New Horizons

Review of activities at Telecom Research Laboratories in 1993

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New Horizons

IN 1993, Telecom Australia saw a period of significant change in both the technological and organisational aspects of the company. This change was strongly reflected at Telecom Research Laboratories.

One of the most significant changes for TRL was the retirement of Harry Wragge. It is inestimable the contribution Harry has made to TRL and to Telecom as a whole. His vision and his ability to translate that vision into innovative and world leading applications, has been well recognised by Telecom. He has also been recognised by Australian society as a whole, as well as by his professional peers. His ideas and research have kept Australia at the forefront of telecommunications technology and I wish to take this opportunity to pay this further tribute to him.

There is not sufficient room to detail Harry's achievements here, but more detail on his contribution is provided on page 50 of this book.

For much of 1993, Ray Liggett was Director of Research. Ray brought to the Laboratories his wealth of experience with Telecom's customer business units, particularly those concerned with Telecom's largest customers. This strongly influenced TRL's interest in and involvement with Telecom's large customers.

The structure of Telecom was then changed to bring the Information Technology Group and Research closer together. There is a need for synergy between operational support systems and the network, particularly when it comes to forward planning and directing the future directions of the company.

With the change, TRL's role has been expanded to specifically include involvement in long term planning for the Telecom network, and an increased role in standards and regulatory strategy. This has lead to an increase in TRL's involvement in Telecom's business activities.

This was manifest in TRL's involvement in three major studies conducted by Telecom during 1993. They are the Future Mode of Operation Study, the Switch Vendor Study and the Transmission Vendor Study, all of which have had a major impact on the network and the management of the company.

TRL continued its significant input into Telecom's major activities such as network design and development, supporting the growth of the mobile telephone market, introducing new intelligent network services and providing the basis for the introduction of advanced applications such as video services and pay television.

A major aim of TRL is to enhance the competitive position of Telecom in the market place to provide an opportunity for customers to differentiate Telecom from other service and network providers.

This has lead to an increased emphasis on quality of service, developing software derived services, developing and improving the mobile telephone service, developing applications which use advanced computer capability and improving the operation support system architecture.

During the year, TRL also maintained a very strong participation and influence on the world wide standards scene and conducted an ongoing fruitful involvement with academia, supporting major contracts with a number of institutions around Australia. TRL's involvement with higher education institutions also provides a commercial and technical focus for those institutions to pass on to their students.

There were many visits to the Laboratories during the year, reflecting the increased interest of business in the future of telecommunications in this country.

I wish to thank and acknowledge the staff at TRL for their efforts during the year and for their achievements, despite the uncertainty and substantial change which occurred. This publication is a tribute to their work.

James Park
DIRECTOR OF RESEARCH

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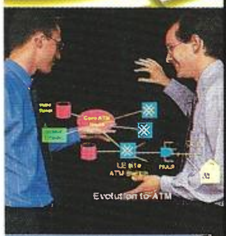
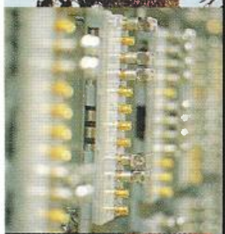
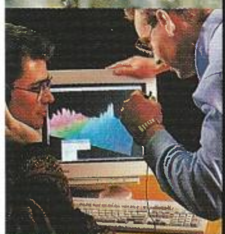


Overview 1993

This year saw the groundwork for Telecom Research Laboratories to focus its energies into fewer but larger projects with specific product outcomes. TRL is now strongly driven by business priorities and the long term planning needs of Telecom.

Mission

Telecom Research Laboratories (TRL) is a sub-unit of Research and Information Technology (RIT) within the Network and Technology Group. TRL provides a research and development focus for Telecom by undertaking commissioned research for Business Units and by conducting medium to long term research aimed at identifying future business opportunities for the Company.

TRL's mission is to:

Build Telecom's competitive advantage in the market place and provide an engine for Company growth through:

Vision of the future

- provide a longer term (beyond 3 years) planning role in all areas of technology, networks, systems, processes, products and services;

Technological leadership

- understand leading edge developments, recognise implications, pick the right technology at the right time, enable Telecom to be a smart acquirer and an innovative deployer of technology,
- provide a focus for cost and performance improvement through research and application of new systems and processes,
- solve operational problems;

Selective development of new and differentiated products and services;

Leadership and management of national and international standards activities.

Strategies

TRL's overall strategy is to sustain the Company's future competitive advantage in the market place by:

- developing, with its major clients, an up-front view of Telecom's longer term plans and
- identifying and developing new products and services.

This requires TRL to move quickly from its past role as a "knowledge factory" and "technology transfer" agent to a role which uses its skills and vision to directly influence the Company's future plans, products and services.

In developing its Business Plan, TRL must focus on Telecom's primary business needs. This dictates a top-down driven program rather than one which reacts to lower-level, task-oriented work. TRL is involving the top management levels in the Company in the formulation of its R&D Program.

In safeguarding Telecom's longer term business future, it is essential that some research and development work be undertaken well in advance of a Business Unit's ability to support the work. In such cases, it is appropriate for the work to be corporately sponsored. Examples of this type of work include business and financial studies of market trends resulting from new technologies and services. Corporate sponsorship will also be used for special field trials in support of the evaluation of such business futures.

TRL is aggressively moving towards the adoption of a more limited number of focussed research areas which are priority driven by the needs of Telecom's Customer Business Units. The move from the currently large number of diverse projects to the new priority areas of work will be achieved by 1995/96, to allow work which is presently commissioned by Business Units to be completed. TRL's major clients will be involved in the definition and phasing of the new balance. Internal discretionary work has already been reviewed and changes have been made to reflect new priorities.

TRL is undertaking a greater developmental role, particularly in software, to ensure that customer and network solutions can be rapidly developed so Telecom is ahead of competitors in taking advantage of new business opportunities. Features of this strategy include:

- a parallel approach to the development cycle by using simultaneous inputs from all groups involved in the process, from concept to operation;
- the alignment of R&D Strategy with Product, Platform and Acquisition Strategies including the development of strong links with industry, exploiting leverage from sector leaders (rather than re-invention), targeting market differentiation by the early development of products and by establishing differentiation in niches by selected in-house developments;
- a greater emphasis on processes which link strategy and business planning to budgets, project management and resource management.

TRL will be involved in some major "demonstrator type" projects such as interactive wideband to the home services and Universal Personal Communications. This strategy is to ensure that the Company has a good understanding of the market effects of future telecommunications services and of the ways in which business and residential customers will operate and interact with one another.

A continuing strategy for TRL is to support Telecom's Business Units and the telecommunications industry to ensure that plant and equipment meets appropriate quality standards. Resources for this work will vary as Telecom's suppliers assume a greater level of accountability for quality. In the interim, however, reliability evaluations and problem solving in production and installation operations will be undertaken in those areas where Telecom has no other options.

TRL is the leadhouse for Telecom's R&D interactions with the higher education sector. The strategy is to maintain a program of research and development which complements the Company's R&D agenda and which fosters an educational sector which can supply Telecom's requirements for future graduates and post graduates. This external program of R&D also includes local industry in appropriate cases.

Business and Customers

The major groupings of work in the TRL Program are as follows:

(A) Commissioned R&D

The Commissioned R&D program comprises work defined by Telecom Business Units and funded by them via transfer pricing, nominally at cost (ie, no profit component). Projects are specified in terms of deliverables, timetable and costs, and are agreed to individually where practicable. Minor and ad hoc work is performed under usage-based Support Agreements. Approximately 70% of TRL's R&D Program is funded by Business Units as commissioned R&D.

(B) Discretionary R&D

The Discretionary R&D program comprises two components:

work which is defined by the Director of Research and which is:

- essentially long term in nature;
- concerned with technologies, systems and services which are at such an early stage of development that commissioned work cannot be expected, or which requires exploratory work to bring understanding to the stage at which commissioned work can reasonably be expected;
- capable of attracting support within a few years; and
- likely to contribute to Telecom's business objectives and imperatives in the longer term.

This work includes the operation of the Telecom Centres of Expertise which undertake contracted R&D in selected Universities.

work which is funded Corporately and which includes:

- larger demonstration projects and studies in such areas as Broadband to the Home, Multi-channel (Radio) Local Distribution Systems, Wireless Local Loop and the newly approved Experimental Broadband Network;
- smaller projects which are corporately important but difficult to fund.

The current guideline for expenditure on Discretionary R&D is that it represent no more than approximately 30% of the total R&D program. TRL is gradually changing the balance of work within the Discretionary Program in favour of a growth in the level of demonstration projects.

(C) Planning

TRL is forming a number of planning project teams to support the longer term planning responsibilities of the Network and Technology Group. Teams comprise experts from TRL's Branches and operate in matrix management mode for the duration of their specific studies.

(D) Standards and Regulatory Strategy

This function comprises work on network-related standards and regulatory issues to ensure the types of network based services which are offered and their means of delivery, suit the needs of Telecom's customers. This work includes:

- numbering plans for new and special services, plus issues such as numbering plan implementation and number portability;
- radio frequency spectrum management to ensure that Telecom has continued access to spectrum at a reasonable price for present and future services, plus strategic and political issues relating to spectrum allocation and environmental issues;
- network service performance standards for optimum business needs, including performance statements for tariff filings with the Regulator and performance aspects of service guarantees;
- coordination and control of the Company's involvement in the national and international standards process and its optimisation for business advantage;
- development of technical regulatory strategies for future products, services, ad hoc standards, regulatory work and options studies.

This work has been transferred to TRL from the former Network Strategy Group of Network Products.

E) Corporate Facilities

The corporate program covers major activities which TRL performs for Telecom as a whole. These include:

- the operation of the National Information Resource Centre;
- the provision of expert advice and service relating to intellectual property matters;
- the management of the Telecom Australia Fellowship scheme for graduates, postgraduates and academics;
- contributions to, for example, the Australian Telecommunications and Electronics Research Board (ATERB) and the Australian Mathematics Olympic Committee (AMOC);
- the provision of Telecom's reference standards for measurement of optical and electrical quantities, and arrangements for traceability throughout the Company of measurements of various physical quantities; and
- the management of Telecom's Product Development Fund to encourage the development by industry of innovate products for the telecommunications market.

Multimedia

Broadband services are developing from the convergence of computing, broadcasting and telecommunications. The possibilities for these services are exciting and will only be limited by people's imagination.

A new term, "information superhighway", appeared a lot in the media during 1993. It vividly reflects where modern telecommunications is heading. The transmission of information will be fast, there will be a huge volumes of it and it will be managed in many innovative ways.

These future services are also called "broadband services". The bandwidth available in the network will easily allow the transmission of high definition television, interactive video services and a myriad of other interactive services such as home shopping and home banking.

Broadband services are developing from the convergence of computing, broadcasting and telecommunications. Information will be available in video, data or voice forms. It will be available from anywhere in the world and it will be just as readily available in a one to many interaction as it will be in a one to one interaction. The possibilities for broadband services are exciting and will only be limited by the imagination.

The work in this area at Telecom Research Laboratories (TRL) will help to ensure Australia will be well placed to take advantage of these services as they are developed.

Information on Demand

Information on demand services will have a major affect on our society. The services will impact on the way in which information, goods and services will be marketed and how they are distributed. They will impact on our business and personal lives, on how we structure our time, what will be our entertainment and even how we use our homes, offices and leisure places.

Work is being conducted at TRL to ensure Australia is well placed to introduce these services, as and when technology permits.

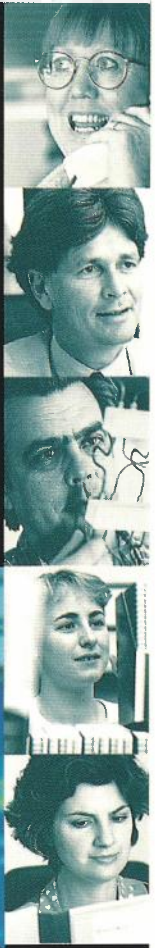
There are many elements to an Information On Demand system. The customer is connected to the network by a set-top unit (which provides the necessary computing power) through which access can be gained to databases. These hold details of the information available. After searching the databases, the customer selects what information is required and a signal is passed from the database to the relevant information provider to initiate information retrieval. The transition from searching the databases to retrieving the information involves several network interactions, but these are kept hidden from the customer who sees a smooth "seamless" transition.

Providing intelligence in the network will be critical to the smooth operation of the services and ultimately to user acceptability of the system. It will also allow the wide range of service possibilities to be "customised" in a package specific to an individual.

During 1993, TRL established a demonstration of an Information On Demand service. This extends the concept of the more widely known "Video On Demand", to encompass a diverse range of information types.

With this demonstration system a user can call up video clips; recorded music; a current weather map and many other services from different locations in a network. The services can be called up to start immediately or programmed to start at a suitable time in the future. A number of information services can be queued no matter what the type of service.

The system is easy to use, it is extremely powerful and allows for the possibility to readily create new services. However, there is still a lot to learn about information on demand. Part of the role of researchers in this leading edge work, is to dream up possible uses of information on demand and then explore how they can be implemented. The demonstration system will help to trial possible services and to investigate the best network architectures. The designer of a user friendly interface for the set-top unit also ranks high on the research priority list.



Alison Payne and Steve Leask examining a weather map from the Bureau of Meteorology, which could be one of hundreds of possible providers of information when broadband services are introduced.

Broadband Services to the Living Room

Information on demand services will provide incredible access to information, whether it be in a video, print or audio form. But while these services are touted as being the exciting new future of telecommunications, there are some practical questions to answer before the services can be provided to the home. And how these questions are answered will affect the cost and rate of acceptance of the services.

What makes this work even more complicated is that at this stage, people are unable to foresee what possible services they may want. If people are not able to try a new service, they do not know how they will use it and they do not know how much they would be willing to pay for such a service.

Apart from the uncertainty at the customer end of the system, there is a lot of hardware and software which needs to be developed for the home, the network and the service providers.

There is a requirement to get started with a practical information on demand system and make it scalable, so new features can be easily added as they are developed.

Interactive information on demand services will be provided through the home television of the future.

There is also a problem in having sufficient bandwidth and transmission capacity to get the information into the home, particularly the large amount of information in videos.

During 1993, research at TRL brought the pieces of this jigsaw puzzle closer together. The problem has a number of possible solutions. Having a combined fibre/co-axial cable, or by using the existing copper system with Asymmetric Digital Subscriber Line (ADSL) technology are two examples.

Electronic information services do exist, but they are really only accessible to sophisticated computer users. Consequently, a lot of research is needed to have this type of service available to people who are not familiar with, or have access to computers.

Although the basic transport technologies are converging, answers are needed to such questions as what is the best way to browse a catalogue, to select a program, and what billing procedures will be required? To this end, TRL is developing a trial platform which can be used to evaluate potential information on demand services.

Research in this area is quite deceptive, in that the end result of this work must be a very simple, easy to use system which effortlessly integrates the use of data, video and audio information. But to achieve this level of simplicity and ease requires a very sophisticated and complex infrastructure.

Digital video services to the home

Researchers at TRL are developing technology to allow home entertainment and information access through the distribution of video signals and video on demand services. This can sometimes involve researchers watching a lot of video clips.

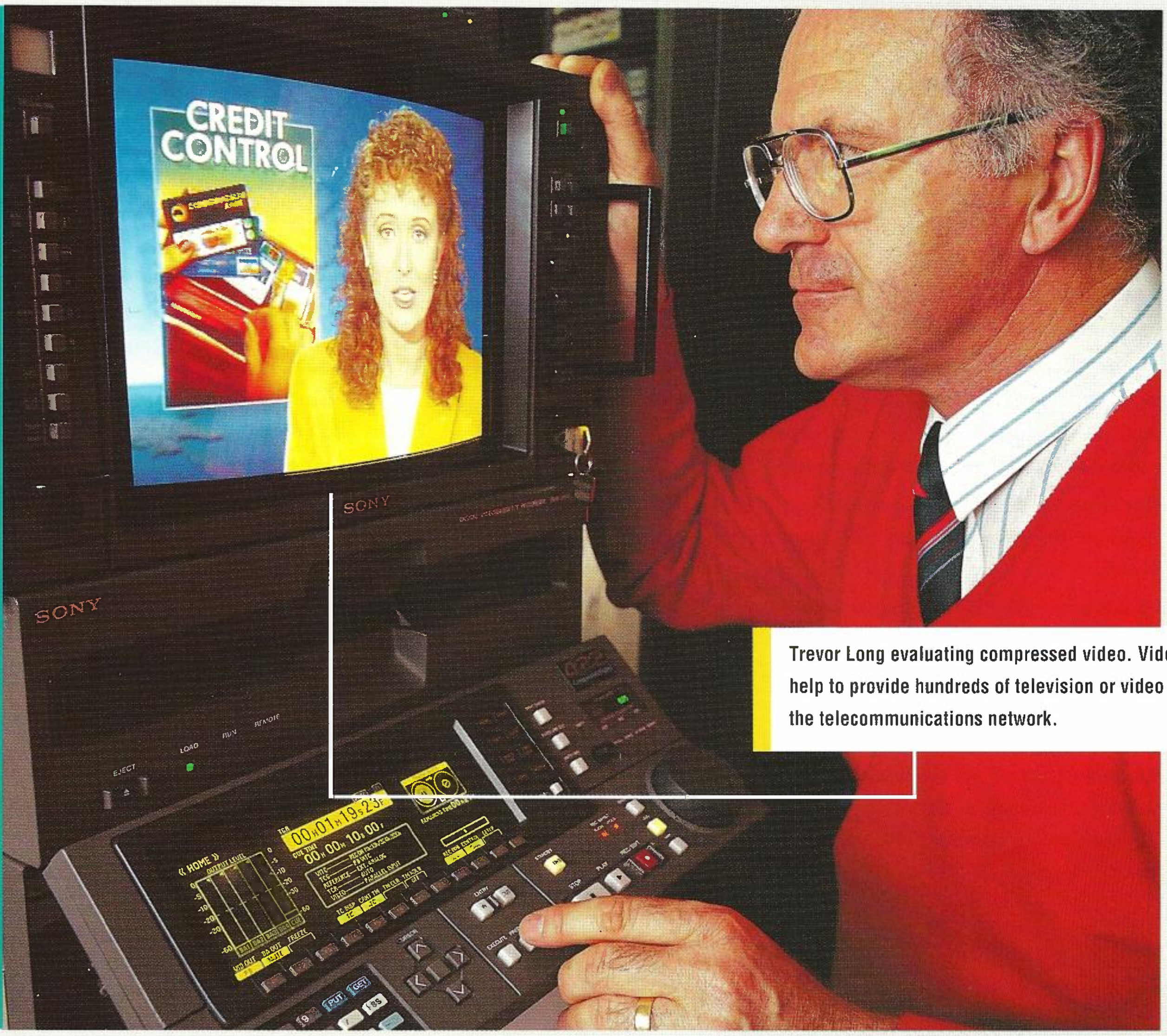
There are many aspects which have to be considered before a video on demand service can be provided. There is the technology shift from analogue to digital transmission, there is the large volume of data which is needed to reproduce video and then there are the physical characteristics of the network, whether the transmission will be through optical fibre/coaxial cable system or copper wire.

Studio quality digital video requires a rate of 216 Mbit/s, but transmitting this amount of data over a telecommunications network would be expensive and inefficient. To reduce the cost of transmission, the digital video data needs to be compressed to a rate of around 2-10 Mbit/s and retain good quality.

Compression is achieved by only transmitting that information which changes from frame to frame in the video. For example, the background scenery in a picture might not change at all over many frames. The coding and compression procedure takes this into account. It does not redefine all the information which is constant between frames, rather it only codes the differences between one frame and the next. It also takes advantage of similarities between different parts of the same frame.

Once the information is compressed, then more digital channels can be transmitted in the same bandwidth, to the point where in optical fibre, 500 television channels could be transmitted at once.

If the existing copper wire network is used for video to the home, then one or two channels could be provided using advanced transmission techniques that



Trevor Long evaluating compressed video. Video compression will help to provide hundreds of television or video channels through the telecommunications network.

can extend the transmission capacity up to around 2-6 Mbit/s. The desired channel or movie can be chosen from a virtually unlimited selection, using switching equipment at the local exchange.

TRL has been able to achieve very high picture quality for a wide range of picture material when it is compressed as low as 4-6 Mbit/s. Some material, such as movies, can be compressed to even lower rates and researchers have successfully compressed entertainment video to 2 Mbit/s.

This research at TRL has allowed Telecom Australia to contribute to the international standards which will play a major role in video applications, including VCRs, computer based multi-media information, desktop videoconferencing and digital distribution of television and high definition television (HDTV). The standards in this area are very general to take into account the wide range of services and qualities possible with video services.

TRL is the only site in Australia to have fully implemented the coding standards to be used in these services. It has exchanged compressed video information with other major players around the world to verify the specifications in the standards and to confirm that high quality image transmission can be achieved.

Distributing Video on the LAN

In September, 1992, Telecom Australia launched FASTPAC, a network which switches packeted information between Local Area Networks (LANs). During 1993, TRL continued its work to develop more applications for FASTPAC.

Progress has been made with the development of an interface for video to be carried on the most popular LAN called Ethernet. Given that Ethernet already "co-operates" with FASTPAC, this means that video can be transmitted from one Ethernet LAN to another via FASTPAC. The whole FASTPAC network is transparent to the user, so it appears to provide a geographical extension of the LAN.

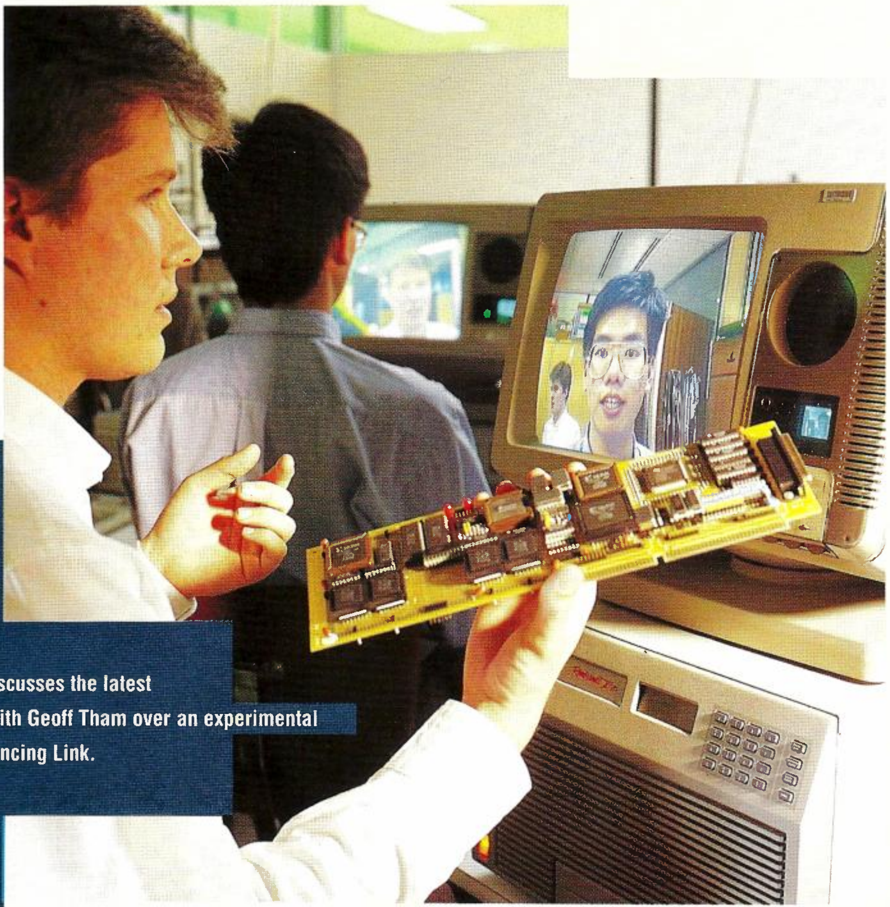
Apart from live video communication, the development has opened up the possibility for any LAN to retrieve multimedia information, including video, through FASTPAC.

There are a number of advantages in sending video over a LAN. There is no need to utilise a separate network, as most personal computers already use a LAN for communication. The LAN is a versatile transport medium which can support several different media channels, and it also allows easy multipoint and broadcast connections (compared to ISDN, which is switched point to point).

However, despite the progress, there is still a lot to learn in developing the standards and protocols required for such a system. The researchers are exploring the characteristics and limits of the new system.

One important study relates to congestion, particularly when the network has many stations. How will the LAN manage multiple video stations and send data at the same time? Through Ethernet, all stations have equal access to the network and if it is congested, then packets of information could be lost. So one of the investigations in 1993 has been to determine how many video stations can simultaneously operate on Ethernet before there is a significant reduction in quality.

Given that some of the latest Personal Computers now have inbuilt multimedia capability, desktop videoconferencing is no longer just a reality in the laboratory, but it is ready for use in the commercial world. The work at TRL will help bring about wide spread desktop video communication quickly and efficiently.



Roger Loh discusses the latest technology with Geoff Tham over an experimental Videoconferencing Link.

Video on the Copper Network

While Australia is leading the world in per capita installation of optical fibre, there is still a huge investment in the copper wire network. The copper network has served telephone communication well, but it was always thought that its transmission capacity would be inadequate for future broadband services, such as viewer controlled Pay TV and other interactive services.

However, this situation has now changed with the development of a new technology called Asymmetric Digital Subscriber Line (ADSL) systems. ADSL will enable digitally compressed video signals to be delivered to the home over the customer's existing copper pair telephone line. The system is currently being assessed by TRL.

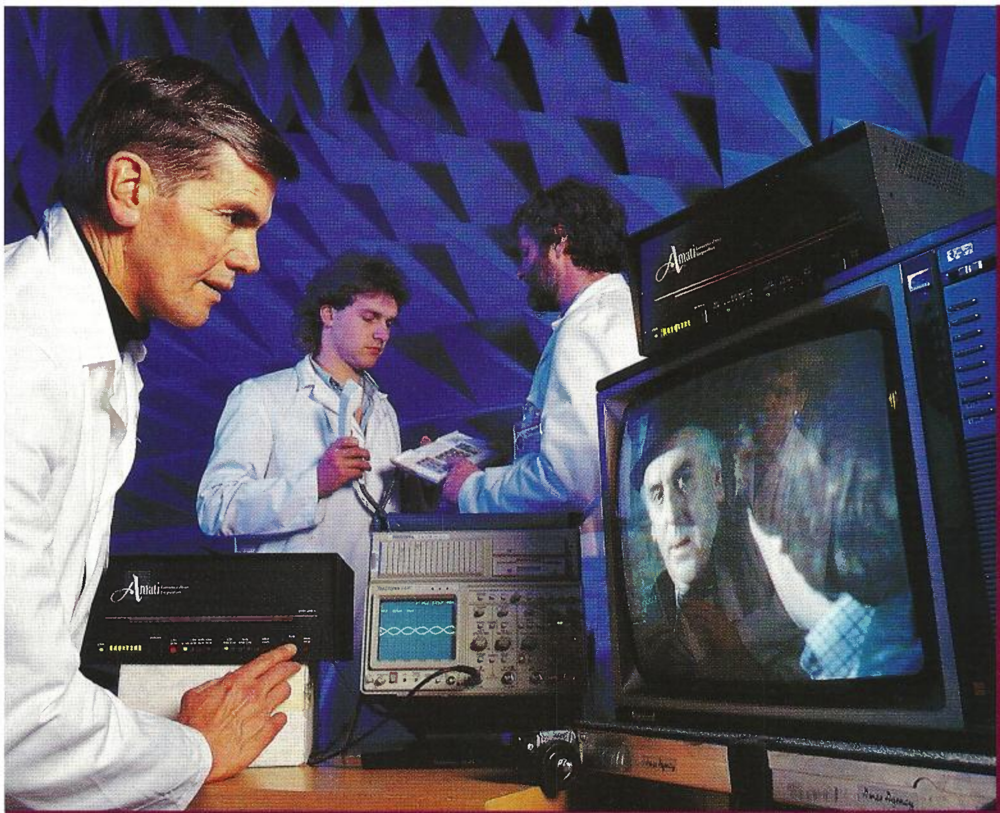
ADSL systems convey the compressed video information downstream to the customer at a rate of 1.5 Mbit/s or more. This is decompressed (decoded) by a set-top unit and then passed on to the normal home TV set. Selection of the program and other viewer control functions such as pause, rewind and fast forward, are performed by means of control signals sent upstream to the exchange via a low-rate control channel. ADSL uses frequency separation to enable the downstream and upstream signals to operate on the same cable pair as the normal telephone service.

The TRL investigations of ADSL include system simulations, assessment of prototype equipment, test specification and development, and a wideband impulsive noise survey. This survey commenced towards the end of 1993 in the homes of volunteer Telecom Australia staff members based in Melbourne.

The noise survey is particularly important, because impulsive noise, while generally of little consequence in normal telephone services, can affect ADSL performance. Consequently, the noise characteristics must be determined to enable adequate countermeasures to be employed. The survey is a joint Telecom exercise involving TRL, the Pay TV Technology Project Team, the Special Network Services Group and Melbourne North and Melbourne South Network Operations Groups.

In addition to the ADSL investigations, TRL is also assessing Very High Rate ADSL (VHADSL) systems, which will enable rates of 10 Mbit/s or more, to be delivered over copper pairs. Unlike ADSL, VHADSL will not be able to cover typical exchange-to-customer distances (up to 5 km). However, it will find application over copper pairs covering the last kilometre of future optical fibre/copper hybrid systems. As such, it will facilitate the delivery of new services such as High Definition Television (HDTV).

Both ADSL and VHADSL are potentially important to Telecom, because by using existing telephone lines, it will enable the new video services to be provided at reasonable cost and with short provisioning times.



Stan Davies assesses picture quality while Tony Cole and Shane Peacock assess telephone transmission quality on a simulated copper pair.

A New Public Key Cryptographic System

One of the problems associated with replacing paper based systems with computer based counterparts has been in finding a suitable electronic equivalent of the handwritten signature. Another problem has also been to find an efficient method of obtaining a (logical) key which anyone can use to electronically lock away the contents of a message so that only an intended recipient can unlock and read its contents. These two problems were solved in 1978 with the invention of what is now known as public key cryptography.

Cryptography is the process of concealing (locking away) and revealing (unlocking) the meaning of a message through the use of an algorithm (a set of rules or mathematical procedures) and one or more (logical) keys. Conventional cryptographic systems use a single key to both lock and unlock information, whereas public key cryptographic systems use two separate keys, one to lock away information and the other to unlock it.

Public key cryptographic systems are seen, internationally, as being a vital element in securing virtually all current and future information technology systems. This technology will be included in such applications as home banking, electronic mail, pay TV, video on demand, charging and billing systems, mobility services, intelligent network services, multimedia management systems, electronic transaction service and electronic data interchange (EDI). In addition, the use of public key technology is playing an important role in many current and emerging international standards. Consequently information technology suppliers can be confident of an escalating growth in demand, from a large and diverse marketplace, for products and services incorporating public key technology.

With public key cryptography each user in a network is issued with a unique pair of keys. For a given user, one key of their key pair (denoted the public key) is made publicly available and can be used by anyone, other than the given user, to lock away information (this process is known as encryption). The other key of the given user's key pair (denoted the private key), is kept secret by that user so that only he or she can unlock the previously concealed information (this is known as decryption).

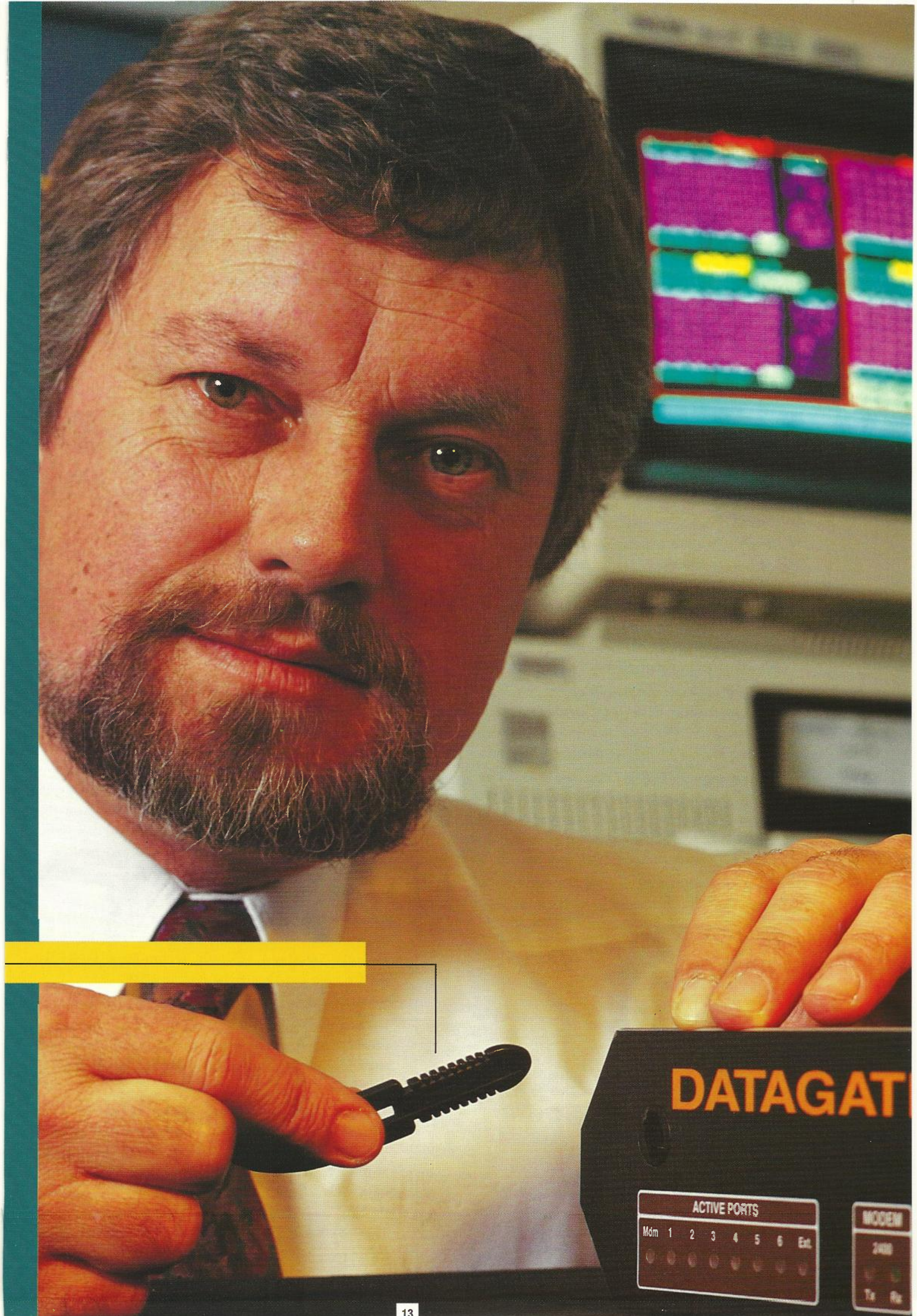
Some public key cryptosystems also allow users to use their key pairs in the opposite order. Thus, a given user may lock the contents of an arbitrary message using his or her private key first, thereby allowing other users to unlock this previously concealed message by using the given user's public key (which, of course, is available to anyone). The important point in locking a message in this way is that the person who created the locked message can be uniquely identified (as being the holder of the private key corresponding to the public key that was used to unlock the message).

Creating a locked message by using a person's private key is known as creating a digital (or electronic) signature. Recovering a recognisable message from a digital signature by using the signature sender's public key is known as signature verification. Again, it should be emphasised that private keys are kept secret and are not revealed to anyone in the process of creating or verifying digital signatures.

Until recently there has only been one public key cryptographic system that uses the same algorithm to both encrypt/decrypt information and to create/verify digital signatures by simply switching the order in which the keys from a given key pair are used. It was invented in 1978 by Rivest, Shamir and Adleman and is commonly known as the RSA algorithm. This algorithm has been patented in the USA and Canada.

It is expected that RSA technology will play a dominant role in many of the information technology systems described above. However, a new public key cryptographic system has recently been invented at TRL that is likely to become a strong competitor to RSA. The new system is based on the use of elliptic curves and is the only known cryptographic system that has similar properties to and the same functionality as the RSA system. The elliptic curve based system is more resistant to digital signature forgery, can be used with relatively short private keys, can be used over a wider range of inputs for similar system parameters and may be more secure than the RSA system. Telstra is currently in the process of patenting this new public key system in Australia, USA, Japan, Canada and Europe.

Nick Demytko using a public key based security system for remote access to a mainframe computer.


DATAGAT
ACTIVE PORTS
Mdm 1 2 3 4 5 6 Ext.
MODEM
Tx Rx

Optical Fibre

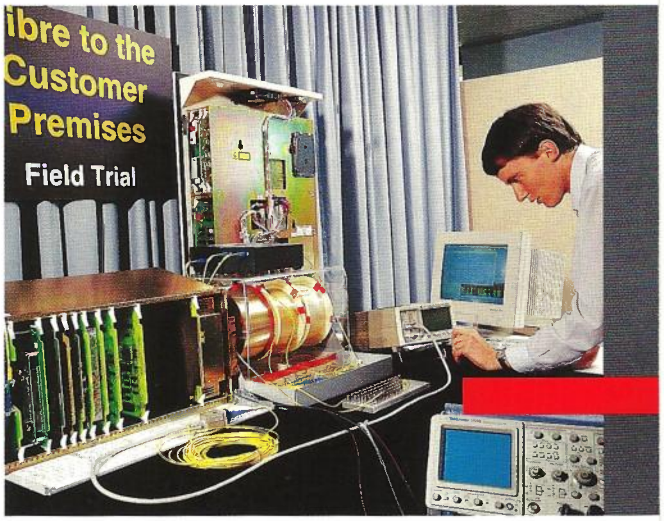
The capacity of optical fibre is the basis on which emerging broadband services are possible. TRL is investigating new and novel ways to increase the utilisation of the properties and capacity of optical fibre.

Optical fibre was only developed in the 1970s, but already it is a mature technology, with widespread commercial application. It is widely used in modern telecommunications by Telecom Australia, which is a world leader in the use of optical fibre in the trunk network. It is now being increasingly utilised in the customer access network. In other words, optical fibre is getting closer and closer to the customer, whether they be at their place of business or at home.

One of the amazing things about optical fibre is that only a small percentage of its incredible capacity is used, something less than 0.1%. This means that once fibre is installed in the network, it is likely to be there for a long time.

However, more of the fibre's capacity can be utilised by improving the technologies at either end of it. And it is the capacity of fibre and its optical interconnections which will help to make possible the multiplicity of broadband services which will become commercially available in the future.

The work at Telecom Research Laboratories (TRL) will ensure that Telecom Australia gains maximum benefit from the investment in optical fibre.



Trial Broadband Services to the Home

Telecom Australia is actively preparing for the delivery of broadband services to the home. This involves the integration of many technologies, ranging from transmission and switching to service provision and customer premises equipment design. Consequently, the work spans most areas of TRL.

A key element of the delivery strategy is the development of technology and service trials. TRL has been actively involved in two technology trials at Wollongong and Centennial Park in NSW.

At Wollongong, the trial is investigating provision of services over optical fibre directly to the customer's premises. Fibre to the curb is also being trialed. These trials incorporate equipment which has been developed by NEC.

The trial system is based on a Passive Optical Network architecture. In 1988, TRL pioneered the development of a laboratory fibre access system referred to as MACNET, employing couplers to split the optical signal power from the exchange unit and hence reduce the per customer cost of the equipment and cable. This has been shown to be a cost-effective access technique.

The Wollongong fibre to the customer premises trial has several world class achievements.

- It is one of the first passive optical network trials which integrates video, ISDN basic rate and primary rate access and telephone services.
- It is one of the first passive optical network trials to carry both one way broadband video and two way narrowband services on a single fibre.
- It includes both fibre to the home and fibre to the curb architectures.
- It has the longest optical fibre length (11 kilometres) between the exchange and customers.
- It has the highest split ratio (32 way) for video service.

TRL has actively participated in a number of technical committees managing the field trial. In addition, thorough core system and network management unit testing was performed in the Laboratories, with other areas in Telecom assessing the performance of the interfaces.

TRL has also been closely involved with the installation of the fibre to the customer premises equipment in Wollongong and has performed extensive testing in the field. In addition, an optical fault finding procedure

Greg Lampard aligning fibre to the customer premises equipment

has been developed which has been implemented in the field trial to assess the viability of testing passive optical networks.

A display of the Wollongong trial was constructed for the Australian Conference on Optical Fibre Technology (ACOFT '93) held at Wollongong in November.

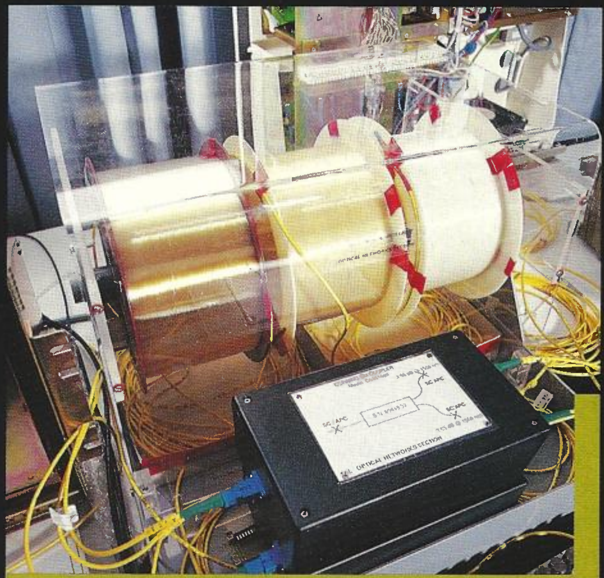
The fibre to the customer premises technology trial has developed Telecom's knowledge and experience in the design, operation and maintenance of optical fibre systems for the customer access network. It is a significant step towards achieving the delivery of broadband services to the home.

While optical fibre to the home remains a long term vision, in the immediate future, the most cost effective delivery strategy for Pay TV appears to be a combination of optical fibre and coaxial cable.

The high capacity of the optical fibre is used to connect the exchange to an intermediate point in the network, with coaxial cable being used for the final drop into the customer's premises.

This architecture is being trialed on the cable TV pilot network at Centennial Park.

The pilot was planned to carry a range of video channels, re-transmission of free-to air TV stations and FM radio, a community TV station and a variety of educational programs. The pilot passes approximately



Transmission is split to provide services to multiple customer premises.

1000 dwellings made up of single residences and high rise flats.

TRL has provided technical support for the trial, it conducted part of a training course for Telecom staff, and assisted in the Centennial Park equipment installation, particularly in the areas of network alignment and field testing.

TRL has also been able to identify the relative merits of different network architectures.

A key aspect of the network design is the video channel frequency plan, in particular, the impact of Composite Second Order (CSO) and composite Triple Beat (CTB) intermodulation products on picture quality and the trade off against the power loss limits. TRL has developed theoretical and software tools to take account of these issues. A number of software design tools have been developed which are able to calculate the Carrier to Noise Ratio (CNR) for single and tandem optical links. In addition, for a given coaxial network composed of a given number, type and location of amplifiers and passives, it is possible to calculate the CSO, CTB and CNR parameters. TRL has been able to identify the relative merits of different network architectures such as the cascade feeder and express feeder designs.

Long Distance Optical Fibre Links

Australian telecommunications embraced optical fibre technology very quickly. Telecom Australia has installed approximately 1.5 million kilometres of fibre in its network. Initially, fibre was used in urban areas to link metropolitan exchanges, but very quickly, Telecom moved to installing a major network of single-mode fibre trunk links between the capital cities. Optical fibre is being installed in the regional network and is increasingly being used in the customer access network.

A question constantly being asked at TRL is "How can we get better utilisation of the capacity of optical fibre?" Only a small percentage of the capacity of the fibre is currently being utilised. It is estimated that 0.1 percent of the theoretical capacity of the fibre is utilised, so there is great potential for increasing the amount of traffic carried on the existing fibre.

Researchers have set a target of quadrupling the capacity of the fibre network every four years, while at the same time making the network more reliable and survivable.

The survivable component of the network relies on having available a reserve capacity which can allow the network to sidestep any major breakdown. In the case of a major communication cable being broken, the greater the reserve capacity on other cable routes, the greater the number of calls that will continue to get through. Researchers refer to this as having built-in redundancy to increase the survivability of the network.

There are many possible approaches to increasing the capacity of the fibre network and a number of these are being researched at TRL.

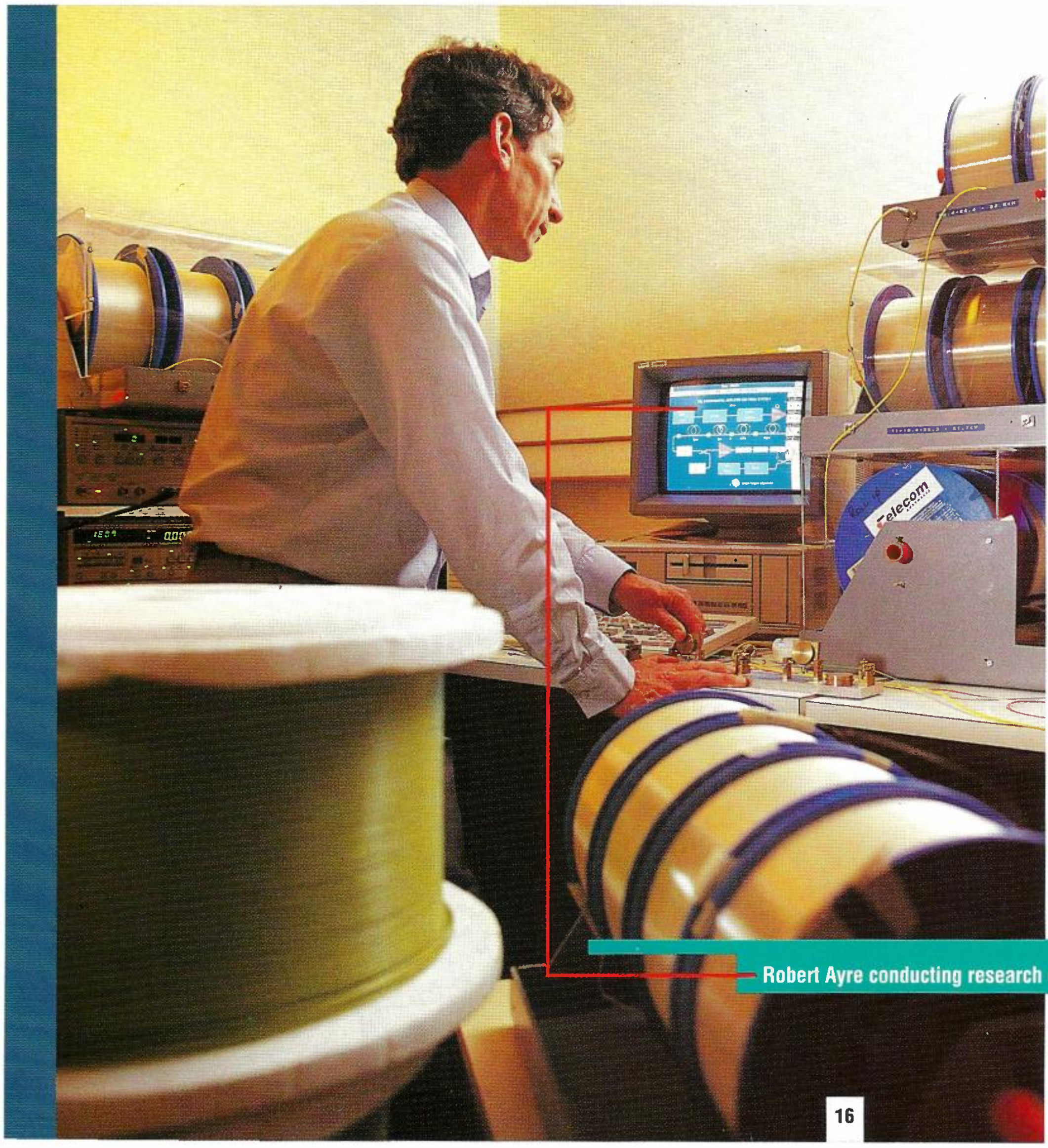
The first of these approaches is simply increasing the transmission rate at which information passes through the fibre. Another way to increase the capacity of the fibre is to utilise more of the low loss region of the fibre. Currently, only a small portion of the low loss regions is being utilised.

Transmission rates have been increased from a bit rate of 34 Mbit/s to 140 Mbit/s to 565 Mbit/s and now to 2500 Mbit/s (or 2.5 Gbit/s). Each step has given a four-fold increase in the volume of traffic carried by a fibre.

Theoretically, this should be able to increase still further and in some overseas countries, 10 Gbit/s rates are being tested. However, it may not be appropriate to use the 10 Gbit/s rate in the long-distance network in Australia because of its geography and the type of fibre installed. Line equipment at this high rate needs more receiver optical power and this means less distance between expensive generators, or the use of optical power amplifiers in conjunction with each laser transmitter. In addition, the signal suffers greatly from dispersion as it travels through the fibre.

Because of pulse dispersion, it is estimated that at 10 Gbit/s, the network would need regenerators at every 70 kilometres and optical amplifiers would not overcome that limit. In contrast, at the 2.5 Gbit/s rate, the signal can be transmitted hundreds of kilometres using optical amplifiers, before reaching a dispersion limit where regeneration is necessary.

However, 10 Gbit/s capacity can be achieved by transmitting four streams of information at 2.5 Gbit/s on the same fibre, but with each stream having its own distinct wavelength. This does not create the power or dispersion problems



Robert Ayre conducting research on a long distance optical fibre link.

of a single 10 Gbit/s signal. In addition, this wavelength multiplexing approach is not limited to four channels, as more can be added as necessary, still sharing the same fibre and amplifiers.

At this stage, optical amplifiers are still quite expensive and although much simpler than a high-speed regenerator, their costs are of similar magnitude. However, the optical amplifier price will reduce as the components become bulk commodity items. There is less scope for regenerator price reductions. In addition, an optical amplifier uses far less electrical power than the regenerator, which is an important consideration in remote areas.

During 1993, TRL established a demonstration optical fibre system which transmitted at a rate of 622 Mbit/s over a span of 268 kilometres. The system uses optical power amplification at the transmitter and pre-amplification at the receiver. This system demonstrates the feasibility of using the technology to create very long span links in the optical fibre network.

The year also saw work on new international standards for transmission quality. A computer model was developed to translate the standards into link performance requirements for specific situations. To meet the new international standards, the error rate has to be less than one in 10^{12} bits of information.

This research is important to allow Telecom to make informed decisions about the best technologies and techniques to either improve the current network, or to plan for the network of the future.

Small Capacity Optical Fibre Systems

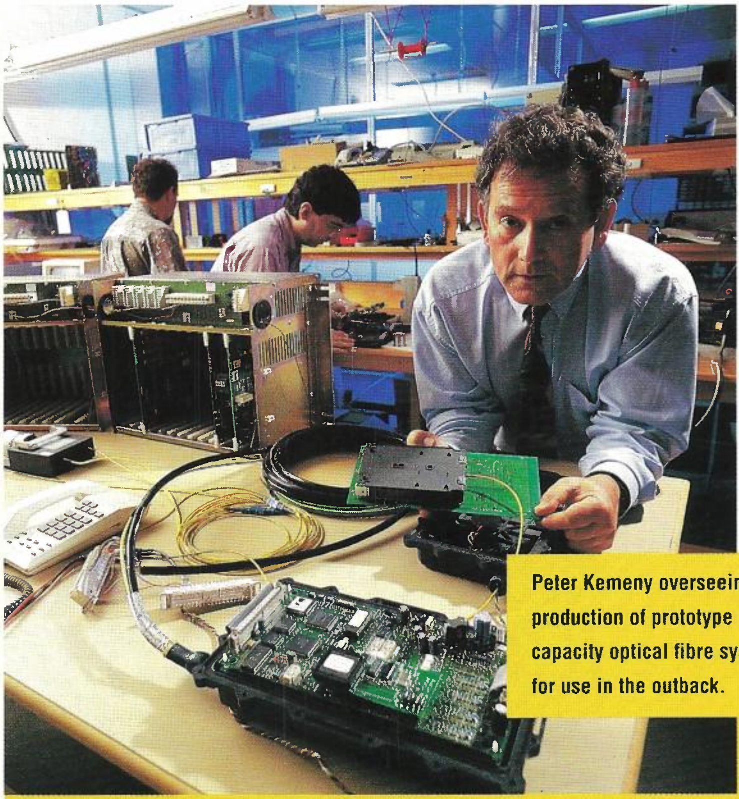
Telecom Australia is leading the world in the use of optical fibre in telecommunications. Australia has laid more optical fibre per head of population than any other country. The fibre is mainly used on the main trunk routes and in the busier major cities, but in 1993, TRL was able to design and offer an optical fibre solution to an outback situation where only 30 services had been requested.

Using optical fibre to provide the last 30 kilometre of a telecommunications link to an isolated community 150 kilometres from Darwin had been considered impractical until researchers at TRL assessed the range of possible solutions.

The requirements for this link were stringent. It is in a tropical cyclone area near the coast, so maintenance during the wet season is virtually impossible. It is also a high lightning area, so metal cannot be used. And it needs to have a large reserve capacity, as the experience with putting in radio links in this area shows that the number of services quickly increase and the link becomes crowded.

When the options were considered, that is, standard cable, extend the digital radio concentrator system, or optical fibre, the fibre came out as the most economical, as well as proving to be the most suitable for the harsh environment.

However, some novel optical equipment has had to be designed and developed to connect the optical fibre link into the digital radio concentrator system. While the equipment may be novel, it is certainly not complicated or expensive. A wavelength division multiplexed device has been developed with simple design features. It is robust and has a large operational safety margin, can work in the area's harsh environmental conditions, and uses simple, low cost components. It also has a low power requirement, which makes it suitable for use at solar powered sites.



Peter Kemeny overseeing the production of prototype small capacity optical fibre systems for use in the outback.

This is an important step for the community concerned and it also has wider implications. The cost of optical fibre has decreased to the extent that it is cheap enough to only use a small fraction of the capacity of the fibre. The capacity of the fibre can be increasingly utilised by upgrading just the electronic component of the system when required.

Wavelength Conversion Technology in Glass

The load on switching equipment increases substantially as bit rates increase in the access network. One attractive means of overcoming the switching bottleneck is to use the capabilities of the transmission network to take some of the load from the digital switching function. This can be achieved by using wavelength as one of the dimensions for addressing information, and using relatively passive and extremely high bit rate Wavelength Division Multiplexing (WDM) technologies to achieve routing. Since the WDM technologies are likely to be used in the core network for increased capacity requirements, it is possible that a simple extension of the WDM functionality will lead to a significantly reduced switching load.

For the WDM approach to decentralise switching, and to be fully effective, some form of wavelength conversion technology is required to allow for redirection, circuit bypass, fault tolerance and generally make the approach more flexible. To achieve full transparency for the WDM network and make the fullest use of the transmission bandwidth, a technology is required for conversion between fibre transmission windows.

Within each fibre transmission window (1300 nm and 1550 nm), the technology for conversion between wavelengths is being developed at various laboratories throughout the world. In Australia, this work is being undertaken by the Photonics Section at TRL, along with the Photonics Research Laboratories at the University of Melbourne.

The most promising technology involves the use of the highly nonlinear optical behaviour of semiconductor optical amplifiers. The conversion from 1300 nm to 1550 nm is simply achieved because photons at 1550 nm have less energy than photons at 1300 nm.

However, the reverse process (conversion from 1550 nm to 1300 nm) is much harder to achieve as it requires an increase in photon energy. The approach taken by the Photonics Section has been to combine two different wavelengths of light in a non-linear material to generate a shorter wavelength, high energy light. This shorter wavelength light can be easily converted to 1300 nm light.

As part of this project, work has been undertaken to locally write highly nonlinear areas in glass waveguides. This has been achieved using a combination of poling (in which the waveguides are heated, a large electric field applied and then cooled) and using ultraviolet laser light to localise the nonlinearity in the glass waveguides.

A New Optical Fibre Attenuator

TRL has invented a novel cheap optical signal attenuator which has the potential to save millions of dollars for Telcos around the world.

During 1993, Telecom Australia technical staff installing optical fibre equipment found that a large number of optical fibre attenuators were marked with a deposit that could not be removed using normal cleaning methods. The Photonics Section at TRL was asked to identify the material and suggest a suitable cleaning solution.

It was quickly found that the markings were scratches from crushed glass, and therefore could not be removed by any acceptable field method. As a consequence, a large batch of imported attenuators was withdrawn from use, causing a major supply shortage of these devices.

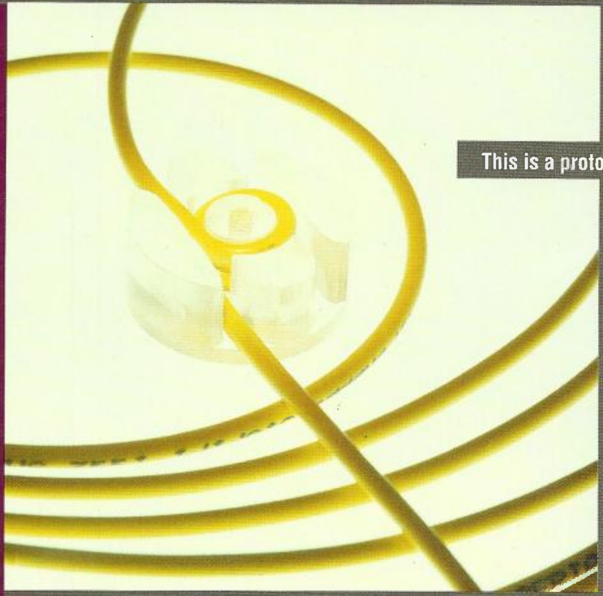
To overcome this shortage, the Photonics Section developed a novel device to introduce moderate optical attenuation (in the range of 5-20 dB) into single mode fibre transmission systems which incorporates standard 3 mm optical patchcords or pigtails.

This cord loop attenuator works by introducing an accurately controlled degree of macrobend in an accessible link of optical cord. It can be introduced, adjusted in small steps or removed without the need to interrupt the optical transmission.

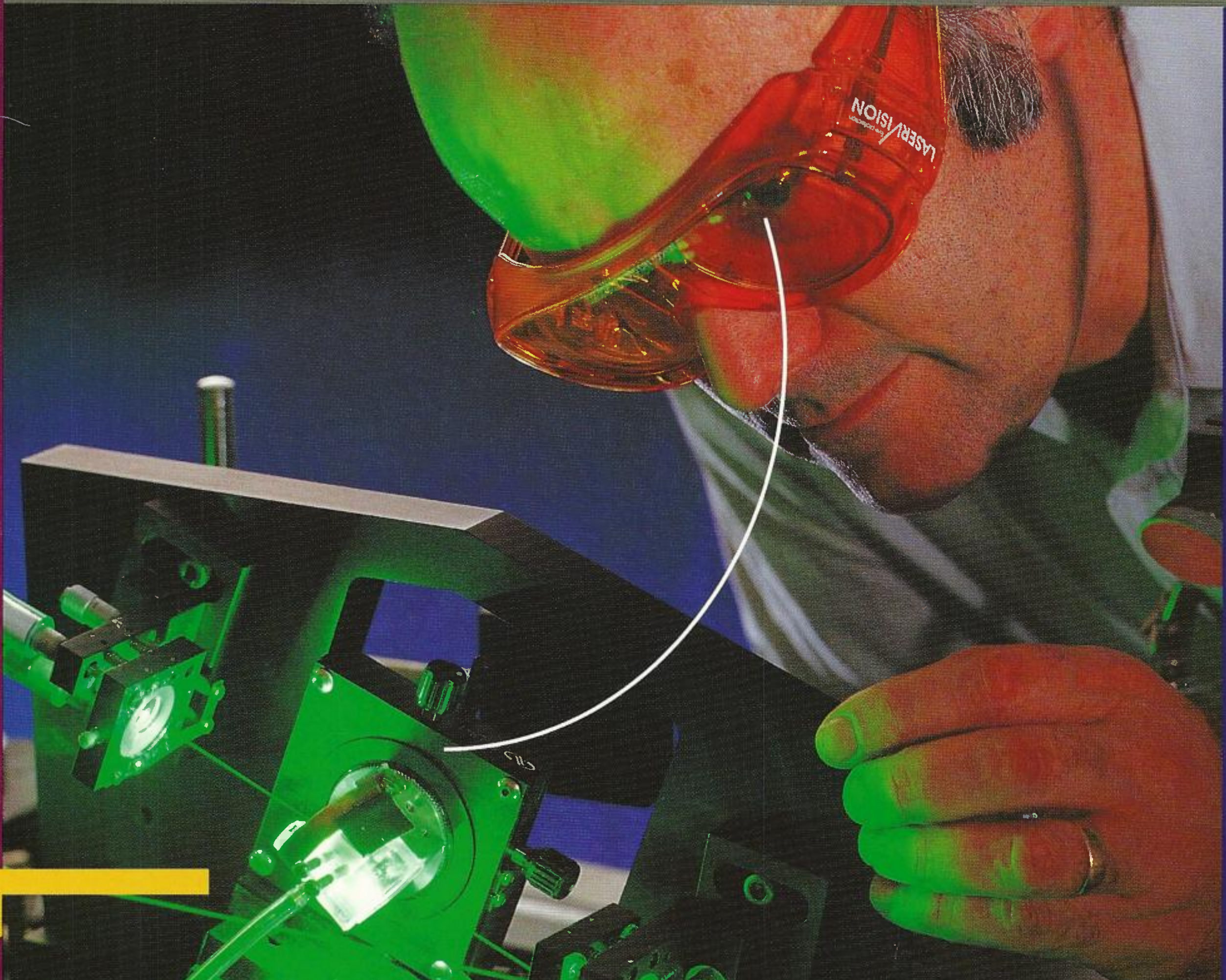
This was initially proposed as a short term local solution. However, there appears to be a wide demand for this type of device and it has been developed further and patented. Work towards its manufacture by Australian industry is at an advanced stage. When used throughout the Telecom network, this cord loop attenuator will save in excess of $500,000 per year. There is potential for world wide sales of the device.

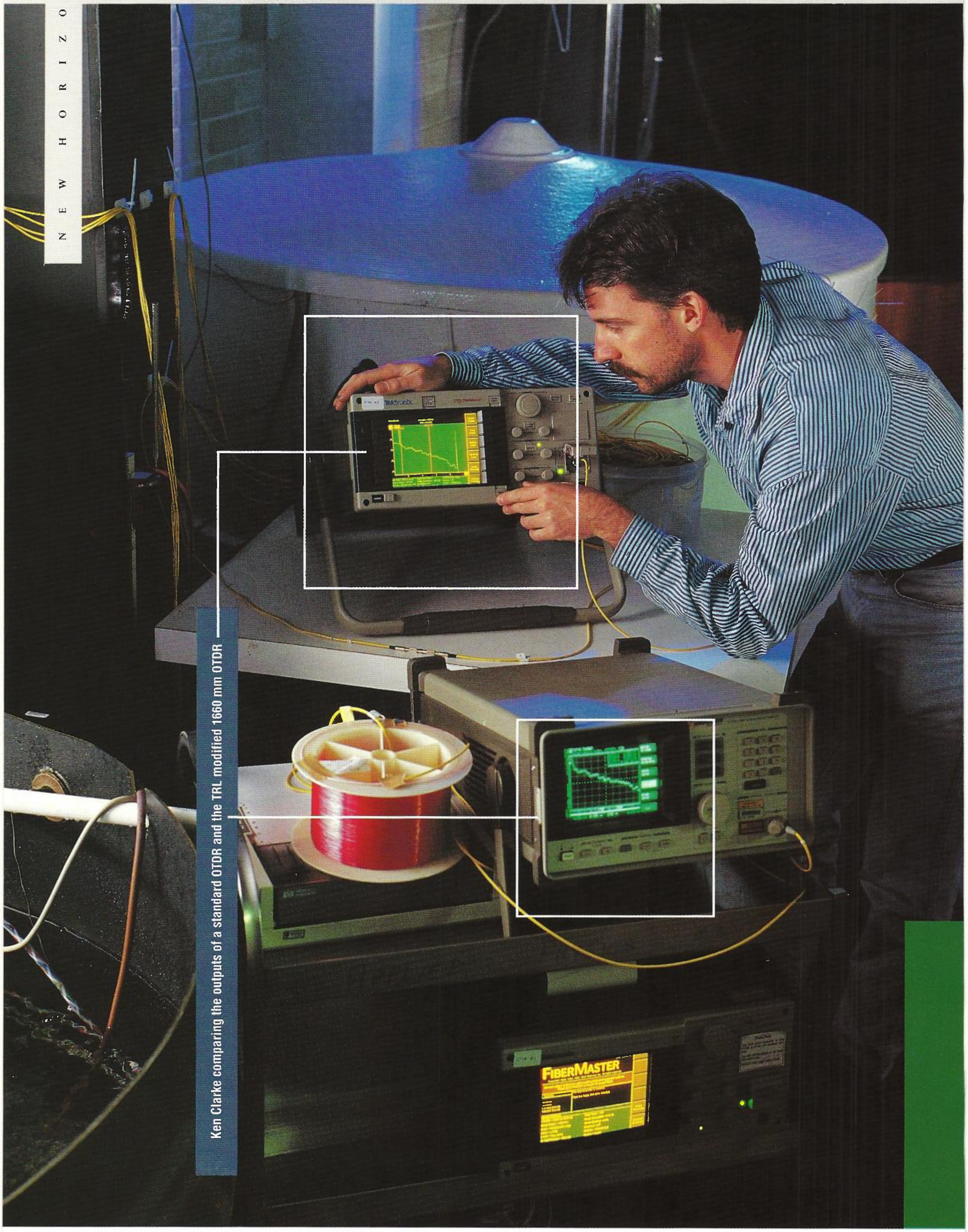
TRL is continuing to examine the theoretical and practical aspects of reliability and further application of this type of device.

Geoff Stone using lasers to research the WDM technology for network switching.



This is a prototype of an optical fibre attenuator which will be significantly cheaper and easier to use than imported attenuators.





Ken Clarke comparing the outputs of a standard OTDR and the TRL modified 1660 mm OTDR

Predicting Faults in Optical Fibre

Fault prediction is a useful and powerful facility to have in an area as complex as telecommunications. Detection of a fault in its early stages allows preventive maintenance to be undertaken, which will reduce the chance of network failure.

Optical fibres are conventionally tested using an Optical Time Domain Reflectometer (OTDR) which is, essentially, an optical radar that picks up the reflections of faults along the length of a fibre. OTDRs operate at the same wavelengths used to transmit data, ie. 1300 nm and 1550 nm. The nature of the light is such that longer wavelengths are more sensitive to fibre perturbations, or faults. Hence, 1550 nm OTDRs provide advance warning of faults occurring in 1300 nm systems.

Extension of this idea to 1550 nm systems, which are becoming more prevalent, showed the need for OTDRs operating beyond the 1500 nm region to give warning of faults in those fibre networks. During 1993, researchers in the Photonics Section of TRL devised such an OTDR.

At the start of the project, there were no long wavelength laser diodes commercially available to do the job, so a fibre laser source was developed at TRL. This was successfully demonstrated, but by that time, the first commercial laser diodes had become available. This offered a faster route to a practical field instrument.

When the 1660 nm OTDR was developed, the sensitivity of the machine was realised immediately. It revealed faults and features undetectable with the standard 1550 nm OTDR in several fibre and cable tests conducted in the laboratories and in samples received from the network. Work now continues to assess the machine in the field.

Further development of the in-house fibre source is taking place also to produce an even longer wavelength source for improved sensitivity.

Powering through the Optical Fibre

Not all research leads to an immediate application or product. Often, there are many important reasons for undertaking a research project, but when it is completed, the prevailing circumstances may have changed. The work may be superseded by technological developments elsewhere, or the economics of applying the research results prohibit any further work until circumstances require it.

Attempts to power some remote parts of the optical fibre network by directing a light source down an optical fibre and converting it to electricity with a solar cell, fall largely into the latter category.

After a number of experiments, it has been concluded that sending power through an optical fibre is both expensive and inefficient and research has been curtailed.

However, there are still some situations which would benefit from this method of supplying power. The optical fibre, being non metallic, does not conduct electricity. Sending power through an optical fibre would be ideal where electrical isolation is needed to protect sensitive electrical equipment from lightning or power line disturbances. Powering through optical fibre would also have application for remote equipment used in hazardous operations such as mining, and in medical sensors where electrical isolation is essential.

TRL is now maintaining a watching brief over the area, particularly looking for improvements and developments in solar cells and laser diodes. If there are relevant developments in these areas, then subsequent improvements may make power supply through optical fibre useful in some critical situations.

Switching Technology

TRL's research is ensuring Australians have ready access to new and advanced services resulting from developments in switching technology. Included in these developments will be a virtually unlimited capacity for people to personalise their telecommunications services to suit their needs.

Advances in switching technology are having a profound affect on the delivery of communication services. These developments are particularly important for the integration of voice, data and video transmission on the same network.

While this integration may appear to be complex, researchers are working to make the operation of the systems easy and "seamless", that is, a customer could move from voice to video to data very easily, without knowing what is happening in terms of network control and switching. To achieve this, a lot of computing power and network intelligence will be needed.

Switching technology will also provide customers with virtually unlimited potential to personalise their telecommunications services to suit their needs. The technologies are expected to provide cost efficient and reliable services. Researchers at Telecom Research Laboratories (TRL) are playing a significant role in the development of these switching technologies.

A New Era of Network Management

The simplicity of using the telephone, the fax machine and the modem belies the complexity of the modern telecommunications system. There are many parts which make up the network. How the parts work together determines the efficiency of the system.

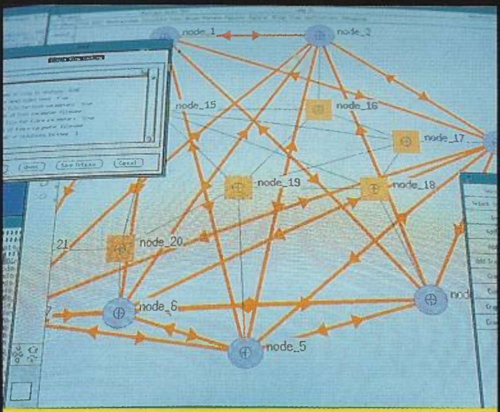
Managing the network and making it more efficient is a hidden part of the overall telecommunications system, but maintaining a research effort in this area is just as important as any other research which aims to create greater efficiency and to provide a better service at a reduced cost to the consumer.

Behind the telecommunications networks that the customer uses are many computer systems that control the operation of the networks. There are computer systems to connect new services, to find network faults when they occur, to deliver as many telephone calls as possible to their final destinations, and to account for network usage.

One of the main factors causing major problems in the existing network is in fact the history of the network. Generally, the network has been built up over a long period of time by adding new equipment and systems and modifying old ones. Keeping the network simple and standardised was rarely a consideration.

Now there are major efficiencies and savings to be gained by simplifying the systems, and increasing the level of standardisation between the many processes which influence the network.

One significant change which has occurred recently is the increased bandwidth available for telecommunications traffic due to optical fibre being installed in major trunk routes. This has led to the need to develop a new way to organise the network to use the increased capacity in a coherent way.



The computer analyses traffic flow to determine the most efficient use of transmission capacity.

The method devised is called Synchronous Digital Hierarchy or SDH. SDH organises traffic in a hierarchy to achieve more efficient use of transmission capacity. In providing uniform transmission, SDH allows for uniform management and uniform systems to be adopted. This in turn leads to more efficient customer services and will drive down operating costs.

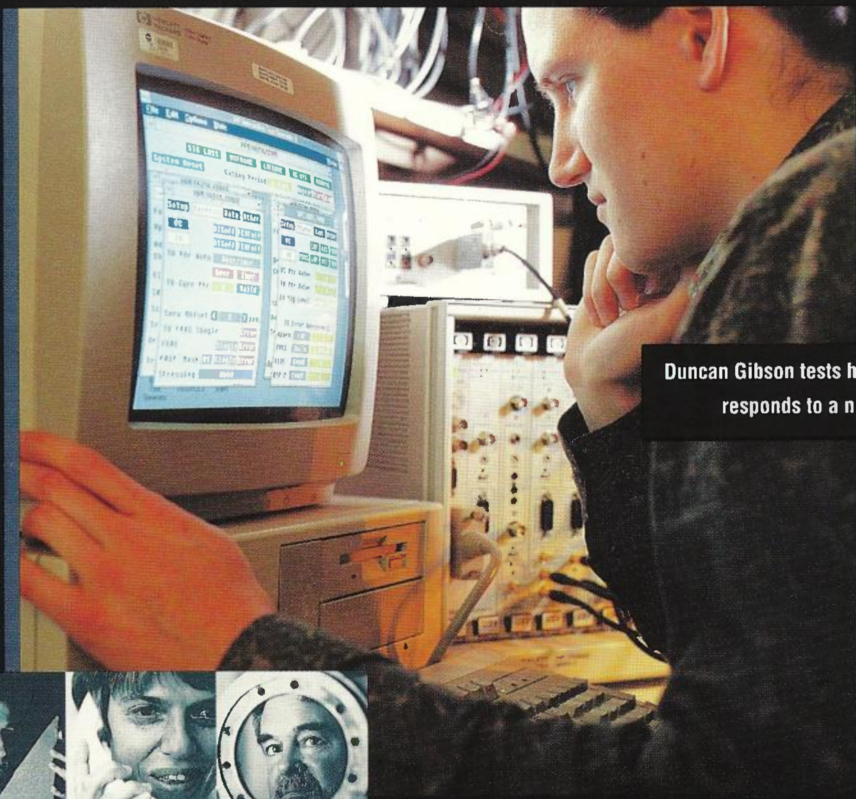
Further, SDH provides a uniform management system across the national digital network. This is in contrast to many state based systems which have operated up until recently. These local systems made traffic management complicated, they were costly to run and it was costly to keep current the data required for efficient network management.

But SDH has an even wider influence on the network than just providing uniformity. It allows near real-time reconfiguration of the bandwidth, so capacity can be increased for one service at the expense of capacity for another. This differs from current procedures which dedicate a part of the network capacity to each service. SDH will permit a closer matching of network transmission capacity to customer requirements.

This feature will be most important to restore services after a major disruption to the main telecommunications bearer – the classic "backhoe through the cable" situation. If there is no duplication of the bearer, that is, there is no unused direct channel available to restore the service, then it is necessary to search for unused paths along which calls can be redirected. With SDH, an appropriate number of pathways would be found.

In the case of a more serious breakdown, a computer system working with SDH can put a priority on the traffic which gets through, so the more important or higher value traffic is given preference, until sufficient capacity is restored.

The work at TRL to optimise bandwidth allocation and management is recognised world wide, and a provisional patent on the work has been granted.



Duncan Gibson tests how SDH responds to a network problem.

ATM Network Links Research Organisations

Since the mid 1980s, TRL has been exploring the capabilities of Asynchronous Transfer Mode (ATM) as the fast packet switching technology to support the true integration of diverse services.

In 1989, TRL began working co-operatively with the Electronics Research Laboratory of the Defence Science and Technology Organisation (DSTO), located at Salisbury in South Australia, to develop a Research ATM Network linking the two sites.

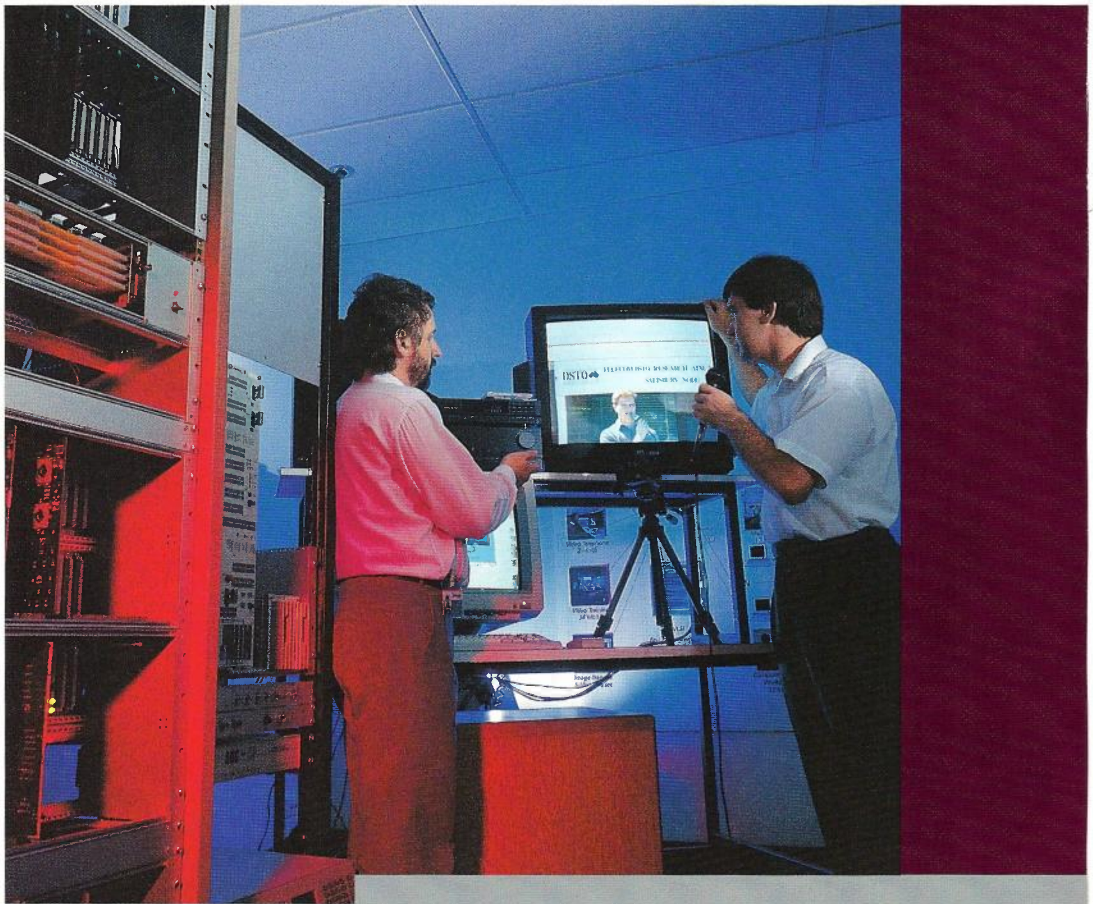
By May 1993, this network became operational and the first integrated voice, video and computer data link between two Australian cities using ATM technology was established. The link runs at 34 Mbit/s, connecting switches with total switching capacities of 1.6 Gbit/s.

ATM switching allows all types of information to be carried over a single integrated network and provides the capability to offer a wide range of access speeds and quality of service classes. Thus it will be possible to offer a full range of services from economy, lower quality, through to premium, high performance services. This allows the customer to choose the quality and performance of the service which best suits his needs.

The Research ATM Network is now being used to test the validity of some of the theoretical ATM traffic models developed at TRL over the last few years. This is an important step towards the future implementation of ATM switching in the Telecom Australia network. Testing of the network has been facilitated by the recent acquisition of an ATM test set designed by the International Business Unit of Telecom's Corporate, International and Enterprise Group.

The co-operative research with DSTO has led to a much deeper understanding of the problems unique to military communications. This has enabled Telecom to work closely with the Department of Defence in satisfying their communications needs which are vital to the defence of Australia.

The co-operation with Defence has also been instrumental in obtaining sufficient resources to enable the construction of a major experimental facility of use to both organisations.



Daniel Kirkham and Peter Ellis talking to colleagues at DSTO, Adelaide over the research ATM Network.

Cost Minimisation of Broadband Switched Networks

Traffic management is very important to achieve an efficient and cost effective telecommunications network. Existing technology can support voice and data traffic without too many problems. However, adding video through broadband services adds a whole new dimension to the management of telecommunications traffic.

For example, voice has a rate of 64,000 bits of information a second, but data has a highly variable rate, and the information tends to be "dumped" into the network, so there are very high peaks of transmission followed by nothing. On the other hand, video requires a transmission rate of several million bits of information a second to provide a clear picture to the receiver.

TRL is studying how a broadband network can readily accept any of these connections, despite the difference in the traffic types and how to make the most effective and cost efficient use of the network.

Each time a connection is made, a part of the network is allocated for that connection to use. One parameter which could be used to describe the traffic generated by a connection is the maximum rate of transmission required. The network would then allocate that amount of capacity for the duration of the connection. This strategy is called peak rate allocation. However, this is inefficient, as over the total time of the transmission, a lot of the network capacity is not being used.

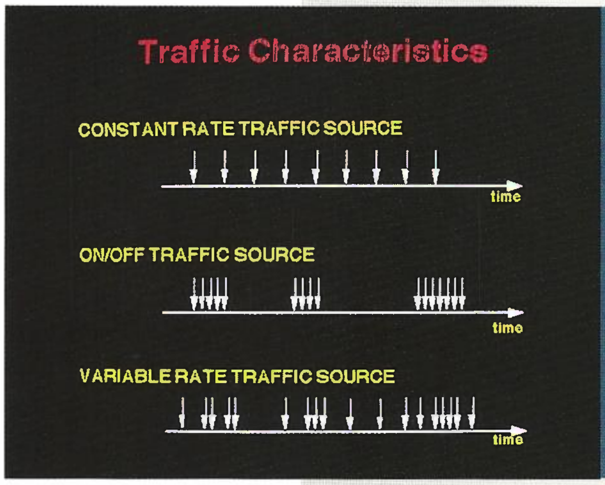
So other parameters are needed to characterise the connection to maximise the efficiency of the network. The characteristics used relate to how bursty the data is and the average rate of transmission.

This information is coded into a signalling message, which allows the network to control the connection. The connection admission control uses this message in conjunction with information previously gained from other connections to determine the capacity of the network and whether or not to accept the connection.

TRL has developed some efficient rules to determine acceptance or rejection of a connection, and in the process has discovered techniques which provide a 25-35% increase in utilisation when compared to using peak rate allocation.

By using these techniques, the broadband switched network will be able to accept more traffic, while still maintaining quality service. This will help to keep the cost of providing the service to a minimum.

Telecom Australia plans to develop an experimental broadband network based on ATM switching and multiplexing techniques by the end of 1994. Commercial services will be developed from 1995 onwards as demand requires.



Broadband switched networks need to manage traffic with different characteristics.

Video Switching with ATM

Pay television was in the news a lot during 1993, but behind the news, there is a lot of work progressing which could mean even more possibilities for the delivery of entertainment services to the home.

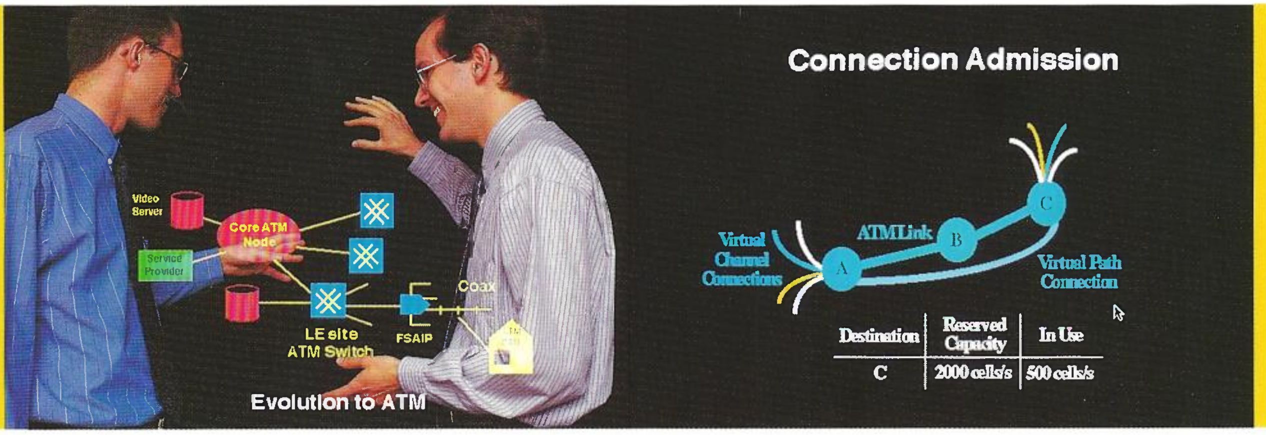
There is no doubt that pay television can be distributed through "cable". In Australia, there are two cable systems currently under consideration. One is a combination of optical fibre and coaxial cable, while the second system is Asymmetric Digital Subscriber Line, or ADSL, which uses the existing copper wire connecting telephones to the network. A big advantage of ADSL is that the distribution network already exists, so no extra cabling is required.

The capacity of the optical fibre/coaxial cable system is large, so all television channels available would be transmitted at once, and the customer would choose a program through a decoder.

However, with ADSL, the capacity of the copper wire is comparatively very small, and it is not feasible to simultaneously transmit all the available channels to the customer.

To achieve choice for the pay television customer over ADSL, some smart electronics is installed at the exchange, as well as the customer having a decoder at the receiver. In other words, switching at the exchange is used to select the desired channel.

So new switching techniques will be an important part of providing an efficient pay television service.



John Burgin and Graham Bate discussing a possible pathway to introduce an ATM switched network.

During the year, TRL research showed that Asynchronous Transfer Mode, or ATM switching, is the best type of switching for both optical fibre/coax and ADSL. This type of switching can accommodate a range of services. It can be installed either as single function switches, or integrated into one switch which can manage a number of functions.

The work showed that integrated ATM switches are more cost effective. Integrated switches can support a wide range of services, both services which already exist and services which are planned for the future, such as home shopping and "dial-a-video". These and other interactive services are expected to be a real growth area for telecommunications business during the next few years.

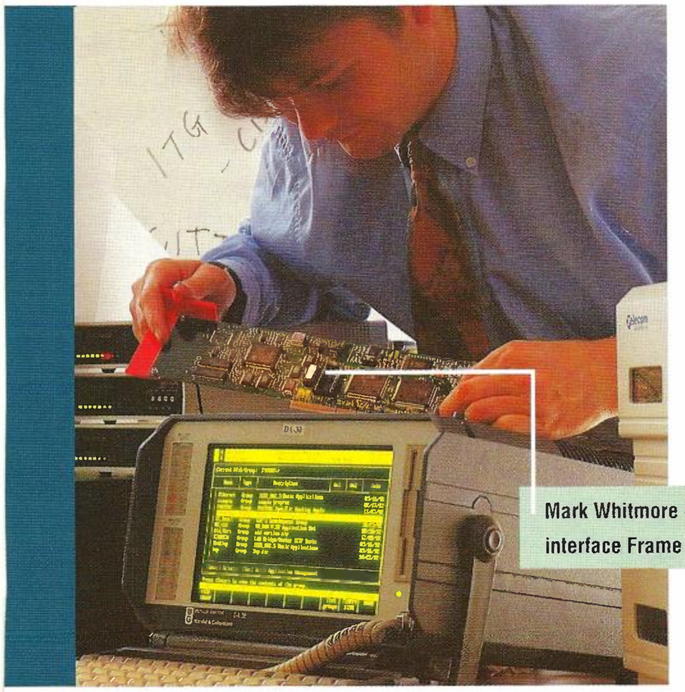
Congestion Control in Frame Relay Networks

The growth of computers in the work place has seen an increase in the demand for the high speed interconnection of Local Area Networks. One technique which is receiving much interest is that of Frame Relaying.

Frame Relay is an interface protocol best described as a 'cut-down' version of X.25, having removed the functions of flow control and error recovery. The frame structure consists of an address block, an information field and a frame check sequence for error checking. The address block consists of a field to identify a particular connection, congestion notification indicators and an indicator to mark if a frame is eligible to be discarded by the network if network congestion should occur.

As there is no flow control or error recovery, users of a frame relay service would transmit data into the network and rely on the higher layer protocols operating in the end-systems to ensure the message gets through. Congestion control relies on the end-systems reacting to the explicit congestion indicators that are provided within the Frame Relay access protocol.

However, there is limited experience in operating Frame Relay networks and hence there is still some uncertainty about how effective these are, and what is the best mechanism for congestion control within the network. During 1993, TRL assessed congestion control mechanisms for a possible frame relay service, compared the performance of frame relay to traditional X.25 packet networks, and is participating in an internal technical trial of Frame Relay.



Mark Whitmore (from Telecom's FASTPAC 2 Project Team) examining circuitry to interface Frame Relay to the FASTPAC network.

Given that statistically multiplexed networks load share, they are subject to congestion. Ideally, when network congestion occurs, control methods will generally decrease the customers transfer rate to avoid discarding frames. However under heavy traffic conditions, frame discarding may still occur, which generally means that the customer's quality of service will decrease.

To quantify the end-to-end quality of service, Frame Relay uses the concept of 'Committed Information Rate' (CIR), which specifies by how much a customer's throughput is likely to be affected by load sharing. CIR is defined as 'the information rate the network is committed to transfer 99% of the time'. As a general rule, the smaller the throughput which is 'guaranteed' to customers, the greater the network efficiency. However, operating a network with customer's CIRs set at half their access line speed causes only a small loss in the mean data transfer rate.

Investigation shows that explicit congestion control is necessary in data networks to achieve high network trunk utilisation, while maintaining low network delay and frame loss. For load sharing to be effective, appropriate customer equipment, responsive transport protocols and a network implementation which responds to or generates explicit congestion notifiers are required.

It is likely that with early implementations there will be few customers who will manage to comply with these requirements. Also since network operators have little control over the equipment and higher layer protocols that customers use, Frame Relay networks will require adaptive rate enforcement mechanisms implemented at the ingress nodes to protect the network from 'non-compliant' users.

An 'adaptive rate enforcement mechanism' is a traffic rate policing mechanism operating in the ingress nodes of the network which reduces customer traffic rates in response to internal network congestion. Adaptive rate enforcement thus protects the network from non-compliant customers who fail to respond to network congestion indicators. During congestion, rather than all users being affected by frames being randomly discarded inside the network, only the non-compliant customers have their excess frames discarded at the edge of the network.

Mobile Services

The rapid acceptance of mobile telephones by Australians reflects the desire for personalised and flexible telecommunications services. TRL's research aims to maintain and improve the Telecom mobile communication network.

Australian's have a reputation for readily accepting useful modern technology and judging by the uptake of the mobile telephone, which frees them to perform their every day personal and business tasks more easily, this like of modern technology has not diminished. The cellular telephone has provided a new freedom to be in contact with friends and family, clients, colleagues and tradespeople without having to be near a conventional wired telephone. It has also allowed many people to establish their own business, given the freedom to operate from an "office on the move".

It is predicted that personalisation of telecommunications will increase, as will the number and type of services available on the mobile network. As this happens, security issues will become more important, as customers will want to protect both their information and the use of their mobile telephones.

Telecom Research Laboratories (TRL) is involved in a wide ranging research program aimed at improving the mobile telephone network.

Improving Mobile Communication

Mobile telephones have been readily accepted in Australia and the number of people using the mobile telephone network is increasing. This increased usage requires continual research to keep ahead of the growth in the service.

An important role for researchers at TRL is to examine how to get more value from the existing technologies, keep up to date with the new technology and to be prepared for future technologies.

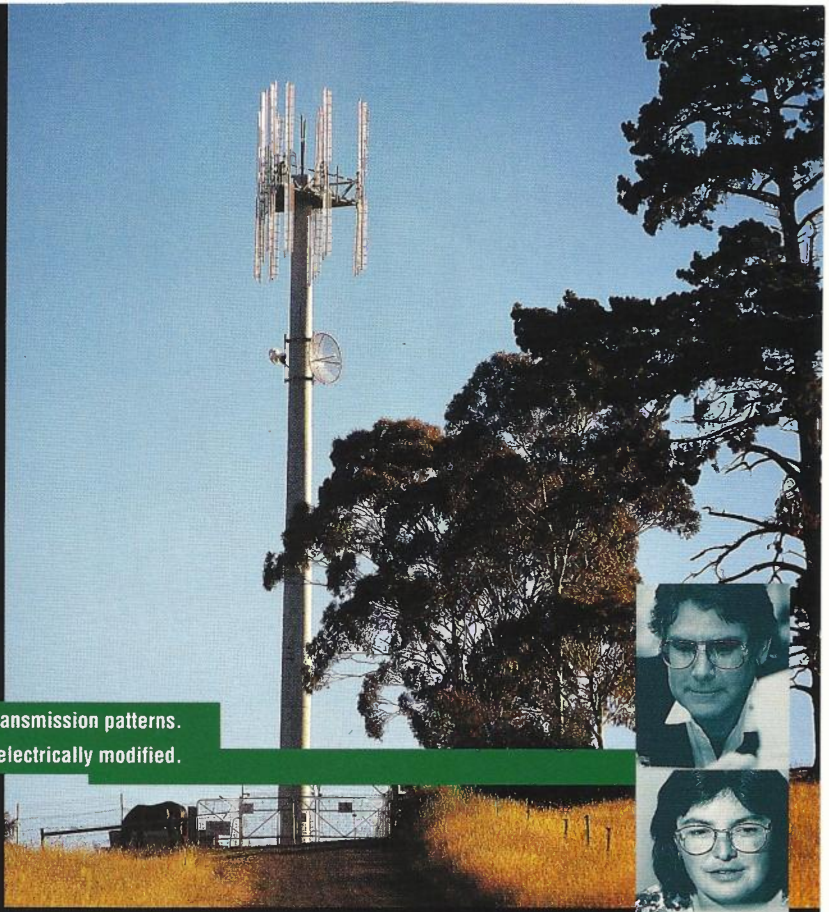
One important tool the researchers at TRL have for studying the mobile network is a computer simulation package, on which experiments can be conducted in "realistic" conditions. With this package, the researchers can ask a series of "what if" questions about all aspects of the mobile network.

For example, placement of antennas is critical for quality, cost effectiveness and efficacy of service in the mobile network. As more customers come on stream, the radio cell size is modified and the antennas have to be adjusted. The antennas used to be physically tilted, but researchers found that it is better to keep the antenna itself vertical and electrically modify its characteristics to create a tilted coverage pattern.

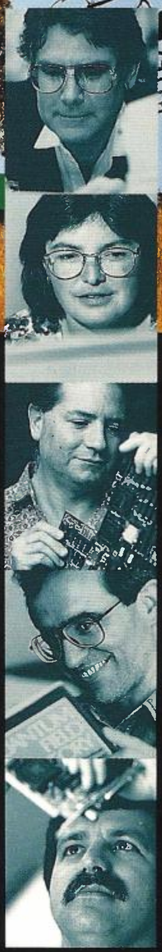
The researchers have also studied a number of technical systems which can be added to the digital network.

Interference arises from other users who are using the same frequency, but in other distant cells. However, the interference on some frequencies can sometimes be worse than on others. A way to improve the quality of the cellular calls is to share the good and bad interfering frequencies between all the users, so each user experiences about the same degree of interference. This is made possible by the technique of "slow frequency hopping", which rotates the frequencies being used within the cell, so the amount of interference is shared amongst all users. This technique will be used on the digital cellular systems.

Another technique which improves the quality of cellular calls, as well as giving longer talk time before the batteries need to be recharged, is to have the mobile handsets transmit power only when the user is talking. Using this technique, which is called "discontinuous transmission", less power is transmitted on average, which means less interference and a longer battery life. For network operators, this also allows for more efficient use of the radio spectrum.



Current mobile antennas are physically adjusted to change cell transmission patterns. In future, mobile antenna patterns will be electrically modified.



Mobile Telephone Security

One important feature of the new GSM Digital Mobile Telephone service is its inbuilt security. Communications over the radio channel are protected to prevent anyone eavesdropping on conversations. Also, GSM uses a cryptographic system to verify the identity of the user. This makes it extremely difficult for anyone to place calls illicitly at someone else's expense.

Pivotal to security is the Security Identity Module, or SIM. This is a plastic card with an embedded electronic chip, which contains all the information necessary to identify the user. It means that the user specific information is not stored in the mobile telephone.

When using the card with a digital mobile telephone, the card is inserted and the owner's PIN (Personal Identification Number) is entered. If the PIN number is entered incorrectly three times, then it will not allow access to the phone, nor can services be booked up to that card.

Part of the information in the SIM is the key data which must be kept secret for the encryption and user identification to be effective. As the GSM telephone has no other user specific information, it can only operate when someone inserts a SIM into it. However, the converse of this is that any telephone with a SIM has access the SIM owner's GSM service.

Telecom Australia realised that real individual security is only afforded if the whole system is secure. When Telecom first discussed the possibility of personalising SIMs in stores which sold GSM phones, security was paramount. The problem was that no system existed which could securely pass the secret customer specific information from Telecom's information data bases to a SIM, in the uncontrolled environment of a shop.

Yet for Telecom to offer customers the convenience of instant connection to the GSM service, the SIM had to be personalised with customer specific information and handed over to the customer at the time of purchasing the mobile phone.

To satisfy all requirements, researchers needed a security protocol which could pass secret information to a blank SIM, so it was not necessary for the store to hold SIMs which contained information which had

A SIM being inserted into a digital mobile telephone.

Robyn Cliffe, of Mitcham Sales and Service Centre, demonstrates the security of the new Telecom Digital 11 mobile telephone.

to be kept secret. The researchers invented such a protocol based on public key cryptography. Public key cryptography rules are complex, but with careful design, the researchers were able to program the SIMs to execute the protocol very quickly and not to take up any of the SIMs scarce memory resources once the SIM is personalised.

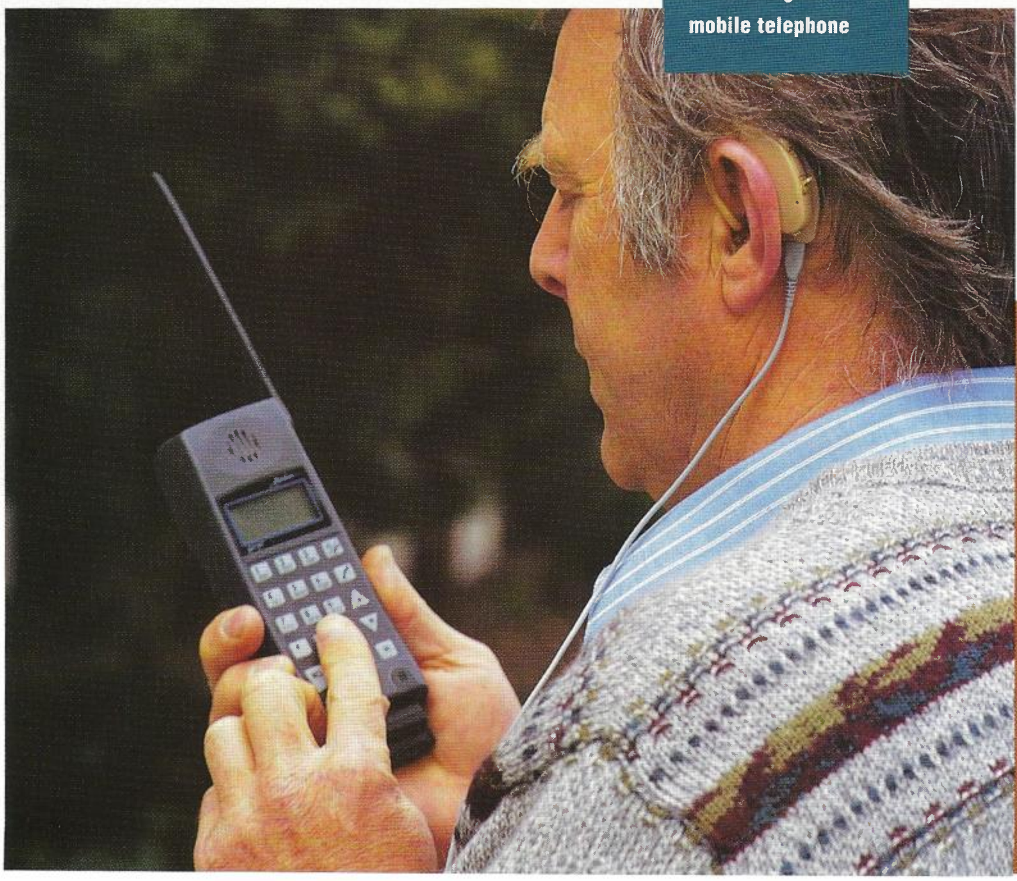
Telecom has a patent pending on the system.

In all, it took just 18 months from the time the problem was discussed until the security system was integrated into an operational system. Today, Telecom can offer instant connection to its GSM service through authorised dealers without any compromise to the security of the GSM system.

Digital Phones and Hearing Aids

Digital mobile telephones may interfere with some hearing aids. For some people, this interference is just a nuisance, but for others, it may be a problem, to the extent that the two devices are not compatible.

To overcome this problem, TRL has devised a hands free kit which connects to the telephone and to the hearing aid via an acoustic coupler. The researchers are working at making existing hearing aids, used in conjunction with the hands free kit, more immune to problems of interference caused by digital mobile phones.



John Gillies demonstrates the hands free kit which connects a hearing aid to a digital mobile telephone

Telecom's Structural Design Expert

The expansion and maintenance of Telecom Australia's network and services utilising radio links requires the installation of new supporting structures, such as poles, masts and towers, as well as constant upgrading of the existing ones. The evaluation process is straightforward if the end-users, eg. radio designers, planners and project managers, are certain of the antenna configurations, and there is no emphasis on cost and time savings. However, this is not so in practice, and with increasing competition, cost and time saving are critical to ensure Telecom's continuing success.

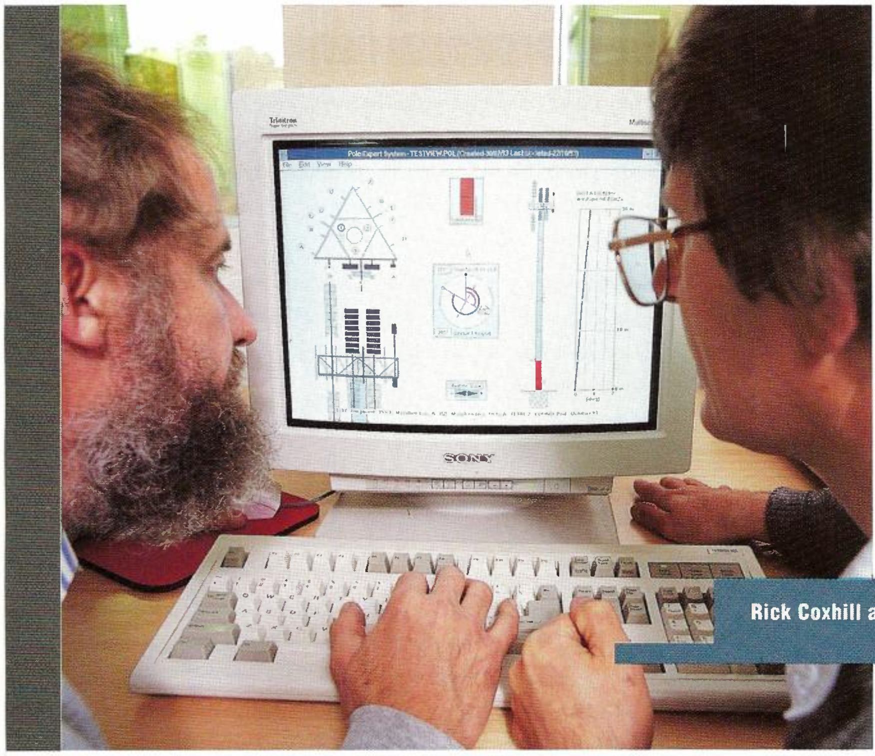
The turnaround time for a complete structural analysis can take up to three weeks and is performed by Telecom's NTG Structures Group which specialises in this field. Consequently, the Structures Group proposed the concept of employing artificial intelligence techniques to the technology of structural engineering and requested assistance from artificial intelligence researchers in the TRL to develop a Structural Design Expert. This Expert System is a national evaluation/decision-making tool, which can be easily used by anyone, and it is aimed at providing Telecom with a sustainable competitive edge in the building and operating of its extensive network infrastructure.

In conjunction with Structures Group and Mobile Communication Services, TRL developed an initial Expert System for use with pole structures which are used in the mobile telephone network. The system uses sophisticated interactive graphics to assist in the evaluation of the pole and headframe with the proposed antenna configuration and selections.

The Expert System evaluates the proposed design and gives instantaneous feedback on its structural integrity and serviceability requirements. For legal reasons, it does not replace the process of detailed structural evaluation by Structures Group but it does provide the end-user instant indication whether the design is acceptable or not. The Expert System caters for all Telecom pole types, and advises on special wind conditions for different environments in accordance with the Australian Standard. A pole which needs to withstand cyclonic wind conditions has different design requirements to one located in the Australian Alps.

Site databases can be set up and maintained for all the poles installed by Telecom and can be easily updated every time structural and antenna changes are made. All details are stored in electronic format and can be printed and edited if required. The graphical reports can be despatched directly to the field staff for action without further drafting requirements.

Using Telecom's internal electronic mail facilities, pole designs and data can be easily and relatively quickly transferred between end-users and structural experts. This eliminates a lot of paper work, reduces inaccuracies and ensures faster turnaround design/installation time.



Rick Coxhill and Adam Kowalczyk refining the Pole Expert System.

At this stage, there appears to be no other system like this in the world, so there is a future possibility to license the technology for use by other telecommunications organisations.

Network Reliability

In a telecommunications network, reliability is paramount. Reliability is a necessary ingredient both for customer satisfaction and for the profitability of the company.

Reliability of modern telecommunications equipment is important for people in Australia, particularly for those in the outback, where distances are vast and the climate harsh. Indeed, telecommunications have to perform under extreme weather conditions, from the freezing temperatures of the Alps to the searing temperatures of the desert and we have come to rely on the technology, because it is reliable.

However, reliability is no accident, particularly now when telecommunication networks are becoming increasingly more complex. There is a constant effort at TRL to ensure that the existing network maintains its reliability and that new systems installed in the network will perform reliably over their designed lifetime.

Modern business relies heavily on communication services. This puts pressure on Telecom to maintain a reliable network, because the consequences of network failure are enormous. Reliability is also important for the maintenance of a cost effective service.

Telecom Research Laboratories (TRL) is involved in reliability studies which cover a wide range issues, from environmental testing to fault finding in microscopic integrated circuits.

New Battery Monitoring Systems

The standard lead acid battery has been around for about 140 years. Despite it being "old technology", it still plays a significant role in modern telecommunications technology and will do so for some time to come.

Batteries are important as a reserve supply of power in the case of mains power failure, or for solar installations, to provide power at night or during cloudy periods.

However, the practices surrounding the use of batteries, such as where they are located in the network and how they are tested, are undergoing major changes and TRL is supporting Telecom Australia in the adoption of these changes.

Telecom has prescribed maintenance practices which aim to ensure the batteries will operate effectively when they are required. Ideally, the procedures should maximise both the service life of the batteries and the likelihood that they will work as intended. Present practices are all manual and in order to best utilise available manpower and maintenance effort, it is necessary to automate data collection with tools such as battery monitoring equipment.

However, researchers in the Battery Technology Group found the commercially available monitoring

Leigh Barling and Neil Whitaker demonstrating the Battery Monitoring System at the Box Hill Exchange.

equipment is expensive and many of them are just data-logging devices and do not provide the information required for maintenance purposes. When Telecom's needs were analysed, it was found that no monitor currently available in the world was suitable.

This lead the group to look at what elements of battery monitoring best suited Telecom.

A battery monitoring system has to be consistent with current Telecom practices, yet be able to be adapted to possible future practices such as automatic, unstaffed networks utilising full alarm systems. The monitors should have universal application, they should not demand additional maintenance or power and they should improve productivity and maximise battery reliability.

TRL has been able to achieve all this with the development of the Battery Monitoring System. The unit is designed to be installed for two distinct applications. One is in a network, where it is required to monitor battery history. The other is at a solar site, where it records events relating to the activity of the batteries at that site. Telecom has about 8,000 solar powered sites around the country, so a system which records the events such as charge in, charge out and the amount of sunlight, provides information which allows a technician to decide on an intelligent maintenance procedure in the event of the batteries going flat.

Semi Conductor Reliability

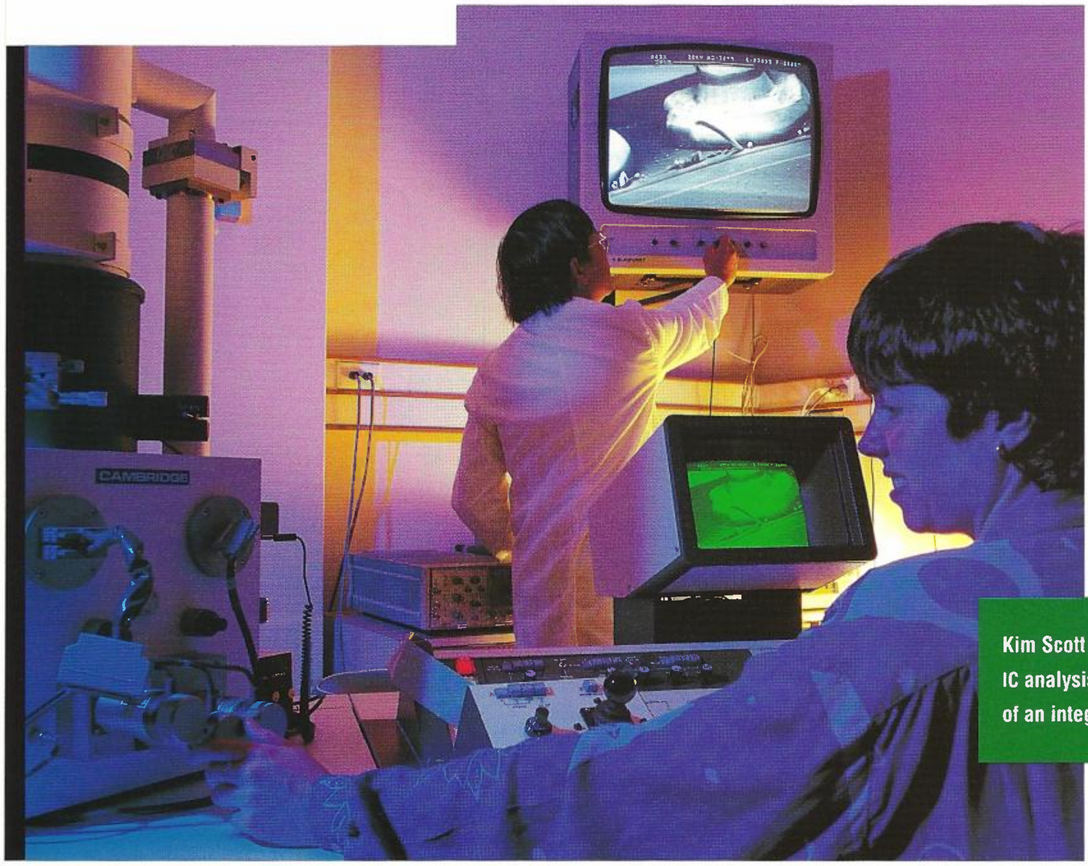
TRL researchers continued to play a vital role to ensure that new high-technology telecommunications equipment, which is being introduced to upgrade network infrastructure, is as reliable as can possibly be achieved.

Unlike previous generations of equipment, new systems make extensive use of ASICs (application specific integrated circuits), with virtually every major function being performed by custom designed circuits. The use of ASICs is one of the key elements responsible for the enhanced performance achieved by new equipment, as some contain nearly one million individual transistors. Without such devices, these systems would not be economically or, in some cases, even technically feasible.

ASICs have lead to a reduction in the number of individual parts used in equipment and this also results in an improvement in the reliability of the equipment. This is a major benefit as the provision of high integrity services, especially data transmission, becomes increasingly expected and demanded. Unfortunately though, some of the leading edge technology being used to produce these highly complex ASICs may be, in the long term, of uncertain reliability. With the dimensions of the individual transistors on ASICs now sub-micron, the correct choice and use of materials for these devices becomes critical in achieving the performance and reliability needed. For example, the properties of combinations of thin layers of materials do not always behave as expected and problems may not appear until devices have been in service for some time.

In addition, ASICs, unlike the standard device types such as memory chips, are often produced only in small quantities. This means that the extensive reliability testing and the improvement that accompanies the ongoing fabrication of standard parts is simply not feasible. If it turns out that a problem does arise several years after the installation of the equipment, sufficient spares may not be available and there will be no equivalent part that can be substituted. Increasingly, ASICs are being sourced from single suppliers, often subsidiaries of the system suppliers. In some cases, the process used to fabricate the ASIC may become obsolete and some of the smaller suppliers of ASICs may go out of business. Ensuring adequate reliability and quality from the outset becomes paramount as, should problems arise, there will be no other source of these critical components.

This type of problem has arisen in the past and will continue to occur despite the best efforts of the ASIC vendors and equipment suppliers.



Kim Scott and Simon Li using the IC analysis system to check the operation of an integrated circuit.

Apart from being able to identify the onset of problems and thereby provide options and strategy that allow cost effective solutions, one of the prime advantages of maintaining an independent group of semiconductor reliability experts at TRL, is the access to commercially sensitive information concerning semiconductor technology and reliability from ASIC manufacturers around the world. Details of specific problems that may not be shared with their competitors in the ASIC market, due to commercial objectives, may be provided, enabling Telecom to purchase from a position of advantage. When major purchases of equipment are being considered a knowledge of individual vendor technology and product history is also invaluable.

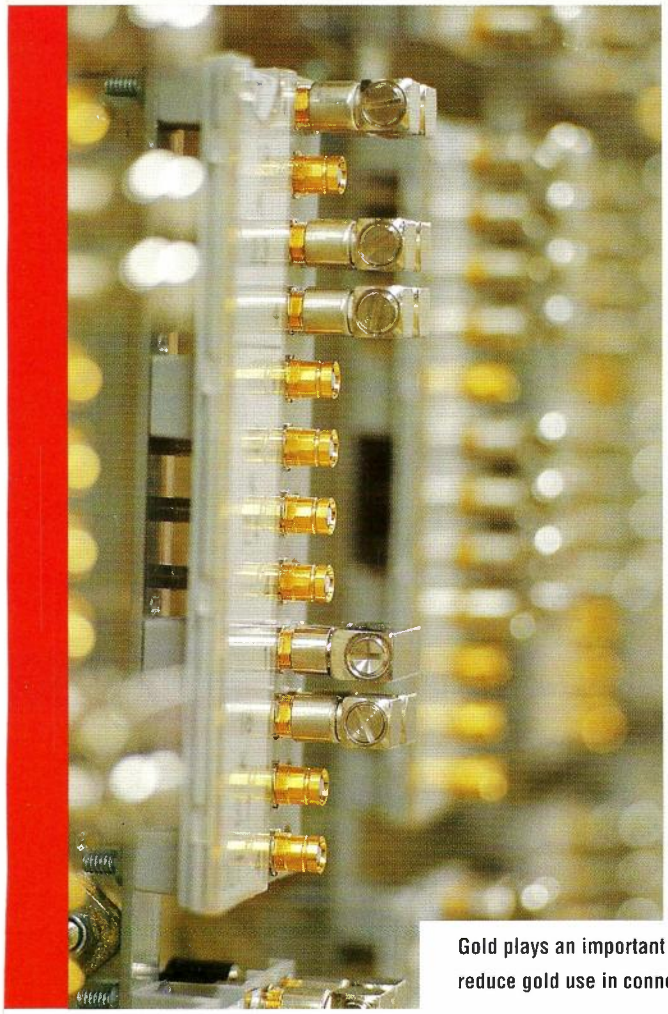
Making the Right Connection

It would be very difficult to count the number of electrical connections in Australia's telecommunications network. Even with a standard telephone call, there are a large number of interfaces between the different elements of the network which connect the telephones together. For each connection, there are numerous designs and types of connectors involved.

Added to this, electronic systems are increasingly expected to work in non-controlled environments, rather than in air-conditioned exchanges. In these more aggressive environments, the elements of the network are exposed to large fluctuations in temperature and humidity and to unclean air or polluted air.

During 1993, TRL maintained its watching brief on connector products, liaised with suppliers about the design and quality of connectors, advised Telecom Australia Business Units on matters relating to practices and procedures with connectors and continued to study the performance of connectors in aggressive environments.

One of the major areas of research into connectors was into improving the reliability and reducing the cost of the Main Distribution Frame (MDF) in a telephone exchange.



The MDF consists of racks of connector blocks which terminate cables entering the exchange and distribute the circuits to the exchange switching equipment. The MDF is basic technology, using simple connection hardware. But within an exchange, the cost associated with the MDF is rising, whereas the costs associated with the switching components are decreasing.

To contain the cost of the MDF, TRL is looking at ways to improve the design of the connector blocks and the design of the hand tool which is used to make the connection. These projects are being undertaken jointly with the supplier of the MDF connector blocks.

Another important area of research is to reduce the cost of connectors.

To counter the corrosive effects of pollutant gasses, which can cause faulty connections, electronic equipment generally uses connectors with gold plated plugs and pins. As the gold is a significant component cost, using less gold reduces the cost of the connector. This can be achieved by using a thinner gold coating and selective electroplating in which only the critical contact surfaces have the required gold thickness.

Gold plating is usually applied over a cheaper "underlay" plating layer, such as nickel. It has been found that as the gold plating becomes thinner, the properties of the underlay plating become more critical. In particular, it has been found that the underlay has a direct effect on the wear characteristics as the gold thickness is reduced.

Research is continuing to determine how thin the gold coating can be, while retaining the anti-corrosive benefits of using gold.

Gold plays an important part in the reliability of connectors. However, TRL is researching ways to reduce gold use in connectors to reduce their cost.

Potential Hazards Testing

A large range of products used by Telecom Australia and telecommunications users operate using radio frequency energy. After the Department of Defence, Telecom is the second largest user of radio frequency spectrum in the country.

Under normal circumstances, radio frequency energy poses no risk to human health. For people working at rigging and setting up antennae, there is a longer and higher level of exposure and precautions need to be taken.

TRL has expertise in testing for potential hazards in this area and recommends procedures which will minimise exposure to radio frequency energy.

Alternative Energy Sources

Since 1974, Telecom Australia has installed more than 40,000 solar modules at about 8,000 sites throughout the country. These are of single crystal and poly crystalline silicon technology. Even though this technology is somewhat expensive, it has proved to be efficient, reliable and cost effective compared to alternative power sources.

In 1993, two new types of solar module were included in the ongoing joint evaluation program, which is collaborative research between TRL and the New Energy Development Organisation of Japan.

In recent years, the research focus has been on thin-film solar photovoltaic technologies. These modules require less energy to produce and use less semiconductor material, so they have the potential to have a much lower cost than existing modules.

However, a major concern with this new technology is whether it has the performance, reliability and length of life required by Telecom. The long life requirement is important, given that solar power systems are usually installed in remote locations and are exposed to harsh environmental conditions.

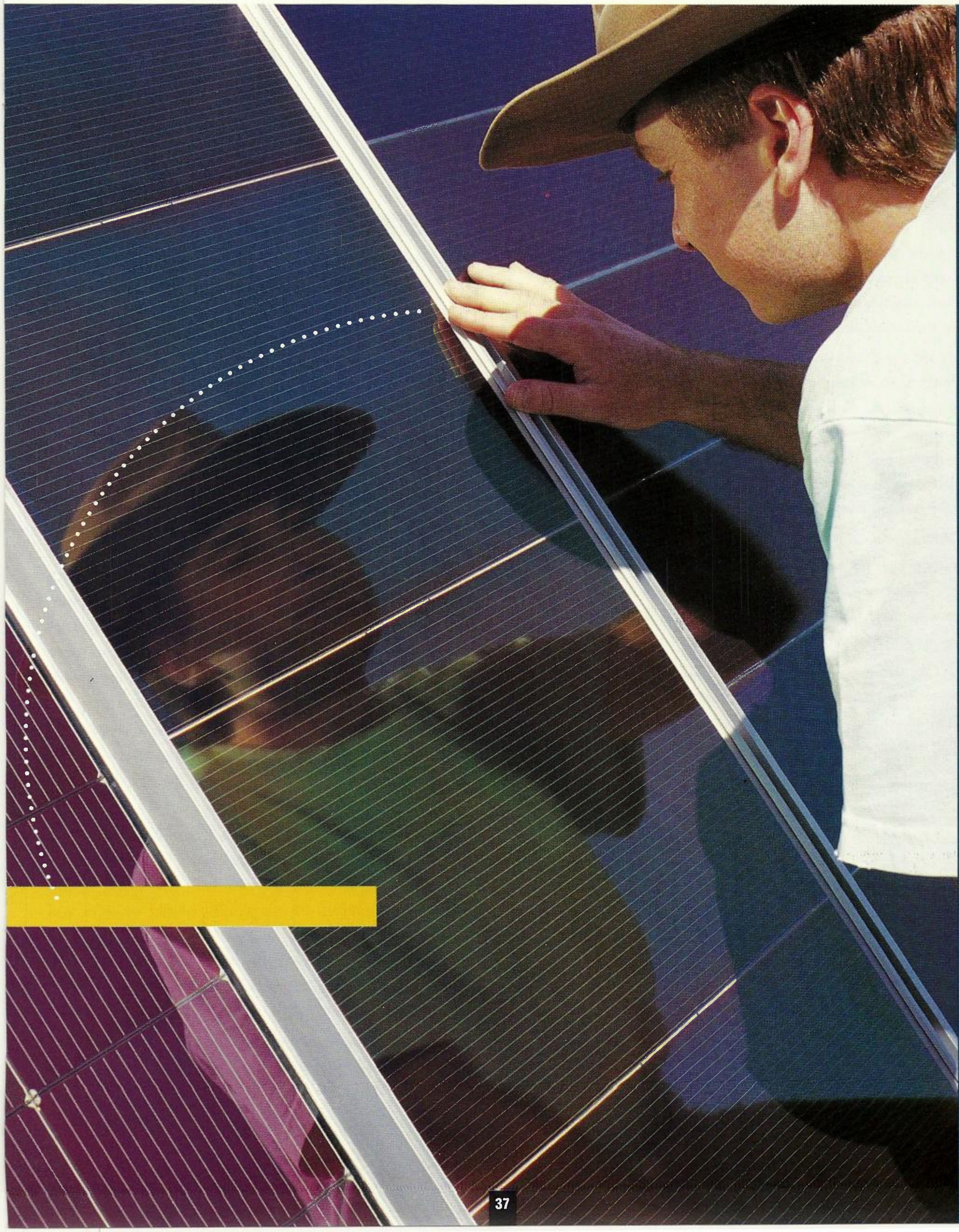
In this project, prototype solar modules are subjected to a range of laboratory tests, as well as undergoing field exposure at selected sites.

While solar modules are now the preferred energy source for most smaller power applications, hybrid power systems, which combine energy from solar, wind and diesel generator sources, have been shown to be cost effective for larger power applications. This is particularly true if the wind conditions are favourable.

In recent years, TRL has been assessing various wind powered generators, and developing design techniques and control strategies for hybrid power systems. By appropriately sizing each of the energy sources, the total system cost and the operational costs can be minimised.

TRL has devised sophisticated control systems to extract as much energy as possible from the renewable sources, while reducing diesel running time and thus keeping fuel and maintenance costs low.

Brendan Edwards inspecting a solar panel at one of TRL's reliability test sites.



Human – Machine Interactions

Technology which intimidates will not be used to its full potential. TRL is working to ensure people get maximum value from modern telecommunications technology by designing services which are easy to use.

Most people have had some experience with modern technology where the operation of the equipment is so complex, that only few of the features are used on a regular basis and to perform other functions requires constant reference to the instruction manual.

As the use of technology penetrates deeper into our daily lives, appliances must be "user oriented" for them to be widely accepted. No longer can manufacturers pass "function oriented" equipment onto consumers and expect widespread acceptance of that equipment. There now has to be detailed attention paid to how people interact with machines before they are put onto the market.

This point is also true of modern telecommunications services. How people use services and how services relate to each other are important issues Telecom must consider when developing new products. Developing a standard "look and feel" is just as necessary as developing the features of the service.

At Telecom Research Laboratories (TRL), how humans relate to modern telecommunications equipment and services is being studied, so these interactions can be more useful, satisfying and easy.

Voice Controlled Interactive Services

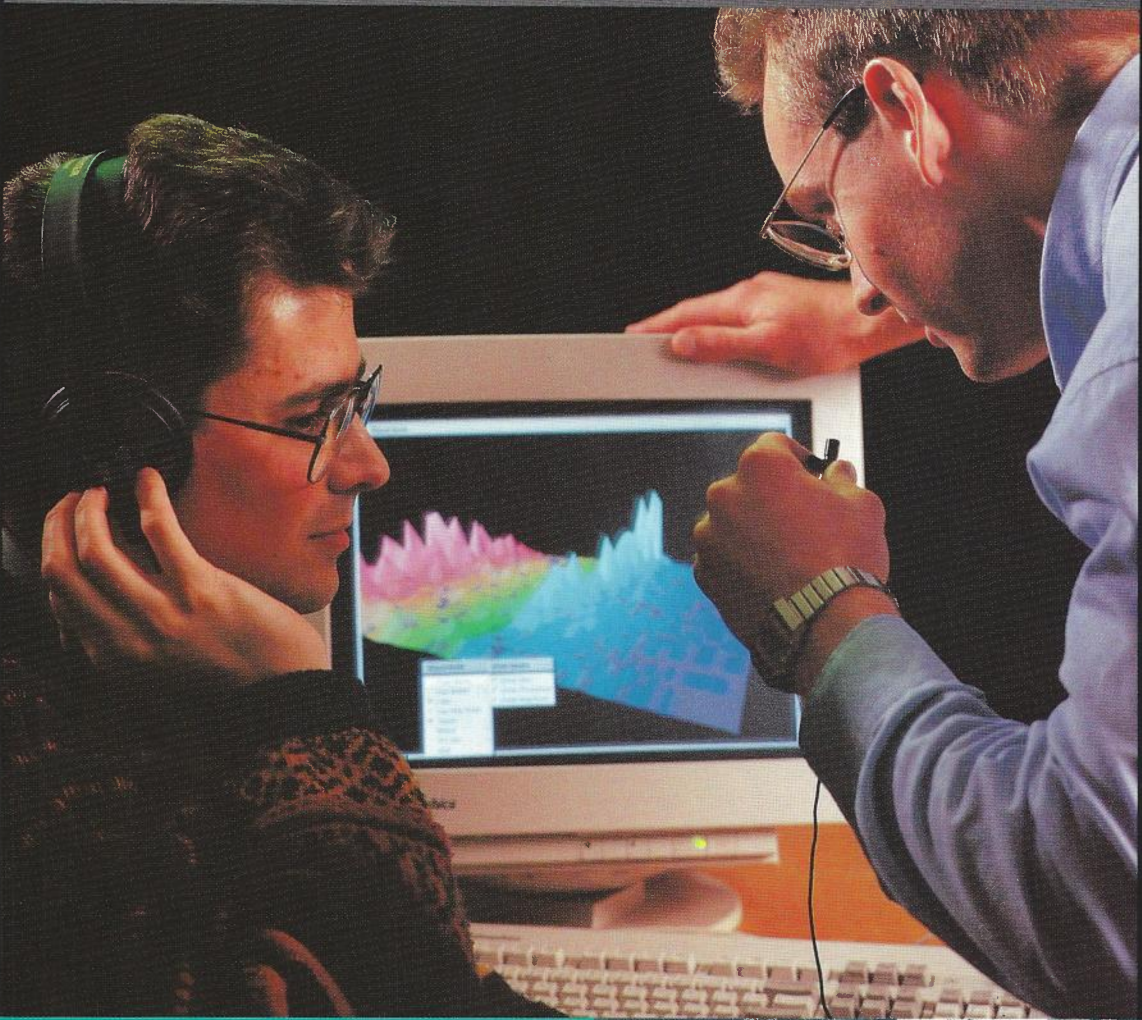
Interactive telephone services are commonly used and most people have had some experience with them. They are the type of service where a computer on the other end of the telephone provides some information and then gives instruction on how to proceed with the transaction, whether it be paying a bill, getting to the department you want or getting some information. The caller provides the information by using the keypad to enter numbers.

The key technology behind the voice controlled interactive service is speech recognition.

There are many factors affecting speech recognition. It is relatively easy to develop an appropriate machine to recognise a specific person's voice, using isolated words from a small vocabulary and using a high quality microphone to talk to the machine. It is a lot more difficult to achieve a system that has speaker independence, (that is, it does not matter who is using the service), to have the computer recognise a continuous string of words with a large vocabulary and using the relatively lower quality telephone to speak to the machine.

There are many possible uses for effective voice controlled systems. Certain directory assistance tasks could be automated to release staff for other tasks. Hands free operation of car phones would be safer and more convenient with voice dialling and control. Information retrieval systems could be automated to provide fast, economical, reliable and useful services.

However, for the control of simple service, using a keypad telephone may be more accurate in the short term. Voice recognition will be used for service access



Todd Sidney and Tim Alton using a speech analysis program to graphically represent voice frequencies.

by rotary dial telephone users. Ultimately, the researchers predict that voice recognition will be the preferred means of service control.

Voice controlled services with as few as 40 words vocabulary would allow for many useful services to be developed, but TRL is also looking at advanced services which could use a vocabulary of greater than 1000 words.

To do this, the researchers are breaking words into sub-unit parts. There is a relatively small number of sub-unit parts which make up the language.

These sub-word units are then analysed using spectral and statistical methods, which are very complex. A statistical model is developed for a word, but it has to take into account the high degree of variability inherent in the spoken word. A person rarely says the same word in exactly the same way.

The speech recognition processor analyses the probability that a series of sub-word units constitutes a particular word. The highest probability declares the word.

The primary focus of this work is to develop useful, commercial applications and services.

The Human Element in Interactive Voice Response Systems

Telecommunications technology can open up all sorts of possibilities for communication and gaining access to information, but even the best technology in the world is next to useless if people find it too difficult to use.

Throughout 1993, the human factors group continued to work with developers of telecommunications services so that by the time the services are offered to the public, they are useful and easy to learn and use.

One major area of work was with interactive voice response (IVR) systems. Customers interact with such systems over the normal telephone to access information, make transactions or communicate with other people in special ways. The system gives recorded instructions (voice prompts) to which the user responds by pressing keys on the telephone, or in some cases, where new speech recognition technology is used, by speaking words into the telephone.

Standardisation of procedures between different systems makes them easier to use. In the past, with the absence of standards and guidelines for the design of IVR systems, many services were developed in isolation and operated quite differently from each other.

For example, different systems within Telecom Australia use the star and hash keys on the telephone for completely opposite functions. It would be easier for users to have the keys perform the same function, no matter what system they were using.

To avoid these problems, the Human Factors Group, with the support of various product areas in the company, has been actively involved in the development of Australian standards for interactive voice response systems. These will ensure that different Telecom services use the same procedures.

Another important element in developing IVR systems is to have a good understanding of potential users of the system. Understanding users and their needs is a critical part of the design and evaluation of services.

A typical human factors evaluation of a new or developing service therefore begins with an analysis of needs and capabilities of users of the proposed system. This information is gained by interviewing product managers, marketers and where possible, actual or potential users.

Once a system is available, the human factors specialists interact with the service extensively to identify what aspects of the interface might cause problems for users. The idea is to test the system to its limits and to make as many errors as possible.

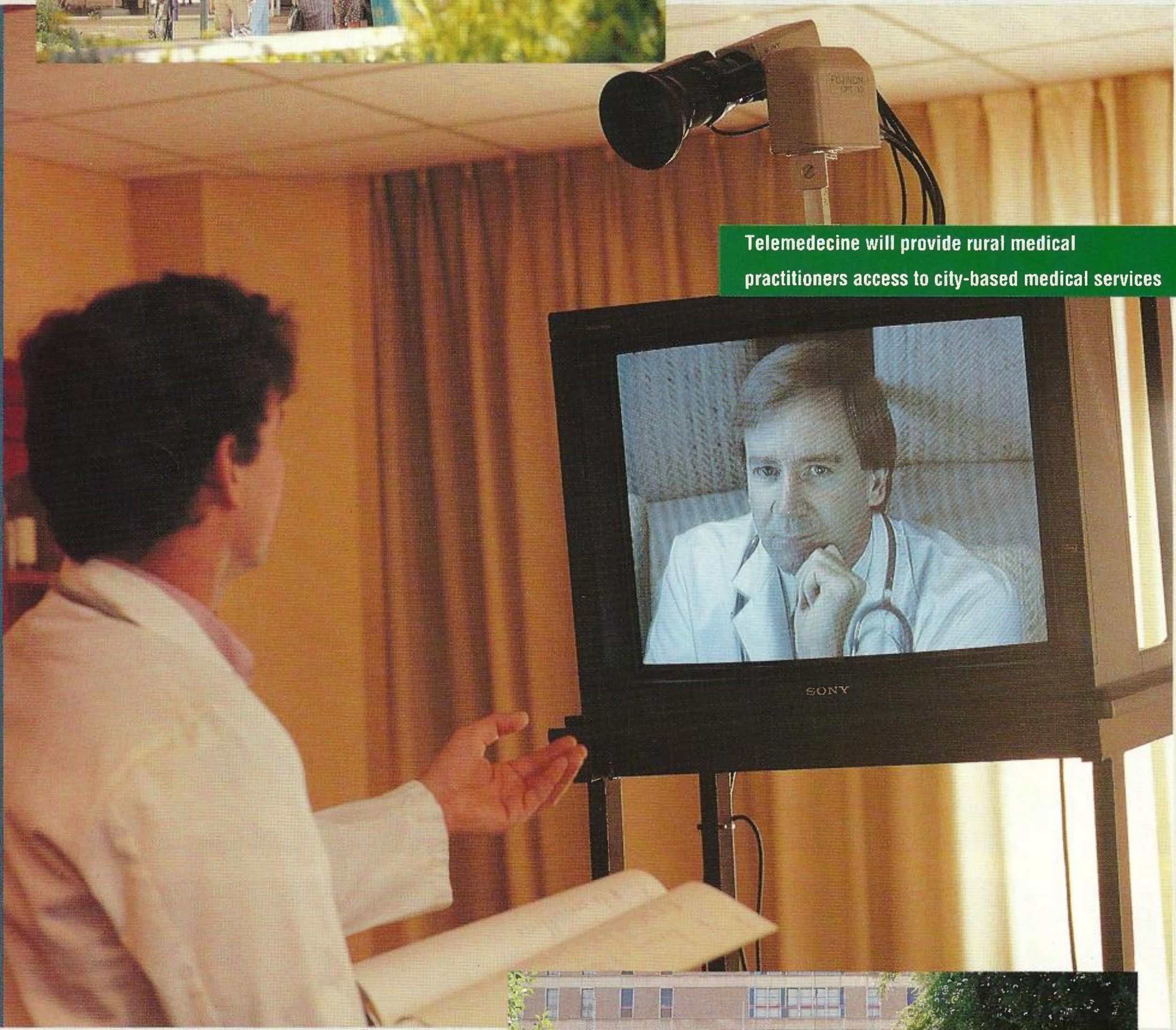
Based on the outcomes of this evaluation, they devise tasks which can be tested with the users. The tasks include typical and potentially problematic ones. Users are observed intensively as they perform the tasks and a record is made of what users do, where they experience problems and their attitudes to the service. The Human Factors Group then work with the service designers to determine strategies for overcoming problems. Relevant modifications are made and the testing procedure is repeated until a satisfactory product is developed.

These types of procedures have been used for several IVR services in recent years. One worked on in 1993 was Telecard, which allows a person to make a call from any telephone and have the cost of the call charged to a business or home telephone account. Several enhancements were planned for Telecard and one was to introduce speech recognition technology. Given the significant number of rotary dial telephones and other telephones in Australia without touch tone dialling, adding speech recognition enables users of these telephones to have access to the automated Telecard service.

The Human Factors Group assisted with the design of the new voice prompts. They drew on knowledge gained through earlier testing of the existing Telecard service and of other services using speech recognition technology, such as VisaPhone and the recently launched HomeLink 1800 service. In the design of such systems there is a need to resolve issues such as how to cater for both new and experienced users, how to offer help to users and how to deal with the slow nature of the speech recognition component.

Experience gained from each IVR system evaluation is used to help develop subsequent systems. While this does not eliminate the need for user testing, it speeds the design process. Based on this experience, specific guidelines are now under preparation to assist Telecom developers of IVR systems to build in maximum useability from the outset. These guidelines will be included in the new Human Factors Kit.

Jo Chessari (left) and Liz Bednall (right) recording the responses Karyn Burger (centre) makes to voice prompts.



Telemedecine will provide rural medical practitioners access to city-based medical services

Telecommunications in the Health Sector

Access to a high standard of health care is demanded and expected in Australia, but for many communities in rural Australia, this access is not readily available.

Generally, it is very expensive to transport and maintain country patients in city hospitals and often, if a little more information was available, or a specialist opinion could be sought, there may not be a need to move the patient at all. It is also very expensive and time consuming to take rural health workers to cities for specialist training. Country practitioners often face professional isolation and do not have easy access to allied health and medical specialists.

So the potential exists for modern and emerging telecommunications technology to greatly improve access for rural patients and health professionals to advanced services and training usually only available in the cities.

For these reasons, a telemedicine trial was established to determine what assistance modern technology could provide the health sector of a rural centre. Between September 1992 and July 1993, the Information Flow Studies team from TRL evaluated a telemedicine trial in South Australia, between the Royal Adelaide Hospital and the Whyalla Base Hospital.

The trial investigated the use of a two-way video-conferencing link between the two hospitals. The link was tested to determine its use in three main areas;

- clinical consultation between the two hospitals;
- continuing education and training purposes; and
- general and professional meetings.

Other possible uses include;

- accessing databases and research information;
- consultations with colleagues;
- on-line ordering of supplies; and
- on-line ordering and receipt of tests for patients.

Facility for image transfer for pathology and radiology applications was also included.

The trial was established to evaluate how people interact with the technology, to determine what works and what does not work and why, to talk to users of the technology to assess the benefits, the limitations and the potential of the techniques and the technologies, and to assess the likely impacts of these services on work practices and institutional structures.

The importance of this trial work can be seen in the results from the Adelaide/Whyalla Telemedicine Trial.

Before the trial, it was hoped the system would be widely used to support decision making in emergency situations and for consultations with distant specialists. This did not prove to be the case for a variety of reasons. There was a lack of access to adequate bandwidth (the later half of the trial ran at 128 kbit/s), the location of the facilities was a problem and there were many time pressures on the specialists.

Initially, it was also thought that clinical consultation would be the most important and popular use of the link between the two hospitals. However, the trial found that staff at Whyalla gained the biggest benefit from continuing medical education. This education was conducted at all levels of staff within the hospital. Patients also expressed satisfaction at having easy access to city based medical specialists.

The clinical sessions were not as successful as anticipated mainly because of the limitations of the equipment used in the trial and because of the limited bandwidth available.

In a clinical session with a dermatology patient in Whyalla and a specialist in Adelaide, the definition of the image was not sufficient to allow for a diagnosis to be made. However, videoconferencing did prove to be beneficial for on-going management of psychiatric cases.

Indeed, one of the findings of the trial was that bandwidth on demand would be a big advantage for telemedicine. This would mean that a simple one-to-one conversation could be conducted at low bandwidth without paying for the full bandwidth required for the transmission of images such as pathology and radiology results.

The trial did not use the latest videoconferencing technology and it was still judged to be successful. This shows the potential for telemedicine in Australia using the latest equipment is very promising.

Information Management

TRL maintains a considerable effort to communicate with many audiences to ensure that Telecom gains maximum benefit from information acquired from a wide range of sources, including its own research program.

With the increasing complexity of the modern telecommunications network, there is an increasing need for people to be informed about how to use and operate the services and to know what new technologies are on the horizon, so they can prepare for the eventual introduction of new products and services.

Telecom Research Laboratories (TRL) maintains a significant effort to communicate with a range of audiences, including the business units of Telecom. To be effective, this communication has to be clear and concise and directed to a range of audience needs. An important aspect of this communication is keeping the decision makers of the country aware of the latest developments, so informed decisions can be made.

Within Telecom as well, there is a great need to effectively and efficiently disseminate information from a wide range of source materials. This in itself is a complex job, given the number and diversity of staff in the company.

And in an increasingly competitive environment, there is a need to protect the intellectual property of the company.

Communication management also embraces the encouragement of skills and expertise in the wider community. This is achieved through sponsorship of various educational and other activities.

National Information Resource Centre

Information is a strategic resource which, when properly utilised and managed, provides a company with a vital competitive edge. In Telecom Australia, much of the responsibility for the strategic management of information lies with the National Information Resource Centre (NIRC), part of TRL.

The NIRC fulfils a number of functions. It obtains and analyses information of a business, scientific or technical nature for the benefit of Telecom. It assists Telecom staff to better manage information, to the advantage of themselves and the company. It also purchases and distributes information from a wide variety of sources.

To fulfil these functions, staff at the NIRC have access to a wide variety of domestic and international databases and CD-ROMS. NIRC staff use these to draw up company and competitor profiles, industry analysis, state-of-the-art technical reports and a variety of research reports. Many bulletins, which focus on critical business and technical issues are also produced. For example the NIRC uses these bulletins to support Telecom's efforts in emerging broadband markets, in exploring overseas business opportunities and in keeping track of competitors' activities. The NIRC also provides support to Telecom's Quality Management efforts through its own Quality Manager and with its Quality Focus bulletin.

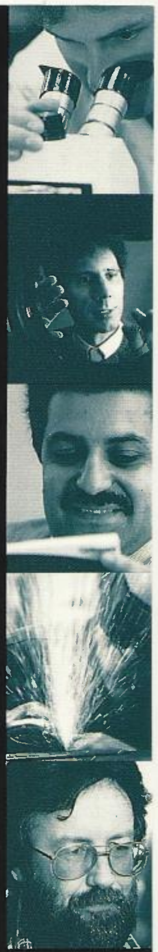
Many NIRC information products are distributed electronically throughout the company. This in turn makes it easier for managers, when required, to disseminate the information to their staff.

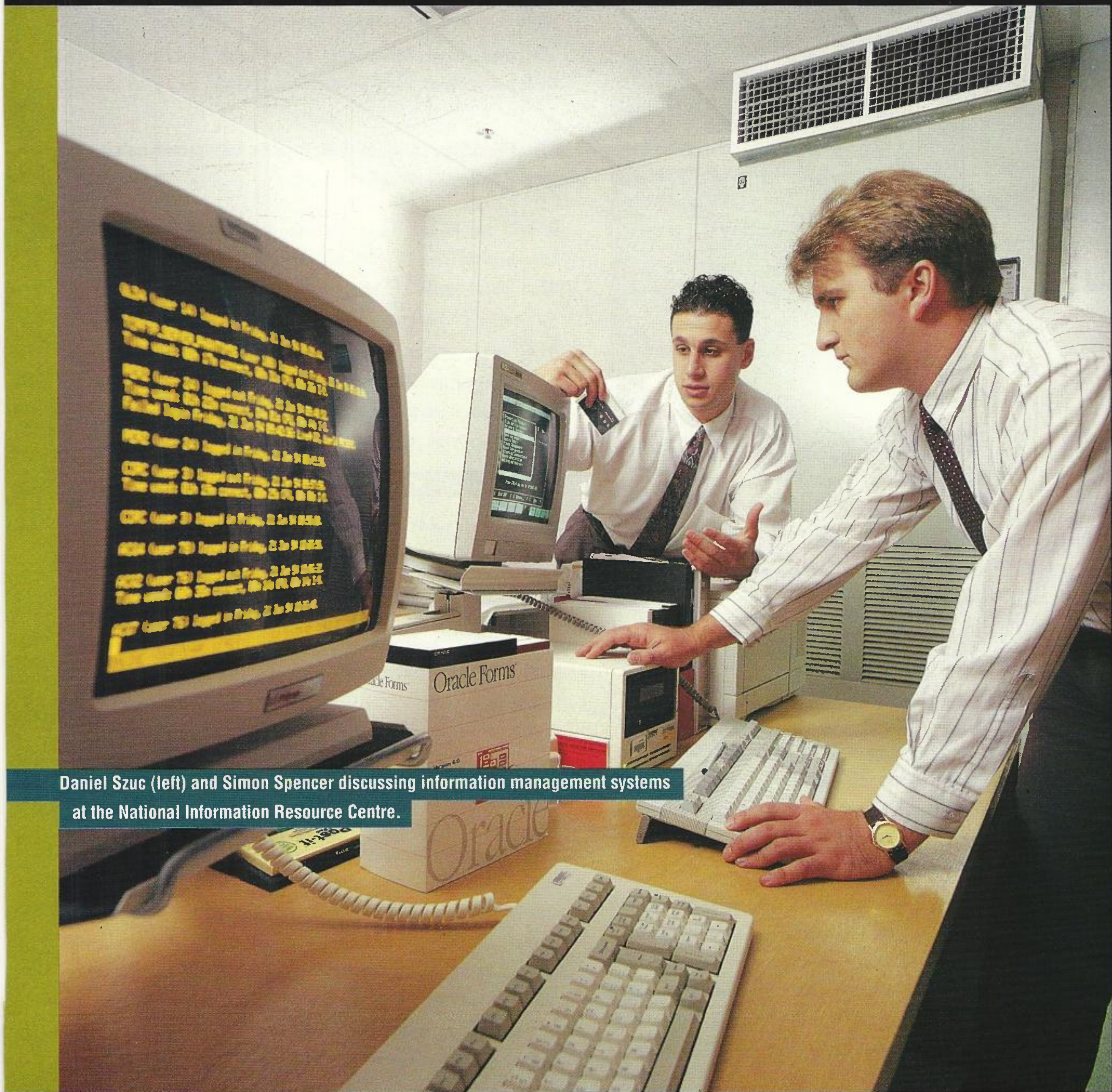
The NIRC's collection is a valuable resource to the company. It includes a wide variety of journals, standards and specifications, reference materials and business intelligence reports. These materials are purchased for the benefit of the whole organisation and are indexed by NIRC staff for easy accessibility. NIRC staff can also advise individuals on where and how to obtain particular publications.

The NIRC has locations in each of the major mainland capital cities. Staff in these locations work as a team in conjunction with Melbourne-based staff to provide Telecom with a seamless national information service.

To further increase the availability of information throughout the company, the NIRC purchased a new computer system in 1993. In conjunction with Oracle, a model system is now being developed for managing text-based information. The NIRC has become a focus in the company for advice on the management of text-based information.

As a vital competitive resource, the NIRC serves Telecom staff only. The information centre does not provide information to outside companies or organisations.





Daniel Szuc (left) and Simon Spencer discussing information management systems at the National Information Resource Centre.

Product Development Fund

The Product Development Fund assists Australian entrepreneurs and inventors to design and develop products which have the potential to benefit Telecom Australia.

The focus of the fund is to support individuals and small to medium sized companies who would not be able to take their ideas from initial concept, through testing and on to final product.

During 1993, two products which will be used by Telecom were developed with assistance from the Product Development Fund.

One product is a security device for manhole and pit covers. The company which designed and developed the devices, Electronic Sign Switching, had supplied locking devices to Telecom and saw first hand the problems which existed in providing security for the covers.

Grahame Kermonde, of Electronic Sign Switching, indicating the locking mechanism attached to the underside of a pit cover.

After applying for support from the Product Development Fund, the company devised two locking devices for the manhole and pit covers. The primary device is a simple locking plug, which fits into the keyhole of the cover. This prevents the entry of fingers or devices to lift the cover. It also has the benefit of preventing the entry of dirt and other unwanted materials into the pit.

The second security device is a locking mechanism attached to the underside of the cover. When locked, this mechanism will withstand a vertical force in excess of 100 kilograms, which puts lifting it out of the range of most people.

Throughout Australia, there are about a million pits providing access to telecommunications cables. Securing the covers of these pits to allow authorised access only is a big responsibility. This solution was achieved by supporting a small firm through the Product Development Fund to work with Telecom to solve the problem.

Another important device which was developed after four years of support from the Product Development Fund is an Impedance Measuring Instrument, which tests the charge of batteries used as a back-up power supply in telephone exchanges.

In normal circumstances, batteries are kept on charge by mains power and it is difficult to test whether they are fully charged or not. There are two ways of testing them, one is to turn off the mains power and see if the batteries maintain the exchange. The other is to disconnect the batteries, apply a load to them and then measure the rate of discharge. Both tests are time consuming and cumbersome.

The Impedance Measuring Instrument is a portable device which takes about 15 seconds to test a battery. It was developed by Elcorp Pty Ltd, who worked closely with TRL to test the ideas and develop a prototype instrument. The battery does not have to be disconnected from mains power and testing batteries with it is a one person operation.

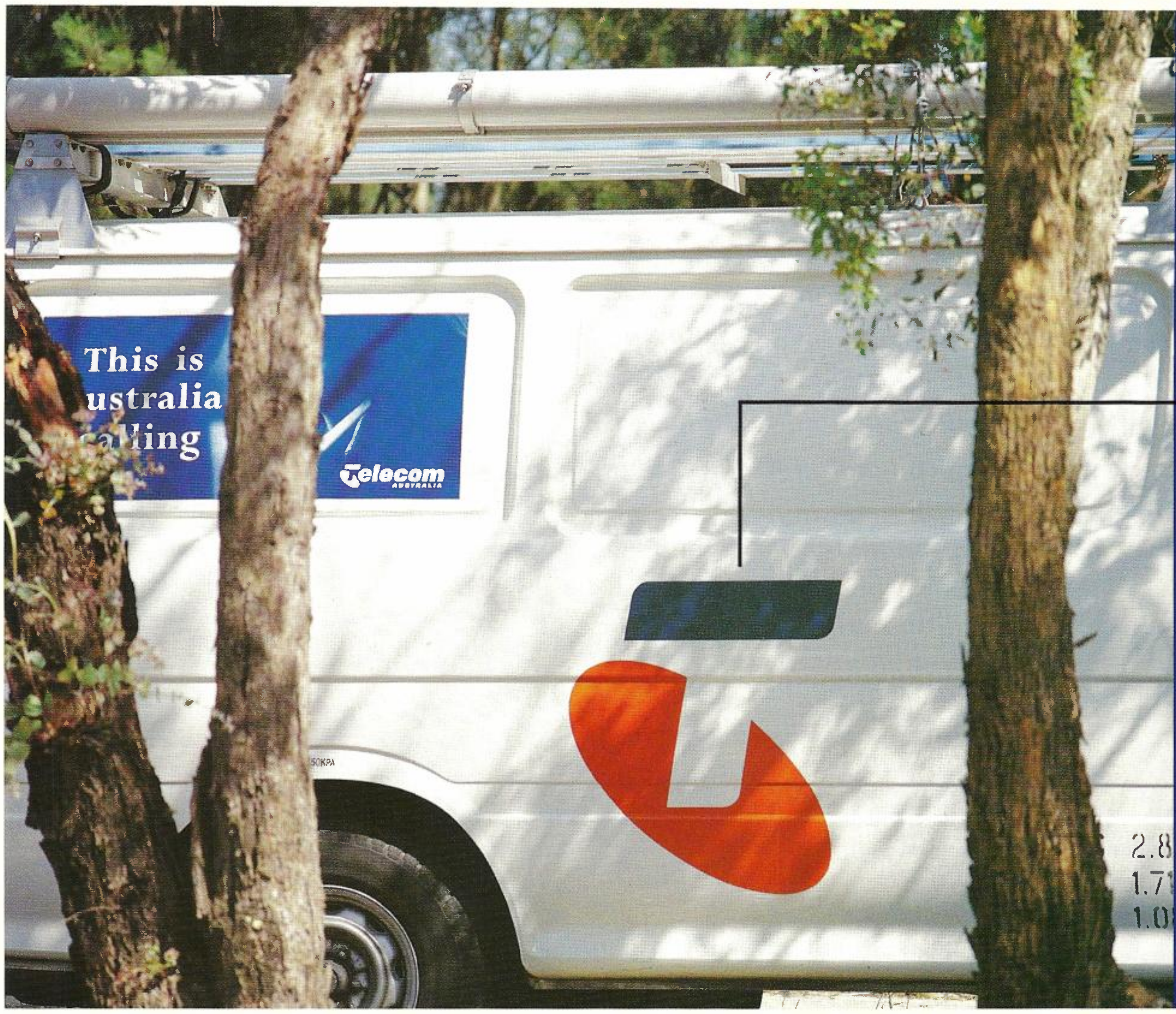
The Impedance Measuring Instrument has the potential to become part of a permanent fixture in an exchange. It will be linked to a data logger and alarms and will automatically test the batteries at a pre-set interval. The alarm will be triggered if there is any change in the battery charge.

This instrument has widespread application in the telecommunications network, but it is also useful for many other situations where batteries are used as a back-up power supply.

Intellectual Property

The legal protection and effective utilisation of Telecom Australia's intellectual property assets is an important part of the overall management of the company. Intellectual property includes patents, trademarks, registered designs, confidential information and copyright. TRL operates an intellectual property consultancy service as a corporate facility for the company.

Given the company's highly technological environment, commitment to substantial R&D expenditures and extensive contracted activity, the negotiation and commercial treatment of intellectual property issues is a key ingredient to Telecom's business success. The major aim of the intellectual property consultancy service is to ensure consistent, business-like practices and processes in managing intellectual property aspects of the company's business. This requires both a sound knowledge of broad corporate policies and objectives and a strong liaison with the business units of Telecom.



Telstra Corporation's distinctive new logo is an important marketing asset both in Australia and overseas. Care is being taken to legally protect the proper use of the logo.

TRL, in close co-operation with the Corporate Solicitor and Business Unit legal advisers, offers a range of services, including:

- legal intellectual property advice via National Manager, Legal & Compliance, Network and Technology who services the intellectual property group;
- assistance in the negotiation and preparation of a wide range of commercial agreements, research and development agreements and intellectual property licences;
- advice in relation to copyright and the protection of confidential information;
- management of Telecom's patent, registered design and trade mark portfolios;
- protection of the company's interests in the event of intellectual property disputes, such as patent or trade mark infringement actions, or the misuse of confidential information; and
- business intelligence on the intellectual property activities of other companies in the market place.

The work of this group has become even more important over the last year with the change of name and identity of the company. In this respect, the intellectual property group is responsible for the protection and policing of the new name (Telstra) and logo both in Australia and around the world.

Intellectual property is also particularly important for the research and technology areas of Telecom where considerable resource is expended on activities such as systems development and software generation.

To get maximum advantage from these developments, a strong commercial focus is required at the earliest possible stage in the development process. The intellectual property group assists in establishing this business framework through the securing of a level of ownership and rights necessary to deliver the desired business outcomes for the company.

Top Rewards for Students

Fellowships were awarded to students from South Australia, Western Australia and Victoria in the 1993 TRL Undergraduate Fellowship Awards. The eight students were in their final year of Engineering, Science/Engineering and Science and were all heading for first class honours in their degrees.

The 1993 Telecom Undergraduate Fellows are:

Engineering	
Linda Davis	University of Adelaide
David Heard	University of Adelaide
Science/Engineering	
Eu-jin Ang	University of WA
Jason Choong	University of WA
James Manger	University of Melbourne
Hans Trinkle	University of Adelaide
Jennifer Yates	University of WA
Science (Hons)	
Marcus Odgen	Monash University

The Fellowship provides a stipend for twelve months to the students. In addition, they had the opportunity to do paid work, with a mentor, at TRL during the long University break.

The students gained a greater appreciation of the research and employment opportunities which exist in Telecom. They are offered an opportunity to be interviewed for a position with Telecom after graduation, thus enabling Telecom to have first choice of the top graduates in Australia.

Fellowship winner, David Heard is congratulated by Frank Blount, Chief Executive Officer. Looking on are Ray Liggett, Director of Research (left) and Fellowship winners Linda Davis and Hans Trinkle.

A Successful "Olympic" Year

A record of seventy-three countries participated in the 1993 International Mathematical Olympiad which was held in Istanbul, Turkey. Australia has achieved its best International Mathematical Olympiad results ever, with all of its team members receiving medals.

The team comprised;

Anthony Henderson	NSW	Gold Medal
Frank Calegari	Victoria	Silver Medal
William Hart	Tasmania	Silver Medal
William Hawkins	ACT	Bronze Medal
Rupert Mc Callum	NSW	Bronze Medal
Simon Schwarz	NSW	Bronze Medal

Coming thirteenth overall, Australia achieved higher scores than any other participating Commonwealth country. It was also ranked ahead of countries such as France, Japan, India and South Korea.

The top countries were Peoples Republic of China, Germany, Bulgaria, Russia, Republic of China (Taiwan), Iran and USA.

The identification and training of the Olympiad team is organised by the Australian Mathematical Olympiad Committee, an activity of the Australian Mathematics Trust which is under the auspices of the University of Canberra. The Olympiad team is jointly sponsored by Telecom Australia, IBM and Westpac.

Presentations on Broadband Services

TRL had a significant input into providing information to the Federal Government on the future of telecommunications both in Australia and internationally. Australia has a telecommunications regulatory regime which is unique in the world and which has the potential to provide a lot of opportunities and great growth for Australian telecommunications businesses.

The opportunities exist in providing pay TV and other interactive services. To achieve the possible potential available for Australia, a strong partnership of Government, Telecom Australia and Australian industry will be necessary.

A series of talks and presentations to politicians and their advisers was conducted during 1993 and these helped to maintain the information flow between Telecom and the Government.

In April, the Minister for Communications, the Honourable David Beddall MP, visited TRL, and was given a presentation which covered the vision for future telecommunications. Information included; the types of services which will be developed; how they will affect education, entertainment and business; the commercial viability of the future services; key factors for success and what it will take to achieve their potential.

After Mr Beddall's visit, the economics adviser to the Prime Minister also visited TRL, as did the Caucus Committee on Transport and Communications.

In October, TRL staff were prominent in presentations to members of Parliament in Canberra.

Part of the message from Telecom was that it is important to make decisions about technology on the basis of what services the technology will provide and on the economics of providing those services. Decisions need to be technology neutral and Telecom will consider all relevant technologies to support services.

Rear L to R: Rupert McCallum, Neil O'Keefe (MP), Frank Calegari, Anthony Henderson, Ray Liggett (Director of Research), William Hawkins. Front L to R: William Hart, Simon Schwarz.

Telecom has already accumulated a lot of experience with some of the new broadband services which will become available during the next few years. There have been trials of optical fibre installed to the home and a hybrid optical fibre/coaxial cable system. Also, many top hotels have installed Lasercast, a video service over optical fibre. TRL underpinned all the development of these trials and services, from the strategic planning to testing, installing, commissioning and the day to day running of the trials and services.

Overall, TRL is concentrating on developing the next wave of applications and services which will incorporate interactivity. Broadband services will be the basis of the "information superhighway", where access to information from anywhere in the world and in any form will be readily and easily available.

The Hon. David Beddall M.P., Minister for Communications, with Group Managing Director, Network Technology Group, Doug Campbell (left) and Doug Capp, Department of Communications.

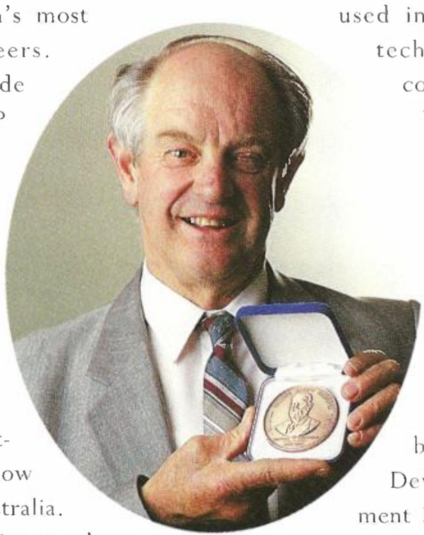
Harry Wragge

An acknowledgement

THE list of awards and honours bestowed on Harry Wragge is testimony to his outstanding contribution to Australian telecommunications.

In the 1989 Australia Day Honours list, Harry was made a Member of the Order of Australia, in recognition of his lifelong contribution to telecommunications technology.

He is a holder of the Kernot Medal, an honour bestowed by the University of Melbourne. This is a prestigious award made to Australia's most distinguished and eminent engineers. Other holders of the award include Sir John Monash, Brian Loton of BHP and Sir Arvi Parbo. When this medal was awarded in 1990, the citation stated that the medal was in recognition of his "distinguished achievements in and major contribution to telecommunications research and to professional engineering education in Australia."



In 1991 he received the rare distinction of being elected as Honorary Fellow of the Institution of Engineers, Australia. This was made for conspicuous service to the profession and eminence in engineering and kindred sciences.

Harry Wragge is an internationally noted expert in switching applications. He showed unparalleled technological vision from his earliest days as a young engineer with the PMG Research Laboratories, which he joined in 1955.

Harry was instrumental in establishing the Integrated Switching and Transmission (IST) model exchange in the 1960's. The project, which investigated the integration of digital switching and transmission, was at the forefront of developments in digital telecommunications internationally. It introduced network capabilities that are now fundamental to modern telecommunications.

This work in switching, along with his latter efforts to have the QPSX switching system and then ISDN terminal equipment accepted within Telecom Australia, became highlights of his career.

QPSX now forms the basis of FASTPAC and is now used internationally. It is "home-grown" technology, which was developed cooperatively with the University of Western Australia and TRL.

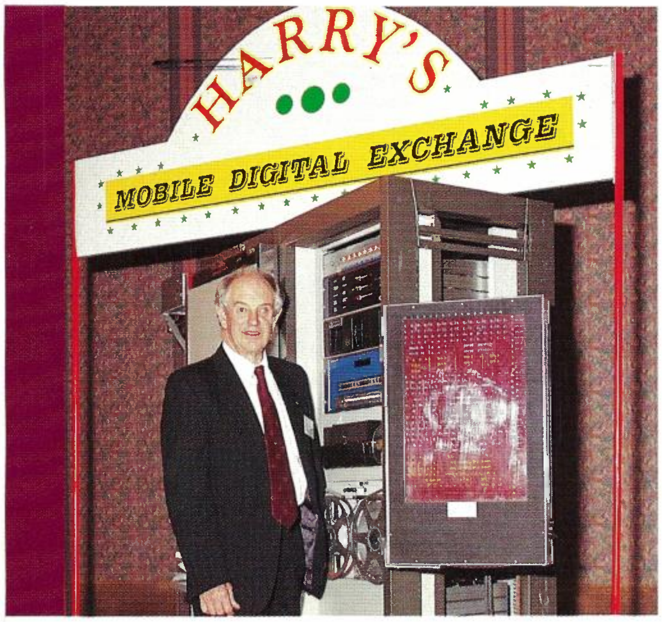
This, along with the digital radio concentrator system, were the first pieces of home grown technology to be introduced into this country.

In 1981, Harry Wragge was seconded to assist the Davidson Inquiry into Telecommunications Services in Australia. After the Inquiry, he became Assistant Director, Strategic Development in the Business Development Directorate. Harry was Director (later Executive General Manager) at Telecom Research Laboratories from 1985 to 1992. He then became Chief Technical Adviser to the CEO, Frank Blount.

Another feature of Harry Wragge's contribution to telecommunications research is the links he forged between Telecom and academia. Throughout his career, he had a strong commitment to the development of training and teaching within the engineering profession. He fostered the concept of Centres of Expertise, whereby a University with a "critical mass" of staff and expertise in a relevant engineering area was encouraged to further develop that expertise and to work with Telecom in developing telecommunications technology. This had other benefits in that TRL was able to expand its research capacity through seed funding of the Centres creating a flow-on benefit to the teaching capacity of the institution with the Centre.

Harry Wragge was largely responsible for launching, in 1967, the publication ATR (Australian Telecommunications Research), and remained as Editor in Chief until 1981. ATR is published twice yearly by the Telecommunications Society of Australia, and Harry guided its development through to international recognition.

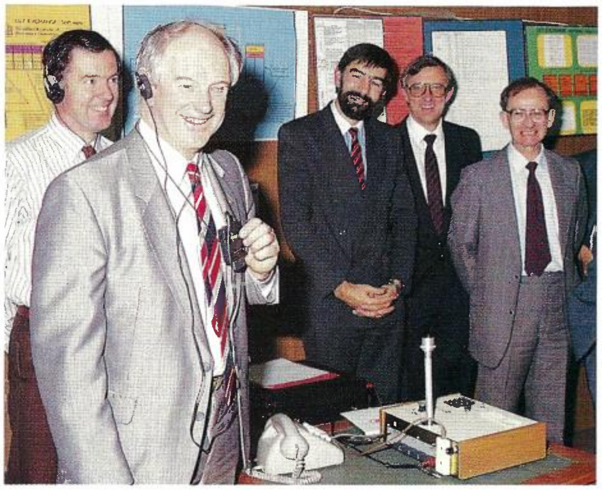
Harry has also made a significant contribution to the international telecommunications forum. His work with the International Consultative Committee of Telephony and Telegraphy (CCITT) study group, responsible for the development of recommendations



for digital switching technology, has been widely acclaimed and rates highly in his own assessment. He was chairman of the group which developed the first set of switching and signalling recommendations for digital switching.

Harry will continue as a consultant with Telecom and has many other projects with academic and engineering bodies. These include:

- Chairman of the Accreditation Board of the Institution of Engineers, Australia, which is responsible for accrediting engineering courses throughout Australia.
- Chairman of the Education Committee of the Federation of Engineering Institutions of SE Asia and the Pacific, which aims to develop mutual recognition of courses across the region.



- Chairman of the Board of Directors of the Australian Information Technology Engineering Centre in Adelaide. This centre links four Adelaide campuses using interactive tele-teaching technology to provide a collaborative teaching program.
- Member of the Strategic Council of the Photonics Cooperative Research Centre. This Council is charged with developing the CRC to be self-funding through commercial activity within four years.
- Member of the Faculty of Engineering and member of the Council, of the University of Melbourne.
- Chairman of the Advisory Board, Australian Science Festival.
- Member of committees of the Academy of Technological Sciences and Engineering.

It is obvious from the list of activities to which Harry is dedicated, he has not really "retired" and he will not have a lot of time to pursue his hobby of wood working and turning.

Telecom has indeed been extremely fortunate in having a person of such calibre as Harry Wragge being involved in the development of the company. His contribution has been outstanding and a great measure of Australia's high standing in the world of telecommunications is due to Harry's efforts.

Harry Wragge, Telecom Research Laboratories acknowledges you.

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