduct of Corporate External R&D Programmes on behalf of Telecom Australia. These include:

- the management of a portfolio of industry and university research contracts. This programme, budgeted at about $3.6 million for 1989/90, complements the intramural Research Programme and seeks to encourage appropriate research in industry and universities.
- participation in the activities of ATERB, the Australian Telecommunications and Electronics Research Board, including representation on the ATERB Board. ATERB is a cooperative institution funded by Telecom, OTC, CSIRO and the Department of Defence, making grants to academe to foster research in the telecommunications and electronic sciences, and
- representation of Telecom in various scientific and academic bodies.

TRL Management

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

The Business Plan is reviewed and reformulated annually as part of the corporate business planning process. It comprises a rolling five year strategic plan, which establishes major R & D thrusts and the direction and magnitude of the TRL programme. Additionally, a more detailed two year operational plan is formulated and includes specific research detail and budgetary allocations.

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

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

Research Programme

- The Business Plan and the Research Programme are formulated internally and decisions are focused around:
- the Corporate Facilities provided by TRL for Telecom Australia,
- the Corporate External R&D Programmes managed by TRL on behalf of Telecom Australia, and
- the major R&D projects, each comprising a number of separately identifiable smaller projects generally grouped in terms of their applicability to Telecom Australia's business and operational activities.

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

TRL Strategic Technological Thrusts

The bulk of TRL's Research Programme caters to the needs of Telecom's Business Divisions and the customers they serve. Though many are narrowly focused on specific short to medium term needs, most projects follow one or more of the following 12 Technological Thrusts:

1 Personal Communications
To use radio and fixed networks to provide new and widely available personal communications services.

2 Optical Fibre
To introduce optical fibre into the Customer Access Network in a cost-effective manner for narrowband and new broadband services. Furthermore, to provide a high capacity, low cost trunk optical fibre network.

3 Human Social & Business Needs
To develop and provide methodologies and knowledge about the communications needs of Telecom's customers, that will enable Telecom to specify, plan, and provide quality telecommunications products and services.

4 Broadband Packet Switching
To provide flexible, broadband packet switched networks capable of carrying a very diverse range of traffic.

5 Network Management
To provide capable network management systems for both Telecom and its customers.

6 Signalling for Personalised Services
To develop sophisticated signalling systems for network services including personalised and mobile services.

7 Customer Service
To provide technology that will allow customers to realise enhanced value from network services concerning information, image, video, voice-activated and multi-mode communication, and position Telecom to provide total service packages.

8 Artificial Intelligence
To improve operating efficiency by incorporating artificial intelligence systems in critical operations and design. And to create a new generation of network services that employ artificial intelligence to make them accessible to the broadest number of customers possible.

9 Reliability
To improve the reliability and performance of the Telecom network and business products.

10 Advanced Material
To conduct research into advanced materials and devices that are of strategic importance to future telecommunications systems.

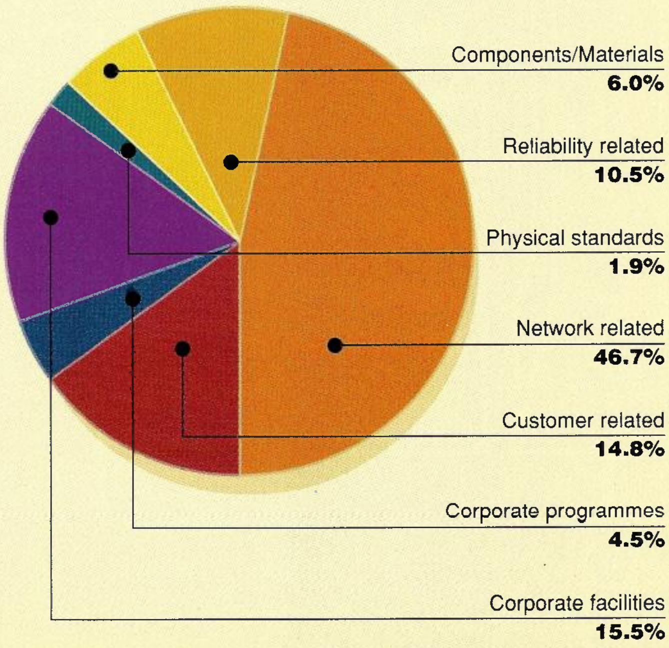
11 Safety
To develop the scientific bases for safe practices with work place hazards.

12 Security
To provide security technologies that will meet the differing needs associated with protecting Telecom's infrastructure and customer services.

Resources

During 1990/91, TRL employed approximately 550 staff. Of the total staff, approximately 260 have professional qualifications in engineering or the applied sciences and 20 in the social and information sciences. A further 150 technical staff supported the professional staff, with administration performed by remaining staff.

The annual operating costs of TRL totalled approximately $62 million. Of this total, about half is expended on salaries and salary-related costs. Capital expenditures, primarily on laboratory test equipment and facilities, amount to about $4 million annually, with the remaining covering operating expenditures on consumable materials, incidental items (including R&D contracts), and buildings and building services. Laboratory test equipment items number about 16,000, with a depreciated value of approximately $20 million.

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MANY exciting challenges are ahead of us in a rapidly changing and globally competitive telecommunications environment. Telecommunications will change so rapidly over the rest of this decade that soon we will be able to deliver over a thousand times more information capacity to customers than we have been able to deliver before. The questions of how we will use such capabilities, and what will be the drivers and the opportunities for communications service creation, are wide open.

Compounding these challenges is the escalating research, development, and manufacturing cost required to deliver new telecommunications products. The lifetime of new products is also decreasing as technologies and standards evolve more rapidly. It might then be reasonable to assume, that the number of major hardware platforms and the number of manufacturers will be fewer in the future. Contrasting with this position, the service opportunities for service providers will be far greater. Increasingly, services will be created in software on commonly available integrated circuit chips or hardware platforms. In this way, services will be differentiated by their providers and will proliferate. They will also become more powerful, more sophisticated and more global in their application.

It is against this backdrop that the Customer Services and Systems Branch (CSS) conducts a broad telecommunications applications R&D programme. The tasks for CSS are to identify and understand new application opportunities, and to develop technical delivery solutions. One of the greatest challenges we face in these tasks is to understand the intersection of technological capability and customer need.

Technological capability is rapidly moving to a position where almost any service that can be imagined can be realised. Our task here is to understand the technology in terms of the costs, options, trends and timing of major technological shifts, and to be smarter in the use of that technology than our competitors. On the other hand, customer need and market stimulation will increasingly be the determinants of successful service creation.

The opportunity for service creation provided by new technology will exist when it allows us as users to accomplish something that we need but cannot yet achieve in our business or social lives, or when it facilitates the use of current capabilities more effectively or at lower cost. As these services become more sophisticated, their interface becomes more important. The use of new services needs to be easy to learn, easy to remember, and easy to find help on when it is needed.

These challenges require a multi-disciplinary approach. In the CSS Branch, skills from the disciplines of anthropology, psychology, sociology, linguistics and geography are used together with those of mathematics, computer science, software and communications engineering, to identify communications needs and to develop solutions.

Items on the following pages are used to illustrate how these skills are brought together for the creation of new services. The information flows and communication needs of a rural community are examined to ensure that the services offered best meet the needs of the user community. Barriers and bridges to new services entry are examined to illustrate the effects of business culture. The technology of Geographic Information Systems is being developed as a decision support system to help answer questions about customer demographics, market penetration, and spatial needs for networks and resources deployment. Other items illustrate how Artificial Intelligence is being applied to the creation of intelligent market services and design systems. The importance of international standards is exemplified in our item on distributed electronic directories for a multiplicity of new service numbers. This is followed by an item describing the technological considerations underlying the management of our many networks so that they appear to the user as a seamless integrated network. Finally, the development of new horizons in video and image services for the new broadband networks illustrates the integration of customer needs, user interfaces, standards, and technical studies that are necessary for a particular service development.

These examples are illustrative of some of the approaches to the matching of customer needs and technological capability in a rapidly changing service creation environment.

Intelligent Information Retrieval Systems

TRL is developing information systems which have high speed network capabilities, are adaptable to the individual customer, and do not require any user training to be used effectively.

New high speed networks such as FASTPAC and B-ISDN, offer possibilities for the retrieval of large items of information such as images, speech and video. As a result, we can project a widespread adoption of information stores containing multimedia documents. When a future customer retrieves an item from an information store, it may well contain a number of different media items, linked together in a page that is displayed on a high resolution screen with accompanying voice commentaries.

In a collaborative project with the Japanese Frontier21 project, a national project for developing the communications technology of the next century, TRL has developed a new approach to information retrieval. This new approach is based on the use of neural networks, a technique that uses large numbers of simple processors that are interconnected via a network of links. Emulating to some degree, the function of the human brain, neural networks are able to provide a seemingly simple and flexible access to large information stores, suitable for access by a broad customer base.

Traditional information retrieval systems operate on a simple system of keywords, with the customer specifying the keywords to describe an item of information to be retrieved. This approach is quite effective amongst a very small community of users, such as a professional association or research group, and has largely remained unchanged since the early 1970s.

However, experimental studies show that keyword based retrieval systems perform poorly in two important applications. First, where the system is being used by novice users; and second, where the system is being used by a large number of people. This problem occurs because the keyword based approach assumes that the customer is familiar with the vocabulary of the information store. For example, if a user is looking for items concerning finance it is not enough for the system to assume that all of the articles are indexed under "banking", since the user may not be familiar with this connection. These issues become even more difficult when we consider systems that can be accessed by natural language.

With the neural networks approach, instead of the user accessing the store via keywords directly, the keywords are mapped through a neural network that associates other meanings with the words. In the example on finance, the neural network will bring the "banking" references to bear directly. Based on the customer's actual use of language, the neural network establishes links between words and related meanings. This overcomes the need for a precise vocabulary, and gives the promise of information systems that can be used by a much wider range of people.

TRL is developing high speed, adaptable information retrieval systems based on neural networks technology.

One of the early applications of this approach may be to access electronic directories, such as the Yellow Pages, by relating different categories in the directory. For example, if a user is interested in plumbing supplies, the neural network approach could look for related entries under "building supplies" and "engineering supplies". A large database such as the Yellow Pages is an enormously rich source of information. By adding the unlimited indexing provided by neural networks, we can add value to the original database and support a wider range of queries. In addition, by making the information available in electronic form, higher value access is possible.

New approaches to accessing and using information are needed to make the best use of future networks, and to create a true information society. We can dramatically expand the use of information by using high speed networks and cheaper computation to deliver new interfaces that are much easier to use.

Artificial Intelligence for Network Design

TRL is applying Artificial Intelligence (AI) techniques to reduce the cost of Customer Access Network (CAN) design, the network between the customer and the exchange, and provide optimum network designs.

The CAN is important because of its extent and its role as the main form of access for most customers into the broader network. Correct design of the CAN can potentially save millions of dollars through the optimum provision of plant and reduced maintenance costs.

The design of telecommunications networks can be a difficult and time-consuming task. Yet because of the costs involved in constructing networks, it is a task of vital importance to Telecom. For instance, a network that is greatly over-dimensioned for the demand placed on it wastes capital that might never be recouped. And a network that is under-dimensioned will have to be upgraded in time to satisfy demand and thus waste resources by duplication. Doing it right the first go takes skill and time.

The CAN is divided into exchange areas and then distribution areas that may contain as many as 300 customers. Manually designing the CAN for a distribution area can take as long as a week. The aim is to automate much of the design process. There are two main aspects to CAN design: first, the choice of an appropriate network implementation strategy for a particular distribution area; and second, the detailed design of the network to implement that strategy.

The first aspect includes decisions as to whether the network should be above or below ground, or whether optical fibre should be used. Usually this stage requires an on-site inspection. Sometimes the designer might try alternative strategies in a "what-if" type of analysis. The second aspect is the actual routing of cables and placement of plant to meet the chosen CAN strategy. This process follows guide-lines set down for plant construction. By automating CAN design, we can quickly satisfy the second aspect, and free network designers to concentrate on the demands of a particular distribution area and "what-if" analysis. Thus, we will achieve better designs faster by allowing human designers to concentrate on what they do best, while removing the tedious, error-prone, low-level design tasks.

TRL is applying Artificial Intelligence techniques to reduce the cost of CAN design, and provide optimum network designs so that Telecom's residential customers will enjoy a more reliable communications link.

The automated CAN design system uses a combination of algorithms and expert systems, or rule-based programming techniques. Some aspects of the design task, such as choosing the correct size for cables, follow well described algorithms. Other aspects, such as cable routing, use design rules and heuristics (ie., rules of thumb used by experts) to choose the lowest cost route.

Different design strategies use different rules and algorithms. The automated CAN system uses the "generate and test" approach. With this approach, an aspect of the design such as the cable route down a particular street, is generated using design rules and then checked by a test module to see whether or not the route can be bettered. To converge on an optimum design quickly, the critical task is to structure the design rules so that the generated designs are good, and then refine these designs until the optimum is achieved.

Capturing the rules and heuristics is an important part of the system's design. Because of the variety of road layouts, network types and range of plant items that are available for use, the total number of possible CAN designs is very large. The automated design system must navigate its way through these possible solutions to find the best. While the "generate and test" approach may eventually find the optimum solution, the design rules must make good first guesses if the process is to converge quickly. To be successful in the field, an automated design system must generate designs that are at least as good as a human designer, but in much less time.

Currently the design system generates underground copper cable CAN layouts for new distributed areas. Eventually it will handle the relief of distributed areas where the existing plant no longer meets customer demand or where the network must be replaced because of its age. Other phases of development include optical fibre, pairgain systems and possibly radio. The system is utilising the Cable Plant Records system for its knowledge of roads, properties and existing networks.

Results of the work so far show that the automated design of optimum networks is indeed possible and will be used to make network design much faster and more efficient.

Network Management: a Distributed Application

Providing Telecom customers with a seamless communications service is quite complex and requires the entire range of technical and engineering expertise available within Telecom.

The view that the customer sees is in reality an integration of many communications networks. The modern network management environment is essentially a very large, highly distributed information processing application, which provides customers with an integrated management view of their communications networks. Such a view is constructed from various Telecom networks, their associated management facilities, operational support systems and customer network equipment.

Technologies that can help to achieve the seamless integration required in the network management environment include object-oriented modelling and database techniques, international standards, electronic directories, and security technology.

Object-oriented techniques are gaining increasing acceptance in areas such as systems modelling and design, programming languages, databases and user interface construction. Despite this acceptance, there is still much confusion about what constitutes the object-oriented paradigm, and what its advantages and disadvantages are. TRL is investigating the application of object-oriented techniques in the Telecom Network Management Architecture. Issues being considered include technology trends, international standards for object-oriented databases, potential for the application of such databases in the network management environment, and integration with, and migration of, Telecom's information architectures.

Some internationally standardised applications are already employing object-oriented techniques. In particular, the Open Systems Interconnection (OSI) network management standards are based on an object-oriented approach. The emerging Reference Model for Open Distributed Processing (RM–ODP) also uses object-oriented techniques for the modelling of distributed systems.

While the OSI Reference Model concentrates on interconnection problems, ODP deals with application interaction issues, providing a framework in which the broader context of distributed applications can be viewed. Its objective is to allow such applications to be defined and constructed while maximising the portability and potential for interworking such applications, and masking the effects of distribution from users. ODP and OSI will be important tools in achieving the necessary integration within the network management environment. TRL will continue their involvement in the development of these and other standards that

Public Information Systems

Electronic information systems can provide the public with a user-friendly, attractive, and interesting information source. Members of the public can touch a colour television screen to make selections of the data they wish to see. This data may be presented as text, graphics or video complete with sound.

A few systems such as this can already be found, and they have proven to be very popular with the public. These systems provide access to a variety of information including shopping centre tenant guides, timetables and locations of events and exhibitions, and tourism guides.

TRL is bringing electronic information systems technology to maturity, improving its performance and enhancing its functionality to take advantage of new telecommunications technology and advanced software techniques. A major research undertaking is to improve the quality and scope of information that a user can access through an information terminal. This can be achieved by providing access through high-speed communications networks to intelligent databases, electronic libraries and catalogues, and video repositories. Software advances would, for example, enable the user to plan itineraries or make detailed transactions using an electronic system.

Many more applications can be realised by making electronic information systems even more useful. For instance, a travel booking system would allow the prospective customer to look at video material of the possible destinations and to choose between alternative accommodation quickly and confidently. While on holiday, the traveller will be able to discover and plan the sight-seeing highlights each day using the tourist information system in the hotel lobby. It would also be possible to book an activity in advance by performing a transaction with the client providing the service and paying for the service by interacting with a bank or credit card company.

TRL is using such systems as a platform to aid the development of enhanced industrial and business services by incorporating techniques from Artificial Intelligence research. Soon, customers will require easy-to-use multi-service terminals accessing a wide variety of information sources. They will be customised to suit the needs of each individual user in any specific business environment — and Telecom will be able to cater for these needs.

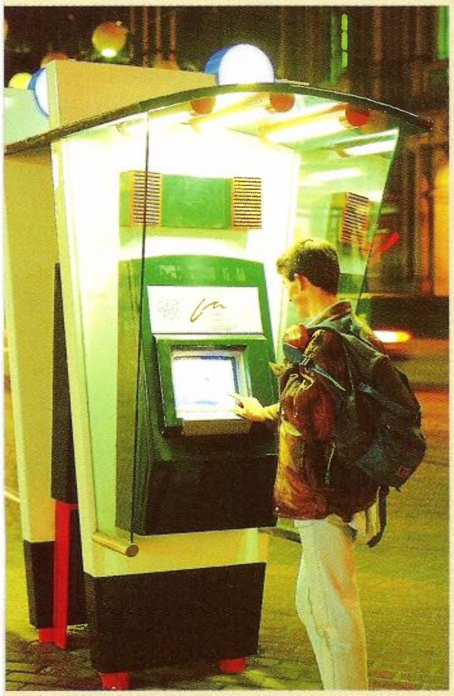
are necessary for the successful introduction of open, distributed network management systems.

Electronic directories are another key element in the integration of network management components. Electronic directories based on the CCITT X.500 Recommendations can be used to provide information on the location and attributes of elements in the network management environment. Applications are then relieved of the need to maintain such data internally. Changes in the location or attributes of components can be reflected in the directory without needing to notify or alter all of the applications that previously interacted with that component.

Preventing unauthorised access to all of the components of Telecom's network management systems is essential to the successful operation of those systems and the networks they are used to manage. Access controls must provide protection against both accidental and malicious intrusion. This is particularly true of the OSI based Telecommunications Management Network (TMN) and Customer Network Management facilities currently being developed and deployed within Telecom.

Application of secure access controls between two communicating entities requires that both parties be able to reliably determine the identity of the other. That is, mechanisms must be available for both parties to authenticate or verify the claimed identity of the other. Only when the identity of an entity attempting to gain access has been determined, can a decision be made about granting access. An authentication framework has been developed for use in the TMN and related systems. This framework utilises a distributed network of authentication servers to provide strong authentication based on cryptographic techniques between end systems.

The contribution of these technologies is a small, but important, part of the efforts being made towards the construction of integrated network management applications that satisfy customer and Telecom needs. Achieving these goals will require the technical and engineering expertise and know-how that TRL can provide.



The very popular information retrieval systems can be seen in use at Melbourne's Bourke Street Mall. Similar technology developed by TRL has limitless applications.

The X.500 Standards for Distributed Directory Systems

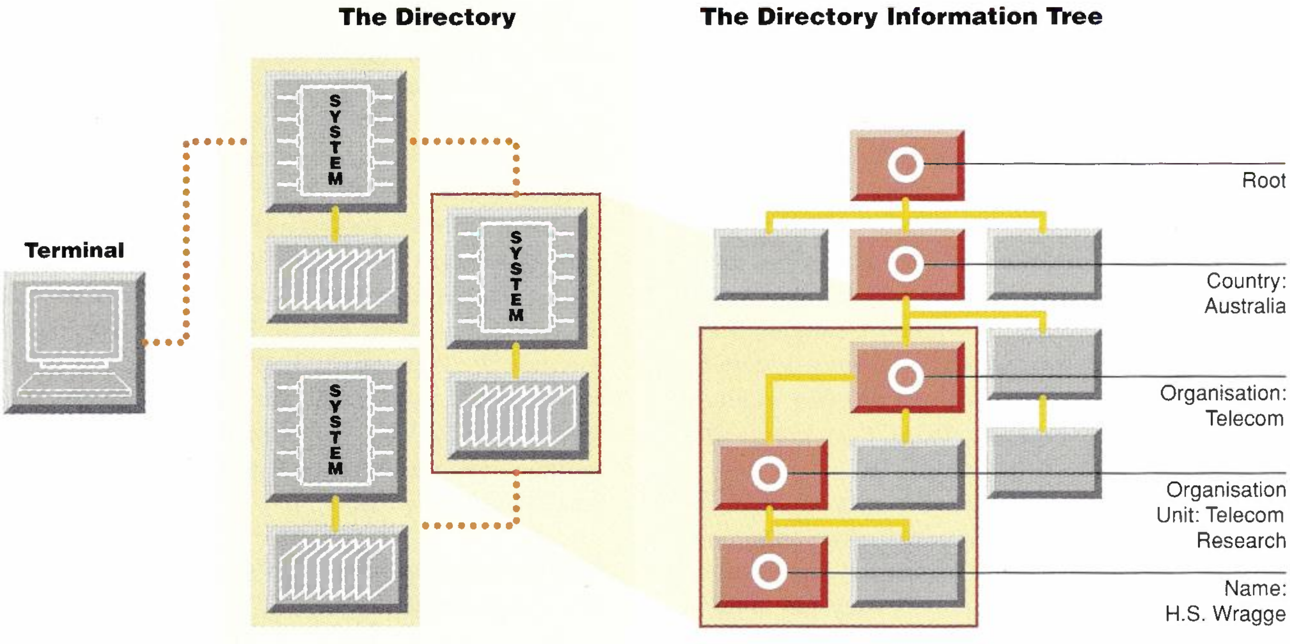
Picture a directory that is always up to date, contains as much information as all of the paper based directories put together, can be readily searched, and would provide immediate access into the entries — TRL has been working with the international standards community to provide such a service.

Directories are an integral part of telecommunications, providing information about service users that allows the communicating parties to get in touch with one another. Most directories today are paper products — separate books or lists that must be consulted manually before using the service. Electronic directories are systems that make directory information available in on-line form, for people to use interactively from remote terminals or for computers to use directly.

Electronic directories offer substantial advantages to both the users and the providers of telecommunications services, especially information services. In the future, they will also have a major role as a tool in the construction of distributed applications, where the complex operation of directories is largely transparent to service users.

An electronic directory will ideally be comprehensive. Over the last few years, the international standards community has been working towards the goal of a global directory service. Such a global directory must respect the autonomy of individual locally-administered directories, and will therefore consist of a cooperative arrangement of separate directory systems.

A global, cooperative arrangement requires the support of all parties for comprehensive interconnection standards. In 1988, the International Telegraph and Telephone Consultative Committee (CCITT) and the International Organisation for



A distributed directory provides transparent access to an entry stored in a remote system, subject to access control. Also shown is the hierarchical relationship of entries.

Standardisation (ISO) jointly defined a new series of standards for electronic directories known as X.500, which specifies:

- a common directory information framework ("schema") to specify the types of data and relationships between data held in the directory.
- procedures for interworking between individual systems, so that data held in one system can be retrieved from another system.

X.500 is very flexible in terms of the services it can offer. A user can read or list directory information (a white-pages service), or search for entries based on their attributes (a yellow-pages service). A typical implementation may allow storage of an organisation's business name, address, telephone number, telex, teletex and electronic mail addresses, as well as business-specific information such as a description of the business type, its daily opening hours and service or advertising details. An X.500 directory could also hold network information, mailing lists, and the like.

TRL was an active contributor to the development of 1988 X.500, and is currently leading a major international standards effort to enhance X.500 by the addition of numerous new features. The revised standard will be published in the 1992 CCITT White Book and will be known as 1992 X.500.

Among the features to be added are: access control, better search facilities, enhancements to the information model, support for full or partial replication of directory data, and the ability to dynamically acquire the schema of a remote directory.

Nevertheless, X.500 is implementable today, and TRL has a high performance implementation of the 1988 standard underway. Work on Telecom's own internal corporate directory has served to motivate a number of the current extensions, as well as to verify the basic correctness of the 1988 standard. With the additions planned for 1992, X.500 will make possible a highly functional global directory service, with Telecom well placed to be an active participant.

Broadband Video Services: Developing New Horizons

In the near future, Telecom's customers will have the opportunity to make new and greater use of the video medium in their day to day communications.

Advances in telecommunications technology will make video services more widely accessible and relatively inexpensive. To help achieve this goal, TRL is working to ensure that these services and products are matched to the communication needs of our customers, are easy to use, and represent the latest in technological possibilities.

To begin with: which services should be developed and how should they be offered? To answer this question, Telecom needs to understand how video might fit into the business of its customers. TRL is using Information Flow Analysis to investigate the current and potential use of video services in business and government. The aim is to identify what types of information must be exchanged in particular industry sectors, what form this information takes, and how it is currently handled.

Researchers have interviewed people in corporate and government positions in diverse fields including mining, finance, law, retailing and education. Analysis of the interview material is then used to shape decisions about the kinds of products and services that are most likely to meet the needs of specific customer groups. The data from these interviews also gives early indications regarding the degree of demand for video, and the conditions under which it would be widely adopted.

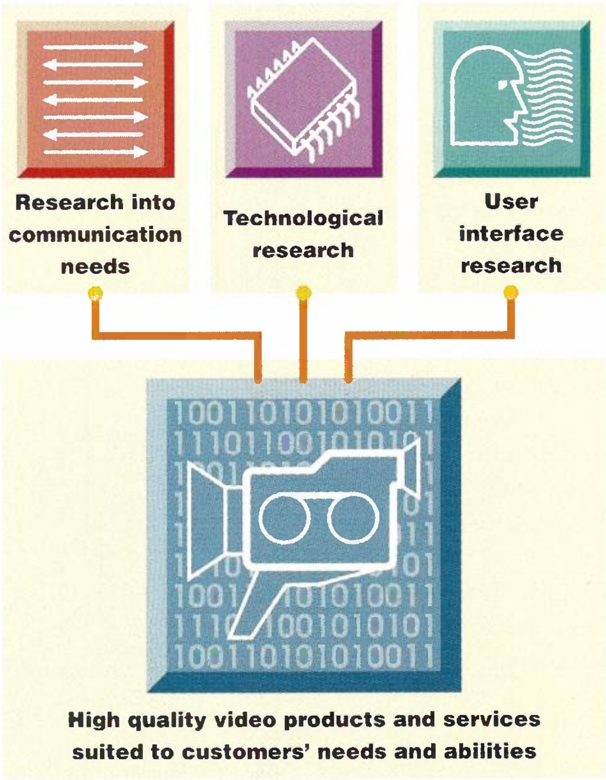
On the technological side, TRL is engaged in fundamental studies into digital video coding and communications. This work is primarily oriented toward future broadband optical fibre based networks.

In the future, networks are expected to deliver all video services — from video telephones to High-Definition Television — on the one optical fibre. Hence, a major research thrust is aimed at integrating all these different services, so that a videophone conversation could be carried out on the same piece of equipment used to provide entertainment television. This flexible, universal video signal representation will allow easy introduction of new video services such as HDTV, and could make multi-site videoconferences cheap and convenient.

This is the largest video coding research project in the country, and is being carried out in collaboration with Monash University, the Australian Defence Forces Academy, the University of New South Wales (supported by a Government R&D grant) and Siemens Ltd. Research results are being fed directly into the international standards forums.

Potential applications and their underlying technology are insufficient on their own. Further steps need to be taken at an early stage to translate the capabilities of new technology into products which match the expectations of users. Consequently, TRL is also involved in designing the user interface for videoconferencing systems. The approach is to focus on potential users of the system to identify the special requirements of the videoconferencing environment, while at the same time recognising the cognitive and perceptual capacity of the human operator. Issues of prime importance to customers include the quality of the service (both audio and video) and the ease of use of the facilities.

In a demonstration videoconferencing system for the trial FASTPAC network, control of both the connection and the video codec have been integrated into a single user interface on a personal computer. Mouse driven, and using pull-down menus and windows, its appearance is similar to standard personal computer software packages. Investigations are continuing on other related issues, such as the effect of sound/picture synchronisation on users, the effect of end-to-end delay on information flow and conversation, and the subjective assessment of video quality.



The end result of integrating research on information flow, technological provision and human factors issues will be a suite of useful, usable, high quality video services suited to customers' requirements in the immediate and longer term future.

Image Database Services

Advances in telecommunications networks and image processing components mean that high performance image based communications services could open up many new Telecom customer service possibilities at a reasonable cost.

In the past, with data transmission restricted to a few kbit/s over the Public Switched Telephone Network, even highly compressed natural images took perhaps a minute or two to transmit. By comparison, modern digital networks offer much greater performance. TV quality images can be compressed and transmitted over the Integrated Services Digital Network (ISDN) in as little as five seconds. Telecom's FASTPAC network will allow pictures to be transmitted at even higher rates, which would be comparable with flicking through the pages of a magazine. As a result, interactive, rapid response image systems become not just practical, but could offer very high performance at reasonable cost.

Advances have also occurred in image compression standards and technology. A standard has now been agreed upon by the "Joint Photographic Experts Group" (JPEG — a collaborative effort between the ISO/IEC and CCITT) for the compression of natural images. Compression of typically twenty times is possible before degradation becomes noticeable. Very Large Scale Integration implementations of this coding method capable of encoding or decoding an image in tens of milliseconds, are now appearing.

The combination of network and compression technology opens up many new service possibilities. Everything from toasters, to used cars, to real estate, could initially be viewed from a central database of images before going to inspect and buy the item. Travel agents could provide a series of images of hotels, golf courses and beaches in an electronic travel brochure. Many applications also exist for the communication of bank cheques, medical images, and legal documents such as titles, to speed the processing and reduce the burden of moving around pieces of paper.

To investigate the performance achievable with image systems, TRL has used the JPEG compression scheme to develop a demonstration image database application. The demonstration is a personnel database, which is linked to Telecom's corporate electronic directory. The system can provide a picture of each person in the database to accompany their work details (location, phone number and so on). It operates with a remote database, and is connected via an Ethernet LAN to FASTPAC. The full details, including the transfer, decompression and display of the image, can be

Changing Communication Needs in Rural Australia

Over the last two years, TRL has undertaken two information flow analysis projects concerned with the telecommunication behaviour and requirements of country customers.

In one of these, an area in was studied with a view to understanding the information flows generated by various sub-groups of primary producers. Of particular interest were the activities of groups of farmers, whose telecommunication requirements were believed to be quite different from those of other rural groups. The central question was: should their behaviour be understood as an isolated instance with specific needs to be addressed in one area alone, or whether it heralded radical change across the rural sector generally. The qualitative studies undertaken were able to identify, in considerable detail, customers' daily activities and their business communications.

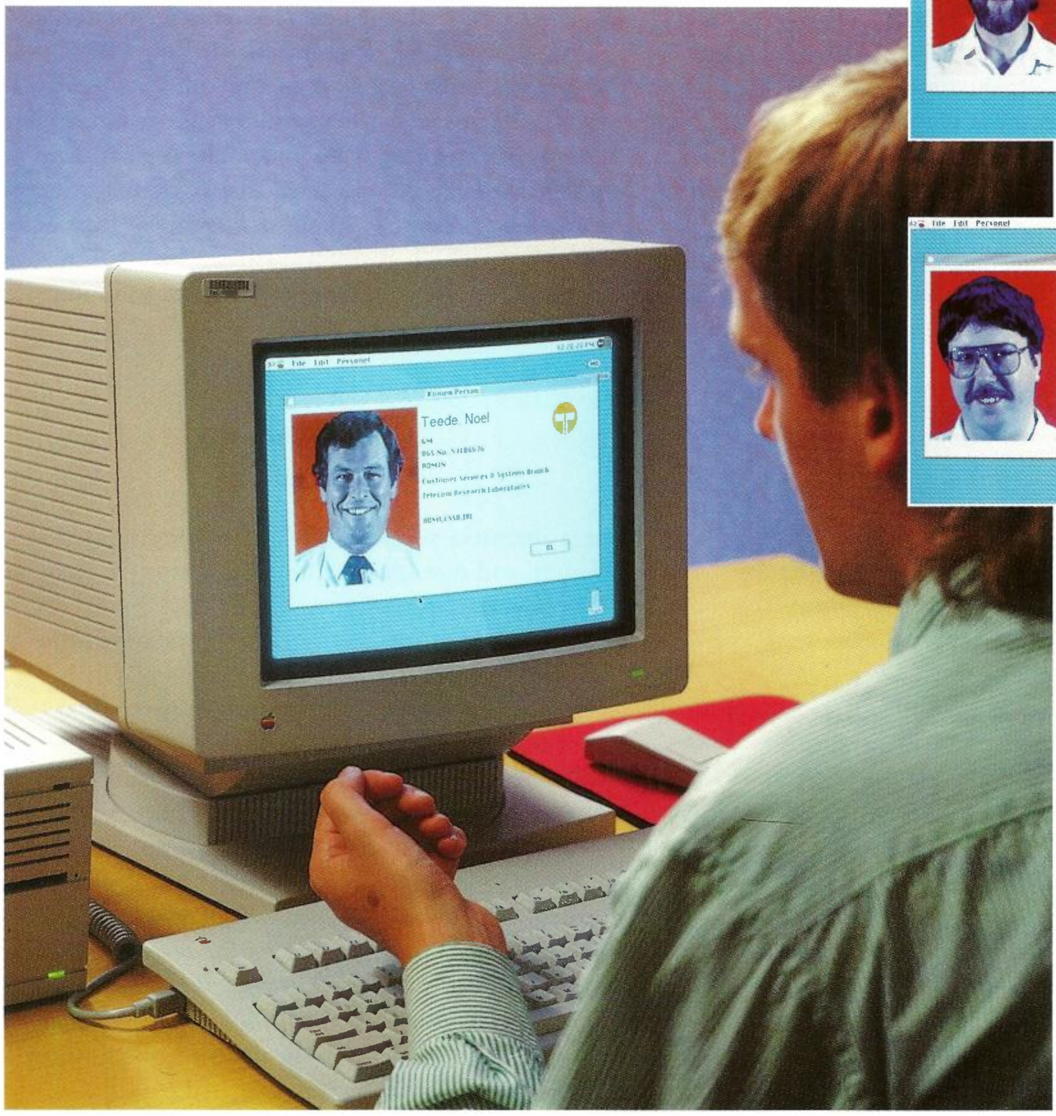
In addition to the agricultural sector, the studies also looked at research activity, education, mining, and secondary industries based in country areas. Telecom's major concern centres on the ability of the existing network to service current demands and on being prepared for whatever is the likely future for a rural Australia which is expected to continue to provide the bulk of our national export income. As the recession is showing clearly, if export marketing efforts are not efficiently expedited, revenue flows in other areas of the economy will be adversely affected. Telecom has a crucial, even if largely unrecognised, role to play in supporting exporters.

These and other studies are helping to identify all customer needs which must be addressed if Telecom is to meet the critical challenges of the 1990s.

presented in less than half a second, even though the database might be in another city.

The demonstration, which could itself have direct applications in a front-desk security environment, is providing both a realistic example of the use of image communications and a testbed for studies of technical issues.

A rapid growth is expected for image communications during the 1990s. The terminal technology and the high performance networks are arriving simultaneously, and provided it can be made as easy and cheap to use, natural image communication may well repeat the extraordinary growth of the facsimile service.



High performance image based communications services, being developed at TRL, could open up many new Telecom customer service possibilities.

Business Culture: Bridges and Barriers to Communication

The Information Flow Analysis team at TRL has been using methodologies from anthropology and sociology to investigate the impact of changes, such as implementing new communications technology, in different divisions of Telecom.

Both the level of acceptance of new communications technology and the effectiveness of communication practices are often determined by the mostly overlooked factor of "Business Culture". The term covers the range of beliefs and attitudes about the purpose of the organisation in which one works, the differing roles of people in that organisation, and the appropriate way to do one's job or to conduct business. Different business sub-cultures can be found amongst, say, different professional groups, even within the same organisation.

Three recent studies conducted by the Information Flow Analysis team at TRL, illustrate the role of business culture as it relates to communication practices.

Laptop computers that allowed field technicians to remotely access fault queues have been under trial in various parts of Telecom. Management was concerned about the possible negative effects of social isolation of the technicians as the use of these terminals replaced many interactions with central office staff. The study showed that by far the stronger factor in this situation was the positive influence of increased professional status that was provided by the new equipment, and the replacement of service uniforms by business suits and the addition of business cards. The enhancement of image and personal competence signalled by these changes was a significant factor in the technicians' adoption of the new technology.

This example shows clearly how the broad cultural context into which the new technology was introduced had a significant effect on its acceptance, which was quite separate from any assessment of its effectiveness as a communication device.

Conversely, established work practices may prevent or limit new ways of communicating. Videoconferencing is an increasingly viable option for communicating as it becomes cheaper and more widely available. However, its uptake by executives is limited at present by their strong belief that body language, which is only available face-to-face, is essential for allowing them to interpret and influence the course of many meetings.

Centre of Expertise in Geographic Information Systems and Applications

TRL's latest Centre of Expertise will enable Telecom to deliver the future services customers want, when and where they want them.

The Centre of Expertise in Geographic Information Systems (GIS) and Analysis was established at the University of Tasmania in 1990 . The Centre is a joint effort between the University's Centre of Spatial Information Studies, CSIRO's Planning and Information Group,and TRL's Geographical Information Studies Group. From the outset, the aim has been to position Telecom at the forefront of research into customer needs for telecommunication services.

The Centre conducts a programme of basic and applied research into the theory and applications of GIS, with emphasis on its use for spatial analysis of social and economic data. GIS, with its wide functionality for capturing, manipulating, analysing and graphically displaying spatial data, is a powerful platform on which to build new tools for analysing and forecasting future demand for new telecommunication services and products.

The Centre's programme focuses on researching methodologies that will utilise the power of GIS as a decision support tool for strategic planning, design, and management for an increasingly complex telecommunications future.

Initially, the Centre will address three primary areas of investigation.

The first area is the optimisation of spatial allocation decisions. New mathematical models that will integrate the functionality of GIS with existing optimisation algorithms will be developed to provide solutions to the "too hard" problems. Secondly, statistical methods will be developed to describe the spatial and aspatial reliability of information derived by spatial manipulation and/or the blending of data held at different spatial revolutions. Finally, the development of time-space GIS is being explored to provide a means of analysing and forecasting changes in spatial distributions over time.

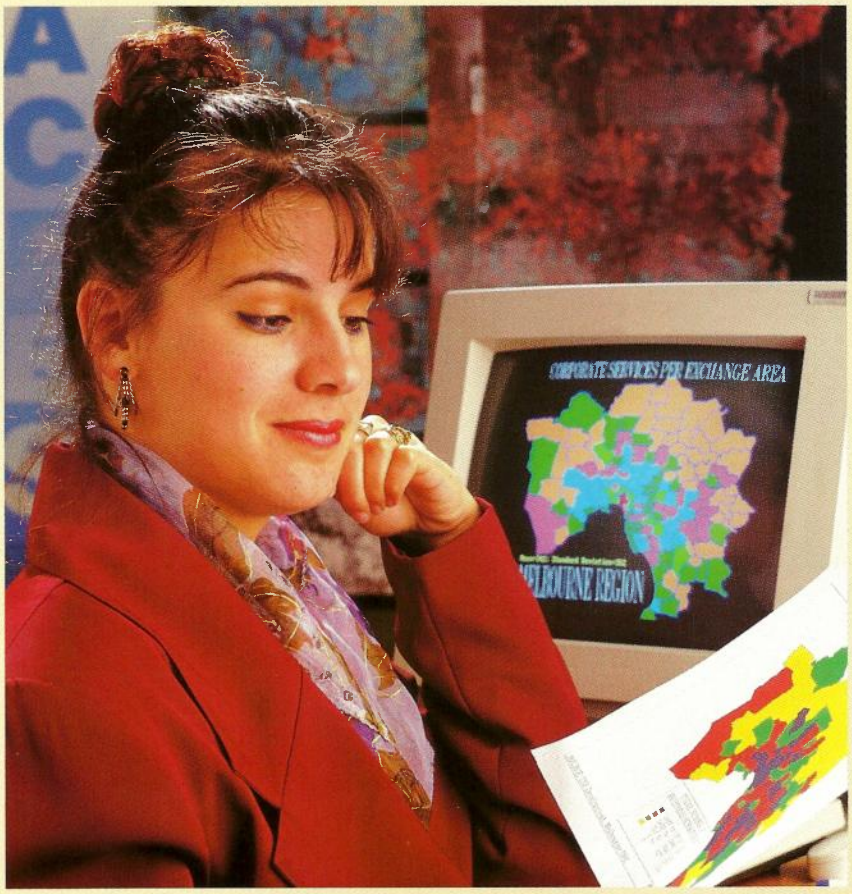
The concept for the Centre is a natural outcome of the co-operative research of the participating organisations. The combined expertise of the three groups will allow a wider range of issues to be tackled than could be attempted by any one group in isolation. For Telecom Australia, the Centre is a key to better customer service.

Another limitation is business protocol, which holds that the lower level manager must travel to the higher level manager, and the account representative to his or her client. Successful strategies for the promotion of videoconferencing as a communications alternative must take such factors into account, and up to a point, be prepared to challenge former assumptions about how to do business.

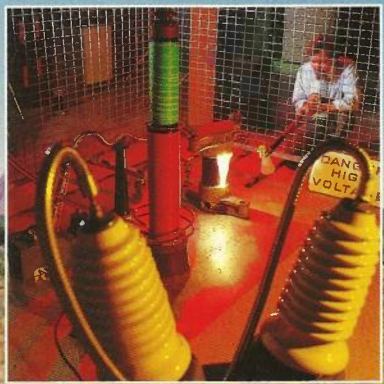
On the other hand, matching communication practices to the way one's clients habitually do business can in some circumstances be a simple means for improving the exchange of information. A study commissioned by a national team that works on network problems across the range of Telecom divisions, looked at the communications operating between the team and its client groups in other parts of Telecom. It was clear that the expectations and attitudes of staff in the various client groups differed, and that a blanket approach towards dealing with them was not the most appropriate communication strategy.

For example, for some client divisions, it was appropriate to present the services offered by the network team in terms of product options. Whereas for others, the preferred approach was a contractual one. For another, the requirement was that the network group join with them in a cooperative relationship. Instances of failure by the network team to adopt the particular orientation that matched each client's culture led to tension and dissatisfaction.

Thus, the concept of "business culture" can be seen as relevant to many business decisions. Although these examples given deal with Telecom's internal practices, the cultural context has an equally significant role in the outcomes of decisions regarding communications with, or communications technology for, Telecom's customers.



Researcher Skev Ioannou demonstrates the importance of statistical and spatial modelling in the planning and future placement of telecommunications services and products.



RELIABILITY, QUALITY AND STANDARDS

Australia's harsh environment makes reliability of key importance when providing telecommunications services that are second to none.

AUSTRALIA'S harsh, and sometimes remote and almost inaccessible environments makes reliability of key importance when it comes to providing telecommunications services that are second to none.

To achieve Telecom's reliability goals, all materials, components and systems in the network must perform for their full design life spans in a variety of Australian environments. Degradation of materials or components, causing equipment malfunction or failure, results not only in costly repair or replacement, but also causes customer dissatisfaction and losses in revenue. In addition, the safety of Telecom personnel and customers must not be compromised by equipment faults, inadequate equipment specifications or incorrect work practices.

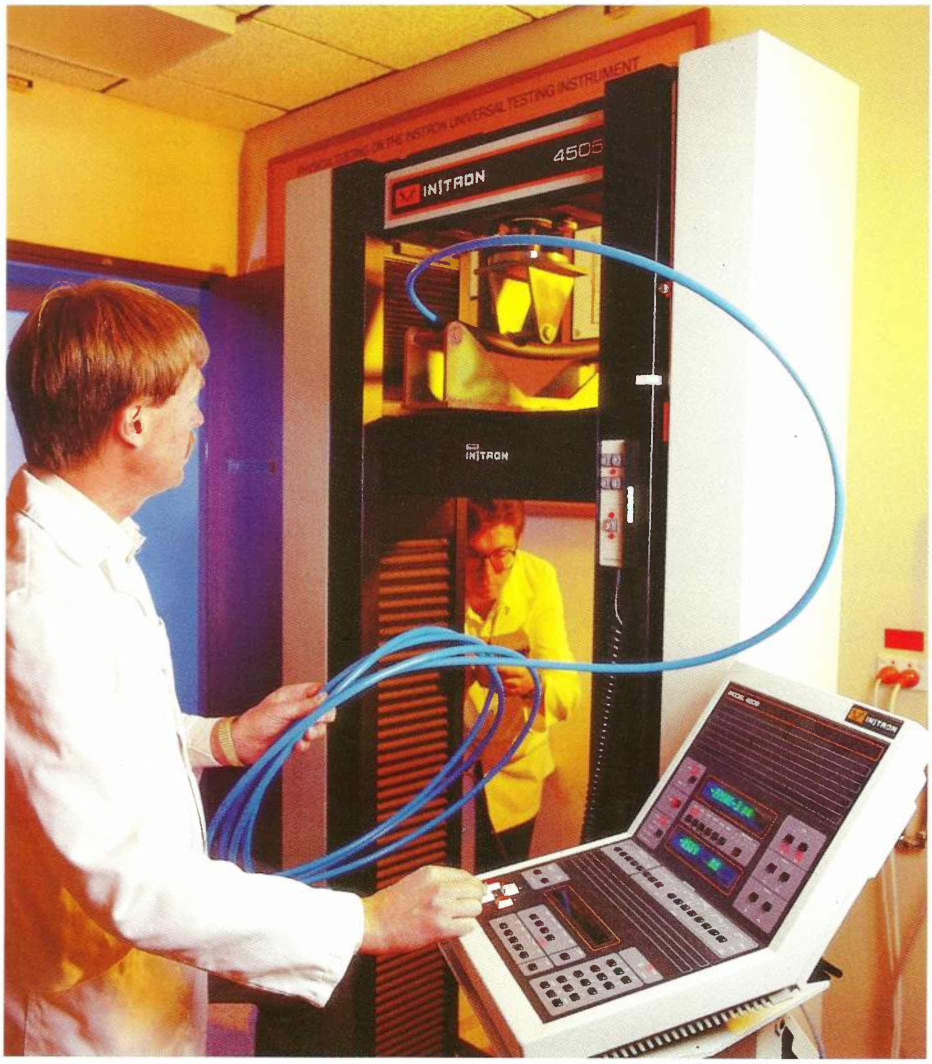
Reliability assessment should preferably occur during the product design phase, so whenever possible, TRL works closely with manufacturers and suppliers to ensure quality and service objectives are met. Laboratory-based testing often requires simulation of the stresses and conditions to which a product may be exposed during its service lifetime and TRL has an extensive capability to perform such work. This is supplemented by an extensive range of analytical techniques. Hence, when problems arise they can be tackled expertly and the most effective solution quickly found.

The following pages briefly describe a few of the projects related to reliability assessment and standards performed in the past year.

Optical Fibre Cable Material Developments

Researchers at TRL provide an on-going review and improvement of network cable materials to cope with the varied and often demanding service conditions in Australia.

The introduction of optical fibre cables into Australia in 1986/7 represented a new phase of cable technology development in which TRL has played an active role. One area of particular importance has been involvement in the correct selection and specification of polymeric materials used in optical cables, and in the hardware required for cable installation, location, marking and jointing.



Researchers Ray Boast and Barry Keon, test the flexural properties and assess the attenuation loss of the new blue nylon cable sheath that distinguishes fibre optic from other cables and protects the cable from insects.

Factors such as the extent to which polymers are used, the greater sensitivity of optical cable transmission performance to changes in properties of cable materials, and the harsh Australian operating conditions, mean that review and improvement of cable materials is essential for maintaining a reliable network.

Optical cables are now well established in the inter-capital and inter-exchange networks (IEN). In the next few years, the major expansion is expected to be in optical cables for the Customer Access Network (CAN). The anticipated growth in demand is in line with strategic planning to prepare for the introduction of broadband services such as Pay TV and high-speed data services.

CAN optical cables are loose tube construction for all standard fibre counts up to the maximum of 120, whereas the slotted core design has predominated for IEN cables. The loose tube design greatly facilitates jointing and fibre branch-off procedures necessary in the CAN. The absence of metal moisture barriers in optical cables used in Australia has initiated present investigations into polybutylene terephthalate grades used for the tubes, seeking improved hydrolytic stability.

CAN cables also differ from IEN cables in two other important ways. First, in locations where the risk of lightning strike is low, steel strength members are used to provide greater mechanical strength and flexibility to enable longer cable hauls. The second difference is the use of a coloured sheath for identification.

TRL was requested to investigate a number of identification proposals to readily distinguish CAN optical cables from existing copper and IEN cables. Because of the excellent performance of black polyethylene sheath and nylon (insect resistant) jacket over many years, initial investigations were directed toward ink and powder marking techniques. This approach failed to meet the stringent practical requirements in the field because these markings are often erased by abrasion during normal handling and underground installation procedures.

The most sound option technically was to use a coloured over-sheath on both polyethylene and nylon jacket cable. A sky blue colour was selected to distinguish Telecom cables from those of other utilities. TRL contributed to the development of a comprehensive material specification for the blue polyethylene compound to provide maximum protection against ultraviolet and thermal degradation.

The technical expertise and resources available at TRL helps provide expert advice that is not only useful for Telecom but also contributes to the development of the Australian cable manufacturing industry.

Solar Powered DRCS Experiment

Battery technology being tested by TRL in outback Australia may save Telecom time and money by improving reliability and minimising maintenance in remote regions.

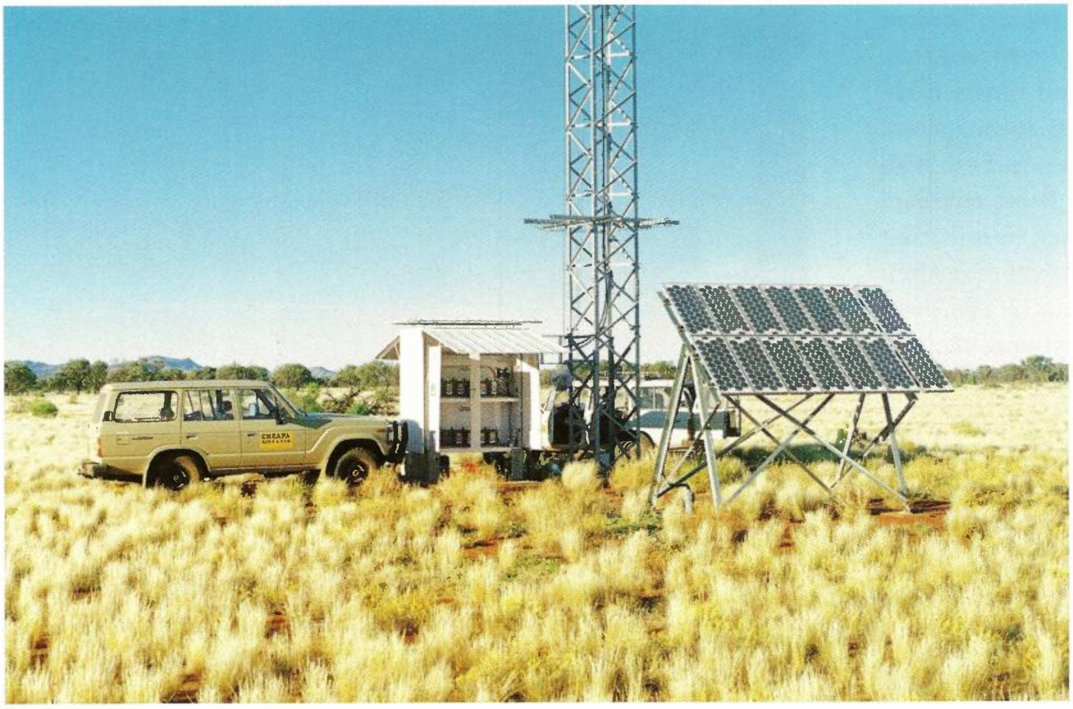
Throughout outback Australia the Digital Radio Concentrator System (DRCS) is providing quality communication services to thousands of customers. Many of the repeaters and subscriber units in the DRCS are powered by solar energy with batteries to store energy on sunny days for use at night and during inclement weather.

Three DRCS repeaters in central Australia are being used as test sites to evaluate a new type of battery technology not previously used in solar systems. Flooded lead acid batteries are normally used in solar power systems and require regular addition of de-ionised water to top up the electrolyte lost during charge. The new valve-regulated type of battery does not require water addition and so maintenance is minimised. Transportation is also easier because the electrolyte cannot be spilled. However, these batteries are far less tolerant to over-charging and are believed to be more affected by high temperatures and regular charge/discharge cycling.

At each of the three test sites the solar power system is being closely monitored. Battery cell voltages, currents and temperatures are of particular interest. One site has valve-regulated batteries from a German manufacturer, the second site has valve-regulated batteries from the USA and the third has locally-made flooded batteries for reference. The three systems are very similar in design and experience the same weather conditions.

Results from the first few months of the experiment indicate a wide variation between battery cell voltages at each site, particularly as the batteries approach full-charge. This suggests that additional regulating components may be necessary across each battery cell to ensure reliable operation in the long term. As yet it is too early to observe any shortening of battery lifetime due to higher temperatures.

For many of Telecom's outback customers the DRCS is their only link to larger cities and relatives around Australia and the world. Batteries that help minimise maintenance requirements for DRCS repeaters and subscriber units will increase the reliability of this very important link and reduce the costly exercise of topping-up flooded lead acid batteries.



Valve-regulated batteries are shown here being tested at a DRCS site at Caroline in the Northern Territory just south of Ayers Rock.

Occupational Health, Safety and Environment

Many Telecom work practices impact upon staff and the public and raise issues in the area of occupational health, safety and the environment. TRL staff regularly assess these interactions as part of Telecom's on-going commitment as a good corporate citizen. Some matters which have been addressed in the past year include:

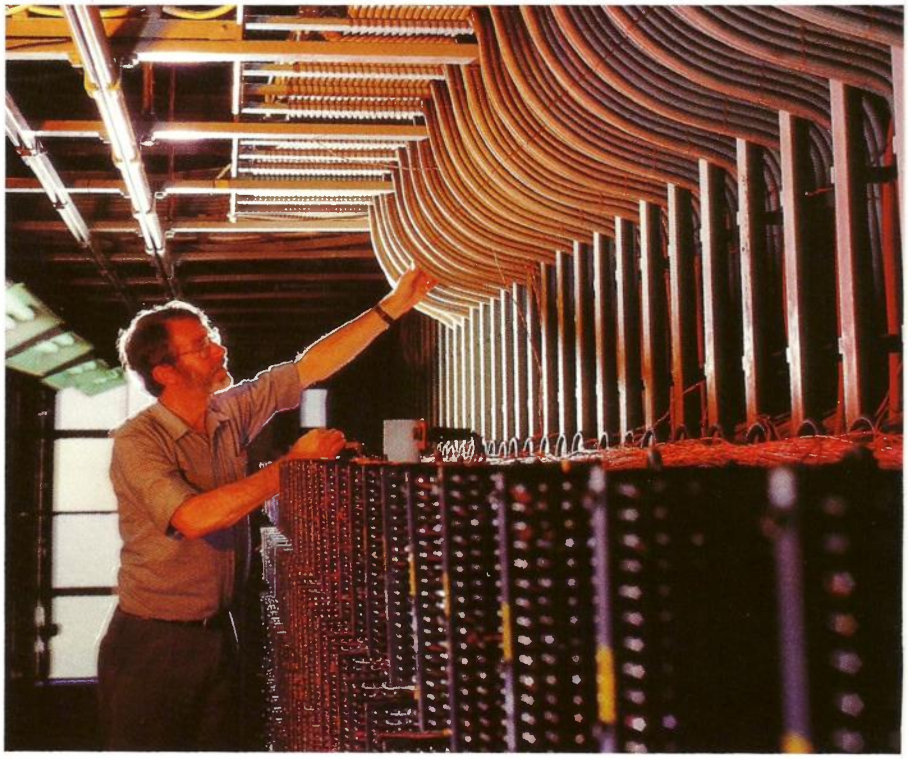
Network Protection — Ant nests on printed wire boards in public telephones continue to cause network faults. Queensland Region of Country Division is carrying out a trial which is attempting to deter ants from entering public telephone housings by placing naphthalene flakes inside the equipment. While this trial has been effective in deterring ants, it raised questions as to the effect of naphthalene on staff and the public. TRL has carried out experiments using a public telephone in an environmental chamber, to determine naphthalene concentrations within the structure over a range of temperatures. The investigations have shown that at ambient temperatures up to 400C, naphthalene vapour in the atmosphere of the telephone housing does not exceed the Worksafe Australia exposure levels for naphthalene.

Technology Up-grade — Many kilometres of cotton braided cable are being removed from step-by-step exchanges as part of an exchange modernisation program. TRL was requested to examine samples of this cable for suspected pesticide content. No pesticides were identified. However, because this cable was some 30–40 years old, the presence of lead in the cable surface coating was investigated. Lead carbonate was present at high concentrations as a flame retardant additive. Workplace monitoring during cable removal was then undertaken to assess the lead content of dust generated. Biological monitoring of workers was also carried out. Work practices during cable removal were also revised so that process could be carried out with minimum risk to workers.

Network Maintenance — Within the emissions profile of the battery maintenance program carried out at all exchange installations, the generation of sulphuric acid mist during boost charging has been an unresolved difficulty. TRL has developed and validated a laboratory technique to quantify the volume of sulphuric acid released, and have field sampled to quantify the problem. The data generated in the field trial indicates that in a well maintained battery installation, with explosion proof vents properly fitted, generation of sulphuric acid mist during boost charging is not of concern to staff safety.

New Installations — During the installation of an SPC switch at Exhibition Exchange, concerns were expressed regarding the detrimental effect of atmosphere quality on the equipment performance. TRL staff extensively monitored on-site dust during varied periods of activity, including internal construction, with the air conditioning on and off. Results from the monitoring significantly enhanced the local staffs' knowledge of the effects of these processes and helped define in-house work practices which will allow the switch to operate at its maximum efficiency. Follow-up dust monitoring indicated the presence of an atmosphere better than Australian Standard Class 100,000.

Telecom is better able to provide an efficient and reliable service for its customers by maintaining high quality standards of occupational health, safety and environment for employees, the public and equipment.



Workers recovering cotton-braided cable from step-by-step exchanges, as part of a modernisation programme, could be at risk from lead contained in a surface coating in the cable. Researcher Roger Pierson is shown examining cable prior to its removal.

Developments in Battery Testing

A reliable communications network often depends on the quality and reliability of the battery power reserve. Therefore, TRL needs to be able to evaluate the batteries and assess them under the broad range of conditions they are likely to encounter in Australia.

A new facility called TAURUS has been developed and recently commissioned at TRL to evaluate a wide variety of electrochemical power sources and to assess their suitability for applications within Telecom. TAURUS is capable of performance evaluation of virtually any battery technology likely to be of interest to Telecom now or in the foreseeable future. It replaces the 12 year old PISCES system. PISCES was a fixed design and not readily adaptable to the more complex test strategies necessary to fully characterise the increasing number and range of battery products.

TAURUS has a modular architecture and uses the latest hardware. A computer controlled d.c. power supply, an active load, and a sophisticated data acquisition system form the basis of each test station. The use of active loads, which have been designed using power MOSFET technology, and the use of switch-mode power supplies results in a considerable space/ size saving over linear designs of similar power. The current-limiting power supply and power dissipation-limited load can be sized according to requirement.

Up to eight stations connect in to a single controlling computer to form a test bay. Thus, up to eight independent and unrelated real-time test regimes can be supported on a bay at any one time. One or more bays connect into a Master Controller and into a Database Workstation. Test profiles are entered into the system on the Master Controller, while data analysis and processing of test results are performed on the workstation.

The use of standardised module interfacing has allowed the development of controlling software which is functionally transparent to the sizing of stations and bays. With this design approach, a battery test may be considered as a sequence of real-time control operations to the power supply. Thus, virtually anyduty cycle profile can be programmed into the system. Most importantly, TAURUS allows scope for simulation testing. Consequently, the study of the behaviour of batteries under simulated operational load conditions is now possible.

To date, two bays incorporating 16 stations have been commissioned using 500W active loads. Two more bays for lower and higher capacity are being introduced as the next stage of the development of the facility.

TAURUS will enable TRL to thoroughly assess the characteristics of the entire range of battery products and therefore Telecom's network will be equipped with the best batteries available on the market.

The new battery testing facility called TAURUS, enables TRL researcher Joe Der to thoroughly evaluate the performance of the entire range of batteries on the market.

Electric Stress and Optical Fibre Cables

The use of glass as a communications medium offers a number of significant advantages over metal conductors, yet glass by itself also has certain drawbacks. Therefore, it is necessary for TRL to continually research and develop ways to make the network better for both Telecom's customers and staff.

Modern telecommunications systems are prone to corruption or failure due to electric stress from lightning, mains power system faults and even electrostatic discharges. In many cases this stress is picked up and transported to the equipment by the copper conductors. This particular problem is eliminated with glass because it is a good insulator.

However, there are some disadvantages in using glass. For instance, glass has a brittle nature, it is difficult to locate buried metal-free cable, and it is difficult to provide power for remote equipment via glass. These problems have forced a review of the initial philosophy of only using metal-free optical fibre cables, particularly in the Customer Access Network (CAN).

As part of this review process, electrical tests have been carried out on a number of optical fibre cables with metal strength members. These tests have been designed to measure the voltage breakdown parameters of each type of cable and also to simulate the worst case situations with lightning and mains power problems. In all cases the breakdown voltage of the metal components to the external surface of the cable has been in excess of 50kV and in many cases is closer to 100kV.

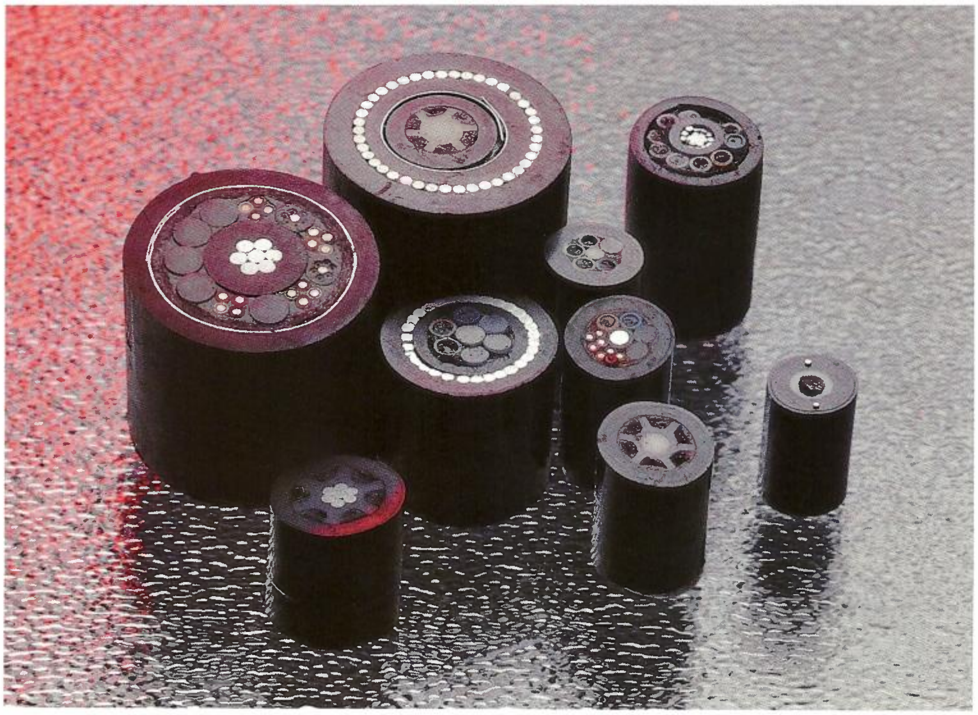
TRL has found that optical fibre cables with metal strength members offer a number of significant advantages over copper cable or just optical fibre alone. They are more durable than just optical fibre. They are easier to locate when buried. They are far less prone than copper cables to electrical stress caused by mains power faults or lightning. And they offer all of the benefits of an optical fibre network for the customer.

Overvoltage Specification for Pair Gain Systems

TRL has developed new specifications to cope with the extensive use of Pair Gain Systems (PGSs) in the CAN as a cost effective alternative to the installation of new cable. PGSs enable a greater number of customers to be serviced via a lesser number of existing cable pairs.

TRL's investigation of the failure of various PGSs, damaged due to lightning and mains related surges, has led to circuitry changes and additional overvoltage protection.

Investigations also revealed a lack of adequate and co-ordinated overvoltage specifications for new CAN equipment, particularly PGSs. Although this new equipment passed the specifications available at the time, damage was still occurring which lead to unnecessary repair costs and disruption to customers' service. This was mainly because existing specifications were tailored for an older generation of equipment, and the introduction of PGSs placed more sophisticated electronics into the relatively hostile CAN environment.



Cross sections of optical fibre cables show the varying types of metal strength members, armouring, moisture barriers, and copper conductors.

Researcher David Willis tests the prototype — 4 Channel Digital PGS Phase 2, which will provide service to four customers' telephones via a single pair of conductors.

TRL has produced a general purpose overvoltage test specification for CAN equipment, entitled "Overvoltage Resistibility Requirements for Customer Access Network Equipment". It is a combination and updating of existing Telecom specifications, and other international standards. Initially, it has been used for a new PGS known as the Remote Integrated Multiplexer.

The specified tests are designed to subject the equipment to the same overvoltage conditions that could occur in the field. Confidence in the test severity levels has been confirmed by good correlation between laboratory test failures and those reported from the field when existing PGSs have been evaluated under the new specified test conditions. Feedback has also confirmed the necessity of many of the tests.

The use of the specification for new PGSs and other CAN equipment will help ensure more resistibility to lightning and other overvoltages, and thus provide customers with a more reliable telecommunications network.

Support of Austel Standards

TRL, with its expertise in both the theoretical and practical aspects of customer safety and high voltage testing, has contributed and continues to contribute, to many technical safety standards via the appropriate committees.

Such standards include:

- **Austel Technical Standard 001 (TS001) "Safety Requirements for Customer Equipment".**
  This standard covers protection of the equipment user from electrical mains supply hazards and telecommunications network hazards, and network personnel from connected equipment hazards.
- **Australian Standard 3260 "Safety of Information Technology Equipment including Electrical Business Equipment"**
  Compliance with TS001 is primarily achieved by compliance with Australian Standard 3260, which in turn is closely aligned with IEC 950 (of the same name).

These contributions are particularly important as few members of these committees have experience in the testing of telecommunications equipment and tend to accept the overseas technical conditions without realising the possible implications for Australia.

One area of particular concern is the level of voltage isolation required between the equipment user and all conductors connected to the equipment, such as power, telecom and the computer. In this case the International Electrotechnical Commission (IEC) has adopted a significantly lower test voltage than that used in Australia for many years and if we now adopt this lower value then the number of customer injuries is likely to increase.

To support Comtest, Telecom's compliance testing group for Austel permits, TRL has also designed and constructed special purpose high voltage impulse generators for safety testing. The generators, which simulate surges occurring in the network as a result of lightning activity, produce a pulse with the wave-shape and discharge capacitance as required by AS3260 and CCITT Recommendation K17. Being microprocessor controlled, the impulse generators also have several features

Leap Seconds in Telecom's Time

TRL maintains Telecom's time standards from which all Telecom time services are derived. Time services distributed by Telecom, who is the major provider of time in Australia, include the Dial-It speaking clocks, hourly time signals to radio stations and the civil time serial time code distribution.

Until 1956, time scales were based on the earth's rotation about its axis, ie the length of the day. However, irregularities in this rotation led scientists to search for a more constant and accurate basis for time. In 1958, atomic clocks based on vibrations of the caesium 133 atom were used to provide a precise time scale. The atomic structure of caesium and the atomic forces within that structure determine the exact period of vibration of the radiation which is emitted when the atom is excited. This is similar to the way in which gravity and the length of a pendulum determines the period of oscillation of the pendulum in mechanical clocks.

An international time scale based on a new definition for the second in terms of these atomic clocks was introduced and is known as Co-ordinated Universal Time (UTC). This replaced the Greenwich Mean Time (GMT) system which was based on the solar second. The second is now defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.

The Central Bureau of the International Earth Rotation Service (IERS), located at the Paris Observatory, is responsible for determining when the insertion of "leap" seconds into the UTC time scale is necessary to maintain an approximate relationship between atomic time and the rotation of the earth.

The leap second which was inserted at the end of December 1990 meant that the last minute of 31 December 1990 on the UTC scale was 61 seconds long. It was the sixteenth positive leap second adjustment since the introduction of the present system of time scale co-ordination using leap seconds, commenced in 1972. If the trend in the earth's speed of rotation changes in the future and increases, then the leap second adjustments required will be negative — the last minute will be shortened to 59 seconds.

The leap second adjustments are made to all time scales based on UTC, including the time scale maintained at TRL. Maintaining a time scale which is synchronised with the rest of the world is very important to both Telecom and its customers and helps to ensure that services remain constant, reliable and timely.

specifically included to assist staff performing the safety tests of TS001.

Safety of customers and equipment is of key importance to Telecom, and research staff at TRL can provide expert assessment of equipment and thus set standards that ensure stringent safety controls for the Australian telecommunications environment.

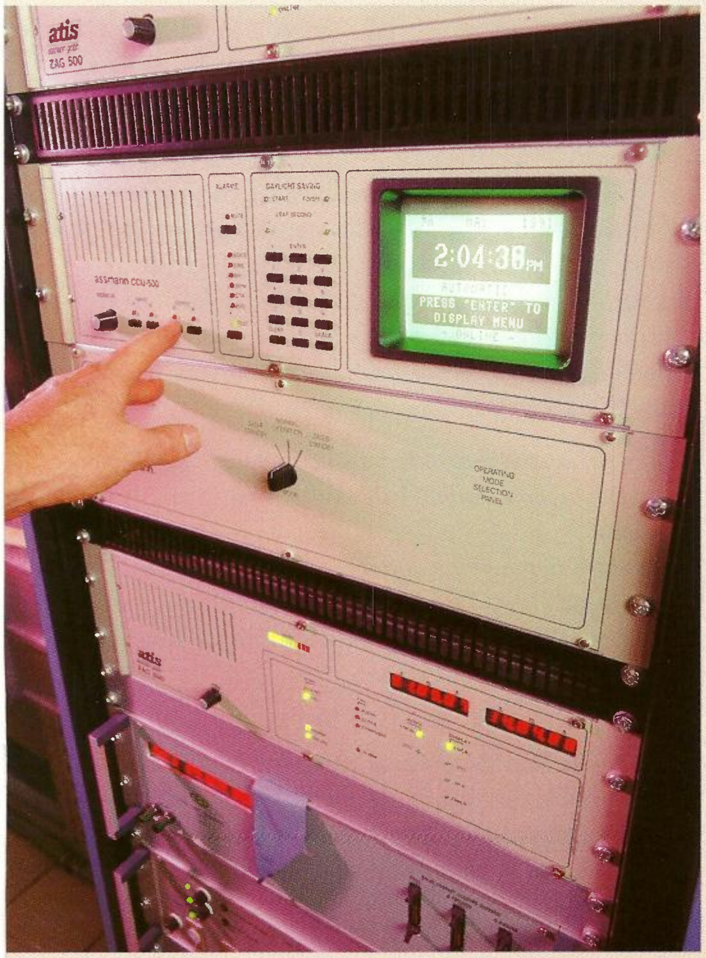
Fusion Splice Reliability

TRL researchers have had to adapt their skills and expertise to cope with the planned installation of over 11,000 km of optical fibre cable during 1991/92.

Servicing fusion splicing machines and examining the effects of physical stresses in fibres and fusion splices, are some of TRL's areas of expertise which help ensure the reliability of the optical fibre (OF) network. The reliability of fusion splice joints in the fibres is a critical factor in achieving long term physical integrity and stable transmission characteristics.

Most of the splices in the trunk network are made with Telecom's one hundred or so specialised fusion splicers. Each machine is worth around $50,000 and plays a key role in the construction of the network. Just over a year ago the supplier of this equipment decided to close its Australian based maintenance facility. The prospect of sending machines outside Australia for repair was not acceptable to Telecom Network Engineering. And because there are few engineering groups in Australia with the know-how to undertake such a task, TRL agreed to provide a full maintenance and repair facility for Telecom's fusion sets. The cumulative experience gained has resulted in staff being able to quickly diagnose, repair and service the fusion sets and more importantly assist field technicians in obtaining good fusion joints every time.

Silica optical fibres, contain cracks or flaws which can greatly modify their physical behaviour. Static fatigue is a phenomenon of particular concern in optical fibres. Here, water and/or water vapour penetrates to the crack-tip, and under the influence of tensile stresses, interacts with the glass at that point causing the crack to extend. This process can continue until complete failure of the fibre eventually occurs.



One of Telecom's Speaking Clocks being adjusted to incorporate leap second information provided by TRL's atomic clock.

Despite the use of splice protectors and joint enclosures, water will permeate to the fibre surface in a matter of months. Tensile stresses on cables and joins may result from bending during installation of the splice in the organiser tray, or from earth movement following cable installation. If the fusion splices are poor and/or contain contaminants, these may act as crack initiation sites and failure may occur.

Any failure in Telecom's network is costly and time consuming to locate and repair. Research into optical fibre means that Telecom stays at the leading edge of technology and thus helps field staff to keep the network running smoothly and reliably.

Electrical and Optical Standards

TRL provides the required reference standards for the telecommunications network to ensure a sound basis for determining and maintaining network performance and other services.

Any measurement made in Telecom must be traceable to the Australian National Standards. These standards are derived directly from the National Standards and are suitably converted for the telecommunications field by TRL, and then distributed throughout Telecom and its suppliers.

TRL has been developing and disseminating standards for electrical quantities since the Laboratories began in 1923. Telecom is now firmly dedicated to high usage of optical fibres in the network and it has become necessary to establish a traceable measurement capability for optical quantities. A system of optical standards is now in service and is developing rapidly. It operates in conjunction with the continually developing electrical standards.

Some advances in the past year in the electrical and optical standards areas include:

- Training seminars in the application of optical standards. These were run by TRL for calibration laboratories throughout the country.
- The calibration of more than sixty reference standards for Telecom and external organisations.
- The granting of NATA registration to TRL for a range of tests related to optical fibres.
- Assessment of wavelength measurement capability and the development of computer controlled calibration procedures to assist in performing optical wavelength and spectral distribution measurements.
- Development of automated procedures for dc intercomparisons and ac/dc transfers.

Metallurgical and Mechanical Engineering Consultancy

TRL's Scientific Engineering Section provides expert metallurgical and engineering consultative support to various areas of Telecom. This support function is additional to its traditional role of design, development, and fabrication of specialised prototype components and equipment for TRL's research activities.

One example of how the group has been successful in its consultative role was its investigation of weld quality in a number of cellular mobile telephone service (CMTS) transmission poles. The emphasis was on ensuring public safety and system reliability. The outcome of this investigation resulted in some poles being modified, and changes being made to the weld inspection procedures during manufacture.

Another example of the groups work was in the evaluation and development of commercially produced antennas for use in the CMTS and Radio Systems. An expert knowledge in materials, manufacturing processes, failure mechanisms, and the effect of the expected service conditions, has enabled items to be tailored to meet Telecom's intended service applications.

Within TRL's transmission research program, the group has been involved in the design, development, and manufacture of a specialised high resolution antenna and associated peripheral equipment. This will be used for research into advanced multiple beam base station antennas for future CMTS installations.

Other recent activities of the group include:

- strain measurement in installed optical fibre cables
- strength of members and security of cable pits
- corrosion
- design and operational problems with remote customer multiplex cabinets
- new QM–MDF

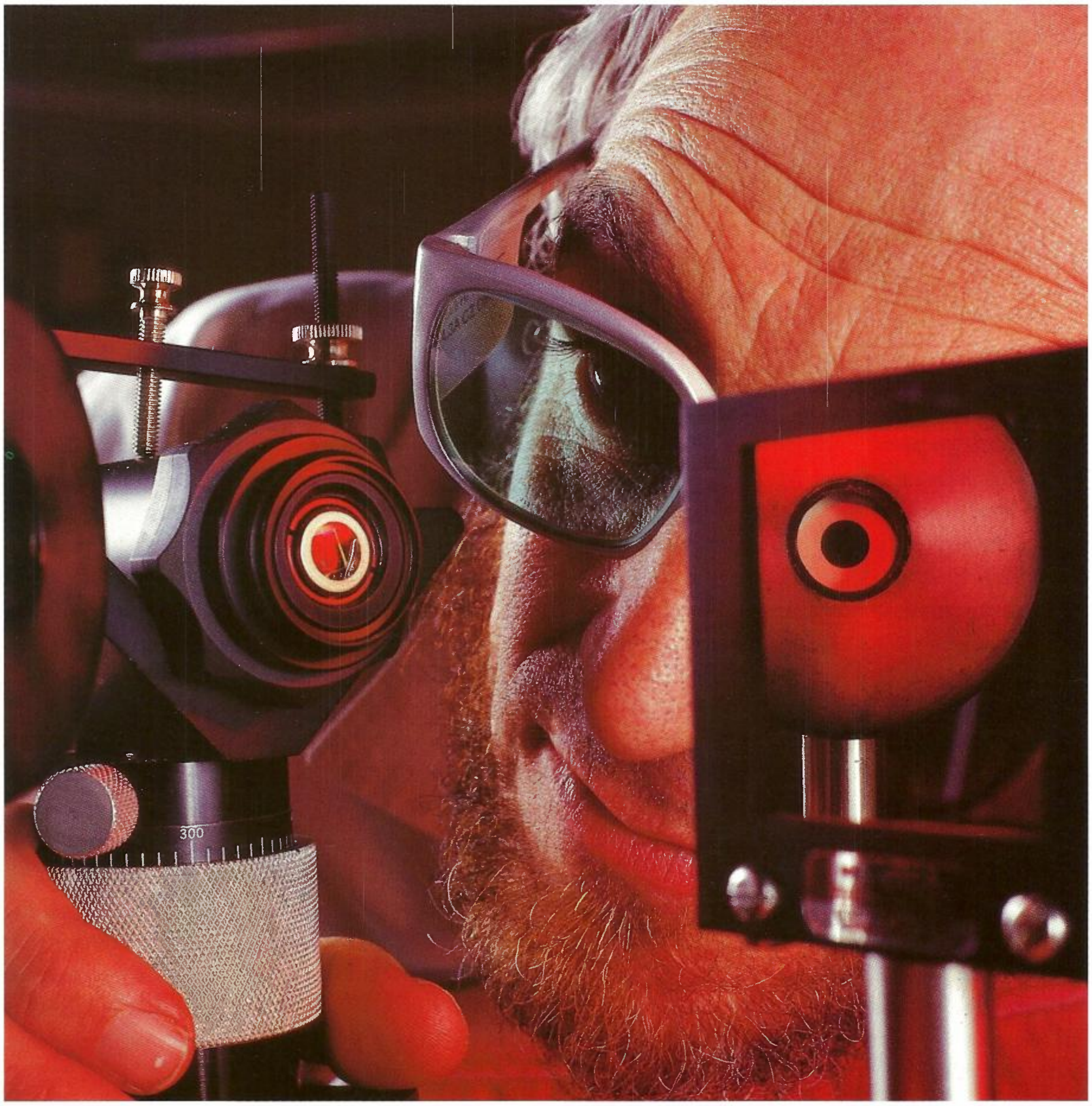
Telecom relies on the skills and knowledge of its' staff to make sure that all of the equipment used has optimum design and quality manufacture. This helps ensure that customer service and satisfaction is fully maintained.

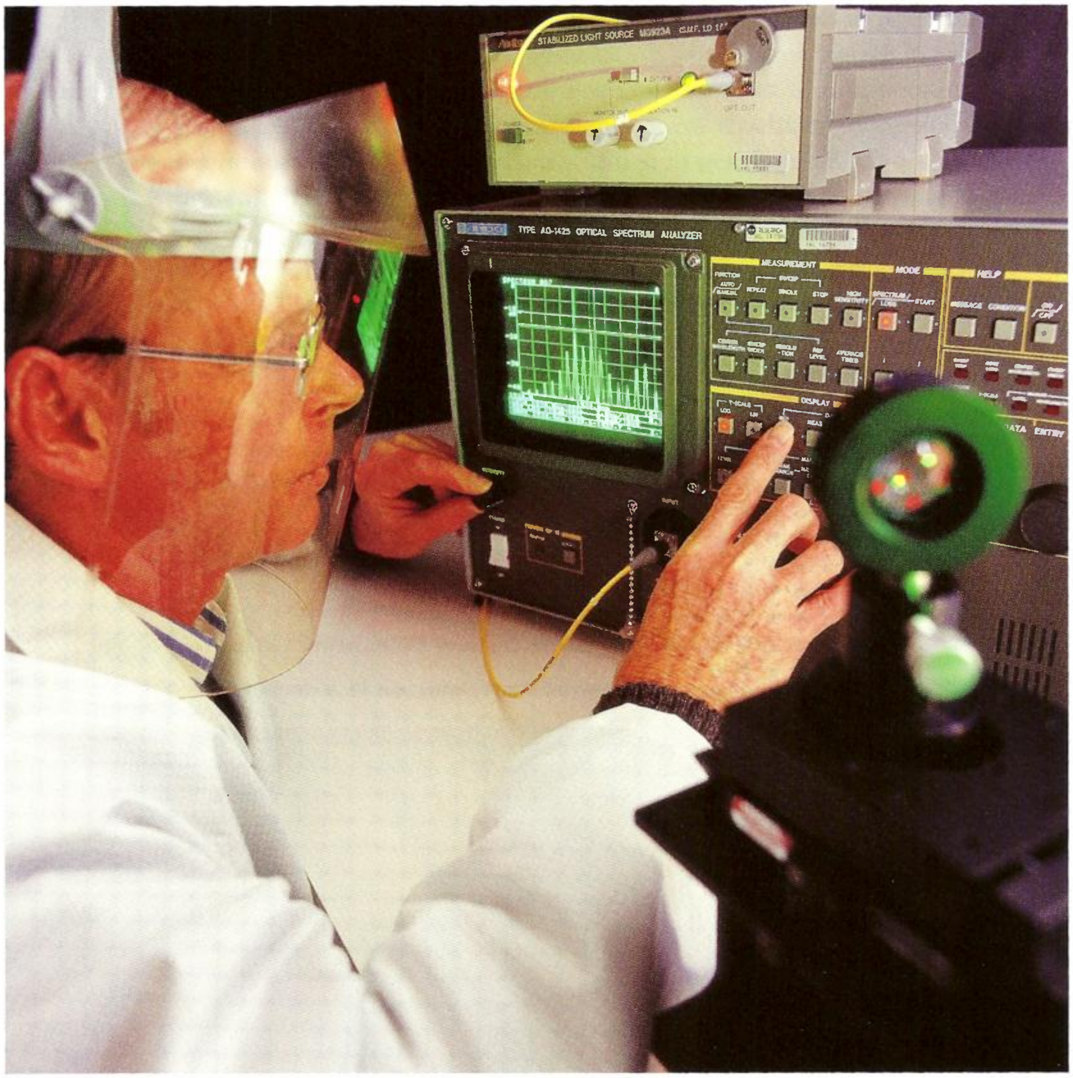
- Promulgation of the internationally agreed shift in the value of the standard volt and the standard ohm.
- The presentation of talks on the need for, and requirements of standards work with particular emphasis on the development of optical standards, and their importance for assured quality in the growth of Australian industry.
- A training course for a United Nations sponsored Engineer from Sri Lanka. They are investigating the requirements for a system of standards similar to that presently based at TRL.
- Continuing advice to Telecom for establishing NATA recognised calibration facilities, and in upgrading their services to include optical calibration capabilities.
- Analysis of Optical Time Domain Reflectometer characteristics.
- Restoration and application of an oilflow microwave calorimeter.

TRL is continually upgrading electrical and optical standards for increasingly sophisticated network operations to satisfy Telecom's expanding needs. Considerable effort is devoted to determining the future standards needs, and assessing their effect on Telecom's network.

TRL's system of functioning and expanding standards helps ensure that Telecom fulfils its obligations in providing a reliable and cost effective system that will allow for rapid growth.

Researcher Rodney Pyke in the Optical Calibration Laboratory at TRL, aligns an infra-red light beam on to a detector.





Tom Doney, researcher in the Optical Calibration Laboratory at TRL, uses the Spectrum Analyser to measure wavelengths of light generated by an infra-red source.

NATA Registration for Measurements on Optical Fibre Equipment

TRL's Reference Standards and Measurements Section has obtained National Association of Testing Authorities (NATA) registration for calibration work in the field of optical fibre.

NATA is an organisation that assesses Australian laboratories to ensure that they meet stringent requirements to guarantee the validity of relevant measurements. The optical fibre field is new, and because TRL is responsible for providing the basis for measurements within Telecom, it was one of the main instigators in creating the optical fibre test categories. There is also a legal responsibility on Telecom to provide traceable measurements on its facilities; so it is in Telecom's interest to advance the acceptance and expansion of NATA registration. To do this, TRL worked closely with NATA in framing the test categories and was the first organisation in Australia to be registered for a comprehensive calibration system intended for use on optical fibre equipment.

TRL has a close working relationship with NATA because of the existing registration of TRL in the electrical testing arena — TRL does audit testing and assessment of electrical laboratories for NATA. Telecom's increasing use of optical fibres has made it necessary to extend the standards and calibration service into the optical region to cover the requirements of a more modern telecommunications system.

The basis of TRL's optical calibration work rests on Australian National Standards of power and wavelength made in free space. These are then converted by TRL to the restrictive confines of hair-thin optical fibres. Wavelength measurements are important because of the very large changes in apparent power that occur with small changes in wavelength. They are also important in analysing the spectral distribution of power in the laser diodes that drive the optical network. These quantities have to be tightly defined to specify accurately the test conditions, because they can all impact on the quality and success of the national network.

TRL offers the wide ranging capability for optical calibration necessary for a facility intended to satisfy an expanding optical network. Output from this calibration facility is available from a number of Telecom calibration laboratories that are directly traceable to TRL.

This comprehensive capability covers optical power, optical attenuation, wavelength, and derivatives from these such as optical spectral distribution. Several optical components are also included in the registration.

The quality ensured by the NATA accreditation is an important component in providing a reliable national telecommunications system that offers customers the latest and the best technology.

Standards of Time and Frequency

TRL provides Telecom with its frequency and time standards which play an ever increasing role in the day to day operation of Telecom's modern and expanding networks, and are the basis of many customer services.

A modern telecommunications network must incorporate accurate frequency and time standards to ensure efficient network operation and to make possible many of the newest network facilities which will become available when synchronous transmission is introduced.

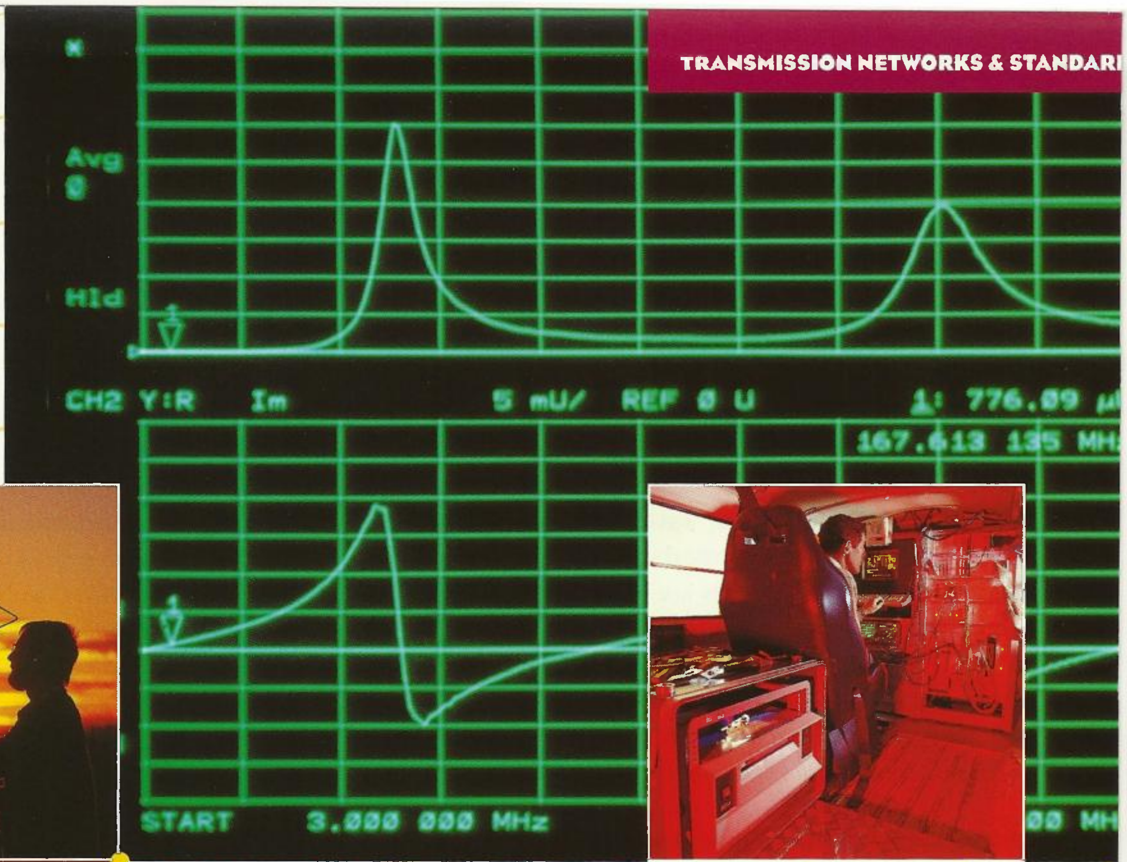
Telecom Australia and its predecessor, the PMG's Department, first established frequency standards within their Research Laboratories in 1930. Since that period the standards installation has evolved to include state of the art caesium beam frequency standards. Also, TRL is now one of only two organisations within Australia, authorised under the National Measurement Act, to operate Australian secondary standards of measurement of frequency and time interval. TRL is also the only telecommunications verifying authority under the Act, and hence has legal status for all measurements performed.

Distributions from the Time and Frequency Standard include:

- Provision of synchronising signals from the National Reference Clock which directly control the clocks at every node of the IDN, ISDN and DDN networks to ensure optimum performance is obtained. By synchronising its digital switching and transmission networks to this world standard reference clock, several important benefits are derived. These include minimised digital slip performance with other networks, nationally and internationally, and the capability to deliver sophisticated network facilities and features as part of the ISDN and synchronous digital hierarchy.
- Precise frequency is also distributed throughout the analogue network for a range of applications. These include, the control and calibration of master oscillators in the trunk network and also to provide standard frequencies for use as master clocks for timing, and in equipment service and calibration areas. Many of Telecom's customers in Government agencies and instrumentalities also utilise this distribution as a source of accurate frequency traceable to the Australian National Standard.
- Provision of accurate and traceable time of day for the Speaking Clock network to the capital and many of the larger provincial cities; and distribution of the Civil Time Code signals transmitted in a binary coded decimal (BCD) form over a voice channel. The Speaking Clock also provides the ABC and a number of commercial radio stations with timing signals which are broadcast as six pips to mark the hour.

To meet a growing demand from computer system operators, Telecom will this year introduce a new time service from its new Speaking Clocks which will provide dial-up access to accurate time and date information in a computer readable ASCII format. A wide range of applications from the automatic updating of master clock systems to the loading of time into personal or mainframe computers exist where this service will be indispensable.

TRL also provides technical consultancy to Telecom divisions and their customers on all aspects of network synchronisation and time and frequency related equipment and system design. Development work is proceeding which is aimed at improving the quality of standards available and implementing remote calibration and verification for customer reference standards.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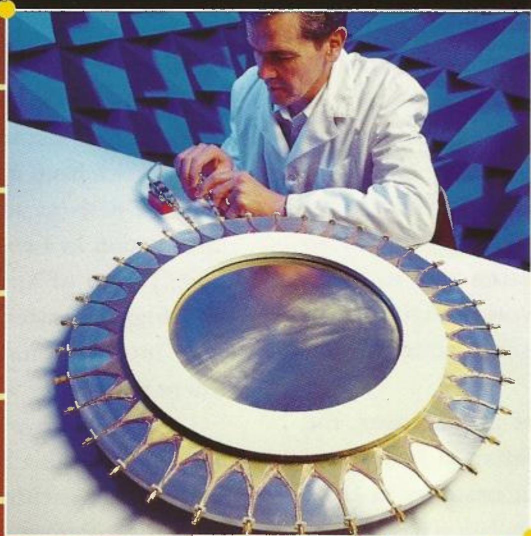
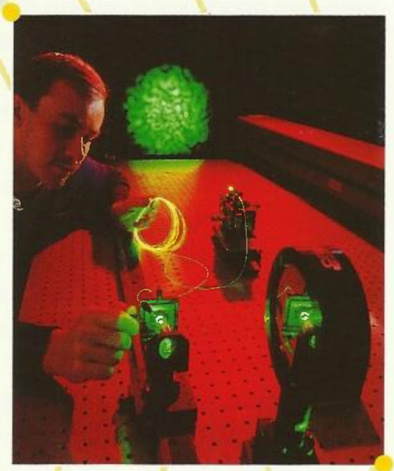
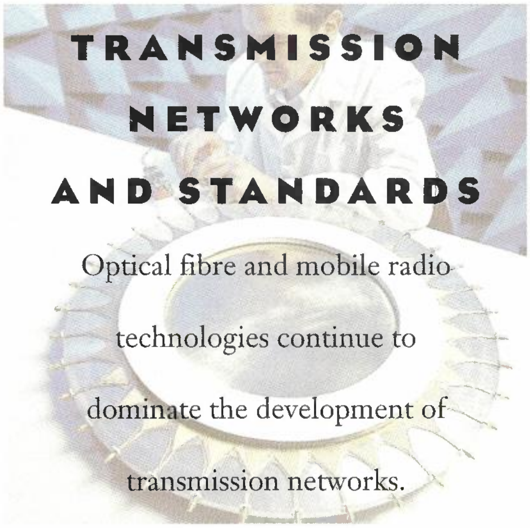






TRANSMISSION NETWORKS AND STANDARDS

Optical fibre and mobile radio technologies continue to dominate the development of transmission networks.

OPTICAL fibre and mobile radio technologies continue to dominate the development of transmission networks with an ever increasing demand for more bandwidth in the inter-exchange network. There is also more customer pressure for communications 'on the move', and the search for cost reductions in the CAN through the use of optical fibre or radio to replace the ubiquitous copper pair.

In the inter-exchange network, near-term research is directed towards technologies which will ensure operation at 2.5Gbit/s over 60km repeater spacings. In the medium-term, much effort is directed towards analysing the technology choices for increasing system capacities to 10Gbit/s. This will be done by using various combinations of higher speed electronics, wavelength division multiplexing and optical amplifiers.

In the CAN, the search continues for network architectures to lessen the impact of the high cost of customer opto-electronics. The debate between fibre to the curb and fibre to the home will continue and must take into account not only equipment costs but also the impact of powering network and customer equipment, network testing, network reliability, and service evolution. The use of radio technology is also being considered for customer access, and many of the above considerations must be taken into account as well as such things as the range of services offered, the regulatory environment and access to spectrum.

Telecom now has over 250,000 mobile service customers and the importance of this market will continue to grow. Research is being directed to increasing the capacity of the existing analog network infrastructure and to understanding system choices for the new developing digital cellular and cordless technologies. These systems will provide mobile access in the office, in the street, in the car and in the home. They will be central to the Universal Personal Telecommunications service, now being standardized worldwide, which aims to allow customers to communicate wherever and whenever they choose.

Inter-Exchange Optical Network Developments

Telecom Australia is currently installing an extensive single-mode optical fibre transmission network linking Australia's major cities and provincial centres. There is scope for significantly enhancing this evolving network to provide the higher transmission capacity needed to serve Telecom's customers far into the 1990s and beyond.

At present, transmission over the long-distance optical network is provided using 140 and 565 Mbit/s transmission equipment with typical repeater spacings around 50 to 60 km. In the future, as the demand for transmission capacity grows, 2.5 Gbit/s transmission equipment will be required.

Researchers Tom Stevens and George Dohsi, test the use of an optical fibre amplifier for increasing the transmission span of high speed optical fibre communication systems.

Recent advances in transmission system technology at 2.5 Gbit/s have made it possible to control the effects of laser diode chirp (change in output optical wavelength as a function of the data pattern). It is therefore possible to maintain the current repeater spacings on the presently installed fibres by using the 1550 nm window, where the fibre loss is low but the fibre dispersion is high. These higher capacity systems can now be installed into the long-distance inter-exchange network with confidence.

The major breakthrough, was the recognition that negatively detuned distributed feedback (DFB) laser diodes are ideally suited to high speed intensity-modulated systems. A laser is negatively detuned when its output wavelength is lower than the wavelength of maximum gain set by the material used in the active region of the device. These devices were previously discarded by most laser diode manufacturers whose prime interest, until recently, was manufacturing low threshold current devices, corresponding to no detuning.

TRL has substantially improved the theoretical understanding of the effects of detuning, and has developed a new and more complete laser diode model that takes these and other effects into account. It is now possible to more accurately predict the performance of laser diodes in 2.5 Gbit/s systems. It is also now possible to appreciate the reason why some early prototype 2.5 Gbit/s systems failed to operate over 30 km when other systems could work over 100+ km.

Using this knowledge, TRL has developed a comprehensive computer model of an entire 2.5 Gbit/s system which has been used to simulate the performance of thousands of high speed systems each using a different laser diode. Suitable specifications and simple measurements have been developed to screen out unsuitable laser diodes, without rejecting too many suitable lasers. As part of the work, a new measure, the dynamic line-width ratio, has been defined and TRL is presently leading the way in CCITT's effort to derive a set of specifications for 2.5 Gbit/s systems by 1992.

Using the simulation results, TRL has been able to identify the characteristics that the best laser diodes have in common. This information could be of great value to manufacturers of laser diodes, and may in the future, lead to better devices being produced for these types of system.

In the longer term, the transmission capacity of the long distance network could be further increased in many different ways. Optical amplifiers are now recognised as a key technology required to achieve this aim. They allow an array of optical signals each at a different optical wavelength or frequency, to be amplified in a single device. They can also be used as power amplifiers to boost the transmit signal level, and can be used as pre-amplifiers to improve the sensitivity of optical receivers.

There are two main types of optical amplifiers — semiconductor and doped fibre — and both are presently being investigated at TRL. This involves both analytical modelling work and the development of prototype amplifiers to demonstrate the capabilities of these devices in both intensity-modulated direct-detection and future coherent optical systems. In addition TRL is studying the impact that amplifiers will have on the future design of long-distance transmission systems. For example, the use of amplifiers can dramatically increase the distance between digital regenerators; therefore the effects of fibre dispersion on the performance of these systems could be a limiting factor if not taken into account.

Developments in the long-distance network have been significant in the last year. As each new technology becomes available many exciting technological challenges appear as we begin to exploit the enormous transmission capacity of Telecom's installed optical fibre network.

CUSTOMER ACCESS NETWORK

Optical Fibre Network Developments

TRL's current research on optical network architectures and access techniques focuses on further cost savings for the eventual replacement of copper pair cables in the CAN.

Fibre is already well established on inter-exchange routes. However, it has not as yet had a major impact in the CAN. To achieve widespread deployment, fibre based systems must reach cost parity with the conventional copper pair cable network for the existing range of narrowband telecommunication services. The rate of deployment of fibre will then be set by growth in new telephone service lines and on the rate at which the replacement of old lines can be justified.

To gain experience with the application of fibre technology in the CAN and more accurate information on system costs, Telcos around the world are conducting fibre-to-the-home (FTTH) and fibre-to-the-curb (FTTC) trials. Techniques being investigated, based on the use of a shared passive optical network, are favoured by Telecom Australia as a flexible and potentially cost effective FTTH option. To this end, Telecom Australia is planning to conduct a passive optical network fibre-to-the-customer-premises trial.

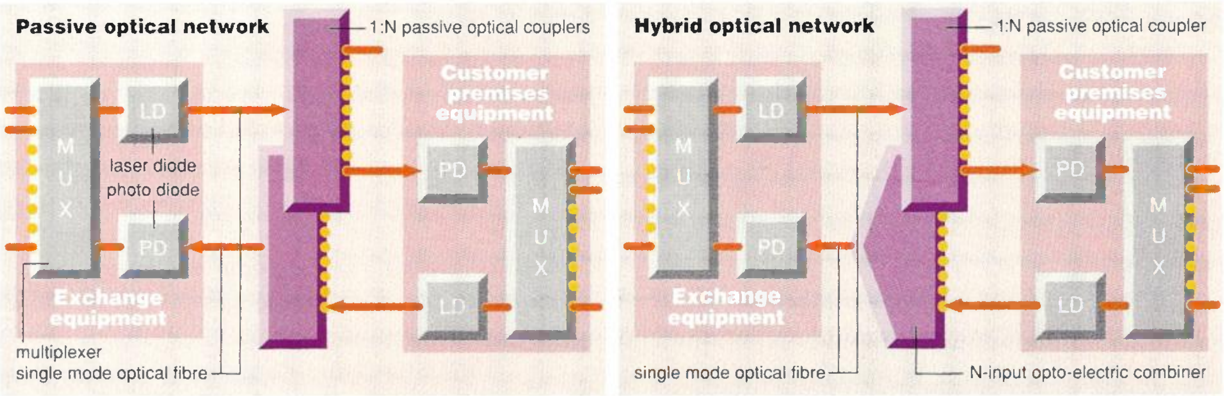
The main stumbling block to the cost effective deployment of FTTH is the current high cost of laser diodes. The FTTC proposals that have emerged, address this issue by sharing the cost of the opto-electronics at the curb-side node between the customers fed from that point. Consequently, although the ultimate goal is FTTH, increased attention is being given to FTTC system developments.

With FTTC, fibre is employed from the local exchange out to remote nodes located near a cluster of customers. The existing distribution and/or lead-in cable pairs are used from these nodes to the customer premises. The opto-electronic devices at each node are then shared by the number of customers (typically four to eight) connected to that point. Network costs for this method are claimed, by some, to already be cost competitive with new copper for the provision of the basic telephone service.

Studies carried out by TRL have focused on the development of cost effective network architectures and access techniques. TRL pioneered the development of a prototype fibre access system, referred to as MACNET, to demonstrate the virtues of a passive optical network for FTTH access. In its most basic form this architecture involves a double star topology, with the use of a passive multi-port optical fibre coupler located at a distribution point near a cluster of customers. This coupler acts as a splitting/combining element for the optical signals transmitted to and from the customers connected to it, and is located in the street, possibly at a cabinet or pillar site.

Based on current laser diode costs, passive optical network systems are too expensive to achieve cost parity with copper for the delivery of narrowband services. In response, TRL has proposed a new approach which replaces the upstream passive combining coupler with a low cost active opto-electronic combiner. This allows the high cost laser diode source in the customer premises equipment to be replaced by a significantly lower cost light source. Cost estimates indicate that a significant cost saving per customer can be achieved. This cost saving is comparable with that which can be achieved with a FTTC network but has the advantage that the fibre infrastructure is installed all the way to the customer premises on 'day one'.

The modified passive optical network retains the downstream photonic transparency of a passive optical network. It allows the use of different wavelengths for the delivery of new broadband services, but at the same time allows a lower cost delivery of the existing range of narrowband services. This proposal promises a cost effective solution for the near term deployment of FTTH but does not have the disadvantages of the FTTC. The benefits of this proposal are still under investigation to establish its possible impact on the deployment of fibre in the CAN.



Customer Access Networks

Performance Assessment of FASTPAC Engineering Pilot

The installation of the FASTPAC engineering pilot network in Melbourne has enabled TRL to develop installation, operation and maintenance practices and to measure network performance. This will help Telecom Australia ensure a smooth commercial take-off when the service is launched in early 1992.

The FASTPAC service will initially provide LAN interconnections over metropolitan areas and between capital cities using bridges from IEEE 802.3/Ethernet or IEEE 802.5/Token Ring LANs into the FASTPAC network. The network topology is that of looped bus subnetworks operated at 34 Mbit/s connected via routers to a 140 Mbit/s backbone loop within each city. These are then connected through routers onto 34 Mbit/s intercapital links. User connections are via LAN bridges into a 34 Mbit/s subnetwork. The LAN bridge will pass the packet onto the 34 Mbit/s subnetwork where it will be switched to the destination LAN bridge, if on the same subnetwork depending on the destination address in the LAN packet. Alternately, it will be routed through the 140 Mbit/s backbone loop into another 34 Mbit/s subnetwork to the destination LAN bridge.

Technical officer Gene Prete takes performance measurements of the FASTPAC pilot network at TRL.

The FASTPAC engineering pilot consists of nodes at various locations in the Melbourne central business district and at TRL. The nodes have been developed by the Telecom joint venture company QPSX Communications, and are based on the Distributed Queue Dual Bus (DQDB) technology, originally developed at the University of WA with support from TRL.

TRL is measuring the performance characteristics of the devices such as LAN bridges, packet processors and routers in the FASTPAC network. This will help determine the end-to-end throughput and delay performance under various traffic load conditions and to identify any possible bottlenecks in the network.

Initial tests have been undertaken on IEEE 802.3/Ethernet LAN bridges used to interconnect LANs within TRL over a 34 Mbit/s DQDB subnetwork. Within these bridges, Ethernet packets are segmented with the addition of some overheads, and the segments are transmitted over the DQDB network. When all segments have arrived at the receiving LAN bridge, they are reassembled into the original packet. With the use of LAN protocol analyzers, personal computers attached to the LANs, and specialist software and hardware designed within TRL, it has been possible to study the differing effects of packet and segment processing for various packet sizes. This is in addition to end-to-end throughput and delay measurements for typical applications such as file transfers. These tests are being extended to larger network configurations, which will eventually include inter-network routers.

Although there has been extensive analysis and simulation of networks based on the DQDB protocol as encompassed by the IEEE 802.6 Standard, actual implementations of bridges, routers etc. are outside the scope of the DQDB protocol and can potentially limit the performance offered by the network. The measurements are therefore required to determine the capabilities of the actual implementation which can then be used for network design.

Results from this testing programme have helped identify issues which may impact on overall FASTPAC network performance. The performance figures will also assist planners in the network design stage by providing information which will help achieve suitable end-to-end throughput and delay performance for customers' applications.

Digital Cellular Investigations

TRL's advances in radio measurement technology assists the evolution of Telecom Australia's national network of mobile radio systems through which telephony services are provided to customers on-the-move in major cities, rural centres, and on major highways. Expansion and modification of this network to meet customer requirements for increased capacity, new services and lower costs, will soon mean that digital radio systems can be added to the Telecom network.

TRL is studying digital mobile radio systems to assist with their introduction. Depending on transmitted signal bandwidths, the operation of these systems can be severely impaired by multipath radio propagation that occurs in urban and suburban areas. Consequently, understanding and description of mobile radio transmission channels has been a priority research activity.

As part of channel modelling studies, TRL has designed and constructed a channel sounder to allow measurements of the time varying characteristics of practical mobile radio channels. The sounder consists of a transmitter, which is normally stationary, and a receiver and logging system which are mounted in a van so that measurements can be made while the van is moving. Field data recorded in the van is subsequently processed to yield estimates of parameters that describe mobile radio channels.

Mobile radio channels are characterised by measuring channel impulse responses and then calculating delay-doppler functions of the type shown in the Figure. These functions can be interpreted in terms of the delays and doppler frequency shifts experienced by electromagnetic fields propagating in the radio channel. Delay-doppler functions contain the channel data required for studies of radio system performance. Calculations based on measurements from a number of locations, enable statistical performance evaluations.

On the move inside the mobile radio studies van, researcher John Millott measures the multipath radio propagation that occurs in urban and suburban areas.

Mobile radio channel characterisation measurements have been made at a number of sites in

Digital Network Synchronisation

TRL provides Telecom Australia with time and frequency standards which ensure that all of Telecom Australia's networks are fully synchronised.

Telecom Australia currently provides synchronisation to its own national telecommunications network, to OTC's network, and to many customer private networks. As the evolution to an all digital network nears completion, and as new services and applications place increasing demands on the performance, operation, and verification of the synchronisation network, Telecom is planning to upgrade the performance of its synchronisation network to meet these new demands.

Network synchronisation plays an important role in the rapid evolution toward digital networks. Network synchronisation is the background technology which ensures that information transfer between the myriad of synchronous time division systems such as switches, cross-connects, and multiplexers, is performed without buffer overflow or underflow events. These events, which introduce degradation into the information message signal, are termed "slips" and are controlled by the clock of the synchronous time division system. To understand the critical role network synchronisation plays, it is necessary to consider some of its key attributes.

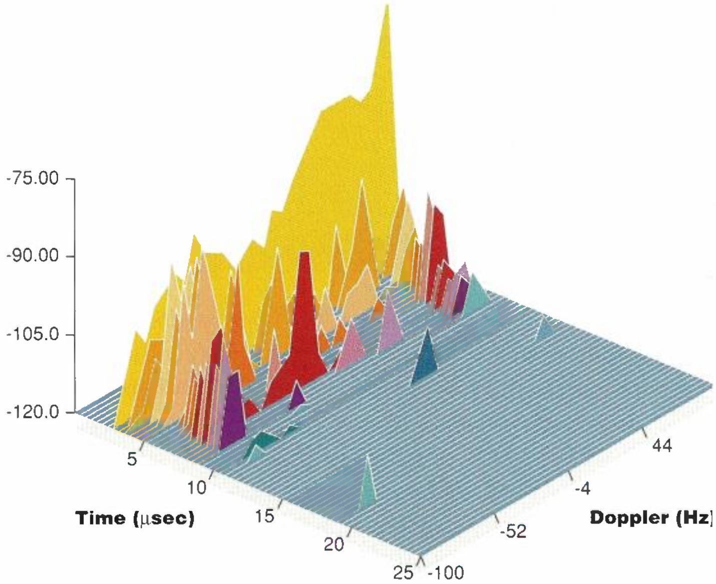
One attribute is that as a background support technology, network synchronisation is a shared resource. For example, in a large trunk exchange, the clock system of a switch may control the timing of thousands of circuits which terminate on that switch and also pass synchronisation down the clock hierarchy. Thus, all services are dependent on the performance of the clock at that switch.

Another attribute of network synchronisation is that it creates an interdependency between networks. When a private network is established, all clocks in the network are referenced to the same clock, which may have a systematic frequency offset from the carrier's network. However, as soon as the private network operator establishes a digital gateway to the carrier's network, network synchronisation must be upgraded to eliminate any frequency offset.

TRL has traditionally supplied Telecom's time and frequency standards for all synchronisation and calibration reference functions, and is playing a leading role in the planning and assessment process which network synchronisation is currently undergoing within Telecom. As part of this role, TRL will commence a monitoring program this year to gather synchronisation performance data from clocks around the network.

TRL will also be studying overseas initiatives in the synchronisation field and making recommendations on the future direction of Telecom's synchronisation network development. Another area TRL will be involved in is discretionary research into the synchronisation problems associated with interconnection of networks as they affect the operation of both Telecom and customer private networks.

Melbourne and country Victoria. Data from these measurements has been analysed to predict the likely performance of digital radio telephony systems and, subsequently, to influence procedures for the design of radio cells in Telecom's digital mobile telephony network.



Delayed doppler representation of a mobile radio channel.

A secondary application of the channel sounder has been to determine the characteristics of radio channels at fixed urban locations. Measured data has been a key technical input to Telecom studies of the feasibility of using digital mobile radio technology to provide residential access to basic network services.

The channel sounder has been a powerful tool during the planning and design phases of Telecom's introduction of digital mobile radio systems. It is also expected to be used in diagnostic investigations when systems are installed in the near future.

Multiple Beam Cellular Base Station

Cellular mobile telephone traffic is almost doubling every year, and TRL is working on the vital task of providing sufficient voice channels per unit area to satisfy this demand with an acceptable grade of service. Major restraints include the limited spectrum allocation, and the cost of base stations.

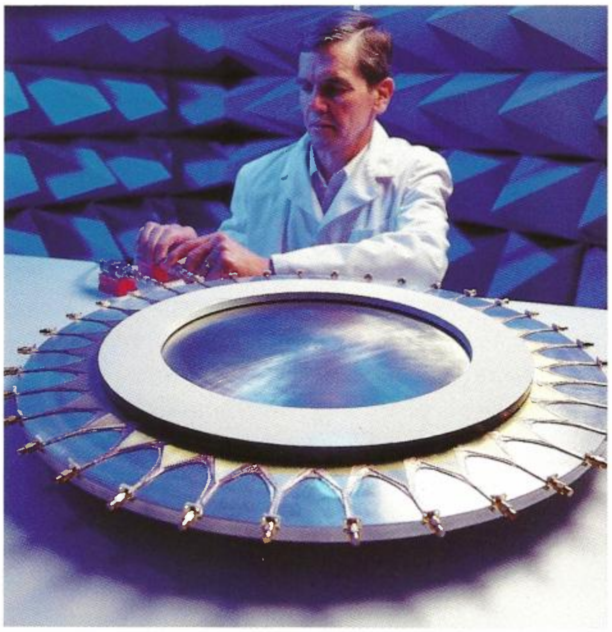
In today's cellular mobile network, the coverage area is divided into hexagonal cells a few kilometres across, and a base station is sited at the common corner of each "clover leaf" group of three cells. Each cell has some of the radio channels assigned to it, and interference from the neighbouring cells is avoided by using other channels in them. The channels are re-used in sufficiently widely separated cells, where the interference between them has fallen to acceptable levels, so that the total network traffic can be many times the number of channels.

Increasing traffic has so far been accommodated by reducing the size of the cells and building more base stations. However, this process cannot be continued much further without increasing the cost per channel, because of site procurement difficulties and the short range radio propagation variations which necessitate reducing the number of channels in a cell.

The multiple beam cellular base station concept involves dividing the "clover leaf" groups of cells into a larger number of narrower cells radiating from each existing base station. For example, six triangular cells each half the area of the previous hexagonal cells could be grouped around each base station. This would reduce the number of distant mobile terminals interfering with each cell, permitting a reduction of the channel re-use distance and a corresponding increase in the number of channels assigned to each base station. It may also be possible to further multiply the base station capacity by re-using frequencies in suitably separated narrow cells at the same base station.

Cell boundaries are distorted, and cells overlap, because of random scattering of the radio signals from various objects. This will limit the interference reduction possible with multiple beam antennas, and will be an important factor in cell handover characteristics.

Propagation experiments with a steerable narrow beam antenna, are proceeding to determine the angle-of-arrival characteristics of the radio signals



Researcher Stan Davies adjusts the "spaceship like" prototype Lens Feed for a Multiple Beam Antenna.

at a base station. Results will be used in the analysis of proposed multiple beam systems.

Cell boundaries are further distorted in the AMPS system now in use, because cell handover is not initiated until a terminal moves to a location where propagation loss exceeds a fixed level. If the loss threshold is too high, cells overlap excessively and interference increases.

Terminals can circumnavigate a base station at close range without any handoff occurring. This would cause catastrophic interference in the case of frequency re-use at the same base station. If the loss threshold is too low, excessive handover activity occurs. TRL is researching AMPS handover criteria and multiple beam layout variations to overcome these potential problems.

The research into angle-of-arrival will be of particular value to future system design. Systems such as GSM, Qualcomm CDMA, and DECT will utilise multiple beam base stations more efficiently than AMPS, because the terminals will detect and report the strength of beacon signals from nearby cells. Consequently, cell boundaries will be less distorted, and less unintended overlapping will occur.

Advanced Antenna Research

In parallel with the systems investigations of multiple beam cellular mobile base stations described in the previous article, TRL is carrying out some associated advanced antenna research and development. The work is directed towards providing either higher customer capacity, or achieving economies in the siting of base stations for mobile telephone services.

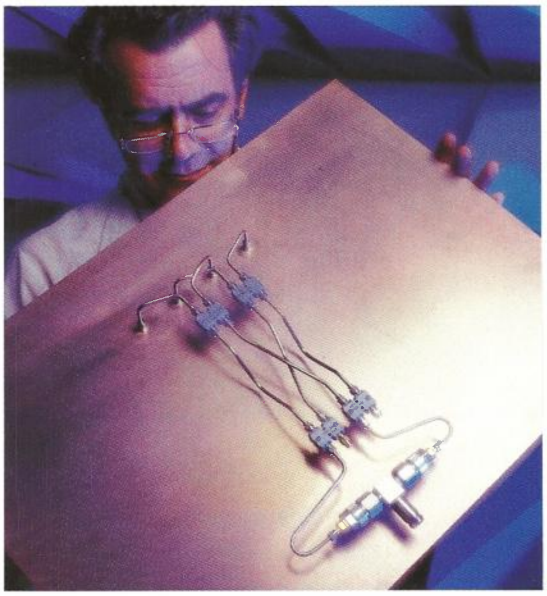
A transportable high resolution antenna for angle-of-arrival measurements at representative base station sites, and research on possible multiple beam base station antenna types is being carried out.

A knowledge of the angle-of-arrival characteristics of the multi-path radio waves at mobile base station sites, is needed to enable realistic performance predictions to be made of the proposed multiple beam stations. The high resolution antenna developed for this purpose consists of a 4 metre wide by 0.8 metre high cylindrical parabolic main reflector, illuminated by a parallel plate sectoral horn-parabola feed unit. This antenna produces the required vertically oriented fan-shaped radiation pattern.

In addition to the novel electrical design, both the antenna and its associated rotator mount have been constructed in demountable sections to facilitate transportation to the roof tops of the buildings from which angle-of-arrival measurements have been programmed. These include the Windsor and the Exhibition exchange buildings in Melbourne.

The research into multiple beam antennas includes investigations of both lens-fed and matrix-network-fed arrays. Each of these antenna types offers the capability of simultaneous operation on the set of N multiple beams, which is a fundamental requirement for the proposed application. However parameters such as the degree of beam overlap, side-lobe levels, gain, vertical radiation patterns, and input impedance match, are being assessed to adequately explore the capabilities of these arrays. As part of this work the experimental prototype Butler matrix feed network, as seen in the photograph below, has been developed. The array employing this feed is capable of producing four simultaneous beams over an 85 degree sector.

Research and development of antennas ensures that Telecom Australia is equipped to provide better quality radio based services to customers more efficiently and more economically.



Researcher Barry Gilbert examines the Prototype Matrix Feed for an Advanced Mobile Base Station Antenna.

Preparations for the 1992 World Administrative Radio Conference

In February 1992, when the International Telecommunication Union (ITU) convenes the World Administrative Radio Conference (WARC-92), TRL will have a member on the Australian delegation to help review and reallocate certain portions of the radio spectrum to meet future growth of a range of radio services.

Australia, like other countries, has a vital interest in the decisions and outcomes of this conference. Key issues for the conference include spectrum provision for a range of future mobile and satellite-based mobile services, a future satellite sound-broadcasting service, high-definition TV, and some other specialized scientific applications. However, meeting these new needs will be at the expense of existing users of the radio spectrum, and outcomes of WARC-92 will have a major impact on radio communications for the next twenty years.

Telecom Australia requires additional spectrum to be able to offer a range of new mobile telephone and other telecommunication services to meet customer demands. But Telecom also needs spectrum to permit many of the existing radio-based services, such as radio relay systems, to continue to operate in the coming years.

To provide a sound technical basis for the decisions of WARC-92, one of the ITU's permanent organs, the CCIR (International Radio Consultative Committee) has the responsibility for producing a report to WARC-92. It has done this by means of a series of specialized meetings which culminated in a 2-week Joint Interim Working Party of all CCIR Study Groups, in Geneva in March 1991.

Australia's preparations for WARC-92 and the CCIR meetings are co-ordinated by an "Australian Preparatory Group" chaired by the Department of Transport and Communications. Membership of the Group includes government departments, corporations, industry, academic institutions, and other specialized bodies. Four key committees have been established by the Group.

The CCIR Joint Interim Working Party for WARC–92 in Geneva in March 1991 — The Australian delegation takes front row.

Telecom plays a major role in the Preparatory Group, with several activities. TRL has a key function, providing advice on future radio-based technology developments and their radio spectrum characteristics. Garth Jenkinson of TRL, chairs the Australian Preparatory Group's Technical Committee and was Vice-Chairman of one of CCIR's Interim Working Parties for WARC-92 and Deputy Leader of the Australian Delegation to the CCIR Joint Interim Working Party.

TRL is undertaking a series of technical studies and investigations on the ability of different radio services, such as fixed and mobile, to share the same spectrum. The studies into sharing between fixed and mobile services are taking a novel, statistically-based approach, and have raised overseas interest. They will provide Australian contributions to future CCIR Meetings, and will contribute internationally to more efficient use of the radio spectrum.

TRL's participation in WARC-92 ensures that Telecom Australia has a say in the direction of telecommunications and can therefore meet customers' needs for the future.

Radio-Frequency Radiation (RFR) Exposures from Mobile Phones

The safety of customers and staff is of highest importance to Telecom Australia, and with the emergence of new telecommunications products and services, TRL conducts tests and research to make sure everything is thoroughly safe and within the Australian safety standards.

In Australia, the Telecom cellular mobile phone network is expanding rapidly with a growth rate of approximately 7 per cent per month with over 200,000 customers nation wide. However, questions associated with the health effects of RFR exposure from hand held mobile phones have been raised in the media, and in one report, the use of a mobile phone was likened to placing one's head in a microwave oven. Such a claim is clearly ludicrous, and because of their low power output, mobile phones are not recognised as a hazard by the Australian Standard governing RF exposure. Nonetheless, it was felt prudent that Telecom check that the energy absorbed in the head, and particularly the eyes, of a person using a mobile phone is not sufficient to cause harmful heating effects. Consequently, TRL has conducted a series of experiments aimed at establishing the level of RFR exposure from mobile phone use.

Initial measurements were made of the levels of RFR in the free space around the popular "walkabout" hand held phone. These measurements showed that the allowable radiated energy limit prescribed for public exposure in Australian Standard AS2772 was only exceeded within a distance of 7.5 cm from the antenna. In the normal mode of operation, the antenna is unlikely to be closer than 7.5 cm to the eyes and it would seem unlikely that the 600 mW of energy radiated from the phone would be sufficient to cause any significant local absorption of energy in the head.

Notwithstanding this, a second series of measurements were made which involved taking E-field measurements in the eye of a simulated human head during normal use of the walkabout phone. The head consisted of a plastic skull & artificial brain, muscle, eye, skin and fat tissues with the electrical properties of their real counterparts. Initial measurements indicate an energy deposition in the eye very much less than the spatial peak limit allowed in a number of national standards.

Material Permittivity Measurement using Monopole Antenna

TRL has expanded dielectric measurement techniques which will help ensure that antenna performance specifications are met, and will enable more economical designs of installations. The measurement technique will also be used to investigate electromagnetic radiation from telecommunications services to ensure the safety of Telecom staff and customers.

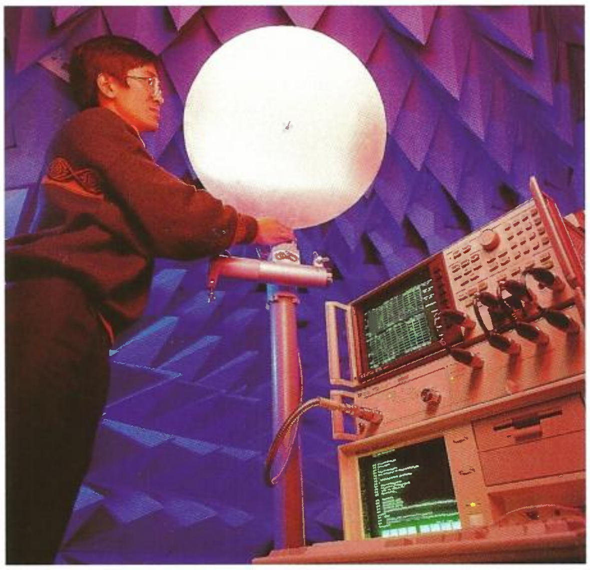
Electrical characteristics of materials are important parameters that are often needed in calculations involving propagation of radio waves. Two general examples illustrate this.

First, radiation patterns of antennas operating in the low frequency (LF), medium frequency (MF) and high frequency (HF) ranges are strongly influenced by the complex dielectric constant of the ground. Knowledge of electrical properties of the ground are of utmost importance when choosing a site for an antenna installation. If the ground parameters at a proposed antenna site are known, the necessary requirements for a ground screen system to maximize antenna efficiency may be determined accordingly. In particular, a knowledge of the dielectric constants of the ground would be useful in HF Over-the-Horizon-Radar related investigations.

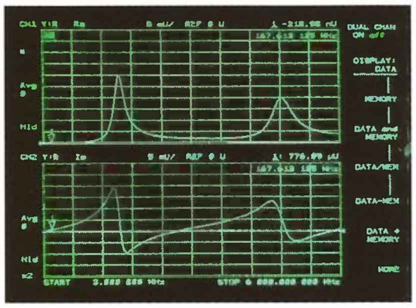
TRL also needs to be able to obtain detailed ground electrical characteristics over small areas. That is, there is a need to measure accurately the ground characteristics at Telecom's outdoor antenna test range, which makes use of ground reflection to establish a near uniform illumination over the antenna under test.

Secondly, in the area of electromagnetic (EM) hazard studies, the knowledge of dielectric properties of biological tissues is also important in investigating their interaction with EM energy. The coupling and absorption of EM energy into a biological system is governed mainly by the electrical constitutive parameters of that system. These parameters are therefore crucial in determining safe levels for personnel exposure to EM radiation.

In view of the limitations of the most commonly used methods to measure ground parameters, TRL has investigated a different technique which uses a monopole antenna as a probe. The principle behind the technique is that the input admittance of the antenna is a function of the complex permittivity of the surrounding medium. Thus, by measuring the input admittance of the antenna, it is possible to obtain the ground constants. One advantage of the technique is that because of the simplicity of the geometrical configuration of the probe, it can be used for in situ measurements so that the sample integrity remains virtually unchanged.



Researcher Anh Tuan Pham, examines the circular ground plain monopole antenna, which has been used by TRL for in vivo measurements of tissues, so that the effects of radiation of mobile phones on human health can be simulated.

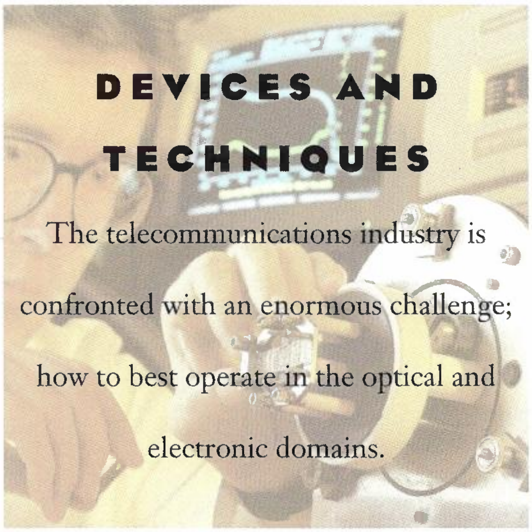


The electrical characteristics, as functions of frequency, can be obtained by a single measurement as seen on this oscilloscope.

The developed monopole antenna technique can also be used for in vivo measurements of tissues. Currently, the technique has been used by TRL in fabricating artificial tissues of known electrical characteristics to be used in research into the effects of the radiation from mobile phones on human health.

The technique has been implemented on a computer-based system to automate the measurements. The key components of the system, shown in the photo above, are the probe, a network analyser to measure the probe input admittance, and a computer controller which collects and processes data passed in by the network analyser. Using swept frequency technique, the electrical characteristics, as functions of frequency, can be obtained by a single measurement; (Figure — left). The measurement technique has been tested by measuring the electrical constants of some known materials and the accuracy was found to be within 5% to 10%.

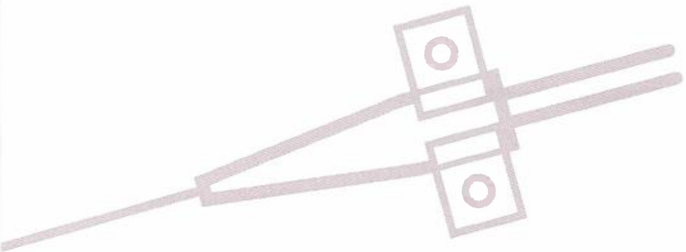
THE development of the telephone itself was once held up for want of an essential device — the microphone. The design was made difficult because the required technology bridged the worlds of acoustic and electrical design. In parallel today, the modern fibre shows how effortlessly information can be carried on the back of a photon, while at the same time electronic information storage and manipulation have advanced noticeably month by month in both convenience and complexity. The telecommunications industry is confronted with an enormous challenge; how to operate to best advantage in these two domains. Before long the systems designer will have an agonising choice to make between optical and electronic domains for many signal processing operations.



DEVICES AND TECHNIQUES

The telecommunications industry is confronted with an enormous challenge; how to best operate in the optical and electronic domains.

The modern challenge seems to possess a disturbing feature which did not distract the pioneers as they attacked their device and materials problems with a strenuous application of common sense and plain hard work. The modern worker has to live in a world where what was once an agreed common sense is under attack from a variety of sources. The most unnerving of these comes from the Quantum Mechanic; a person who seems determined to confront us with a manifestation on a grand scale of most outlandish devices whose principle of operation is drawn from the hitherto secret life of certain fundamental particles. Electrons are ingeniously constrained to move in just two or maybe only one dimension. Light has its very statistics squeezed. Stimulated emission within a fibre core is used to produce optical gain; an optical amplifier.



In the following pages you may get some idea of this way of thinking, which verges on particle physics in the service of telecommunications. Notice how beams of photons, electrons, and even molecules all have a role to play, be it as the power source for a device, the diagnosis of materials and devices, or even the fabrication of devices.

Optical Interconnection for Broadband Switching

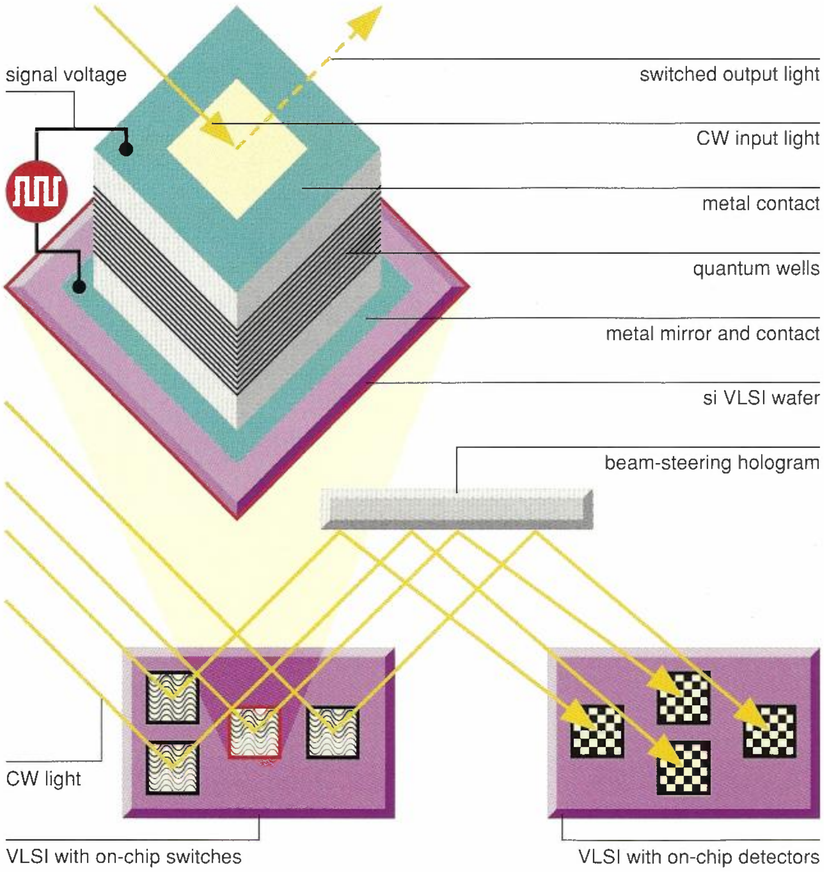
Switches developed at TRL are prime candidates for optically interconnecting high-speed integrated circuits such as those used in broadband switching equipment.

The demand for ever-increasing bandwidth is posing serious problems for designers of broadband switching equipment. The complex high-speed signal processing is performed by a few large-scale integrated circuits. Modern silicon chips can easily handle the switching operations, but there are severe difficulties involved with transferring the signals from one area to another. System designers want to be able to switch several parallel gigabit signals simultaneously, but electrical parasitics and cross-talk problems set limits to what can be achieved.

These difficulties could be overcome if the interconnections took place using light beams instead of electrical signals. It is possible to have many optical signals very close together, even intersecting one another, with no interference or cross-talk. Light beams do not generally interact with one another, and, while this makes all-optical switching hard to achieve, it makes optics the medium of choice for the transfer of information.

For integrated circuits to be able to communicate via light beams, it is necessary to place arrays of sources and receivers on them. Research on the light sources has been under way at TRL for some years. Arrays of vertical-cavity lasers are one possibility. Another promising approach is to use arrays of reflective switches. In principle, a single laser would be used to illuminate a multitude of these switches, which could be toggled between highly-reflecting and non-reflecting states by electrical signals. The reflected light beams, now carrying information, would be steered to receivers on another integrated circuit.

All of the high-speed reflective switches that are being developed world-wide are based on gallium arsenide (GaAs) and similar materials. Systems engineers would like to place them on silicon integrated circuits, but growing high-quality GaAs on silicon is a major technological problem. Researchers at TRL have invented and demonstrated a new hybrid device that uses a thin film, containing GaAs and AlGaAs layers, bonded to a gold film on a silicon wafer. This hybrid approach provides no compromise in the quality of either the silicon circuit or the GaAs-based switches. In operation, reflections from the gold film and the front surface of the device interfere with each other. The amount of optical absorption in the quantum wells can be controlled electrically. And by choosing suitable values, the net reflection at resonant wavelengths can be varied from around 50% to virtually zero. Early devices, fabricated at TRL, gave switching ratios greater than 25:1 with 10 V electrical signals. The switching effect is intrinsically very fast, since the device looks like a small capacitor (around 1 pF) to the driving circuitry and gigabit switching rates will be readily attainable.



Optical Interconnection of VLSI Circuits.

Early TRL switches already give comparable performance to all-epitaxial devices made on GaAs substrates overseas, and perform better than devices made on silicon. One can imagine large-scale chips of the 21st century that have only a few external electrical connections to bring power in, and communicate with each other via arrays of these switches and corresponding arrays of receivers, with one small solid-state laser providing all the light.

X-Ray Mapping of Glass Materials

In the early '80s, experimental results finally convinced the sceptics that the low optical loss of bulk silica glass could be delivered in a practical fibre form. This remarkable success inspired a number of telecommunications laboratories around the world to broaden their materials research to include other glass systems. TRL is currently examining the potential of glasses based on fluorides of heavy metals, such as Barium and Zirconium. From our understanding of optical loss processes in glass, there is a possibility of achieving even lower loss than silica on the basis of known scatter and absorption co-efficients, but only if the glass can be realised in its ideal form.

Already these fluoride glasses have shown promise in providing an alternative host for the fabrication of active fibres in a way that supplements the performance of silica. Both optical amplification and lasing action have been demonstrated with fibres drawn from TRL preforms.

A wide range of diagnostic techniques are required to produce glass free of optical defects. Even when the more obvious defects due to impurities and crystallities have been eliminated, there remains the problem of optical inhomogeneity. Glassmakers of old encountered the same problem and spoke of striations or streaks where the bulk glass appeared to contain streams of unmixed syrup. More quantitatively, these striations were found to be visible when the index of refraction varied by as little as one or two units in the third decimal place.

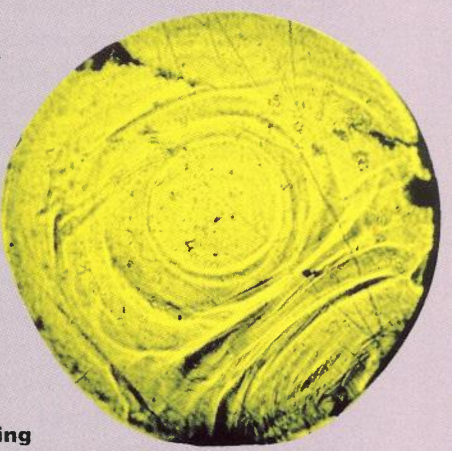
Since TRL's fibres operate with a core index only 0.3% above that of the surrounding cladding glass, the presence of visible striations is cause for concern because the fluctuation in index will cause light to be lost from the guiding process.

TRL has successfully applied the electron beam microprobe to diagnose striations in terms of fluctuations in glass composition. An electron beam is focused onto the surface of the glass and the wavelengths of the resulting characteristic x-rays are analysed to determine the concentrations of elements present.

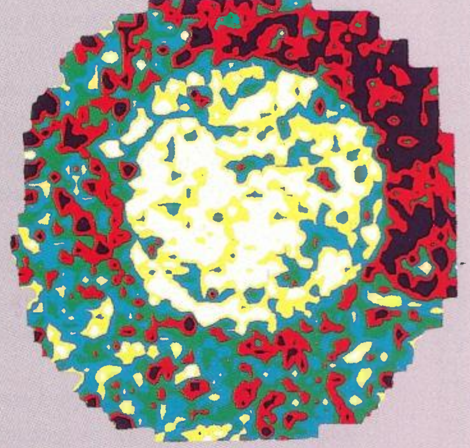
Unfortunately the x-ray counting rate, which can be safely produced on glass, is much lower than for other solids such as metals or even semiconductors. Further complication arises with a multicomponent glass — several elements must be analysed to yield the necessary information. TRL adapted the standard microprobe to obtain a statistical significance in the x-ray count. The mapping of thousands of points in terms of elemental concentrations may take days. The stability problem was overcome by a combination of additional electronics and dedicated computer software to maintain the stability of calibration over such a long period.

Once equipped, the microprobe system is very versatile, allowing the mapping of areas as small as the cross section of a fibre (100 mm) or as large as the longitudinal section through a preform — typically 10x23mm. Electron and cathodoluminescence light micrographs of the area of interest can also be produced simultaneously with the compositional analysis. Should precipitates be encountered, the wavelength dispersive x-ray spectrometer can deliver both the composition and spectral information indicative of the compounds in the precipitate.

Continued research in this area will eventually provide Telecom Australia's network with optical fibre that is far more pure than existing fibre and can therefore allow signal transmissions over much longer distances without the aid of optical amplifiers.



The final appearance of the striations is affected by pouring the glass into the mould. Compare the circular nature of the striations that appear on the optical cross section (right), with the map of zirconium concentrations (below). This same perturbation in the core of a fibre would cause excess loss by scattering light out the core.



The contours on this map of zirconium elemental concentrations, taken on a transverse section by an electron microprobe, is consistent with the image of the striations obtained under an optical microscope. The information depth of the maps is below 1 mm.

Fault Detection in VLSI Circuits by Image Processing

TRL has developed image processing techniques that simplify the detection of circuit faults and enable a visual comparison with good circuits of the same type — tests that could have taken months to perform using conventional mechanical probes, are now possible in a matter of hours.

The development of semiconductor technology has resulted in the size of the individual transistors used on Very Large Scale Integrated (VLSI) circuits being reduced to sub-micron dimensions. At the same time, the complexity of integrated circuits has grown enormously, from several transistors to today's several million. A consequence of this level of integration is the difficulty encountered in testing circuit operation, which is required both during the development of prototype circuits and in determining why a particular device may have failed. Conventional test techniques, such as the use of mechanical probes to make contact with individual transistors, are time consuming because of the positional accuracy required to place probes onto sub-micron structures and the limited information obtainable. Consequently, over the past few years, the development of techniques which enable more efficient testing of complex integrated circuits have been sought.

For some time TRL has been utilising stroboscopic voltage contrast imaging and waveform acquisition by means of an Electron-Beam Probe System which is used to "image" the potentials present on an integrated circuit. Two of the main advantages of this technique are that relatively large numbers of circuit elements can be observed simultaneously and that circuit operation can be examined in "real-time". However, with modern circuit complexities, the amount of information contained in a single image can be overwhelming, and locating a single faulty transistor can still be likened to "trying to find a needle in a haystack".

TRL has developed image processing techniques to simplify the detection of faults using the E-Beam Probe System. The techniques enable a faulty chip to be scanned, and a set of images acquired, which can be compared with those obtained from a known good circuit. A number of processing techniques are utilised to highlight incorrect circuit operation. They involve, extracting time and voltage information from the changes occurring in each black and white stroboscopic voltage contrast image, and encoding these changes as colour information back into a single image. Regions which do not vary, are retained in their original black and white states. Rather than display information which also shows correct operation of the circuit, it is often more useful to highlight only differences, such as excessive propagation delays, or incorrect voltage levels. This is achieved by setting limits so that only those variations which are not characteristic of normal circuit operation are encoded.

After the raw images have been obtained using the E-Beam system, preliminary processing can be performed to correct for brightness/voltage non-linearities and effects arising from drifts in instrumental parameters. Corrections for image rotation and alignment of images can also be applied. In addition, an optical colour video image of the circuit being tested, can be overlaid on the voltage contrast image to assist in the location of any region of interest on the circuit.

Prototype circuits and faulty circuits can be quickly analysed and examined using TRL's new image processing techniques — researcher Tim Rogers demonstrates.

The result of this development is a semi-automated test facility which provides solutions to VLSI circuit failure, design debugging, and validation — all in a much faster time than would be possible using conventional techniques.

A Dynamic SIMS System for Materials Analysis

Materials analysis equipment that has been enhanced at TRL through in-house software and hardware modifications, serves as a powerful technique for the investigation of new opto-electronic materials, and as a problem solving technique for failed devices and components.

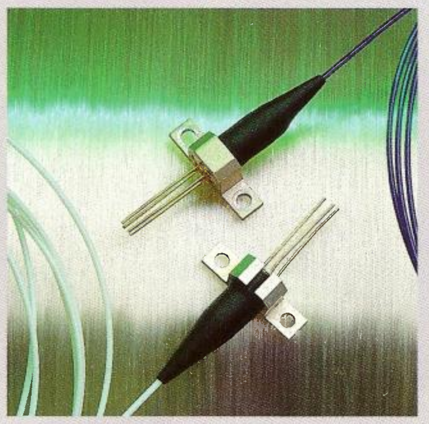
Secondary Ion Mass Spectroscopy (SIMS) is a technique used for surface and materials analysis. It can detect most elements with unmatched sensitivity. The sample to be analysed is bombarded with an argon ion beam which erodes the surface, causing secondary ions to be ejected into the vacuum chamber where they are captured and their mass identified by a quadrupole filter.

TRL's enhanced SIMS equipment can track elemental concentrations through the depth of a sample (depth profile). This "Dynamic" SIMS is filling an essential niche for the analysis of impurities and low level dopants in multi-layered opto-electronic devices including interlayer boundary effects such as diffusion and thermal migration. Impurities and inclusions on surfaces or in the bulk can be monitored and atomic concentration levels determined in both conductors and insulators alike.

Modifications to the SIMS equipment included replacing and upgrading major components to increase the sensitivity of the technique. An ultra high vacuum environment is essential when carrying out SIMS analyses for trace elements to prevent contamination of the surface by residual gases present in the vacuum. The argon ion gun was also refurbished for a higher beam current and smaller beam size to produce a faster sputter etch rate and hence obtain profiles more rapidly. The spatial resolution and accuracy of the technique is enhanced by the highly focused beam, which is important when

Low-cost Receiver for Fibre to the Home

Successful introduction of fibre to the home will require the development of high performance, but low cost opto-electronic integrated circuits (OEICs). The need for such high performance OEICs is the catalyst for TRL's research into the Heterojunction Phototransistor (HPT) and the Heterojunction Bipolar Transistor (HBT). These devices are seen as being viable economic alternatives to the more conventional long-wavelength photoreceivers for use in the CAN. The HPT can provide a large photocurrent gain and a high level of performance without the high bias voltages and excess avalanche noise characteristic of conventional long-wavelength photoreceivers.



HPTs and HBTs also have a technological advantage over the conventional long-wavelength photoreceivers in that they can be fabricated out of identical material structures. Because of this, an HPT can be integrated with HBTs to form a monolithic integrated optical receiver without requiring the sub-micron fabrication tolerances that are necessary in the fabrication of conventional long-wavelength photoreceivers.

To guarantee the highest possible performance, the materials from which the integrated optical receiver is fabricated need to be carefully considered. The material properties of the InP/InGaAs system that make it ideally suited to the fabrication of HPTs and HBTs with high gain and high cut-off frequency (Ft) are:

- the high saturation velocity of the InP,
- the large low-field electron mobility of InGaAs,
- low surface recombination of InP,
- the large valence band discontinuity (Ev = 0.366ev), and
- strong absorption of light over the 1.3–1.6 um wavelength spectrum by the InGaAs.

For the HPT we want the light to be absorbed at the base collector junction. This results in a photocurrent being injected into the base and then amplified by transistor action.

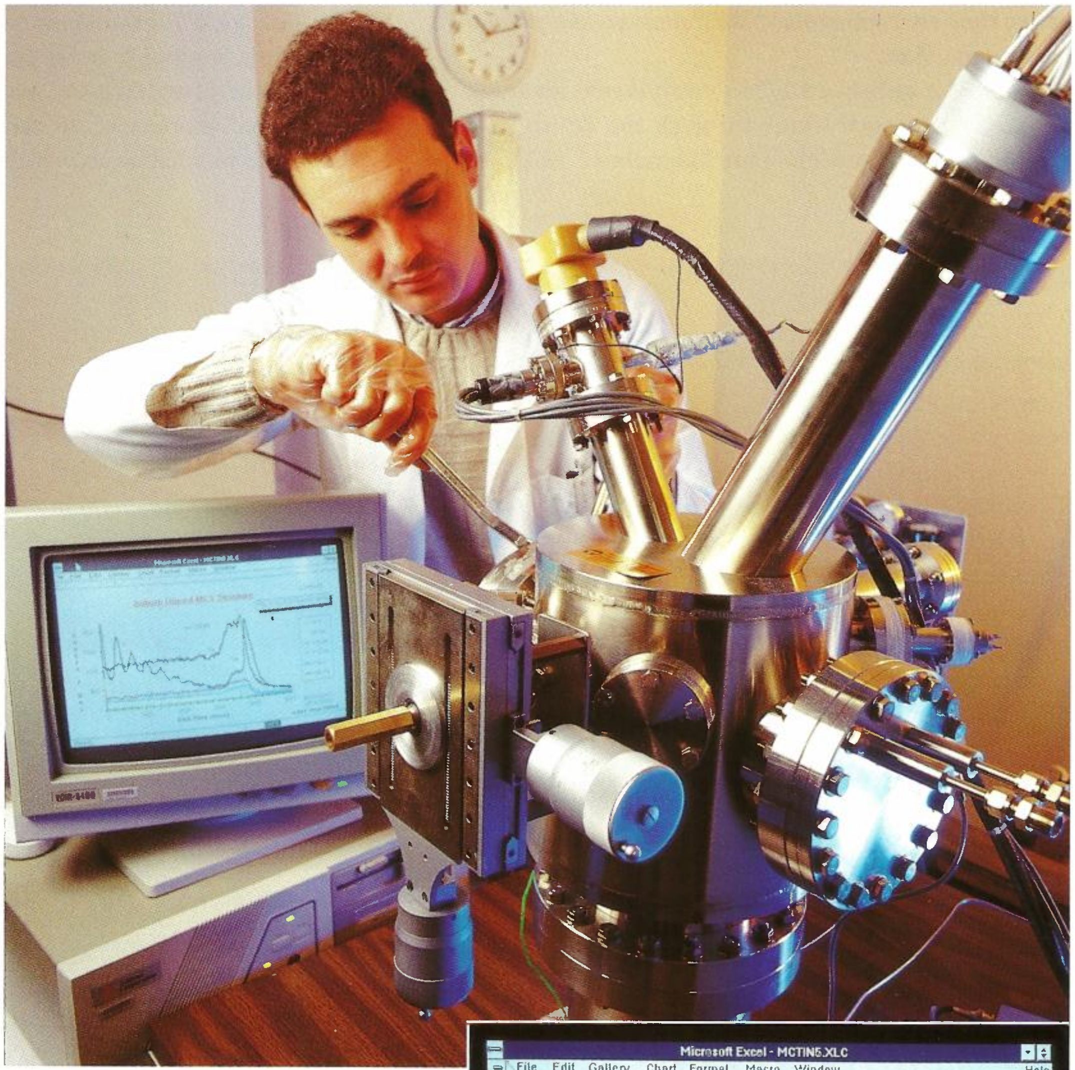
The results to date are very promising. Fabrication of high gain HPTs and HBTs from identical structures in the InP/InGaAs material system has been achieved. Although these prototype devices were relatively large, (approximately 200 microns in diameter) the optical gains for the HPTs were in excess of 2000, with a unity current gain (Ft) at approximately 1 GHz, while the HBTs had current gains in excess of 10,000.

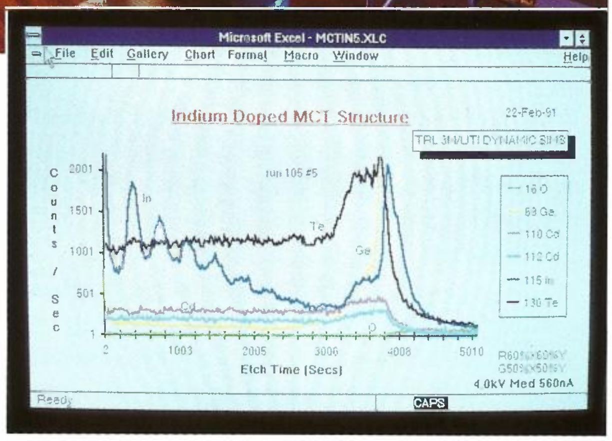
Work is continuing on further optimising the device structure and design, with the objective of fabricating HPTs with Ft in excess of 20 GHz, and then integrating them with HBTs to form a high performance integrated receiver for CAN use.

analysing the elemental distributions at interfaces in multi-layered samples such as the opto-electronic devices being developed at TRL.

An example of the usefulness of this depth profiling capability is the precise location of indium intentionally added at the parts per million concentration within MOCVD grown multi-layer structures of interleaved cadmium telluride and mercury telluride. The profile indicated that although the HgTe and CdTe layers were somewhat interdiffused, the indium remained primarily within the CdTe layers. A depth profile using Auger spectroscopy confirmed that the CdTe-HgTe layers had interdiffused but the small indium concentration was not detectable, only the SIMS technique could show that.

This SIMS depth profile precisely locates the parts per million concentration of indium present in an otherwise interdiffused structure of CdTe and HgTe grown by MOCVD.





Researcher Craig Frost, adjusts the Secondary Ion Mass Spectrometer (SIMS) which is used at TRL for surface and materials analysis.

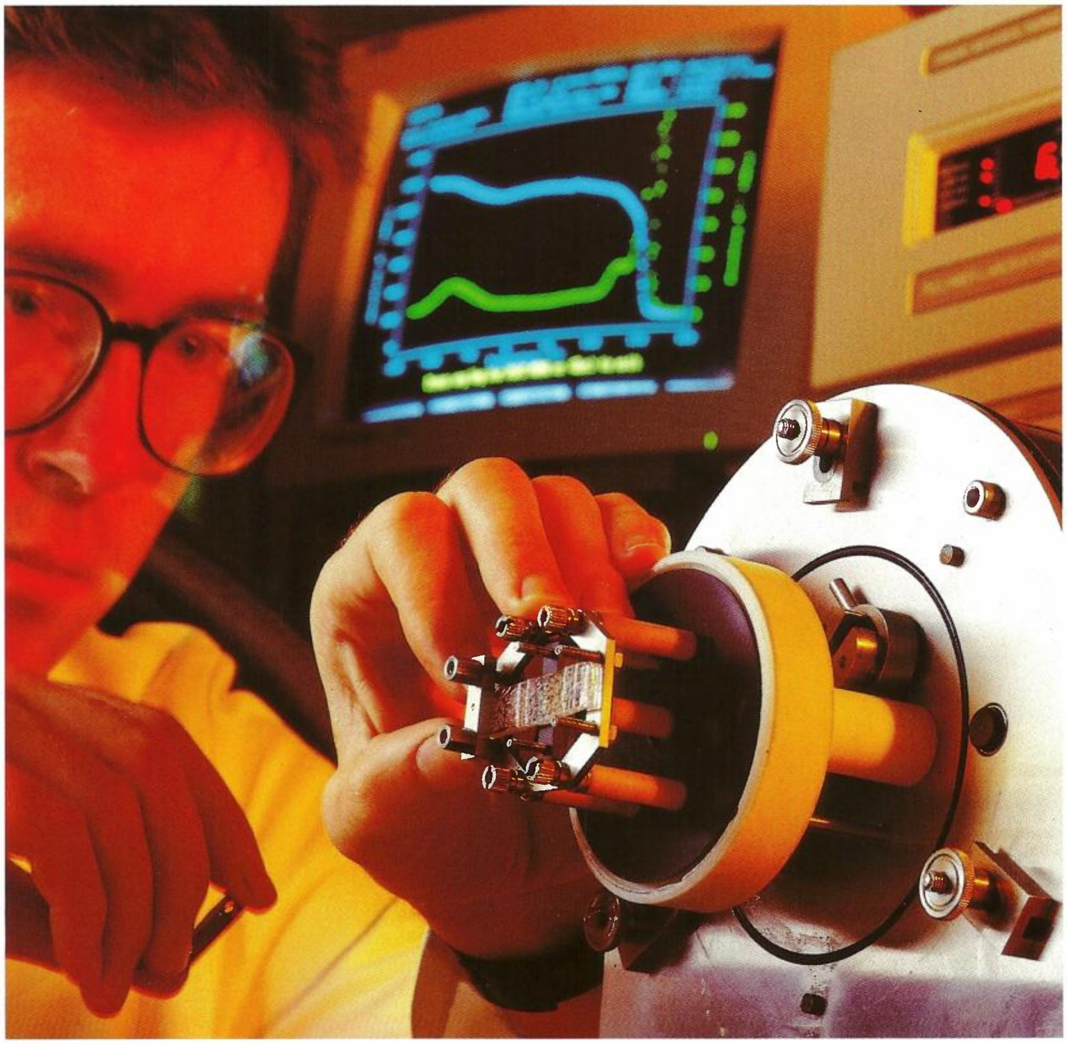
Dynamic Mechanical Thermal Analysis (DMTA)

Thermal analysis is the study of physical properties of materials as a function of a controlled temperature program. Within TRL, the static thermal analysis techniques of Differential Scanning Calorimetry (DSC), Thermo Mechanical Analysis (TMA), and Thermo Gravimetric Analysis (TGA) have been widely applied to polymers to determine properties such as thermo-oxidative stability, dimensional changes and weight loss.

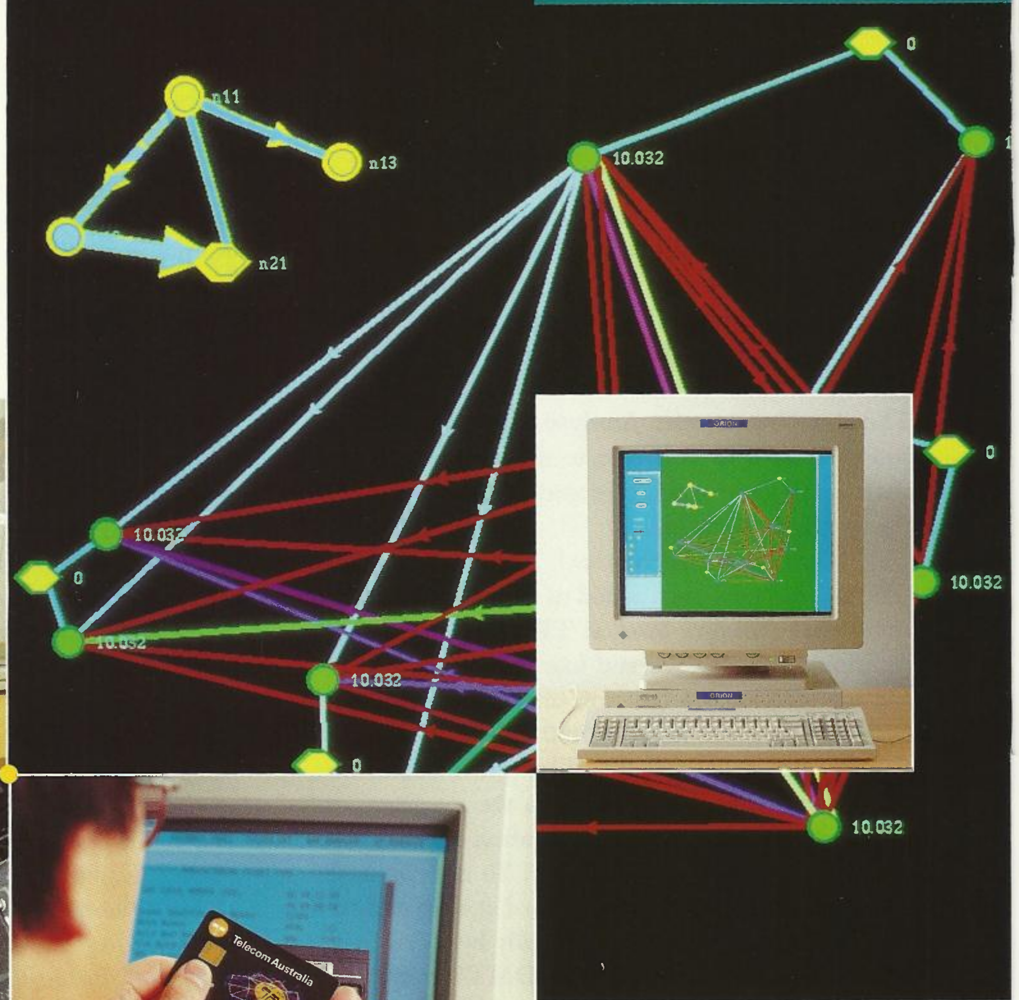
Dynamic Mechanical Thermal Analysis (DMTA) has now been added to the range of thermal analysis techniques used at TRL. This technique determines the storage and loss moduli (E' and E") and tan (E'/E") as a function of temperature and/or frequency over the ranges -1400 to 3000 C and 0.01 to 200 Hz respectively. The glass transition temperature (Tg), is derived from the tan curve and this important value gives an indication of the rubber-to-brittle behaviour of a polymer. To determine the modulus or Tg, a sample is clamped at both ends and its central point vibrated sinusoidally by a drive shaft at a predetermined strain. The DMTA is far more sensitive than DSC or TMA for the detection of the Tg of polymers. The versatility of the DMTA allows testing in tensile, bending or shear geometries on a range of sample types including films, composites, moulded samples and finished products.

The main application of DMTA at TRL to date, has been to research the properties of the ultra-violet cured, acrylate coatings applied to optical fibres. These coatings are important because they provide the necessary buffer (inner coating) and mechanical protection(outer coating) for the glass fibre. The DMTA is able to simultaneously measure the transitions of each coating on a typical single mode fibre. Experiments have shown that shifts in Tg occur due to absorption of oil from the cable filling compound or the presence of moisture. These measurements have assisted research into the stability and hence long term performance of these coatings.

The DMTA has also been used for determination of butyl rubber in polyethylene cable sheath, flexibility of non-halogenated flame retardant (NHFR) internal cable sheath and other applications. Developing the full potential of the DMTA technique is a challenge for the future.



Researcher Barry Keon adjusts the moduli and transitions of a clear plastic material.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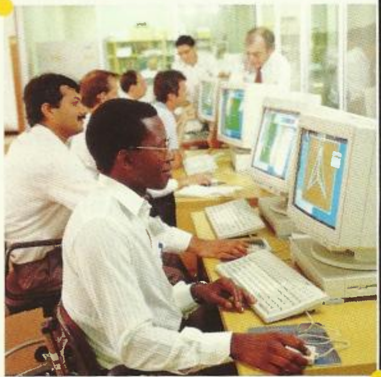

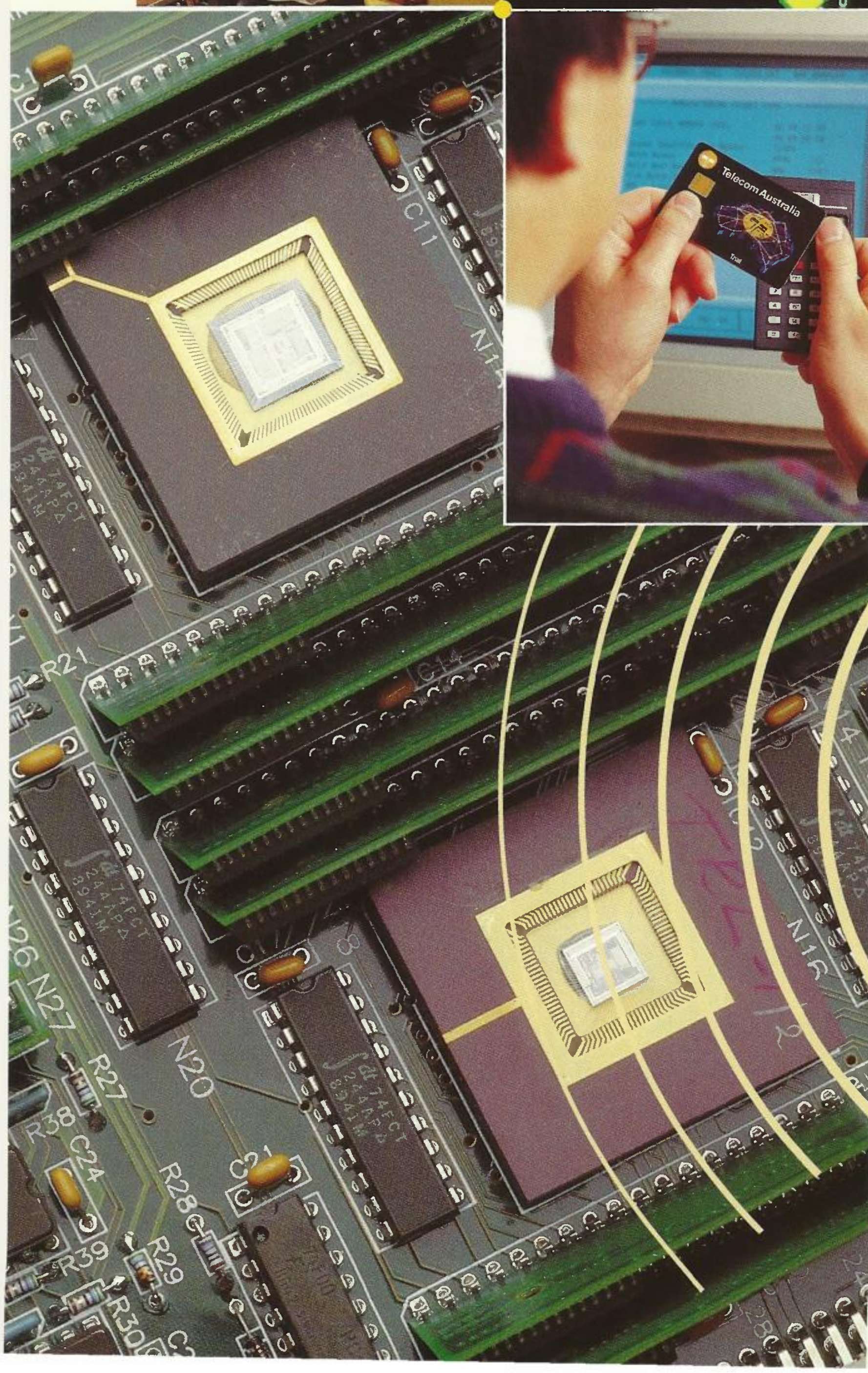
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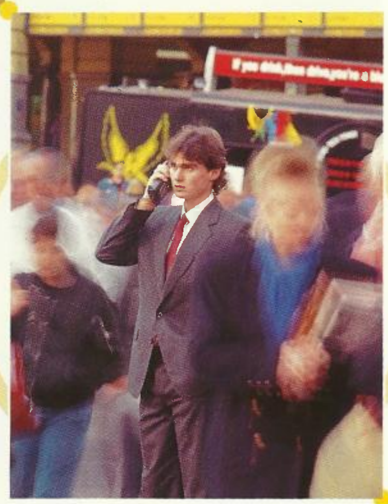


SWITCHED NETWORKS RESEARCH

THE switched communications network has a very strong dependence on the use of internationally agreed standards. The rush of new network technologies and capabilities has seen especially high activity in the International Telegraph and Telephone Consultative Committee (CCITT), which is the predominant worldwide body for these standards. TRL continues to maintain a high level of participation in those groups covering switching technologies, signalling systems and network management for Telecom's various networks — including the telephone network, ISDN, Broadband ISDN, the packet switching network and the mobile network.

Customers are now using various intelligent network services available from Telecom. TRL is undertaking substantial research in this area — resulting in some exciting network capabilities expected to arise in the next few years. In due course there will be a move towards what is known as Universal Personal Communications — communications wherever, however and whenever you wish.

One important new network capability is the "virtual network". Virtual networks use subsets of the widespread public switched network, and they provide more personalized capabilities for particular customers. By virtue of being part of the wider network, they can offer a significantly better quality service than networks of leased lines or small private networks. They also offer a much easier and cheaper means of keeping up with and taking advantage of the advances in network technology. More capable network management systems are also possible.

The technology for broadband switched networks continues to advance. CCITT now has a number of important recommendations in place, aimed at defining the structure of the networks and their interfaces. Much effort is being applied to the required signalling systems. Several manufacturers have already given public demonstrations on early systems — a notable example being at the Fast Packet Switching Workshop conducted by TRL July 1990 in Melbourne. TRL is also jointly involved in this research with the Defence Science and Technology Organization in South Australia.

The future will see networks becoming more complex with customers demanding even higher quality service without the cost becoming too great. Consequently, pressure will increase on the requirements of network management systems and on network design and analysis tools — TRL's continued research and development will address both of these areas.

The next few pages illustrate some of the activities being undertaken by TRL to provide Telecom Australia with timely advice and assistance relating to the future adoption of new technologies and operational practices in the Australian switched network.

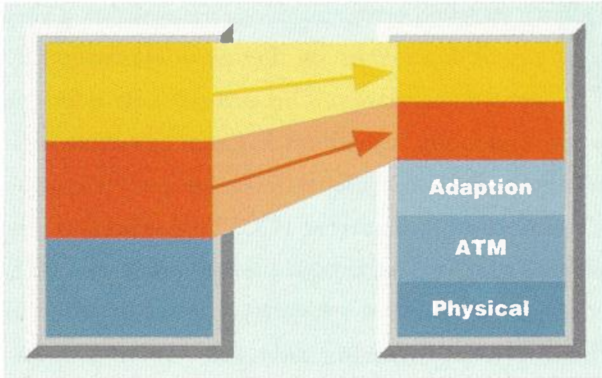
Signalling in the Broadband ISDN

One of the key features of the Integrated Services Digital Network (ISDN) is its user network signalling — a flexible, powerful and extendable signalling system that gives the customer high levels of control of the network.

The rapid development of standards and products towards the Broadband ISDN (B-ISDN) has now fostered changes to ISDN user-network signalling. The impact of the B-ISDN also requires changes to the signalling used inside the network and the means of transporting signalling. These changes are needed to meet the new requirements of B-ISDN, but are evolutionary; the need for expansion of the signalling protocols was foreseen by the CCITT standards body.

TRL has been active in all aspects of B-ISDN standardisation at CCITT, including the ongoing work to determine the new requirements for B-ISDN signalling. The impact of Asynchronous Transfer Mode (ATM) is the crucial factor. ATM is the transport for all user information and user network signalling information in the B-ISDN. TRL has also studied and proposed the use of ATM for network signalling.

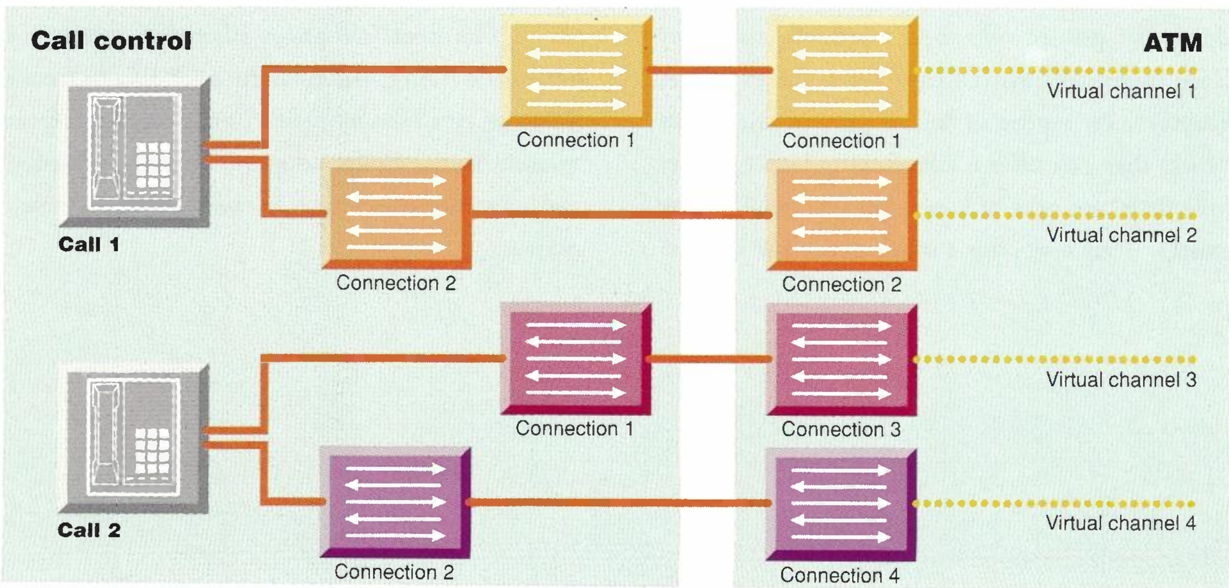
New capabilities, such as multi-connection calls for multimedia services, will be introduced with the B-ISDN and will require additional signalling capability. Early B-ISDN products will provide signalling capabilities based on the current standards for ISDN. Since B-ISDN signalling standards lag other B-ISDN aspects, some initial B-ISDN products may offer very limited control capabilities emphasising high speed and connectivity rather than control. Networks will eventually evolve to full B-ISDN capabilities, including multi-connection calls for multimedia services.



The evolution of ISDN network signalling for B-ISDN — the existing protocol stack of three levels (left) being transformed to place the top two levels onto a B-ISDN protocol reference model (right).

Asynchronous Transfer Mode (ATM) will be used at the user-network interface and within the network to transport user information. The use of ATM to also transport network signalling is possible, and has performance benefits beyond the B-ISDN application, such as Mobile and Intelligent Network signalling. This use of ATM is strongly dependent on the role of existing signalling networks in evolution scenarios.

TRL has shown that the lower levels of the existing ISDN signalling protocols may be replaced by ATM protocols with an additional layer, the ATM Adaptation Layer (AAL). Currently ISDNs use 64 kbit/s links to carry signalling, but with this change in



Enhanced B-ISDN signalling will allow multiple connections to exist for one call. The connections are identified by the ATM virtual channel identifier, while the calls are separately identified by the call control functions.

B-ISDN, much higher speeds (in the Mbit/s range) will be possible. At the same time, re-use of the existing functions of signalling will help speed-up the availability of signalling systems for B-ISDN. This includes signalling for intelligent network and network management protocols.

An ATM connection may be specified with an arbitrary channel bit rate up to the full interface rate (over 100 Mbit/s) and is not limited to multiples of 64 kbit/s. The network must use information sent by the user to determine capacity parameters for the connection; sufficient information must be included at connection establishment as part of user-network signalling procedures. TRL has studied the nature of these parameters; amongst the conclusions was the need to standardise the parameters to ensure that terminals and networks operate on a common basis — CCITT has recently agreed to this proposal.

In the longer term, multi-connection control is required in signalling to allow signal calls to handle multiple connections. By coordinating the available connections within a single call, multimedia services can be handled simply, whilst retaining full control of each network connection. It is important to allow signalling to separate the control of calls, connections and network accesses so that complete control of any type of call can be included in the B-ISDN user-network signalling.

Broadband ISDN Congestion Control

Techniques of B-ISDN congestion control, being investigated at TRL, will help ensure that customers using the network will utilise it efficiently and thus receive the best possible benefits with the least possible disruptions.

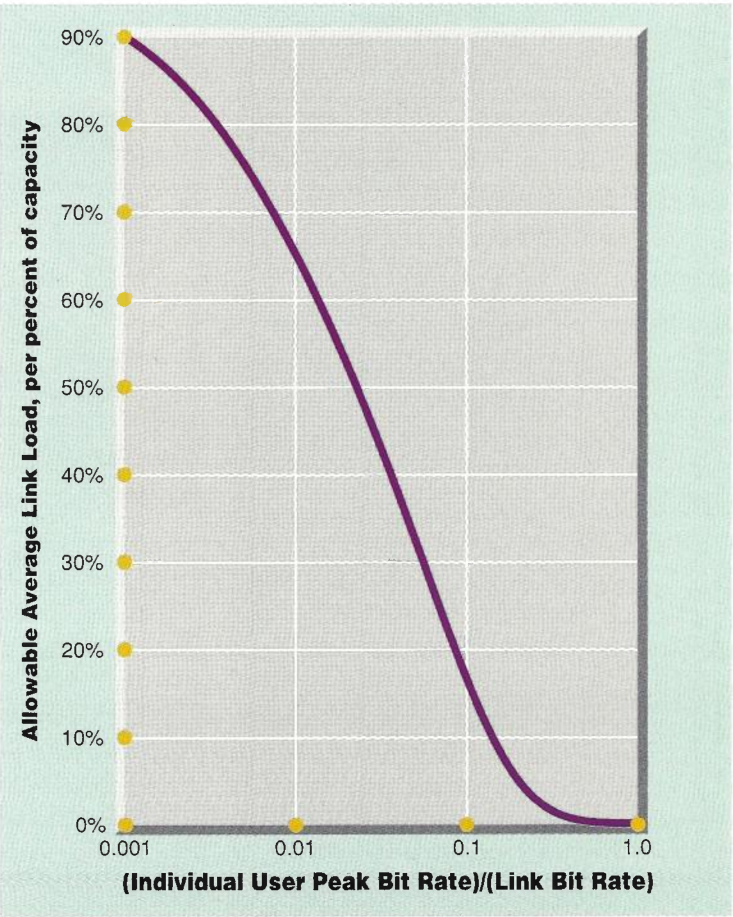
The B-ISDN will enable services to time-share resources on demand on a very short time scale. Because the time scale is short, it will not be possible to precisely pre-allocate resources before use. Hence there is a small chance that network resources may become overloaded or congested. The objective of congestion control is to control users' access to network resources so that the probability and duration of congestion is acceptably low while at the same time allowing a high utilisation of network resources.

Initially, B-ISDN customer access to the network will be controlled by a connection acceptance procedure, and by a predetermined limit on the maximum amount of network resources that can be used by each connection. This will give a degree of control over the probability of congestion and allow a moderate utilisation of network resources.

A higher utilisation of network resources is possible if the network can vary the resources that each connection is allowed to use during the progress of the connection. Such a technique has been proposed by TRL and is called peak rate throttling. It is based on the observation that the average load that a network can carry is increased when users' individual peak resource use is limited to a smaller share of the network resources.

The graph shows the average load that a network transmission link can carry as a function of the peak bit rate that individual users are allowed to send, divided by the bit rate of the transmission link. This applies for the case where the allowed cell loss probability is one in a million. It also assumes that all users transmit at the allowed peak bit rate. The graph shows that if the average network load increases, the network operator can prevent the cell loss probability from increasing by reducing the peak bit rate at which users are allowed to send their data. TRL has been developing this technique and investigating ways of forecasting the cell loss probability, determining the appropriate throttle peak rate, if necessary, and signalling users about the allowed peak rate.

The technique will allow the resources of the future B-ISDN to be time-shared much more efficiently and thus help provide a high-speed, high quality service with maximum customer satisfaction.



Allowable average network link load as a function of individual user peak bit rate.

Data Network Evolution

Public packet switching networks are continuing to obtain greater capability in a number of ways including: higher speeds, increased facilities and more interworking capability.

Higher speed interconnections, both within and between networks, are now becoming possible, with some use being made of 2 Mbit/s, and most international links now using at least 48 kbit/s or 64 kbit/s in place of the older 9.6 kbit/s links.

TRL takes a strong interest in packet switching network quality of service and has developed means of measuring it, both nationally and internationally. These techniques are now being incorporated in CCITT Recommendations.

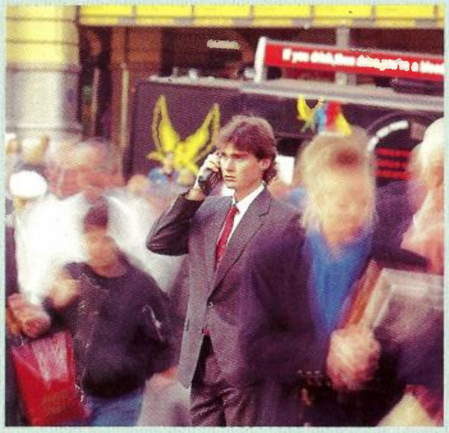
It has often been the case that new network capabilities first appear in public packet switching networks and later in other types of networks. At present, new capabilities being considered by CCITT for the X.25 and PAD interfaces include multicast calls, sophisticated call redirection and deflection, mnemonic addressing, and facsimile capability. Further capability is also being added to services such as X.400 electronic messaging and X.500 electronic directories.

Customers expect networks of different types and capabilities to be able to interwork, often underestimating the complexity of interworking. However, further capability has been added, particularly in relation to interworking with ISDN.

Teletraffic Studies of Cellular Mobile Systems

TRL is investigating teletraffic aspects of cellular mobile systems to support Telecom's MobileNet. The teletraffic investigations aim to increase the maximum traffic density that can be handled, ensure a high quality of service, keep costs low, and achieve the best use of scarce radio spectrum resources.

Mobile customers use radio links to connect with other customers who may be on MobileNet or the fixed telephone network. Because the radio spectrum is a limited resource, frequencies are reused many times to allow the development of a nationwide network with the potential capacity for millions of customers.



Mathematical analysis and computer simulations of mobile communications systems are used to experiment with design options. Such studies link in with work carried out at the Centre for Mobile Communications at the University of South Australia, and at the Centre for Telecommunication Research at Bond University.

Although equipment in MobileNet — ranging from computerised exchanges to personal handsets — is manufactured in accordance with international standards, Telecom must still choose between options that affect service quality and cost. Several of these design choices, and the study of their teletraffic aspects, are described below.

A single mobile call may require a number of channels, one after another. Initially, the call must be assigned to a free channel on a suitable base station. As the mobile caller moves about, and other calls arrive and depart, the call may require a handoff to a free channel on another base station. If all goes well, the mobile customer can establish a call and then move about without losing the connection. However, if traffic levels are high relative to the system capacity, the call attempt may be rejected or delayed before the call commences, or the call may be dropped while in progress. TRL is studying the best arrangements for assigning calls to radio channels and base stations, and queueing of calls that require handoff, to ensure that calls have an acceptably low probability of encountering congestion.

The amount of traffic per square kilometre can reach very high peak values in small areas, such as central business districts, so TRL is studying models of micro-cells in areas of peak traffic demand. The study assesses whether a layer of microcells can allow for high levels of peak traffic density at reasonable cost.

A means of filtering fast moving customers to larger cells has been proposed and analysed. Fast moving mobile customers create special problems if they move through a number of micro-cells in succession. Unless they are given special treatment, they will need many handoffs in quick succession — resulting in a high probability of being dropped and also excess processing for the call-control system.

TRL's research efforts are providing strategic support to Telecom's endeavour of satisfying customer demands placed on the enormously popular mobile services.

Open System Interconnection continues to be developed. All the basic CCITT/ISO standards are now in place and are sufficiently developed for various governments to have adopted a "Government OSI Profile" which covers mandatory requirements for equipment purchase.

Higher speeds, greater and more variety of facilities, and more interworking capabilities, are the types improvements to the public packet switching network that TRL continues to develop so that Telecom's customers see the benefits of the latest technology.

Wideband in the ISDN

The existing ISDN is based on 64 kbit/s end-to-end connectivity. Access to the ISDN includes 64 kbit/s channels, known as B channels. However, some services require data rates that are greater than 64 kbit/s. These services include video conferencing, video telephony, LAN interconnect, video database access, and high speed data transfer between computers.

Some ISDN exchange designs can support data rates of multiples of 64 kbit/s. They achieve this by establishing calls with multiple B channels. These B channels are kept together at all times so that they all incur the same delay. The exchange switchblock must also have a constant delay for all connections through it. The transmitted data can then be spread across the multiple B channels, transmitted across the network, and then recovered at the receiving side.

This method of connecting calls can add a new range of capabilities to an ISDN. Within CCITT it is called Nx64. Several values of N have been standardized, giving data rates of 384 kbit/s, 1536 kbit/s and 1920 kbit/s.

Other types of ISDN exchange designs cannot support Nx64 services because they cannot maintain equal delay for all the B channels that make up a Nx64 call. They may not have equal delay for all connections through the switchblock and they cannot switch a group of channels and keep them together. Each B channel connection establishment is treated as a unique event and no attempt is made to route the channels on the same path.

To allow a network of switches that cannot support Nx64 to provide the required service, a means of detecting the different delays in each channel must be devised. Then that difference must be compensated by adding extra delay to the 'faster' channels. TRL has been involved in investigating various methods of inserting a delay into each channel. Each method reduces the available bandwidth by a small amount. For some services this does not matter, but for some others the loss of some of the 64 kbit/s from each channel is unacceptable. To overcome the problem, another B channel is added which results in N+1 channels being used to carry N64 kbit/s.

Under the guidance of Austel, the national telecommunications regulatory authority, TRL and industry groups have worked together to produce a national standard for how to combine multiple channels with differing delay. The combining process is known as channel aggregation. This standardization effort has resulted in a draft Voluntary Technical Standard VTS002 which was produced in March 1991.

The standard requires that there is special Nx64 equipment on the sending and the receiving ends of a group of channels that require aggregating. This equipment can be on the ends of the ISDN access (i.e. customer premises), at the exchange end of the ISDN access, or between a network that requires channel aggregation and one that has Nx64 capabilities.

The draft standard has several novel concepts which result in less bandwidth being stolen from each channel. Equipment that is based on this standard is being developed by Australian companies.

Telecom will support the adoption of this Australian Standard for channel aggregation as an international Standard.

Network Management Integration

TRL's technical expertise and initiative in implementing international standards places Telecom Australia in good standing to keep pace with the complex and rapidly changing network capacities and customer demands that require network management integration.

Network management, broadly defined, is the set of actions used to operate, administer and maintain Telecom Australia's various public networks. Network technologies now provide greater integration of services, (as in the B-ISDN, in which potentially all services could be carried on the one network), but network management functions have not kept pace with these developments. In addition, there is a market need to provide customers with an integrated view of, and an integrated control mechanism for, their network facilities.

By contrast, the current generation of network management systems is characterized by special systems for particular network products, with functions dependent on the underlying technology. In this environment, it is difficult to provide an integrated view of a set of network products for a particular customer. Furthermore, there is much worldwide concern that the costs of provision of network management systems has grown disproportionately in relation to the costs of provision of network services. Therefore, there is a strong drive for greater integration, to simplify procedures and to drive out costs.

Telecom Australia is in a good position to lead the world in the integration of network management. First, Telecom has already deployed AUSTPAC — a national packet data network on which communications for network management can be carried. Second, Telecom has a strong commitment to international standards which can greatly simplify interconnection of vendor-supplied systems. Third, Telecom has made an early start in implementing a Telecommunications Management Network (TMN) using the appropriate international standards.

TRL is furthering the aim of network management integration in a number of ways. TRL provides technical advice on international standards (CCITT and ISO) that are appropriate for network management. TRL's technical experts who are at the forefront of developments in the TMN, provide advice on naming and addressing — a key issue if uniformity is to be achieved — and on suitable performance measures. This advice leads directly to implementations that will achieve simplified network management at a reasonable cost.

TRL, jointly with operational experts, is investigating methods to provide a consistent control hierarchy for network management. Some actions, such as restoration of service after a major cable fault, are required quickly under automatic control. The current Digital Services Protection Network provides this function. By contrast, traffic management for forecast peaks may take place through human intervention over a matter of hours or days. A consistent control hierarchy brings all management controls into a single framework of layers, divided according to time-scale or extent of influence. The use of synchronous digital hierarchy standards will provide a technology driver in this context.

TRL has also provided significant input to Customer Network Management (CNM), providing a systems view of CNM and detailed commentary on system design and evolution. Given the market necessity of CNM, this area will provide significant impetus to network management integration in the future.

High Speed Networks and Protocols

Australia now ranks among the world leaders in high speed networking. TRL's contributions to CCITT and IEEE standards, various telecommunications conferences, and international journals have made a significant impact on the evolution of broadband networks.

The invention, by researchers at the University of Western Australia, and enhancement and development by Telecom and its joint venture company QPSX Communications, of the Distributed Queue Dual Bus (DQDB) protocol, earned Australia international recognition. The final approval of this protocol as the IEEE 802.6 standard for Metropolitan Area Networks (MAN) was of major significance internationally.

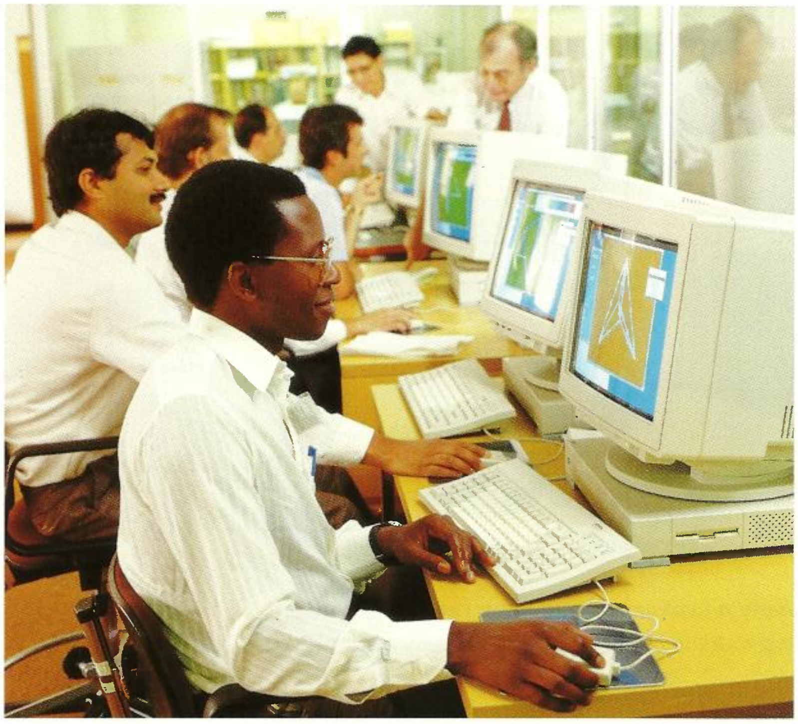
Two significant enhancements to the DQDB protocol have been developed and patented by TRL:

1. A modification based on a new concept of CYclic REquest Control (CYREC) has been introduced to provide guaranteed bandwidth and to minimize delay jitter for real time services such as voice and video.
2. A new protocol permitting the reuse of network transmission resources has been developed within the DQDB framework to increase the network capacity, particularly, when most traffic is local.

Telecom's FASTPAC network, initially based on multiple DQDB subnetworks interconnecting Australian major cities, is among the world's first implementations of public high speed data networks. Initially, FASTPAC will provide data services such as image and file transfer, transactions, interactive and remote computing, and data communications. In the future, FASTPAC may also be able to carry voice and video traffic as market demand grows. TRL supports the development of FASTPAC and its evolution in line with B-ISDN by providing expert advice and protocols for resource management, congestion control and routing.

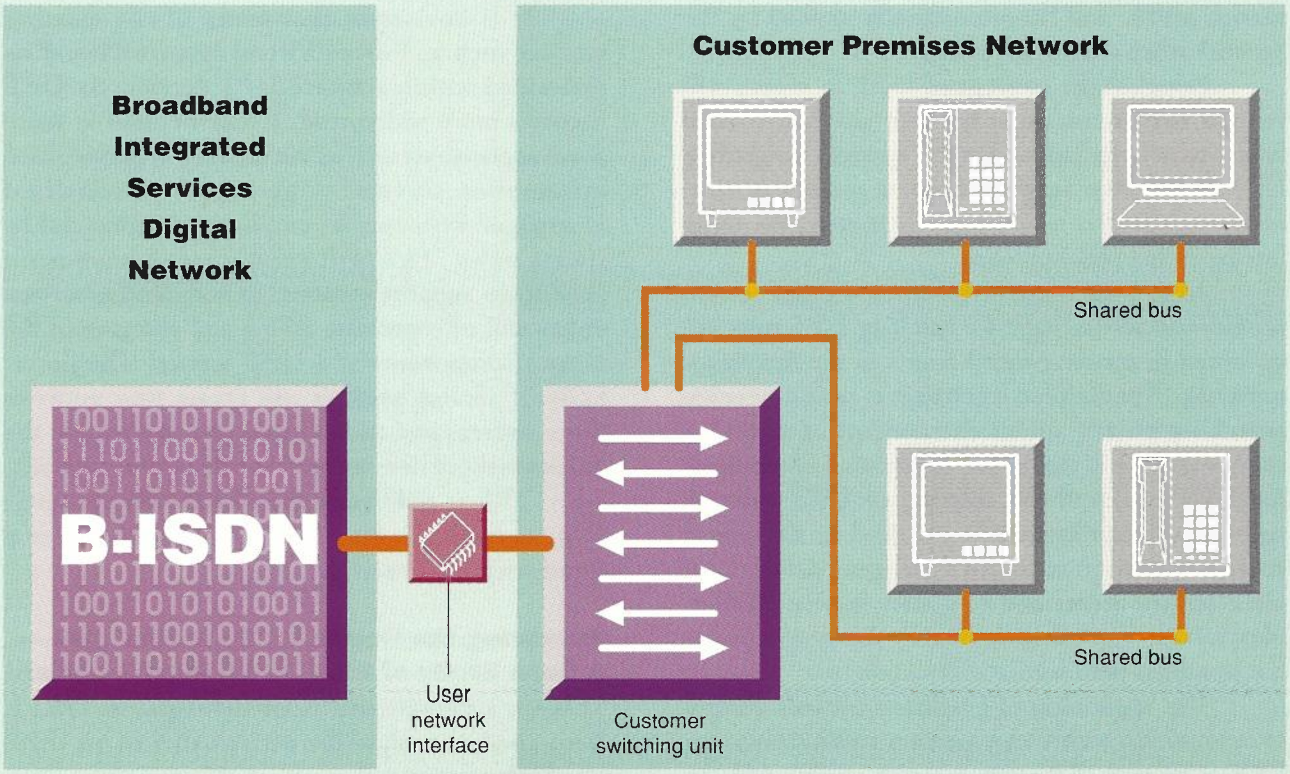
One of the important standards activities of CCITT Study Group XVIII is related to the Generic Flow Control (GFC) protocol for B-ISDN. This protocol will regulate multiple terminals within the customer premises network (CPN) accessing the B-ISDN through a single user interface. It is expected that the CPN will incur a major part of the costs involved in providing Broadband services. Therefore, it is important to develop an efficient GFC protocol which will ensure the cost effective operation of the CPN.

Based on multi-priority distributed queueing with multiple requests and preceded by a traffic shaping function, the Australian GFC protocol provides the necessary flexibility to match different service requirements.

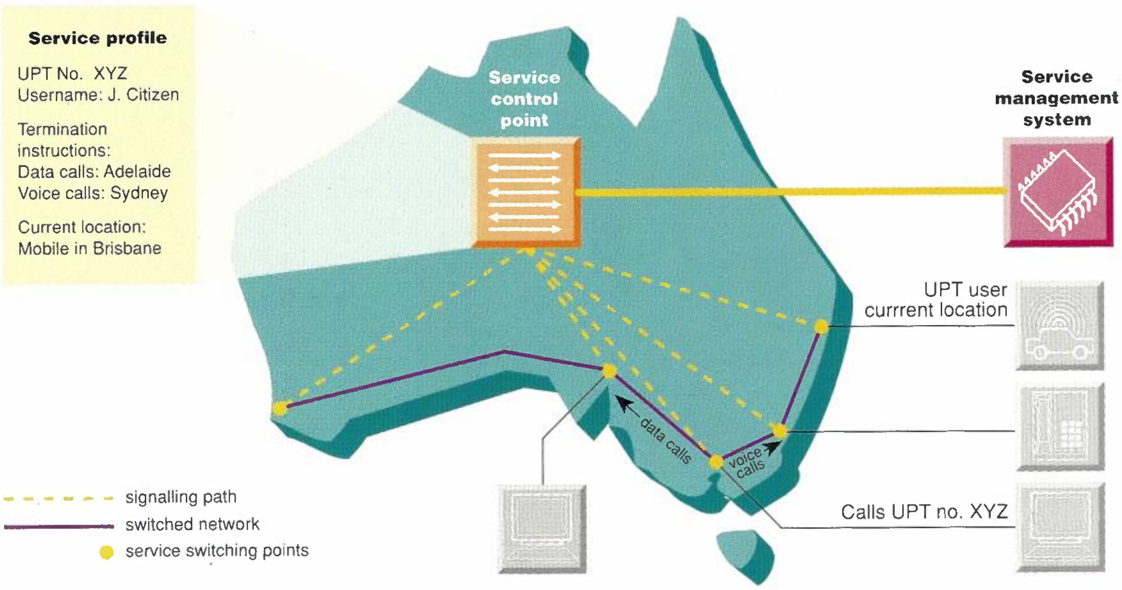


TRL is furthering the aim of Network Management Integration.

The proposed GFC proposal provides guaranteed bandwidth and acceptable delay performance for connection oriented services. Additionally, it ensures controlled fair sharing of the remaining non-guaranteed bandwidth, and achieves efficient bandwidth utilisation under mixed traffic load conditions.



Customer Premises Network and its interface to B–ISDN.



UPT service will allow a customer to receive incoming calls, and initiate outgoing calls from any terminal on any network.

Making UPT a Reality

A fully fledged Universal Personal Telecommunications (UPT) service will allow a customer to receive incoming calls, and initiate outgoing calls from any terminal on any network — based on a unique, personal number called a UPT number. Charging of calls will be based on the UPT number instead of a terminal identifier.

The delivery of telecommunication services could also be personalised, by defining a set of customised call handling instructions in a service profile at subscription time. Instructions in the user's service profile will be automatically applied by the network when a UPT call is made.

Bringing the concept of UPT to reality will require modernisation of existing network control functions and operations support systems. To provide UPT to the mass market, and at a reasonable cost, network providers are turning their attention to an intelligent network approach.

To provide a network-wide coverage, service profiles and service logic for handling UPT calls will be stored in service control points in the intelligent network. Specialised exchanges called service switching points, under the control of a service control point, will handle the registration of terminals for UPT use, and the routing of UPT calls. A subscription interface will be provided by the service management system in the intelligent network, to place service orders and to update service profiles. New service data will be verified by this system before it is downloaded to service control points.

The application of intelligent network control techniques and service management methodologies to UPT is an area of intense research world-wide. An advanced UPT service is being prototyped at TRL's Intelligent Network Service Evaluation Testbed — INSET. The prototype service will use smart card technologies to provide easy and secure access to UPT. Signalling protocols that can be standardised are also being designed for INSET to support advanced personal mobility features. Additionally, the study will progress towards the design of UPT databases which will optimise the distribution of UPT data in the network. These experimental system and service prototyping activities will generate expertise for the development of UPT standards and networking technology.

It is envisaged that many of the existing services such as Private Virtual Network could be embedded within a future UPT service. As UPT becomes more widespread, it may be used in more novel applications such as the delivery of personalised information services — perhaps a personalised newspaper with special emphasis on financial or sports news. This will create new demands on operations support systems, to standardise service orders and to coordinate billing and charging of the various components of a UPT service. The portability of service profiles will create new network usage patterns and traffic levels, and will require the development of new network management strategies.

TRL is addressing these challenges by developing technologies for the eventual introduction of a feature rich UPT service.

Improving the Quality of Specifications — A Case Study of IEEE 802.6 MAN Standard

TORAS, a software tool being developed at TRL, is being used to analyse the performance of an IEEE standards protocol that affects Metropolitan Area Network (MAN) reliability. The protocol will be used to ensure that the MAN automatically and quickly recovers from bus faults, to a fully operational state with minimum disturbance to customers.

IEEE has been developing a standard for MANs based on the DQDB access mechanism which will be used with Telecom's FASTPAC service. Amongst the various protocols that have been developed in the standard (IEEE 802.6), the Configuration Control Protocol (CCP) is perhaps the least understood. CCP is the protocol which ensures that nodes of a DQDB network are configured into a correct dual bus topology. For instance, in the presence of bus faults a looped topology can be automatically re-configured into an open topology and the faulty links closed down. TRL has undertaken a study to assess and subsequently improve the quality of the CCP specification .

CCP has been analysed using TORAS, a software tool being developed at TRL. It analyses state spaces, or possible results, which are generated from a mathematical model of a system, currently a Petri Net description.

Verification of CCP involves: interpreting IEEE 802.6 and creating a Petri net model; running the model on TORAS until it confidently reflects the written description; and finally, exploring the properties of the model to verify CCP.

The modelling of CCP was broken down into several parts. Separate models for a node of a network; the dual bus transmission links; and the interfaces with the 'users' of the protocol, were replicated and combined as necessary.

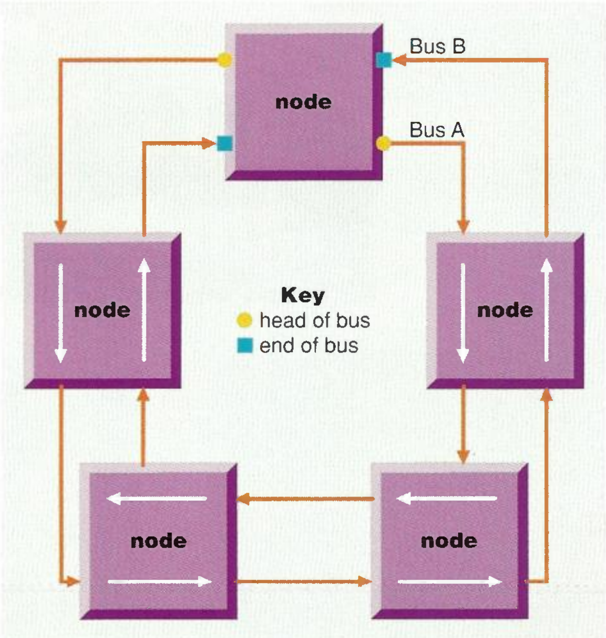
The analysis that TORAS performs, demonstrates the good and the bad things that can happen. The more TRL knows about the protocol, the more confident TRL is about its design. TORAS helps find deadlocks, livelocks (unwanted cyclic behaviour), and other undesirable properties of the protocol. In addition, it finds positive things, like states which must be reached if the protocol is correct.

To ascertain whether or not CCP is correct, TRL needed a precise idea of what it is meant to do. CCP's intent is only informally indicated. The intent is that at network start-up and after bus or external timing failures, the network must be configured into the stable dual bus topology which maximises the number of communicating network nodes. TRL developed a precise definition of the intent.

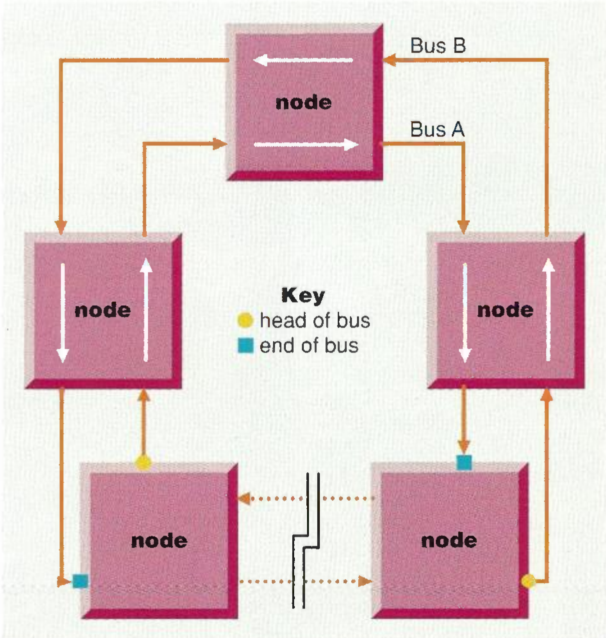
The analysis demonstrated a number of problems with the CCP specification. In particular, ambiguities and inconsistencies in the text permit a number of interpretations. The literal interpretation of the text and tables does not allow the network to start-up. An interpretation was found that avoided this problem — this interpretation was the third variation analysed in an attempt at finding a workable version.

The analysis was the first large-scale application of TORAS and as well as the results on CCP, it provided a test of the soundness of the basic ideas. The verification work on CCP revealed a number of problems with TORAS, some anticipated, others unexpected and requiring further studies of the underlying algorithms, theory and methodology. In particular, TRL found some performance bottle-necks.

TRL is working to address any problems found with TORAS so that the process of verifying systems like CCP will be substantially improved.



Looped Bus Topology of a DQDB network

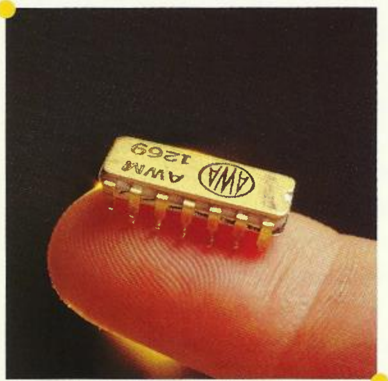


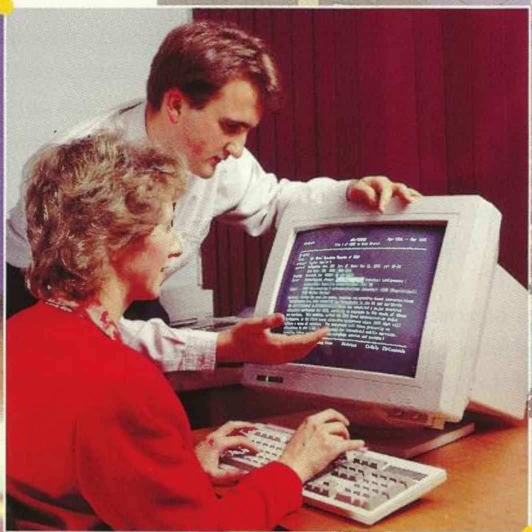
Open Bus Topology resulting from looped bus topology reconfiguring after a line break

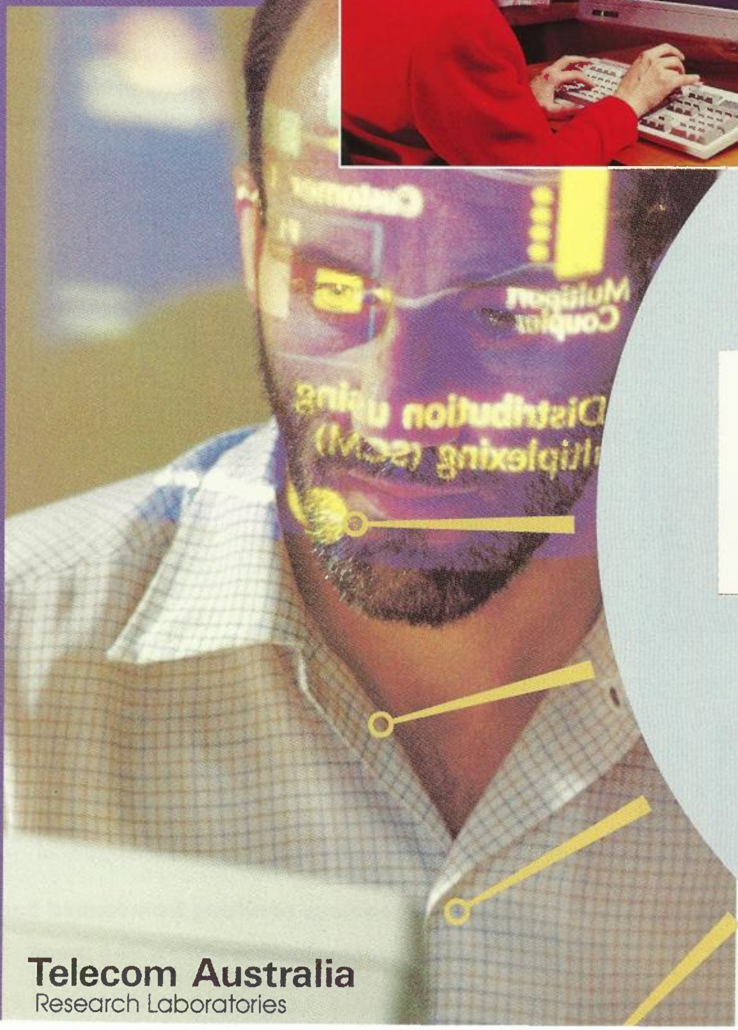
Telecom focuses on AI as key to market, profits

Telecom's R & D essential for Australian technology

IT chalks up big changes in learning







RESEARCH

Telecom Australia
Research Laboratories

TRL ensures that Telecom Australia has timely and relevant advice regarding new and existing technologies. Know-how is transferred to customer divisions and other shared resource units of Telecom Australia, and is applied in specific projects relating to the planning, implementation or operation of networks and services. Such processes of technology and information transfer are on-going and multi-faceted and are an important part of Telecom Australia's responsibility as the provider of telecommunications services throughout Australia.

Technical reports, papers, journals, and seminars communicate and document significant technological outputs arising from TRL's R & D programme. Audiences are wide and varied. They include industry, academe, external research and development organisations, Telecom management, Telecom customer divisions and their clients, and Telecom staff — information is transferred around Australia and to the four corners of the world.

Seminars and conferences convey, on a more personal level, the types of R & D TRL is engaged in, and the direction that research is leading telecommunications developments for business and the community at large.

Other formal and informal processes provide avenues for technology and information transfer to and from TRL. Collaborative R & D contracts and sponsorships enlist assistance from both industry and academe. Less formal peer group interactions also take place.

Involvement on standards committees and organisations at national and international arenas ensures that Telecom's research is in line with world directions or even leading the way.

Intellectual property licences are negotiated with external organisations for the commercialisation of inventions and other forms of intellectual property arising out of work done by TRL and other parts of Telecom.

Over the past year TRL has seen many important examples of technology and information transfer. Some of the more significant examples are illustrated throughout the following pages which provide an insight into the importance Telecom Australia places on communicating and transferring technological information.

Telecom Australia's Product Development Fund

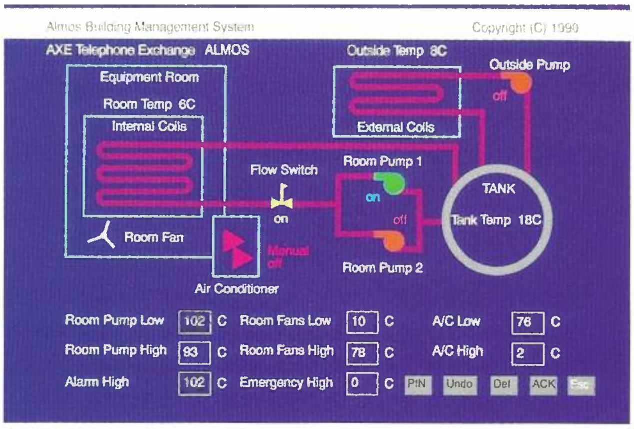
The Telecom Australia Product Development Fund (PDF) was established in 1987 to encourage Australian innovation in the fields of telecommunications and related technologies. The fund was designed to encourage small and medium sized Australian companies who could not otherwise afford to take their product through all the necessary steps from concept to final testing.

Examples of products supported by the Fund, as illustrated, demonstrate the results of some of the $6 million already invested in over thirty Australian companies. In addition to financial assistance provided to entrepreneurs and inventors with potential worthwhile product concepts and plans, Telecom can also provide expert assistance and advice from engineers and scientists. In return for funding and assistance, Telecom seeks intellectual property rights in a particular product commensurate with its inputs to the project.

The Fund's full time manager is located at TRL but uses resources and knowledge from all avenues of Telecom to aid the assessment of applications for funding. In particular, the Intellectual Property Section at TRL, and the Technical Liaison Office (Network Engineering SRU) play vital roles in the operation of the Fund. Furthermore, technical aspects of the procedure and liaison with the successful applicants have and continue to involve all Branches of TRL.

Telecom's commitment to the Fund is Australia-wide and has seen successful products evolve from many of the States with the return from the PDF investment taking several forms. These returns include, royalties, products to use, products to market, and a local supply to replace imports and boost exports. The success of the PDF has demonstrated Telecom Australia's willingness to discover Australian business talent and work with this talent to produce a 'win-win' outcome.

Below: **Security Domain Pty Ltd (NSW) EDI Security.**



Above: **Almos Systems Pty Ltd (WA) Building Management Software.**

Right: **Perceptive Systems Pty Ltd (VIC) 3-Dimensional Security System.**

5th Australian Teletraffic Research Seminar

The 5th Australian Teletraffic Research Seminar (5AusTRS) was organized by TRL and held at Monash University in early December, 1990. This seminar series was originated by TRL in 1986 as a forum to bring together academics, researchers, Telecom Planners and industry representatives for discussion of teletraffic issues. In this context, the term teletraffic embraces network planning and design, traffic measurement and monitoring, performance implications of customer mobility and service integration, and traffic control for future networks — in short, anything that is affected by the uncertainty of future demand or the performance of systems. The seminar series has proved extremely valuable in giving Telecom planners insights into the latest academic thinking, while feeding back to researchers current concerns about existing and future networks. Every alternate seminar in the series has been organized by TRL, the others being run by universities.

5AusTRS continued the success of earlier seminars. Over 90 delegates from Telecom, industry and academe attended. They heard and discussed 24 contributed papers from researchers in Australia and New Zealand, in addition to a keynote address by Professor Uri Yechiali of Tel-Aviv University, Israel. Professor Yechiali's address, on polling systems, stimulated much interest in these systems as models of telecommunications processes. As a result, it is likely that polling system models will be more frequently used in future teletraffic studies.

The contributed papers ranged over many topics: network design and planning; network performance and management; mobile communications systems; broadband ISDN; metropolitan area networks; and new methods for teletraffic science. A particularly pleasing aspect was the strong contributions from the TRL-sponsored centres of teletraffic expertise at Adelaide and Bond Universities. There are now valuable, coherent teletraffic research programs at these universities.

The general standard of the papers showed that teletraffic research is conducted at a very advanced level in Australia. A particular emphasis has been placed on future broadband networks. In this area there were new results on modelling the transient behaviour of traffic and on congestion control, which will directly influence control methods for Telecom's Fastpac service. A further area of growing interest is mobile communications services. Papers at the Seminar showed that the basic modelling of mobility and control has now reached an advanced level, and many useful results can be expected.

The next seminar, the 6th Teletraffic Research Seminar, should continue the tradition of value contributions to Telecom's network planning and management activities. It will be held in late November, 1991, at the University of Wollongong.

Sponsored External Research and Development

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

TRL acts 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 Telecom's networks and services. In some cases, TRL also contracts out development projects in specialised fields to meet technical needs that cannot be satisfied through normal sources of supply.

TRL's major activity in external R&D is the establishment of Centres of Expertise in major Australian universities. These centres are contracted for the performance of high level research work and are selected on the basis of nationally recognised expertise in a technology or field of research of direct relevance to Telecom.

During 1990/91, TRL managed a portfolio of five R&D contracts for Centres of Expertise, seven R&D contracts with industry and a further thirty-one R&D contracts with academe and other R&D institutions. In addition, TRL managed a further seven R&D contracts on behalf of other Divisions within Telecom. The duration of the contracts vary from less than one to several years.

Total expenditures on extramural R&D by TRL in 1990/91 was approximately $3 million. Of this total, $0.25 million was disbursed to academe via ATERB for R&D on telecommunications topics. The remainder comprises direct payments made to R&D contractors and occasional specialist consultants.

Telelcom Centres of Expertise

TRL has a strong interest in supporting and influencing the direction of research in Australia's universities. The value deriving from this collaboration includes:

- the establishment of research facilities which support the future needs of TRL, Telecom generally, and the industry which supports Telecom;
- the establishment of undergraduate curricula which meet the present and future needs of Telecom and its supporting industry;
- the establishment of retraining and skill redevelopment courses; and
- access to a highly qualified and motivated pool of graduates.

An important method of encouraging this collaboration is the establishment of Telecom Centres of Expertise in selected universities.

The Centres of Expertise scheme seeks to match Telecom's needs for research in important telecommunications topics with academic skills in the tertiary education sector. Telecom is aiming to support Centres which:

- have already achieved a degree of eminence and national recognition for research in the particular focus topic;
- demonstrate a commitment and capability to develop the topic; and
- can transfer the skills to graduates and/or postgraduates.

Important criteria are that the focus topic be supported by at least several academics and several research students, that the work be mutually supportive for maximum synergistic gain, and that the work have scope for support from other organisations.

The work of each Centre is supported by a contract between Telecom Australia and the tertiary institution. The contract defines the research topics to be studied in terms of specific deliverables (reports, prototypes, etc) and institutes a liaison board to plan, maintain and review the agreed work.

Involvment in GIRD Scheme

In recognition of the desirability of increasing private sector R&D, the Commonwealth Government, through its Industry Research and Development (IR&D) Board, operates a scheme of Grants for Industry Research and Development (GIRD) to promote private R&D activity and to enhance the capacity of Australian industry to compete in world markets.

Of particular interest to Telecom Australia are the generic technology GIRD grants which are designed to support new or emerging technologies of fundamental importance for industry competitiveness, but which require assistance to aid their development and transition into the market place. Under this programme, the IR&D Board encourages researchers in industry, government, academe and private research institutions to enter into collaborative arrangements for the conduct of applied research on specific projects in key target areas. The intention of the programme is to successfully commercialise the results of the research, through designated commercial partners in each project.

The Telecom Research Laboratories is currently involved as a researcher in four such GIRD projects, and is a party to two further applications for new projects which have been approved by the IR&D Board during the past year. The projects involving TRL are in the fields of new materials technology and information technology and cover the following topic areas:

- Mid-infrared optical fibres
- New opto-electronic materials technology
- Planar waveguide developments
- Universal video codecs
- Hybrid video transmission systems
- ATM implementation of networks.

While not a recipient of funding from the IR&D Board under the GIRD scheme, TRL contributes both research effort and relevant intellectual property to assist the other researchers and the commercial collaborators in the fulfilment of these projects. The benefits to Telecom provided by this involvement lie in access to the results of the combined research and in the local development of key technologies of importance to Telecom's future operations. In addition, where the results of a particular project are successfully commercialised, Telecom receives royalty-flows commensurate with its relative contribution to that project.

The five Centres which are operating are as follows:

Centre of Teletraffic Engineering

The Centre of Teletraffic Engineering is at the University of Adelaide. The research programs undertaken at this Centre assist Telecom's investigations and timely application of traffic engineering tools and techniques to meet its evolving needs in the planning, design and management of its networks and in the maintenance of adequate standards of its telecommunications services.

Centre of Expertise in Distributed Information Systems

This Centre is at the University of Queensland and undertakes detailed studies on distributed information systems. These systems employ databases at various points of the telecommunication network and the work of the Centre examines ways of ensuring that data is readily available to all parts of the network and capable of being updated no matter where in the network it is currently stored. Services such as directories and other network control systems benefit from these studies.

Centre for Communications Security Research

Security topics are studied at the Australian Defence Force Academy in Canberra (part of the University of New South Wales). The recommendations of the Centre for Communications Security Research ensure that Telecom can provide the highest integrity for data and electronic funds services. The work includes the design of various encryption schemes and related security techniques.

Switched Networks Research Centre

The Switched Networks Research Centre at the University of Wollongong conducts specialist research on Intelligent Network and Asynchronous Transfer Mode (Fast Packet) topics. These studies include the performance of Intelligent Network architectures in current telephony networks, the design of test and performance measurement instruments, the effects of protocol design on Asynchronous Transfer Mode signalling performance, methods of providing enhanced supplementary services (such as call forwarding), and techniques required to enable a single call to use the public telephony, ISDN, AUSTPAC, MobileNet and Asynchronous Transfer Mode networks.

Centre of Expertise in Geographic Information Systems and Analysis

This Centre is part of the University of Tasmania's Centre for Spatial Information Studies. The Centre conducts research into the fundamentals of geographic information system technology and its application to strategic studies, policy development and telecommunications planning. The Centre develops methods for combining telephone exchange boundaries with telephone customer information to identify the location of future telecommunication services, the means of delivering such services, and the necessary network infrastructure. This includes studies of the capabilities of various software and hardware systems and the development of demonstration systems.

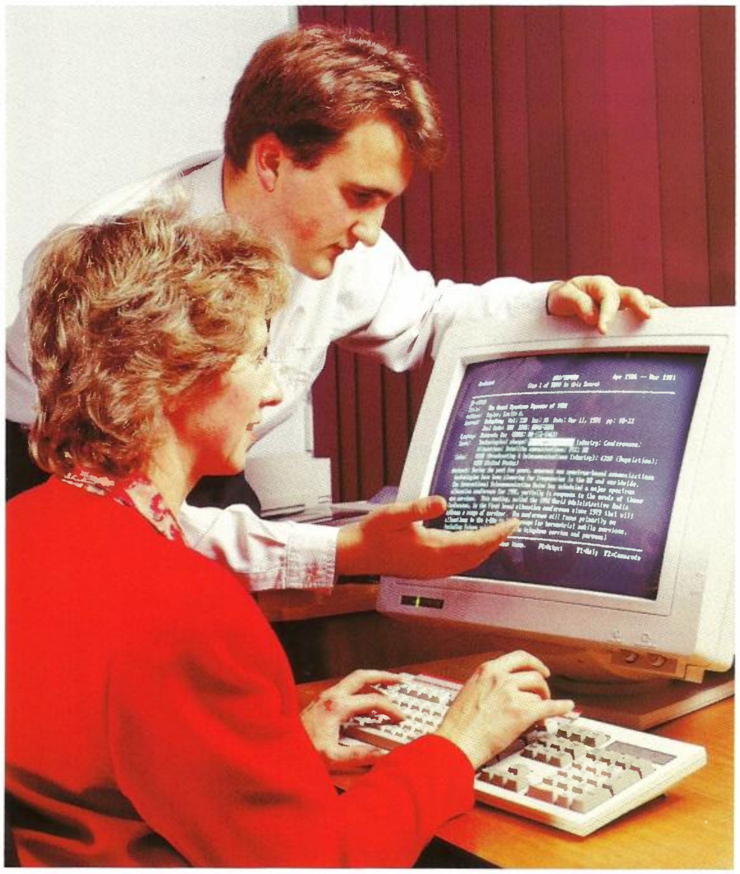
The enhancement of research and development skills in the telecommunications sciences and technologies is an activity which is most effectively done in partnership between Telecom and Australia's tertiary institutions. By contracting research and development tasks to tertiary institutions, TRL seeks to:

- augment the specialist R&D skills of the Laboratories, particularly those associated with the fundamentals of telecommunications sciences and technologies;
- conduct specific investigations and research work in fields where detailed expertise is not available within Telecom; and
- influence the undergraduate course curricula and post-graduate research programmes in tertiary institutions to ensure that Telecom is able to recruit suitably skilled professionals in future years.

National Information Resource Centre (NIRC)

Information is an essential component in the success of any business enterprise, and the effective provision and management of that information will be of great strategic value to that organisation. Information is only of true strategic value if it is in the right place, at the right time and in the appropriate format. In a large, geographically scattered company such as Telecom Australia, the provision and management of information presents a number of challenges.

For a company such as Telecom, which is technically and commercially oriented, the successful management of information requires both a high level of information skills and a thorough knowledge of the organisation. The NIRC, established within TRL, is a focal point for the management of information



On-line searching facilities at Telecom's NIRC enable information officers Janet Lindner and Simon Spencer to provide strategic technical and commercial information to Telecom's key planners and decision makers.

throughout Telecom. Established in mid 1988 in response to the technical needs and the competitive commercial orientation of Telecom, the NIRC is provided by TRL as a corporate facility, on behalf of Telecom Australia. Centres are located at TRL, and in major metropolitan areas throughout Australia. It aims to provide high tech, high quality enhanced information services to Telecom, Australia-wide.

The NIRC is Telecom's access point for information originating outside Telecom. Such external information is vital for the key decision makers and strategic planners who need to be aware of the current commercial environment in which Telecom is operating.

The NIRC has a staff of highly skilled information professionals with a wide range of expertise in many aspects of information handling. These staff have also developed a thorough working knowledge of Telecom, and this knowledge is essential if they are to provide clients within Telecom with superior information products and services, relevant to Telecom's needs.

The NIRC provides a full range if information products and services which have been tailored to be of specific value to Telecom people. Products and services are largely based on acquiring information from external sources, then analysing and packaging that information so that it meets the needs of particular client groups. General products and services include:

- access to several thousand data bases, covering a comprehensive range of subjects of interest to Telecom. These include extensive information in science, technology and business,
- access to an increasing range of information available via CD ROM,
- access to our extensive collections of information materials, including large collections of standards, integrated circuits/semiconductor files, business intelligence files and an excellent collection of hard copy reference tools, journals and conference proceedings,
- consistency services, relating to the management of information by Telecom people,
- a range of publications, available in paper copy or electronically, produced by the NIRC, for the use of all Telecom staff. These include Daily News Bulletin, Infotopics, Update, Conference Lists etc.,
- use of a wide range of equipment to ensure the availability of products and services in appropriate, high quality formats and in a timely manner,
- in-house data bases that include details of:
  - Telecom Australia publications
  - annual reports from many Australian and overseas organisations
  - market research reports commissioned by Telecom
  - details of forthcoming conferences, both Australian and international in science and technology and in management and marketing

- current journal articles, and items of interest to Telecom selected from the daily press, and
- a limited range of traditional library services.

The NIRC aims to provide products and services that are relevant to the needs of Telecom people, and of significance in assisting Telecom to maintain a competitive position in the market place. The range of products and services varies as a result of changes to Telecom.

Increasingly, a range of value-added products and services is being sought by our clients. These enhance the worth of the information provided by the NIRC and assist senior clients in their decision making. Many of these products relate to business information, and the NIRC now has considerable professional expertise in the provision of business information products.

Six Young Champions Head for the Olympics

After a year of hard calculating and training, six young Australians left Australia in July 1990 to compete in the 21st International Mathematics Olympiad in Beijing. The one female and five male students from year 11 and 12 were chosen after a vigorous selection process involving thousands of high school students from around Australia.

A series of mathematics competitions are coordinated each year by the Australian Mathematics Olympiad Committee (AMOC), which is sponsored by the Federal Government, private industry and now, Telecom who has committed $20,000 to AMOC. The money will be used over the next 18 months to sponsor contests and correspondence programmes in the lead up to next year's Australian Maths Olympics.

The Federal Member for Burke and Chairman of the Government Transport and Communications Caucus Committee, Mr Neil O'Keefe presented the Australian team members with their air tickets to China during a ceremony at TRL.

"For many reasons, Telecom is currently facing its most challenging decade," Mr O'Keefe said.

"The importance of enhancing technological skills cannot be overstated. That means developing young talent and encouraging Telecom to continue its already unquestionable high level of technological R&D.

"The rigorous selection process for inclusion of the team speaks highly of the intellectual capacity, persistence and discipline of each team member.

"The Federal Government wishes to encourage these characteristics in all young Australians."

The students were in Melbourne for two days of final training and to receive their air tickets before the Beijing event. The presentation ceremony was hosted by TRL's Executive General Manager, Mr Harry Wragge who showed the Olympic contenders what maths and science are all about.

Mr Wragge said that TRL is a prime example of how Australian skills are leading the way in telecommunications R&D.

"Australia's future will be written in the language of science and technology — mathematics.

"Today, more than ever before, Australia needs young people to not only study mathematics at high school, but to achieve the highest levels of ability and understanding and to continue to study mathematics at tertiary level," he said.

"These people will lead Australia towards its destiny as an international supplier of high technology which has been designed and built by Australians who are not just mathematically literate, but expert.

"Telecom sees the opportunity to help broaden these young people's already significant talents, as an investment in the future of Australian technology," Mr Wragge said.

"Telecom is committed to sponsoring young Australians in this way because to forge ahead as an international supplier of telecommunications we have to maintain the momentum."

Mr Harry Wragge, Head of TRL, and Mr Neil O'Keefe, Chairman of the Government Transport and Communications Caucus Committee, farewell six young Australian mathematicians and their team leaders as they head for the International Mathematical Olympiads.

Telecom and Defence Combine Forces

Harry Wragge, the Head of TRL and Scot Allison, the Director of Defence Science and Technology Organisation's (DSTO) Electronics Research Laboratory, signed a Memorandum of Understanding which could have far reaching implications for the defence of the country.

TRL and the DSTO's Electronics Research Laboratories in Salisbury, SA, will co-operate in research into advanced communications networks which will meet civilian and defence needs at the end of the decade and beyond.

These Laboratories recognise that future defence and public communications both need to flexibly support a range of voice, data, image and video communications. However, vital issues such as survivability, security and performance under stress, eg. congestion, must be resolved if Defence is to benefit from the advantages of the fully integrated very broad bandwidth capability of modern civil telecommunications systems.

Military units in battlefield situations need to have access to reliable, robust and secure communications. The rapid transmission of graphics and images portraying terrain quality, troop and equipment positions, weapons aiming information and enemy movements to widespread locations in the field, will play a key role in Australian Defence Force's communications strategies. In addition, military units will need to be connected through secure, survivable links to all levels of the military command.

Video conferencing will allow disparate units to formulate plans instantly. These requirements closely parallel the everyday communications needs of business and commerce. Both Telecom and the DSTO recognise that there would be advantages and efficiencies in developing and integrating new technologies so that services operate smoothly and seamlessly across both military and public networks.

A key area of development will be radio access to the public network which will allow all services to reach remote locations in the battlefield via digital radio links.

Research into applications of B-ISDN, and in particular ATM (Asynchronous Transmission Mode) based switched networks is a key part of the program.

Narrowband ISDN is an established and proven service allowing transmission of voice, image, video and fax digitally and simultaneously at 64 kbits/sec — this is much faster than conventional analogue telephone networks.

Broadband ISDN will allow the same services to operate up to 1000 times faster (155 Mbits/sec). Fully interactive operations such as video conferencing and the transmission of moving video images in real time will be possible.

The areas of signalling, network control, resource management, network survivability, network security and radio access, will be closely investigated with both parties co-operating and sharing results.

The first phase of the programme will see the interconnection of experimental ATM switches at DSTO's Laboratories in Salisbury and TRL via Telecom's advanced high performance digital network, Fastpac.

Work in the areas of dynamic call control, video terminals, ISDN terminals, telephony, radio interfaces and security will follow.

Harry Wragge (Right), the Head of TRL and Scot Allison (Left), the Director of Defence Science and Technology Organisation's (DSTO) Electronics Research Laboratory, signed a Memorandum of Understanding which could have far reaching implications for the defence of the country.

1991 Fellowship Awards

Twenty-one outstanding tertiary students studying telecommunications-related courses were awarded fellowships in 1991.

The Telecom Australia Education Fellowships were awarded to 18 undergraduates to assist them through the final year of their studies. These Fellowships carry stipends of $7,500 and offers of up to three months paid employment at TRL during the 1990/91 summer vacation period.

In awarding Fellowship certificates to the students, the Deputy Managing Director of Telecom Australia, Doug Campbell, noted that six of the recipients were studying at the Universities of Cantebury and Auckland in New Zealand.

"In part, that is a recognition of the Closer Economic Agreement that is developing between New Zealand and Australia," Mr Campbell said, "but it is also a recognition that telecommunications is a regional and global industry, one that transcends national boundaries through technology. Both New Zealand and Australia have changed the structure of their telecommunications industries over the last few years to take account of the changing nature of the industry and its new priorities."

The Australian recipients of undergraduate fellowships are studying at the Universities of Queensland, Western Australia, Melbourne, New South Wales, Tasmania, Wollongong, and Adelaide, as well as Monash University.

Three outstanding postgraduate students were also recognised with the award of TRL Postgraduate Fellowships. These were awarded to students undertaking postgraduate study at the Universities of Sydney, Tasmania and Melbourne. Each receive incremental payments totalling $11,000 for each year of postgraduate study, as well as the offer of paid vacation employment at TRL.

The vacation work experience is an important aspect of both undergraduate and postgraduate fellowships. It provides talented students with the opportunity to experience life in a non-academic research environment at the leading edge of telecommunications technologies. A selection of interesting and worthwhile projects integral to TRL's research programme are made available to the students, and mentors are provided to supervise their activities.

The 1990 Fast Packet Switching and Video Communications Workshops

The 1990 Australian Fast Packet Switching (FPS) and Video Communications Workshops were held at Monash University, July 1990. The workshops were hosted by TRL and the joint workshop format was chosen as a conscious attempt to strengthen ties between the video and FPS communities at a time when both are involved in critical standards and development activities. Telecom Australia activity in these fields was shown to be of international standard and represents a leading-edge in the formulation of many key concepts and technical solutions.

The 268 delegates attending the workshops came from government bodies, industry, universities and Telecom. Industry support was very strong considering the specialist nature of the workshops. Keynote, and invited speakers from Australia and overseas provided timely descriptions of broadband systems, services and standards. The presentations were complemented by specialist papers covering key technical issues. Two Broadband ISDN demonstration systems, provided by Alcatel and Fuijitsu, served as the focus for high levels of both delegate and public interest. The services demonstrated, including video-telephony and distributed television, were a forceful illustration of the scope for productive interaction between broadband systems and services.

The 1990 Workshops took place at a time of significant change to the infrastructure of both the telecommunications and broadcasting industries. The scene is being set for the convergence of traditional telecommunications and broadcasting and this theme was addressed in both workshops. It is apparent that the standardisation of a major new public network structure — the ATM based Broadband ISDN, can serve as the vehicle for the unified and universal provision of all forms of video service. All this leads to a fruitful and exciting environment for commercial exploitation.

Australian research is at the forefront in these areas of technology, and industry is becoming increasingly aware of the possibilities.

Innovating Protection within Telecom

The protection of Telecom's intellectual property has become an issue of vital importance in recent years as the organisation is exposed to competition across a broad spectrum of its operations. Telecom's Intellectual Property Section is based at TRL, and has the responsibility for managing Telecom's portfolio of patents and registered designs. It also acts as a source of expert advice on a range of intellectual property matters for the organisation. In the past year, developments in respect of which patent applications have been filed include:

- a system for controlling usage of mobile telephones by employees, thereby minimising cost;
- a terminating device which enables connection of analogue terminal equipment to the ISDN;
- a device for accessing time slots of ISDN Primary Rate transmissions, which forms the basis of a test instrument now licenced overseas;
- an "intelligent" pay telephone, which does not require the installation of dedicated charging equipment; and
- a technique for predicting optimum compositions of fluoride glasses for use in optical fibres.

In addition, a number of patent applications have been filed overseas to support Telecom's international marketing activities.

Closure of Experimental Digital Exchange

"Processor controlled exchanges and PCM transmission systems are becoming increasingly common overseas and are currently being introduced in Australia. The next logical step in the development of telephone switching is the combination of these two developments to produce a fully electronic exchange..."

IST Information Booklet circa 1973

When the above passage was written, a nondescript out-building at the back of Melbourne's St.Kilda telephone exchange was changing the technological direction of Australian telecommunications. Inside was the first fully electronic telephone exchange equipment to switch telephone traffic in Australia.

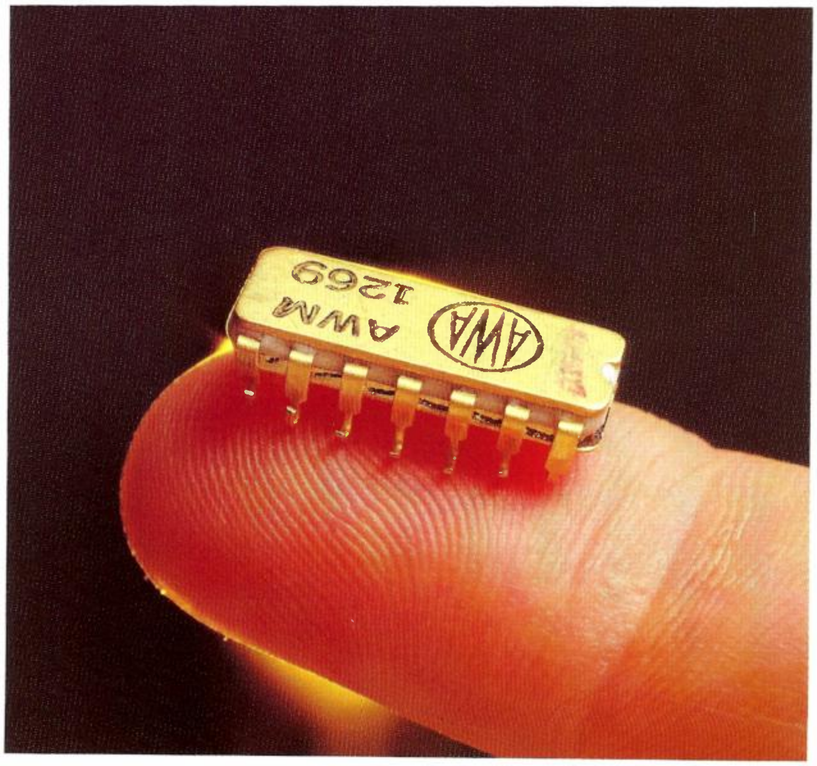
This building and its equipment was known as the Integrated Switching and Transmission (IST) model exchange. When work began on the IST model exchange in the late 1960s, the project was at the international forefront of developments in digital telecommunications. The exchange was designed to evaluate the performance and characteristics of emerging digital switching technologies, and has provided Telecom with the knowledge and expertise that today underpins Australia's digital telecommunications networks.

By 1991, time had overtaken the IST model exchange. With modern digital exchanges now commonplace, and little more to be learned, the time had come to shut it down.

To commemorate the project, a special closing ceremony was held. Over 60 former IST project staff attended including many who came out of retirement. Among those present were the Managing Director of Telecom Australia, Mel Ward, and the head of TRL, Harry Wragge, both of whom had spent the early part of their careers on the IST project.

Videoconferencing equipment was installed for the occasion so that those attending the closure ceremony could see and talk to Greg Crew, another former IST project worker who is now Managing Director of Cable and Wireless (Hong Kong) Ltd. The modern videoconferencing equipment contrasted sharply with the racks of now outdated experimental electronics.

Work on the IST exchange was aimed at amalgamating two distinct aspects of telecom-



Telecom's IST Exchange spurred local industry to manufacture Australia's first computer chips.

munications — digital switching and digital transmission. Until the IST model exchange was built these two areas of technology were quite disparate.

During its useful lifetime the IST project produced five major outcomes.

First, dozens of Australia's brightest engineers and computer scientists spent time on the project gaining first-hand experience of digital communications systems. Many who cut their teeth on the IST project went on to occupy senior positions in academe and the telecommunications industry, both in Australia and overseas.

Second, the ability to merge digital switching with digital transmission was the conceptual beginning of the Integrated Services Digital Network (ISDN). And it was Harry Wragge who was later to become Vice Chairman of the CCITT international standards Group that brought ISDN into reality.

Third, software control of exchange switching was in its infancy when the IST project began. The early exposure provided by the project was an invaluable experience for Telecom because major changes in network management and control were soon to come.

Fourth, the IST project ushered in the era of modern telecommunications signalling, including the Pulse Code Modulation signalling schemes that later allowed Telecom to introduce digital networking. Further advances that took their first steps with the IST project include the now internationally accepted No.7 Common Channel Signalling Standard, and it was TRL that ran the first international trials of No.7 Signalling.

Finally, the arrival of solid state components caused TRL to initiate work in a new field of research — electromagnetic compatibility (EMC). Ian Macfarlane began studies of the IST exchange's componentry to ensure that its integrated circuits were not adversely affected by radio-frequency radiation emanating from other equipment. EMC has been an area of growing importance ever since, and today Mr Macfarlane is an acknowledged international expert in this field.

For Australia, the IST model exchange was an early introduction to many of the technological capabilities which are now fundamental to modern telecommunications networks worldwide. For the researchers, the IST project was a proving ground for them as much as it was for the technologies they were assessing. It was a project that demanded the best from those who took part in it, and which rewarded those who learned its secrets.

Multiple Honours for Head of Research

The Executive General Manager of TRL, Harry Wragge, has been awarded two major honours for his outstanding contributions to Australian telecommunications.

Mr Wragge was awarded the University of Melbourne's coveted and prestigious Kernot Medal in late 1990; and in early 1991 he was made an Honorary Fellow of the Institution of Engineers, Australia — the highest honour the Institution can bestow.

The Kernot Medal is awarded by the University of Melbourne's faculty of Engineering to Australia's most distinguished and eminent engineers. Past recipients include Sir John Monash, Brian Loton, and Sir Arvi Parbo. The medal was established by a public subscription in 1925 to commemorate Professor William Charles Kernot, the first Professor of Engineering at the University of Melbourne who held this chair from 1882 until his death in 1909.

Mr Harry Wragge was awarded the University of Melbourne's prestigious Kernot Medal in late 1990; and in early 1991 he was made an Honorary Fellow of the Institution of Engineers, Australia.

The Chancellor of the University of Melbourne, Sir Edward Woodward, formally bestowed the Kernot Medal on Harry Wragge at a ceremony held in the university's Wilson Hall. The award citation stated that the medal was being awarded to Harry Wragge in recognition of his "distinguished achievements in, and major contributions to, telecommunications research and to professional engineering education in Australia."

Similarly, Mr Wragge's elevation to Honorary Fellow of the Institution of Engineers, Australia, was made for conspicuous service to the profession and eminence in engineering and kindred sciences. The Institution stated that in his role as a senior manager in one of Australia's largest public authorities, Mr Wragge had made a significant contribution to the development of telecommunications in Australia.

"He is a tireless contributor to the Institution," the Institution said, "and is an active participant in various committees at the University of Melbourne and Chisholm Institute to promote engineering education. A significant driving force in the creation of the inaugural Chair of Telecommunications at Monash University, Mr Wragge has presided and continues to preside over one of Australia's foremost engineering research laboratories."

Harry Wragge joined the Research Laboratories (now TRL) of the former Postmaster-General's Department, as a cadet engineer in 1954 after graduating from the University of Melbourne with a Bachelor of Engineering (Honours) degree. He also took out the Exhibition in Electrical Engineering. His early contributions to telecommunications technology were in digital switching applications. His work was extremely advanced for its time, and is today recognised as the foundational work that led to the implementation of an Integrated Services Digital Network in Australia.

A strong advocate of international standards, Harry Wragge was a vigorous proponent of Open Systems Interconnection and protocol engineering standards. In the late 1970s he was appointed Vice-chairman of an international standards group responsible for switching, signalling and synchronisation — a post at which he excelled.

He left TRL in 1981 to assist the Davidson Inquiry into Telecommunications Services in Australia. Returning to Telecom in 1983, he was appointed Assistant Director of Business Development where he prepared key strategies for industry policy and the interconnection of services. He became head of TRL in 1985.

Among his many involvements, Harry Wragge is currently a Fellow of both the Australian Academy of Technological Sciences and Engineering, and the Institution of Radio and Electronics Engineers. He is also one of the founding Vice Presidents of the newly formed Australian Association of Engineering Education.

Within the Institution of Engineers, Australia, he is Chairman of three groups: the National Committee on Electronics and Communications; the Institution Task Force on Engineering Education to the Year 2000; and the Institution Accreditation Board. His opinion and involvement is also sought by many academic institutions. For example, he is President of the Committee of Convocation at the University of Melbourne, a member of the Steering Committee of Monash University's Business Technology Centre, and a Member of Council of Swinburne Institute of Technology.

In 1989 Harry Wragge was appointed to the General Division of the Order of Australia in recognition of his outstanding contributions to telecommunications technology in Australia.

New Administration Building Opens at TRL

The commissioning of a new administration building has allowed all of TRL's staff to work together on the one site for the first time since 1942. This is a significant 'homecoming' for TRL, and marks the fulfilment of a long-term quest to centralise TRL's 550 staff.

Previously, TRL's administrative staff, library and cafeteria occupied valuable space in special-purpose laboratory buildings located in the suburb of Clayton, 20 km southeast of Melbourne. The new building not only houses all these resources, but also contains a 400 seat auditorium and frees-up enough

Mr Doug Campbell, Deputy Managing Director of Telecom Australia, declares TRL's new administration building to be officially open. The ceremony took place in the 400 seat auditorium in front of over 300 industry and government representatives, academics, journalists and Telecom corporate customers.

space in the special purpose buildings to allow the last 200 of TRL's staff occupying leased premises to rejoin their colleagues on the home site.

Research staff became scattered throughout numerous Melbourne locations during World War II when the demands placed upon research required them to quickly expand their operations. At the time there was no opportunity to plan for a centralised research facility, and it was not until the early 1970s that a decision was made to remedy the situation. Land was then acquired in Clayton adjacent to the new Monash University and since the mid 1970s special purpose buildings have been progressively built. Over the years TRL has gradually coalesced into a single fraternity of researchers.

The new building was officially declared open on 22 July 1991 by Telecom's Deputy Managing Director, Doug Campbell. The ceremony was attended by over 300 industry and government representatives, academics, journalists and Telecom corporate customers. Foyer displays and tours of selected research projects were available so that those attending could gain an appreciation and understanding of selected research activities.

In his opening address, Mr Campbell said: "I regard Telecom Research Laboratories as a key part of Telecom's overall business. It is not a luxury, or even a business cost — it is a strategic advantage for Telecom, and an invaluable weapon in our arsenal."

"This administration building is the last to be built here, some years after the complex of laboratories," Mr Campbell said. "Surely that tells us that there is something different about the priorities of the management in a place like TRL: in any other organisation, housing the administrators would have come first. There is something in the priorities of the people who work here that could teach us all a lesson."

The Executive General Manager of TRL, Harry Wragge, said he expected the coming together of all TRL staff to produce a high level of synergy that will have a major impact on TRL's performance.

Symposium Awards TRL Speaker

The project leader of TRL's Human Factors research group, Dr Gitte Lindgaard, was awarded the John Karlin Award for best paper at the 13th International Symposium on Human Factors in Telecommunications. The Symposium was held in Torino, Italy, where about 90 papers were presented by delegates from all major telecommunications companies.

Dr Lindgaard's paper explored computer system weaknesses and the problems encountered by users to devise a design method for computer help systems. The method has been successfully piloted on Telecom's electronic white pages.

1990 Spring Seminars

TRL's annual Spring Seminars were held once again in Melbourne and Sydney. The theme for 1990 was 'Corporate Communications — a Future Analysis', and papers were presented which examined the communications networks and services that will become available to Telecom's corporate customers during the 1990s.

About 400 Telecom corporate customers, industry suppliers and media reporters attended the seminars.

In an opening address to delegates at the Sydney Seminar, the Managing Director of Telecom Australia, Mel Ward, told delegates that with the arrival of full competition, Telecom's customers will now face additional complexity in their business dealings. "From now on," he said, "you will need to know not only the latest trends in the world's fastest changing technologies, but whether the new Telecom/OTC is the best telco to deliver the services and products you need in terms of time, quality and price. Indeed, the challenges and responsibilities have increased for us all."

Mr Blair Feenaghty, formerly of Corporate Customer Division, welcomes delegates at the 1990 Melbourne Spring Seminar.

Mr Ward said that TRL gains intimate knowledge of technology trends by being at the international forefront of those technologies that will impinge upon corporate Australia in the 1990s. Telecom's corporate customers can get access to this information by talking to their account managers in Telecom's Corporate Customer Division (CCD).

"To our corporate customers," Mr Ward said, "CCD is the human face of Telecom. But remember, through CCD you have access to the substantial knowledge and expertise of TRL to help you achieve greater business success. No other telecommunications company in Australia can match that capability."

Obituary

Norman James McCay — 1896–1990

It is with regret that 'Review of Activities' records the death of Norman James McCay, a former head of the Laboratories. He passed away peacefully on 9 November 1990 at the age of 94.

Norm McCay retired in 1960, and therefore he would not be known to many of the present staff members of TRL, or to others in the telecommunications industry. However, his contributions were profound and long lasting, and much of the high standing which TRL today brings to Telecom Australia can be attributed to his efforts.

Mr McCay joined the former Postmaster-General's (PMG) Department as a clerk in 1913 but, like so many of his generation, his direction in life was abruptly changed by the Great War of 1914-18. Soon after joining the Army at the age of 18 he was seriously wounded during the first ANZAC landing at Gallipoli. He recovered and went on to serve in France, and rose through the ranks to become a commissioned officer.

Norman James McCay

1896-1990

Norman James McCay, Lieutenant-Colonel in the Australian Corps of Signals during World War II and a former head of the Laboratories, was instrumental in building the foundations of Australia's post-war trunk network.

After five years service he returned to civilian life as an Engineer-in-Training in the PMG's Electrical Engineers Branch — a position which led him back to study and he obtained a science degree from the University of Melbourne in the 1920s. His early engineering work involved the installation of the Western Electric Type B 3-channel carrier systems in Australia. This technology was advanced for its day and Mr McCay was one of the first engineers to work on it.

It was fortunate that during this period he worked with Sidney Witt, the man who in 1923 had founded the PMG Research Department — the precursor of today's Telecom Research Laboratories. Mr Witt was an enthusiastic proponent of research and it was perhaps this early association that later led Norman McCay towards his role as a researcher.

Mr McCay transferred to the Transmission Section of PMG Headquarters in 1931, and by 1938 had risen to the post of Assistant Supervising Engineer. But war again interrupted his career, and in 1942 he re-joined the armed forces as a Lieutenant-Colonel in the Australian Corps of Signals.

His wartime responsibilities covered 'Civil Communications' and he installed several important aerial, cable and microwave radio installations throughout Australia, New Guinea and the Pacific Islands.

In 1946 he was back in the PMG as Supervising Engineer in the Transmission & Long Line Equipment Section. Progress in developing the Australian telecommunications network had been put in abeyance by the war, and Norm McCay began building the foundations of Australia's post-war trunk network.

Then, in 1953, he succeeded Eric Wright as the Supervising Engineer of the Research Laboratories — Mr Wright having taken over from Mr Witt in 1945.

During his time at the helm, Norm McCay was a great promoter of Australian research and devoted himself to elevating the status of the PMG by highlighting the work of its Laboratories. His experience and expertise helped to guide the technological direction of telecommunications in Australia during the important post-war years when Australia's population was growing and the demand for service was increasing.

He also initiated and maintained strong and fruitful contacts between the Laboratories and many scientific and engineering bodies, an activity which helped to gain recognition for the increasing amount of research work that was being undertaken. He retired in 1960 having earned the highest respect from his peers in Australia and overseas.

It was during the closing years of Norm McCay's varied career that many of today's older Research staff began their working lives as young Cadet Engineers under his direction. They remember a dedicated, firm but courteous man who demanded professional excellence of himself and of those who worked with him.

He was a man upon whose shoulders we all stand today.

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