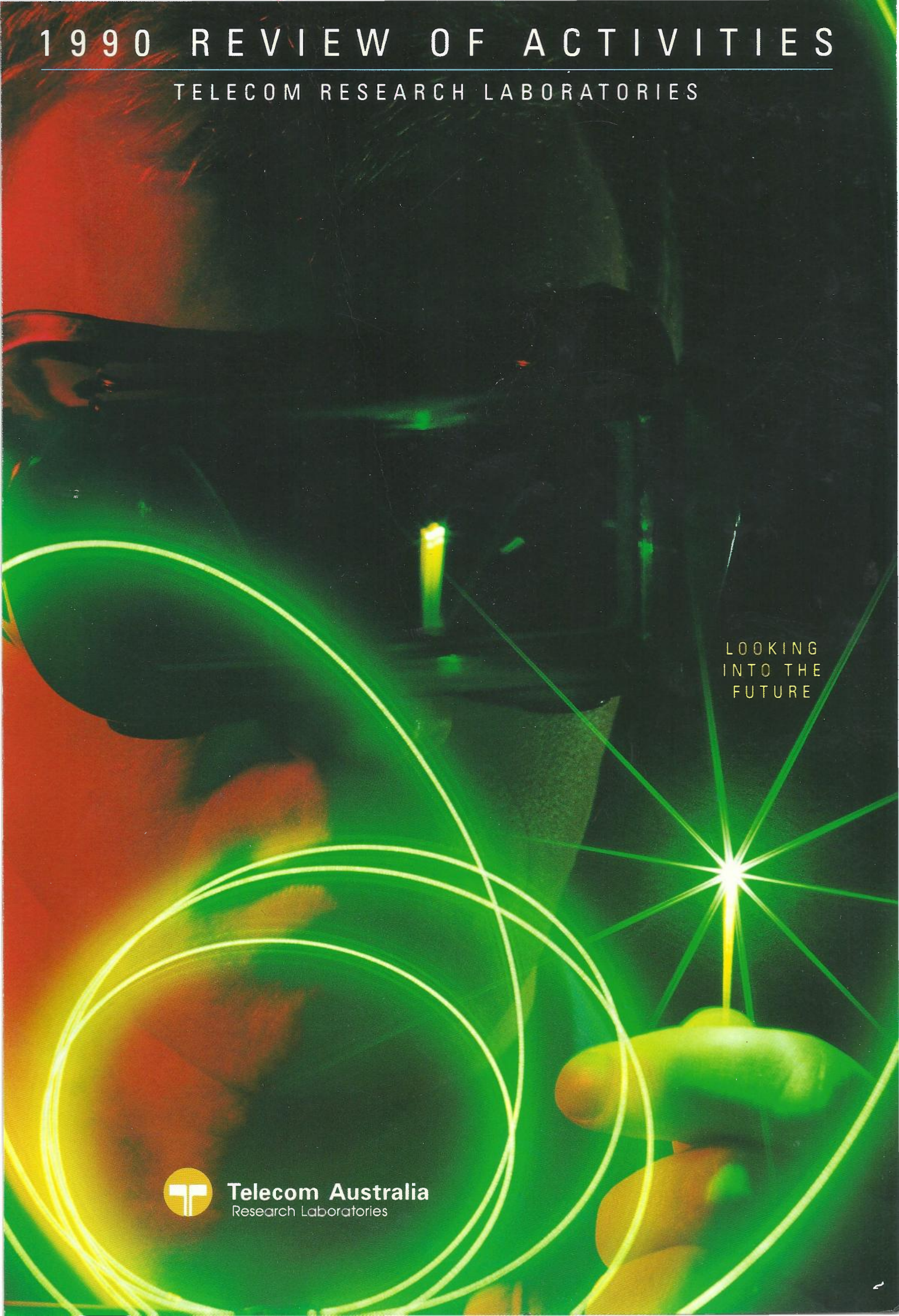
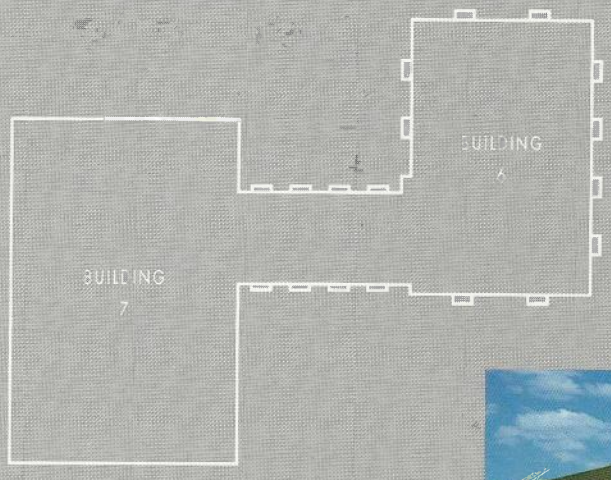
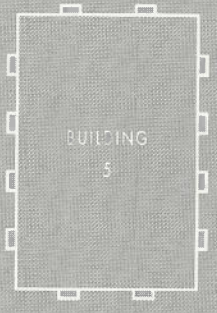
1990 REVIEW OF ACTIVITIES

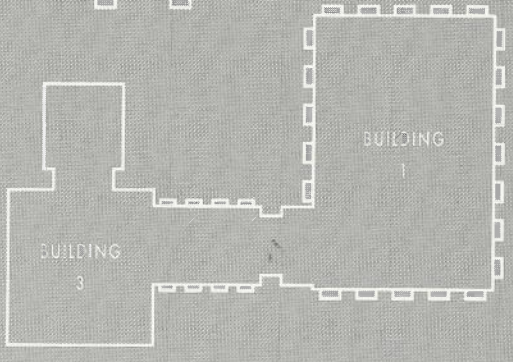
TELECOM RESEARCH LABORATORIES

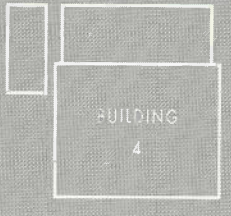


Telecom Australia
Research Laboratories









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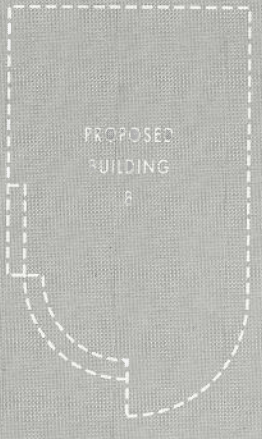

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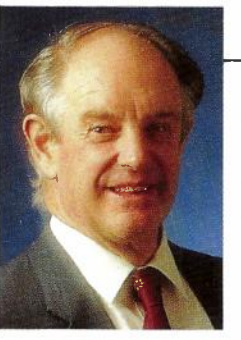
FOREWORD

The activities of Telecom Research Laboratories during 1990 provide a window on the decade that lies ahead - a decade that will be one the most challenging yet faced by Telecom Australia and its Research Laboratories.

Upon its conception in the early 1920s, the Laboratories took on a vanguard role - searching out and assessing the best new technologies from around the world for incorporation into a young nation's fledgling telecommunications network.

The tremendous acceleration in the pace of technological change that has occurred since has served only to reinforce this responsibility. Today, the Laboratories provide Telecom with the resources of a team of highly trained, business-minded scientists, engineers and technicians who can critically assess the merits of new services and products as they appear on the technological horizon.

LOOKING INTO THE FUTURE



Armed with this knowledge and expertise, Telecom Australia will be able to meet the twin challenges of the 1990s: a deregulated telecommunications market, and the increasing complexity of modern telecommunications technologies.

The activities of the Laboratories during the past year reflect its vision for the 1990s, and for this reason we have given the 1990 Review of Activities the theme "Looking into the Future". It is fitting because many of the Laboratories' current research activities will manifest themselves as new services and products during the 1990s.

In particular, 1990 saw advances in the development of Fast Packet Switching - a technology that will be the cornerstone of a new range of image-based services for the 1990s. The Laboratories are at the global forefront of this technology and have taken a leading role in developing the all important international standards. These efforts, years in advance of eventual service delivery, have been made so that Telecom's customers will be able to choose from the widest possible range of terminal equipment made by the greatest number of competing manufacturers.

Telecom Research Laboratories have also been conducting tests of the revolutionary Distributed Queue Dual Bus (DQDB) technology in preparation for its commercial launch. This new service for Telecom business customers will be called FASTPAC and will be Australia's first Metropolitan Area Network service. FASTPAC will be able to interconnect Local Area Networks of personal computers and enable them to send and receive data and video signals at high speed.

When released in early 1993, FASTPAC will represent the culmination of many years of intensive research and development, both by the Laboratories and Telecom's joint venture development company, QPSX Communications Ltd. The Laboratories were first to recognise the potential of DQDB when it was conceived at the University of Western Australia in the early 1980s. Now, after many years of development, this technology has found its niche as a standard for Metropolitan Area Networks worldwide. The export value to Australia is forecast in the hundreds of millions of dollars.

The following pages describe many other research activities that will provide the reader with a view of the road that lies ahead. Whatever the twists and turns of technology trends, Telecom Research Laboratories will continue to research new services and products so that Telecom can continue to be the best provider of telecommunications in Australia.

H.S. Wragge
Executive General Manager

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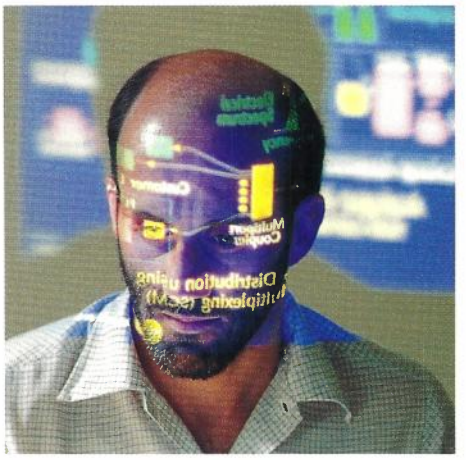

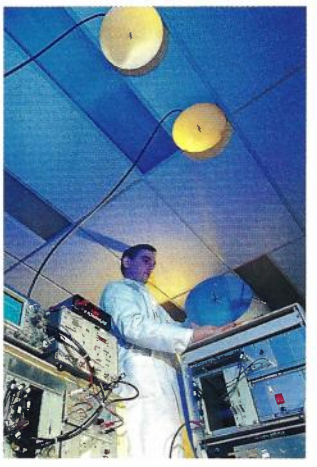

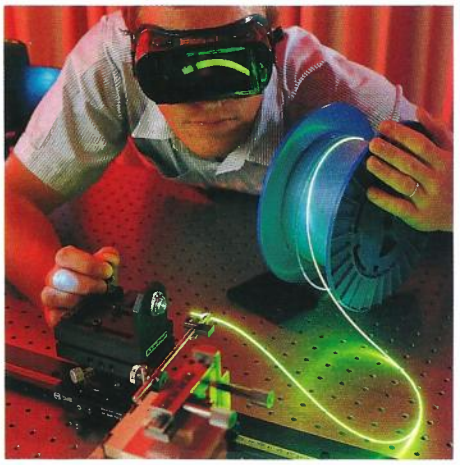

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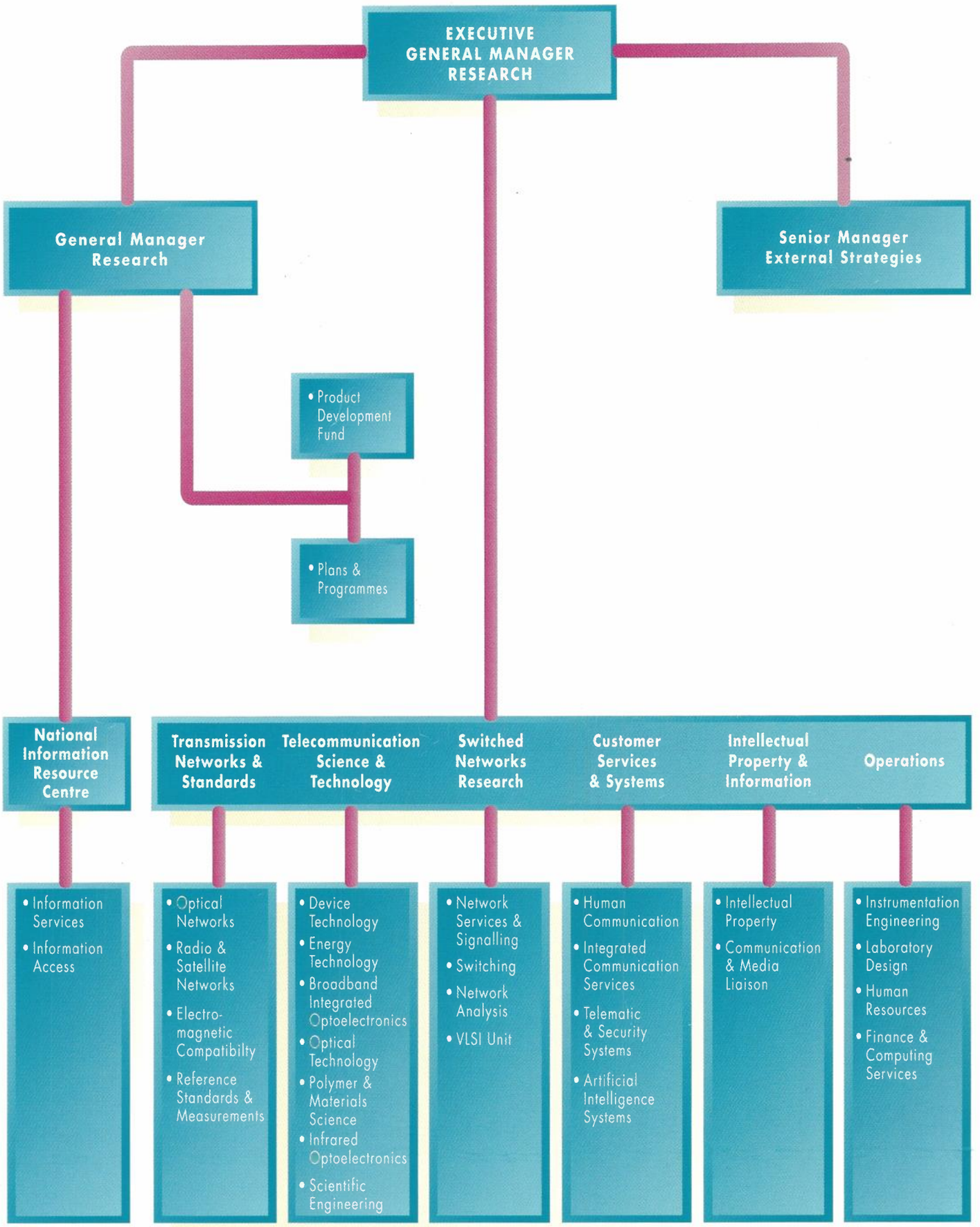
TRL MANAGEMENT COUNCIL

Front seated L to R
Alan Gibbs: General Manager, Transmission Networks & Standards
Harry Wragge: Executive General Manager, Research
Roger Smith: General Manager, Research

Middle seated L to R
Geoffrey Willis: Senior Manager, External Strategies
Brian Donovan: Manager, Communication & Media Liaison
Helen Rodd: General Manager, National Information Resource Centre
Jim Park: General Manager, Switched Networks Research
Noel Teede: General Manager, Customer Services & Systems

Back standing L to R
Owen Malone: General Manager. Intellectual Property & Information
Geoff Mitchell: General Manager, Telecommunication Science and Technology
Brian Douglas: General Manager, Operations

TRL ORGANISATION



MISSION STATEMENT

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

To contribute to Telecom's efficiency and progressiveness in the area of reserved services.

To contribute to Telecom's competitive edge in the area of non-reserved services.

AN OVERVIEW

THE MISSION

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

The mission is being achieved through seven key areas:

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

RESEARCH EXCELLENCE FOR TELECOMS SUCCESS

A SHARED RESOURCE UNIT OF TELECOM AUSTRALIA

TRL is a Shared Resource Unit within Telecom Australia. It is responsible for performing Telecom Australia's research needs. TRL conducts a Research Programme derived from a corporately endorsed and approved Business Plan. The services that TRL provide are available to all other organisational units of Telecom Australia.

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

Deliverables include:

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

THE ROLE OF TRL

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

TRL provides:

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

By providing expert advice regarding the application of new or existing technologies, TRL strives to:

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

TRL provides delegates to participate in the development of national and international standards relating to telecommunications. This is considered a key element in the role of TRL. In this way, TRL can represent both the interests of Telecom Australia and Australian industry in national and international fora. TRL's technical experts are able to debate complex issues from a position of in-depth knowledge and expertise, and can thus influence the development of standards to be in harmony with Australia's telecommunications needs. These fora are also a source of strategic information regarding future trends in service provision and system development. So then, TRL is able to advise Telecom Australia on the current status of technical standards and the probable directions of evolving standards. Telecom can then apply standards in a timely manner with assurance that they are the most up to date, therefore makes the applica-

tions credible and viable. TRL can use this information to their advantage by developing tools that will optimise the application of new standards.

CORPORATE FACILITES

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

- The National Information Resource Centre (NIRC), which provides up-to-date library and information services covering a wide range of topics relevant to Telecom's operations,
- Intellectual Property Consultancy, including the management of Telecom Australia's intellectual property portfolio, and
- Telecom Australia's Technical Reference Standards for Time Interval and Frequency, with accuracy traceable to national and international standards.

The later is funded directly by the Business Divisions and SRUs.

CORPORATE EXTERNAL R&D PROGRAMMES

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

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

TRL MANAGEMENT

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

The Business Plan is reviewed and reformulated annually. Specific research projects must be endorsed and notionally funded either by specific "clients" among the Business Divisions and other Shared Resource Units of Telecom, or by the Corporate Centre.

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

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

RESEARCH PROGRAMME

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

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

TRL STRATEGIC TECHNOLOGICAL THRUSTS

The bulk of TRL's research programme caters to the needs of Telecom's Business Divisions and the customers they serve. Though many are narrowly focused on specific short to medium term needs, most projects follow one or more of the following 11 Technological Thrusts:

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

- Future indoor wireless office networks, mobile satellite networks and advanced micro-cellular networks will need to operate in an already crowded radio spectrum. The challenge for TRL is to refine the design and implementation of new personal communications services so that they are not only technically feasible, but are cost-effective and of high quality.

2. To use optical fibre as the basis for new and widely available broadband services, and to provide a long distance communications medium of low cost and high capacity.

- Optical fibre can deliver new services, such as Pay-TV, to residential customers, and can provide corporate customers with fast, cost saving alternatives to private networks. TRL is working in a variety of optical technologies that, in the longer term, will see the extension of optical techniques from present point-to-point transmissions to routing and switching, and ultimately to an all photonic network.

3. To increase the emphasis on satisfying the human, social and business communication needs of Telecom's customers when planning, specifying and interfacing new products and services.

- The study of human-machine interfaces gives TRL the knowledge to design new services and equipment that are more usable and efficient because they harmonise with customers' natural expectations. Similarly, knowledge of the geographical distribution of customers in relation to the network, and the way telecommunications can enhance the flow of information, allows Telecom to deliver the services and products that customers want, where and when they want them.

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

- TRL is working to provide network-wide capabilities that match those currently available over networks that only serve limited geographic areas, such as Local Area Networks. TRL is at the forefront of developments in Metropolitan Area Networks and a Broadband Integrated Service Digital Network - both public switched networks that can transmit voice, data, image and video at very high speeds.

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

- Telecom needs new network management systems to provide seamless interconnection between its growing range of network services. Using the internationally accepted Open Systems Interconnection standards as a framework, TRL is developing unified interfaces to achieve this aim. Additionally, TRL is using artificial intelligence techniques, such as expert systems, to widen the availability of Telecom's network management skill base.

6. To maintain leadership in packet switching technology.

- Packet switching is of major importance to the business success of many of Telecom's major corporate customers. It is fundamental to modern services such as electronic banking, funds transfer, and the interworking of computer systems. By maintaining its expertise in the basic technology, and by keeping abreast of rapidly occurring developments, TRL will continue to be the acknowledged world leader in quality of service for packet switched networks.

7. To develop sophisticated signalling systems for "personalised" and mobile services.

- Signalling systems lie at the heart of network services and provide the basis for interworking between them. TRL maintains an in-depth knowledge of signalling systems including Common Channel Signalling, ISDN access and Open Systems Interconnection. Techniques being developed for the Intelligent Network concept and the mobile network aim to allow customers to be reached on single, personally assigned numbers, regardless of their location.

8. To add value to network services by providing secure messaging, information, image, video, voice activated and multi-mode customer service.

- Research is underway in the areas of voice, text, video and databased information exchange. For example, TRL has developed an advanced electronic directory for inclusion in products for corporate customers, and is developing video coding techniques that will allow video to be transmitted over FASTPAC - Telecom's forthcoming Metropolitan Area Network service. Further value is being added through the incorporation of new security and speech recognition techniques to services and products, and by providing integrated customer access through the development of multi-service terminals.

9. To increase the use of artificial intelligence techniques for a range of cost saving tools, and for intelligent assistant and market services.

- Artificial intelligence (AI) techniques can make complex systems easy for customers to use, and can make expert knowledge available to non-experts. TRL has used AI to develop a touchscreen-based, multi-media information system that links databases of textual, image, voice and video information. Systems have also been developed that have taken the best network design and network maintenance knowledge available inside Telecom, and built it into expert systems. The knowledge is then widely available to many non-expert staff via personal computers. Leading edge AI research into neural networks will allow the development of services and products that can understand and respond to customers' spoken commands.

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

- This Thrust is directly supportive of Telecom's commitment to Total Quality Management (TQM). Its application cannot be foretold as it applies when network materials and components fail in the field. When such failures occurs, in-depth scientific and engineering investigations are conducted to ascertain the causes and to propose remedies. The results are discussed with component manufacturers so that the quality of the products they supply can be improved. This strengthens Australia's telecommunications industry by focusing its attention on quality.

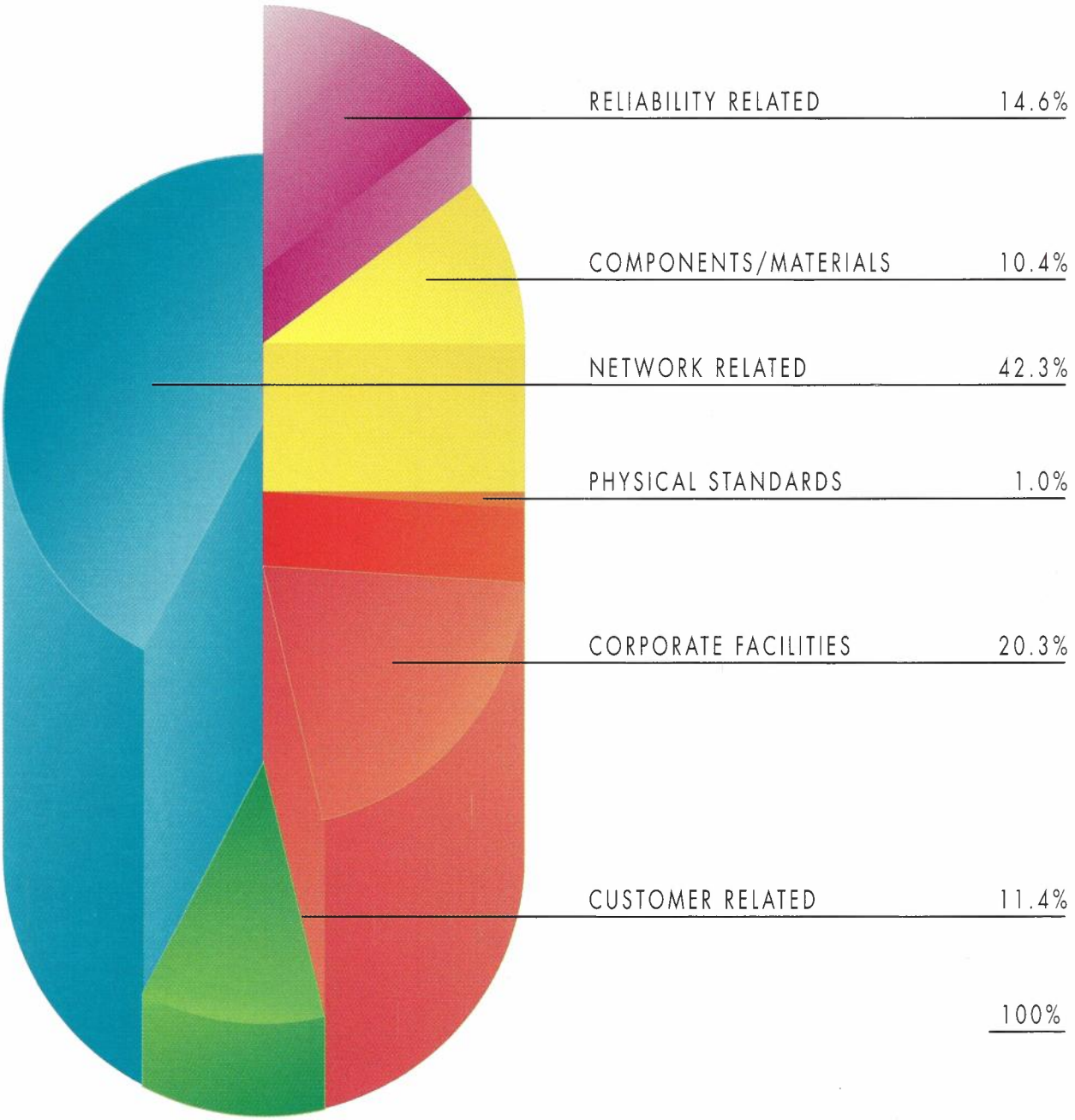
11. To conduct research into advanced materials and devices that are of strategic importance to future telecommunications systems.

- TRL conducts pure research into novel materials and devices that will form the basis of tomorrow's telecommunications technologies. This includes research into new photovoltaic materials for solar modules, optoelectronics devices for future broadband networks, and long distance optical fibres and optically active fibres. This research equips TRL with the knowledge it needs to assess new communications technologies as they emerge. TRL is then equipped to guide Telecom's technological direction. By being a 'player' in international research efforts, TRL also gains priviliged access to the current thinking of researchers in major overseas laboratories - those who set world technology trends. With this information, TRL helps Telecom to plan well both for itself and its customers.

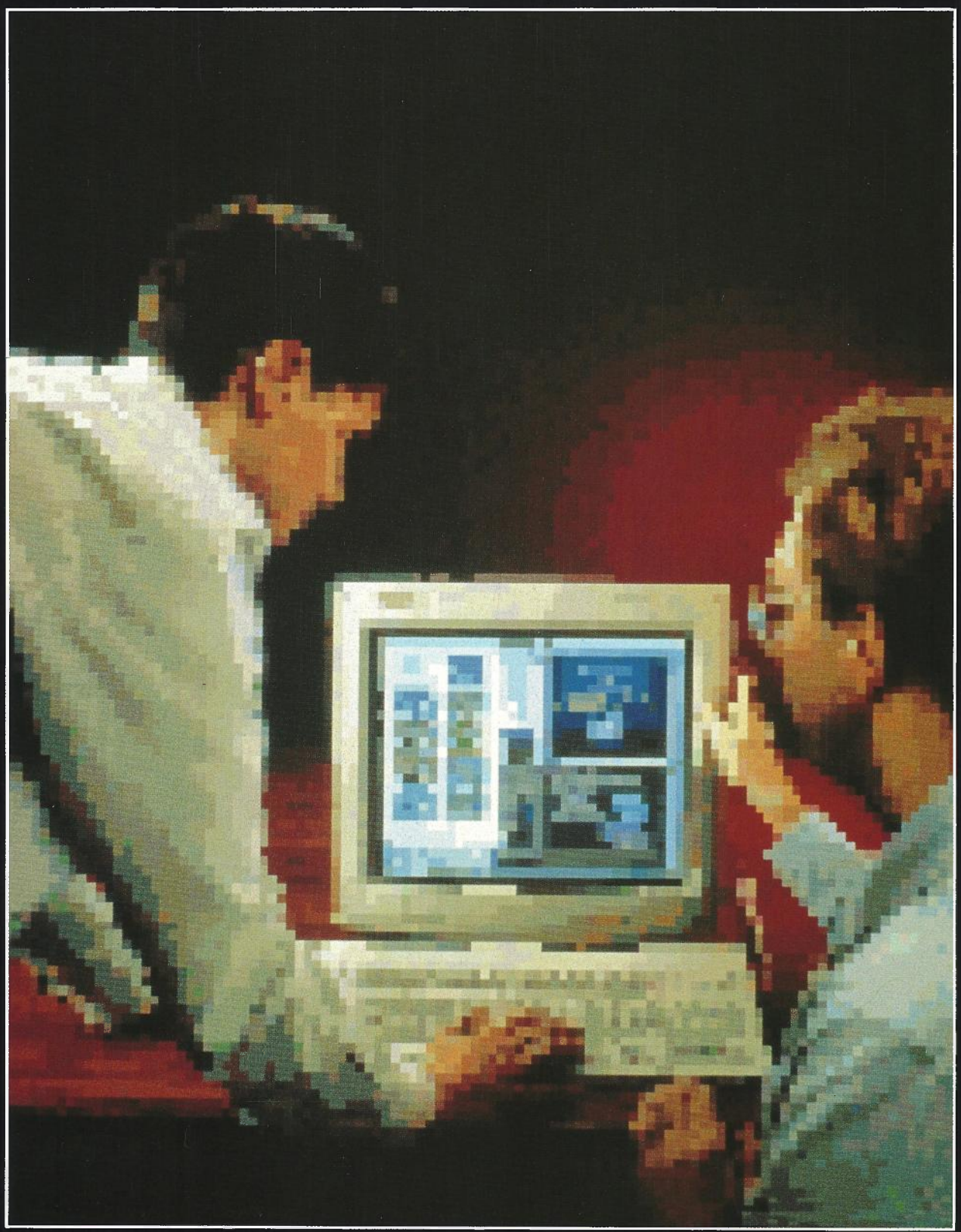
RESOURCES

During 1989/90, TRL employed approximately 530 staff. Of the total staff, approximately 230 have professional qualifications in engineering or the applied sciences and 20 in the social and information sciences. A further 190 technical staff supported the professional staff, with administration performed by remaining staff.

The annual operating costs of TRL totalled approximately $64 million. Of this total, about half is expended on salaries and salary-related costs. Capital expenditures, primarily on laboratory test equipment and facilities, amount to about 13%, and the remaining 37% covers operating expenditures on consumable materials, incidental items (including R&D contracts), and buildings and building services. laboratory test equipment items number about 16,000, with a depreciated value of approximately $13 million.



Disposition of TRL resources



CUSTOMER SERVICES AND SYSTEMS

The last decade of the 20th century, the 1990s may well be the most exciting in telecommunications. 1989 provided a glimpse of the rapidly changing environment we might expect; rapid technological change, increasing complexity, strong regulatory changes and global competition.

Information technology will be driven into increased prominence as information becomes a major commodity. Advances in low cost desk-top computing, multimedia services, wideband networking and intelligent network services are all peaking in about the same timeframe. This provides an important opportunity for coherent infrastructural planning to enable these advances to satisfy information needs in the future.

THE LAST DECADE OF THE 20th CENTURY, THE 1990s MAY WELL BE THE MOST EXCITING IN TELECOMMUNICATIONS

Recognising this challenge, Telecom is investing heavily in R & D to provide new and improved services, both end-to-end and within the networks. In the customer services field, emphasis is focussed in the areas of fundamental user needs through to the network interface. To ensure the services offered by Telecom will meet the evolving needs of customers, TRL has built strong multidisciplinary R & D teams, in the areas of fundamental human communication needs, intelligent tools and services, and electronic information services definition and delivery systems.

As the present Integrated Services Digital Network evolves into the broadband ISDN many new service opportunities become possible. Switched visual information services, such as graphics and image retrieval, video telephony, video conferencing, entertainment and educational television and high definition television can all be supported on the broadband ISDN. Signal coding and compression techniques currently under development are aimed primarily at reducing transmission costs but will also facilitate the integration of voice and data with a hierarchy of video services, all having access from a common terminal.

Speech interactive services also offer exciting options. Initial implementation of speaker activated services are likely to be speaker dependent, small vocabulary systems but they will find many applications over the next couple of years. Although universal speech recognition technology is less mature, natural language understanding and artificial neural networks approaches with their inherent pattern recognition and learning capabilities, are being developed to overcome some of the speech recognition limitations.

Artificial Intelligence techniques are finding applications in the development of expert systems tools, intelligent assistant services and intelligent information services. Earlier successful application in public information systems has led to the development of more complex applications including interactive business information systems. Expert systems based on knowledge processing capabilities combined with conventional algorithmic data and text processing are proving to be powerful software productivity tools. Taken together with the reasoning and learning capabilities of the neural networks approach, these techniques provide us with the tools to maximise value added service opportunities.

Other electronic information and transaction services under development include electronic directories, electronic data interchange and integrated messaging systems. Enhanced electronic security services and products are also being developed under new international standards. Standards compliance in all electronic services is becoming increasingly important as we move into an era of open systems interconnection and distributed processing.

With the plethora of networked information services options now emerging, one of the greatest challenges is the identification and delivery of quality services to customers. Quality services will be judged ultimately by how well they satisfy basic human social and business communications needs. Identifying information transfer needs, between which locations and in what format, is the task of a small group of cognitive scientists. This approach to services provision using the skills of information flow analysis, geographic information systems tools and user interface design, will become increasingly important for the specification, planning and delivery of quality services in the future.

The next few pages highlight some of the activities undertaken in the customer services and systems area.

HUMAN COMMUNICATION RESEARCH - PURSUING QUALITY

The first of Telecoms four major corporate objectives is "The delivery of affordable, quality services to all our customers". Whether it achieves this objective will be determined by the customers themselves, because they are the final judges of quality. Human communication research in TRL is contributing to this objective in two ways:

- by working to understand how customers judge quality in telecommunication services, and by providing improvements to the quality, and
- the methods for delivering services, in keeping with the philosophy of Edward Deming's "Total Quality Management".

Because of the complexity and diversity of human activity, human communication research is best served by multi-disciplinary teams. To this end, TRL has recruited people skilled in different social sciences, added a blend of technically trained people and formed several teams for the different aspects of the research. Disciplines represented include anthropology, sociology, geography, psychology, linguistics, surveying, town planning, engineering and computer science. The following three articles illustrate how this blend of disciplines has proven effective in identifying quality as the customers see it, and improving the quality of services that are made possible by new technology.

IDENTIFYING QUALITY

There is no easy way to understand what "quality of service" means to customers. There are many dimensions to "quality of service", and few people are able to state explicitly what their measures are without a considerable investment of effort. Few people are willing to make such an investment, except perhaps in discussion with trained interviewers. Furthermore, customers' measures of quality are essentially community measures derived by people talking amongst themselves about their experiences with Telecom. As a result, quality becomes the level of service that a customer hears, rather than what he or she should have expected in one circumstance or another.

So how do researchers find out what customers mean by quality? They ask customers. Not directly, since direct questioning, either in surveys or interviews, generally elicits only part of the quality measure, or produces only what the respondent thinks the questioner wants. Even worse, a respondent may use the opportunity to deliberately provide misinformation for any of a number of reasons.

Fortunately, there are indirect methods that can be used to inquire about customers' measures of quality. People are more willing to tell researchers about their communications activities and experiences in the context of their business or social life. They may relate stories that they have heard from their friends' and fellows' experience. Records of interviews with customers about these matters become the data that human communication researchers analyse in order to identify quality from the customers' point of view.

The methods of analysis being developed by TRL researchers are applications of qualitative research methodologies drawn from urban anthropology and sociology - methods like "idiom analysis" and "constituency analysis".

A typical example studied by human communication researchers is transmission quality. In many regions and for many groups of people, the researchers found that transmission quality was not an issue, since it largely met the customers' expectations. However, other dimensions of telephone service quality did not. On the other hand, there were regions and groups for which transmission performance was not up to expected quality. The implications of the study are important for Telecom in providing services. Firstly, it showed that there is not necessarily a one-to-one mapping between the transmission quality of the telephone service as measured by customers and by Telecom. Secondly, it is not necessarily in the customers' interest to have uniform standards of quality throughout Australia. As a consequence of these findings, Telecom can direct resources to improving transmission performance where it is perceived to be low, while maintaining standards in other regions where performance is satisfactory.

Researchers in other studies have found similar types of results that contribute to Telecom's ability to deliver quality services.

DELIVERING QUALITY - IMPROVING THE PLANNING

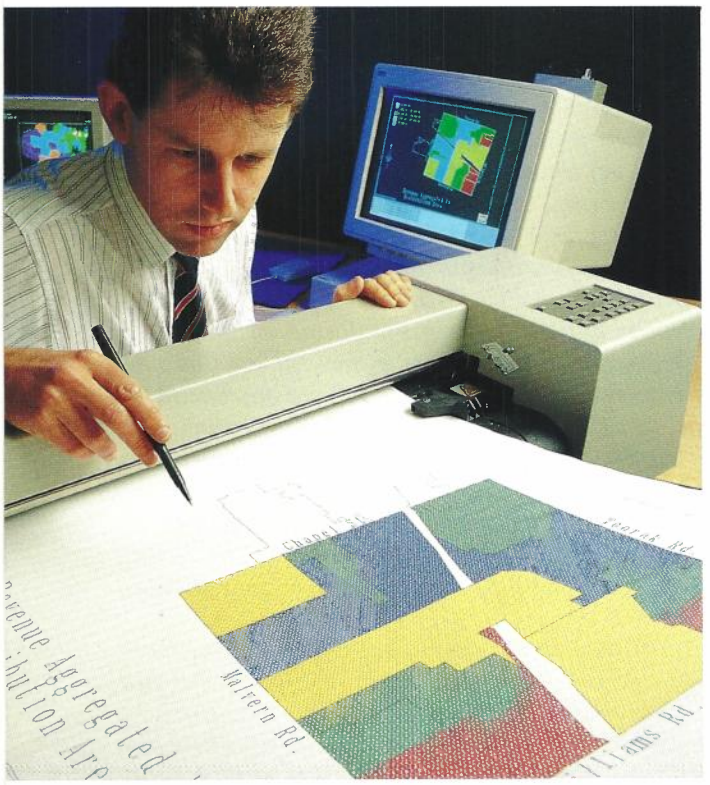
One aspect of providing quality services to customers is making them available when and where they are needed. Well established services, like telephony, are generally well catered for in Australia. However, there are many new services in prospect based on technologies like optical fibres, fast packet switching, broadband ISDN and mobile networks. These new services have the potential to transport vast amounts of information almost instantaneously for uses such as high resolution medical images or high definition maps. But what exactly these services should be and where they should be located which businesses, organisations or communities are likely users, requires considerable research.

Researchers at TRL are using the discipline of geographical analysis to help answer these questions. Research is directed towards developing new computer-based tools that will improve the methods for delivering quality services. Geographic Information

Systems (GIS) are complex software systems that enable analysts and planners to examine the spatial distribution of anything for which data is available. Examples of variables that are of interest in planning service provision include the distribution of population, households, businesses, telephone users and potential users of new services

Spatial analysis is not new. Geographers have used it to understand social and business activity for a long time. The difference comes from harnessing the power of the computer so that a GIS can access innumerable sets of maps from a variety of databases, instead of having at best a few maps laboriously drawn and marked up by hand. Different data sets drawn from the GIS database can be correlated, overlaid and displayed very rapidly. The spatial relations displayed can then be examined and analysed in terms of telecommunications markets and consequent network requirements to serve the markets.

The research task is not trivial. For instance, the researchers need to be able to provide future GIS users with the knowledge of the scale and accuracy of the computer held maps that suit their analytical purposes. Methods and systems need to be developed to obtain, store and maintain data relevant to the telecommunication planning processes that the GIS will serve. New analytic methods are needed that make effective use of the array of data available and the processing power of the computers on which they will run.



Geographical InformationSystems allow researchers such as Chris Bellman to co-relate the spatial distribution of customer needs with Telecom exchange boundaries

During the year, the geographical information studies group developed pilot GIS that are being used to study problems associated with mapping at different scales. A result of this work has been the development of small PC-based GIS for marketing groups in Telecom customer divisions. Work has also been directed at analysing potential users of new services. A joint research activity with the CSIRO national infrastructure study is aimed at identifying information intensive industries that fall into this category. This work entails a new methodology that takes advantage of the data that is available from the geographic information studies.

Geographic information research is aimed at improving the processes of strategic, market and network planning that are needed by Telecom to provide quality telecommunication services.

DEVELOPING QUALITY - GETTING THE HUMAN/COMPUTER INTERFACE RIGHT

Service quality depends on the usability of the computer interface. That is, whether a computer based system or service is easy for novices to learn and for experienced operators to continue to use efficiently. This proposition applies both to customer services and to the systems used by Telecom in providing services. If a customer service is difficult to operate, then customers may suffer delays in getting new services or may suffer from a loss of quality in an area such as the maintenance of their service. As a result, service quality depends on getting the human/computer interface right.

Human factors researchers are active in both areas. A range of customer services have been examined for customer divisions, and improvements proposed as the result of extensive scientific evaluation. The research methodology used, has the double advantage of identifying improvements in actual services and at the same time furthering understanding of the process of human/computer interaction. In the case of Telecom systems, the researchers have investigated systems for customer orders and for network management and are continuing to work with designers in developing effective interfaces. Many of the lessons learnt from this research have been documented in a series of guidelines. These guidelines are available to Telecom designers of computer-based systems to help them get the quality right.

A CORPORATE ELECTRONIC DIRECTORY

A major advance in TRLs' work on distributed directory systems has been the release of an electronic directory based on Telecom's corporate structure for internal Telecom use. The directory was

developed as an implementation of the X.500 international standards for distributed directories. The innovations made in developing the directory are being fed back into the standards via the active participation of TRL in the current extensions being made to X.500 by the CCITT.

The Telecom Corporate Directory is more than just an electronic list of departments, employees and phone numbers. Entries in the directory can contain addresses (for electronic mail, telex, facsimile or post), job titles, or descriptive comments such as the expertise or responsibilities of a department or the current availability of an employee. Each entry is uniquely identified using the corporate structure so subordinates, superiors or associates can be easily identified.

The real sophistication of electronic directories lies in their ability to support automatic searches. The custom need database incorporates state-of-the-art concurrency control and indexing to ensure that searches are completed without interference from any concurrent on-line modifications to the database. The Telecom Corporate directory supports searches for entries with a specified name (ie. "Show all the Smiths in TRL"), or for entries containing specific information (ie. "Who is the current owner of phone number (03)123 4567"). The development of high performance, approximate-match search strategies means that the user does not have to specify the information accurately or completely. Instead, the directory will try to correct typing mistakes, approximate phonetic spelling, or complete words as it attempts to match entries in the database. Key-word matching is also provided for some search requests.

TRL is working with the Telecom Internal Networking Team to expand the directory database to include all staff within Telecom. Changes to entries in the database can be made remotely by delegated personnel. Thus, staff changes or section name changes can rapidly be made available to other parts of Telecom. The electronic directory can also be used to produce quality printed directories of any part of Telecom for distribution within the organisation.

Most corporations experience the problems of organising, updating and accessing large amounts of corporate information in directories. The basic software that has been developed for the Telecom directory can be tailored to other applications, thus becoming a commercial product that Telecom could supply as a value added service for all customers.

User enter surname	approximate match used	directory returns entries with names
Smi	prefix match	Smi*ley*, Smi*rnoff*, Smi*th*, Smi*thers*
Done	phonetic spelling match	D*ea*n, D*ea*m, D*in*h, D*u*nn, D*u*nne
Jines	typing correction	*H*ines, J*o*nes, *W*ines
J*son	substring match	J*ack*son, J*ame*son, J*enkin*son, J*ohn*son

Examples of approximate matching on search requests to Telecom Corporate Directory

THE "UNIVERSAL" VIDEO CODING SCHEME

Video coding converts an analogue picture from a camera into a stream of bits for transmission over a communications network. Because the number of bits required even for pictures of reasonable quality is very high, digital compression techniques are used. These techniques can dramatically reduce the bit rate, hopefully with a relatively small perceived deterioration in the reconstructed pictures.

In the past, services such as facsimile, video conferencing and television have employed quite different and incompatible coding techniques. The advent of the packet-based networks will, however, require the simultaneous redesign of all coding schemes so that they are optimised for this new environment. This provides a unique opportunity to define a common, or "universal" coding scheme that will be used by all video (and even image) services, regardless of their quality. A universal coding scheme will enable a single terminal to display signals from all services: from low quality 64 kbit/s ISDN video telephony through to high definition television (HDTV).

TRL has entered a joint arrangement with Siemens Ltd., Monash University and the Australian Defence Forces Academy (University of NSW) to perform research in this area. A Government Industrial Research & Development grant has been awarded to the consortium, providing $1.8 million over three years. Including contributions from Siemens and Telecom

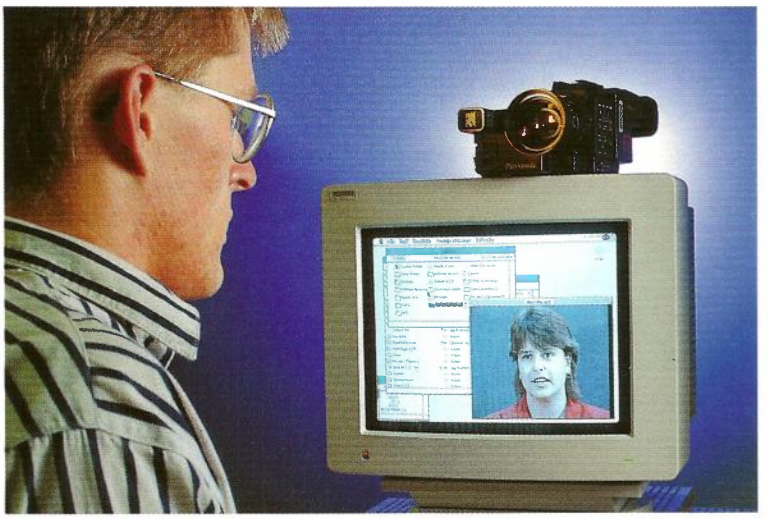
Australia, the total value of the work will exceed $3 million. It will involve up to eleven full time researchers investigating alternative video coding schemes, optimising them for packet-based networks and making contributions to international standardisation.

Work on the project officially began in April 1990 and the first outputs were reported at the "Video Communications Workshop", held in Melbourne in July 1990. At the conclusion of the research stage, Siemens Ltd. intend to commercialise the research with the goal of manufacturing, in Australia, video coding equipment that will lead the world.

VIDEO SERVICES ON FASTPAC

FASTPAC, Telecom's new Metropolitan Area Network (MAN), will support information transfer speeds of many Mbit/s both across and between cities using fast packet switching (FPS) technology. Use of the FPS approach means that transmission capacity is used only when it is needed. FASTPAC is therefore an ideal network to support bursty data services, such as the interconnection of Local Area Networks like Ethernet. FASTPAC has some of the features of the Broadband Integrated Services Digital Network (B-ISDN), and may eventually evolve into that service.

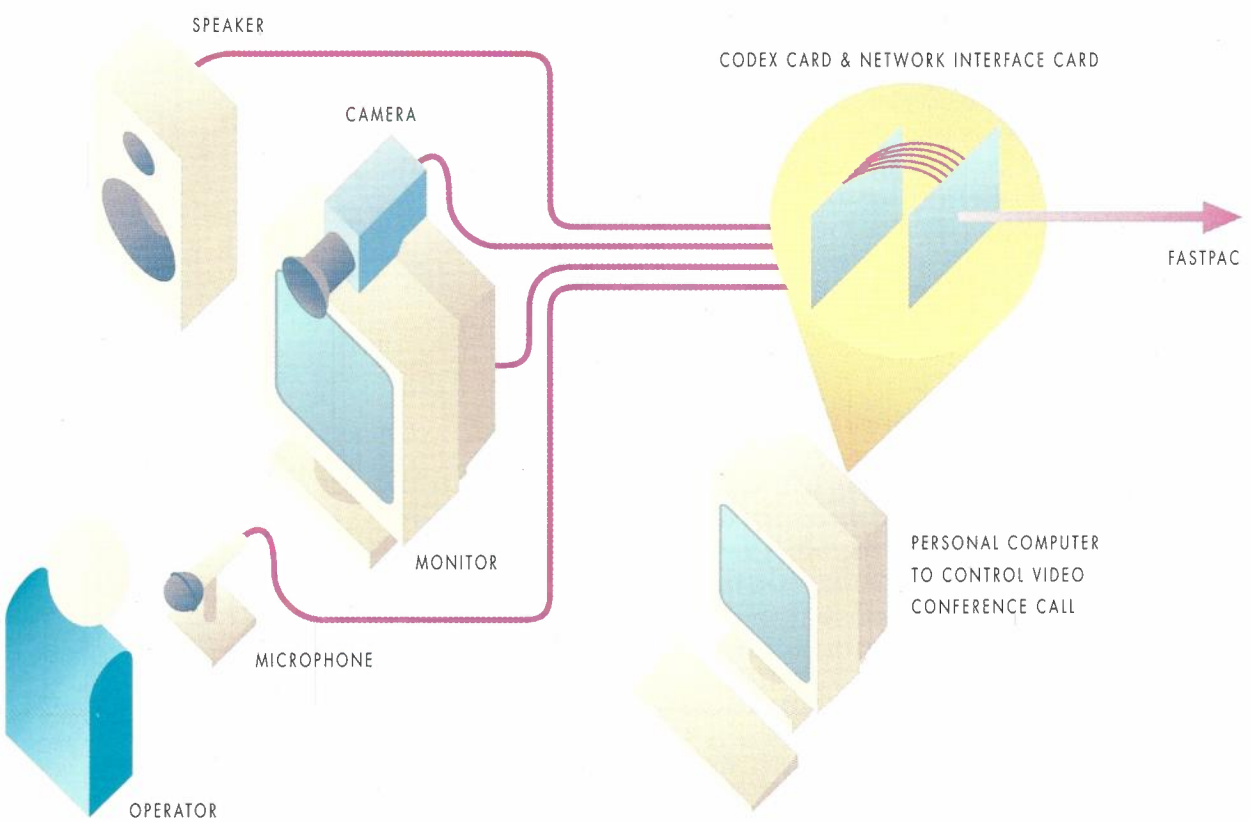
These features of high capacity and bandwidth flexibility make FASTPAC well suited to video services, particularly videoconferencing. Consequently, it will be the first network to allow high quality switched (dial-up) videoconferencing, and research projects are underway to support this service. Initially, existing fixed-rate videoconference codecs (coder/decoders) will be supported over FASTPAC via special interfaces. This will allow early introduction, demonstration and development of videoconferencing services on FASTPAC.



Researcher Matthew Leditschke experiments with PC to PC videoconferencing using FASTPAC.

A new video codec is also currently under development in a major joint project between TRL and Texas Instruments Australia Ltd. The aim of the project is to produce a prototype variable-rate video codec initially targeted at videoconferencing. The

Personal Computer based videoconferencing being developed for FASTPAC



variable-rate approach to video transmission is a new concept that can be used on an asynchronous network like FASTPAC. In this system, the transmission bit rate varies in accordance with the information in the video scene, as opposed to being forcibly maintained at a constant rate as in existing video codecs. This results in a large channel capacity being utilised only when there is significant motion in the video sequence. As instances of high activity are relatively infrequent, the channel can be efficiently shared with other video or data sources. Though there is much current research in the area of variable rate coding, the Telecom/T.I. codec will be one of the first commercial units in the world to exploit this approach.

The variable-rate codec development will ensure an in-house capability to provide Telecom's customers with video codecs of the latest technology for use on the broadband packet-based network. The partnership with industry in this development will also enable the cultivation of Australian expertise in the design and manufacture of state-of-the-art video codecs. This expertise will be particularly useful in the light of the predicted growth and dominance of video-based communication services on the mature B-ISDN.

To complement the codec development work, TRL is also undertaking fundamental studies into variable-rate coding for FPS networks. This work is being done as a combination of internal research, joint projects with industrial partners, and support of university research work. The aims of the work are to determine that video coding schemes are most suited to FPS networks, and to define common coding schemes that could integrate many video services so they can be accessed from a single terminal.

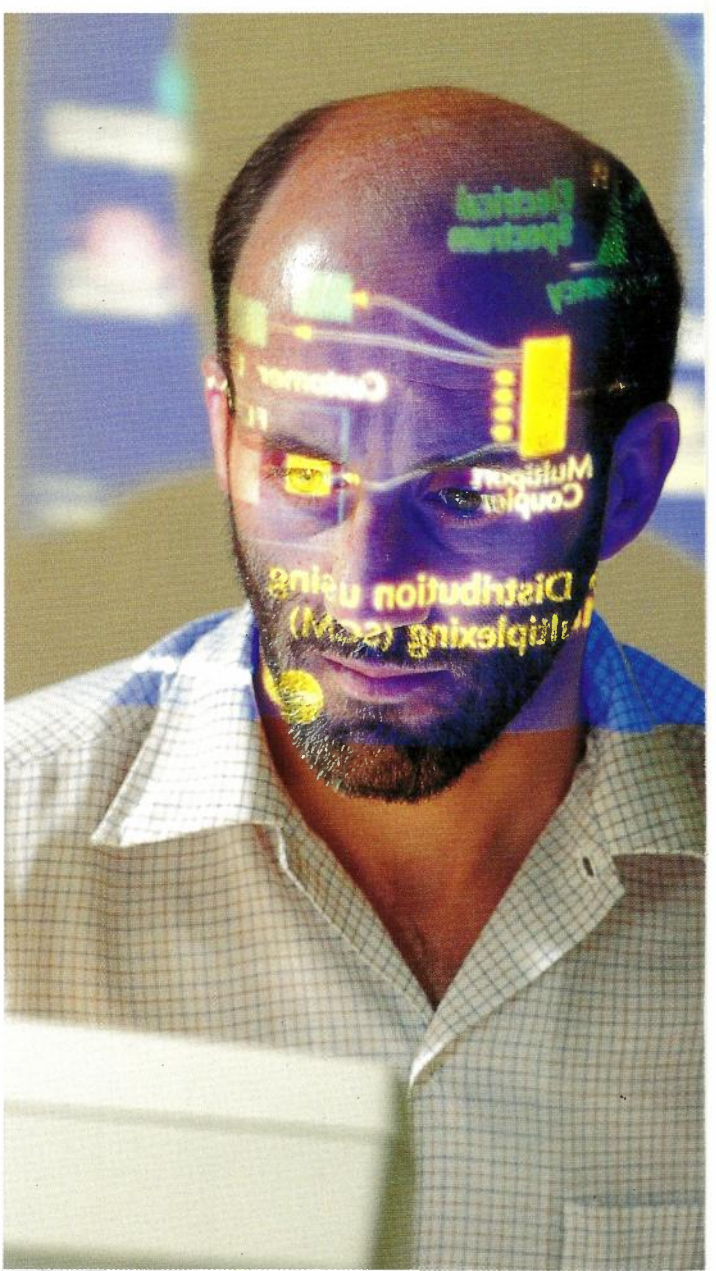
It is intended that this range of video research will allow Telecom's provision of video services to evolve from initial videoconferencing/videotelephone services on FASTPAC, to a single universal video terminal accessing all the video services (from image retrieval through to High Definition TV) that might be delivered over the B-ISDN.

ARTIFICIAL INTELLIGENCE

Telecom is increasingly applying Artificial Intelligence (AI) technology to perform complex knowledge-critical tasks. Whereas conventional computing approaches allow the processing of numerical data or text, Artificial Intelligence is the next logical step in computer technology, allowing the processing of knowledge: the practical meaning behind numbers and text. With these new capabilities come new opportunities for productivity-enhancing tools and products.

One of the first AI successes has been Expert System technology. By representing relevant human knowledge as a set of rules, expert systems can act as intelligent assistants, undertaking tasks of considerable complexity with significant productivity improvements for their users. Some of the earliest successful applications of expert systems in Telecom have been for network design and costing and network fault localisation. In both cases, significant cost savings have resulted from productivity improvements. Spurred on by these successes, expert systems are now being developed in more complex areas including control and fault diagnosis.

Expert systems perform best on well-defined problems where human expertise can be easily represented as rules. Many engineering problems, however, do not fit this mould, and more sophisticated AI techniques must be used. The design of telecommunication networks to suit the demands of populations, growth and geography is one such in-



A team of researchers are working to make complex communications simpler through the application of artificial intelligence

stance. For some aspects of the problem, rule-based techniques are useful, especially when supplemented by heuristics: rough "rules of thumb". Usually it is the combination of algorithms, machine reasoning, knowledge representation and rule-based techniques that solves the problem.

Neural Networks are another branch of AI that attempts to mimic human thought processes. Although a very simple model of human neural processes, neural networks show promise for many of the traditionally difficult AI problems such as pattern classification and speech recognition. In most cases, the benefit from neural network technology will be in new product areas.

An example of a new, AI-based product is the Public Information System. By concentrating on the information that people want from computers, we can fundamentally change the way in which information is presented. The combined use of different media and AI-based information retrieval techniques allows us to, in effect, remove the computer out of the process and provide a more visual information service.

The following projects are examples of applied AI in Telecom. Each in its own way is changing the way people use computers to improve their activities.

PENEE

The Private Expert Network Evaluation Environment tool (PENEE) is used to design and price networks provided by Telecom Australia. Penee is a software tool that runs on an IBM PC or compatible machines. It will be used by Telecom's communications consultants and other sales staff to configure and optimise customers' networks based on Telecom's public network services.

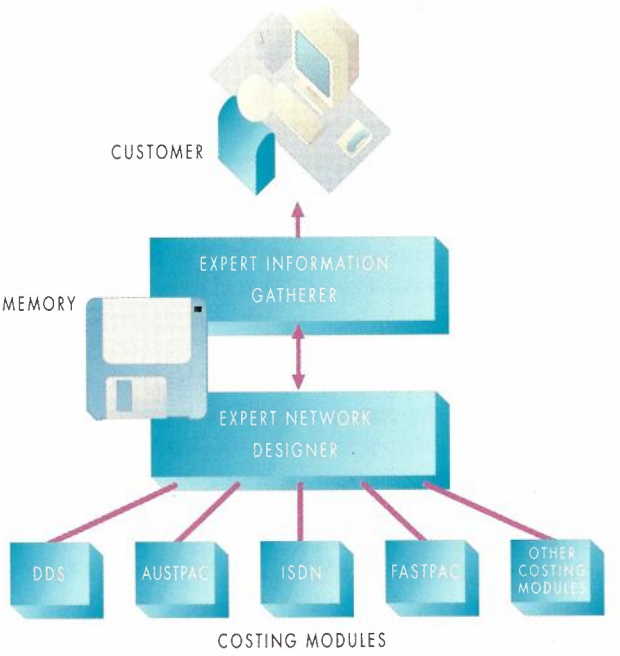
The problem with the existing method used to price a solution for a customer is that an extremely high skill level is required to thoroughly understand and to accurately price all of the numerous services provided by Telecom. This skill level is difficult for Telecom to maintain in an area where the prices and services offered change frequently, and which traditionally has a high staff turnover.

By contrast, an automated tool that prices Telecom's services (such as Penee) allows sales staff to increase their productivity by concentrating more on the customers' needs and less on the details associated with pricing a particular network solution. Similarly, variations in the prices quoted by sales staff due to the use of different network design techniques can be minimised. These advantages are recognised by our clients and demand for Penee products within Telecom is very high.

Three Penee products are available today - one each for the Digital Data Service (DDS), AUSTPAC and ISDN. Two further products will be available shortly - FASTPAC and Tran$end.

DDS Penee is more mature than either AUSTPAC or ISDN Penee and is used on a day-to-day basis by Telecom's sales and consulting staff. ISDN and AUSTPAC Penee are in the prototype stages and are being tested by future users. Feedback from customers on user interface inconsistencies and possible enhancements are continually received. This feedback is essential for the development of the products to continue.

Turbo Prolog was used as the development environment initially, as it provided an efficient means to



Functional block diagram of Integrated Penee

rapidly produce high quality prototypes. However, as the complexity of each Penee product increased, memory restrictions on Prolog in the MS-DOS environment, and, to a lesser extent, speed limitations, required the use of a more efficient language. As a result, all future Penee products will be constructed using the C++ language. The current Penee products will be converted to C for their next major release.

The next phase of development for Penee is Integrated Penee (iPenee). iPenee will capture the expertise of Telecom's best network designers and complement this with a more thorough understanding of tariff structures than any single person can maintain. It will generate customer solutions optimised over the full range of Telecom's services and will enable the customers to benefit from Telecom's wide choice of communications networks without the difficulty and expense of employing external communications consultants or in-house communications managers.

ARTIFICIAL INTELLIGENCE LOWERS CAN COSTS

The Customer Access Network, or CAN, provides the distribution of telecommunications from exchanges to customers. It is an enormous and diverse network that is costly to build and maintain. Due to the high cost of building the network, Telecom aims at a long service life, but the harsh operating environment and the age of older parts of the network combine to exacerbate the maintenance problems. In an attempt to reduce costs, TRL is applying AI technology to network maintenance and design.

CAN maintenance costs can be dramatically reduced and customer satisfaction enhanced if we can identify which part of the network is going to fail and perform the necessary repairs before it leads to a customer reported fault. With many CAN faults this can be done by periodically measuring the electrical characteristics of cables and using network information to locate "incipient" faults: fault conditions that if not corrected will eventually produce "no-service" faults. Currently this analysis must be done manually by attempting to correlate electrical tests of different cables, but as it is difficult and time consuming, it is usually not done at all.

EXPRES is an expert system that has been developed by TRL to automatically test and analyse networks to locate incipient faults and recommend corrective action. EXPRES operates by tracing fault conditions through the CAN from the customers premises and looking for a convergence of these conditions. Once operational with the CANES fault management system, EXPRES will improve network reliability and reduce maintenance costs through its integrated treatment of CAN faults and preventative fault detection.

CAN design consists of two problems: how to provide the services required in new areas and how to extend the network to meet new demand in redeveloped areas. In both cases, service provision for minimum cost is the goal, but other factors such as growth rates, topography, plant age and maintenance costs provide differing constraints. In each case, CAN design is a difficult, complex and important task.

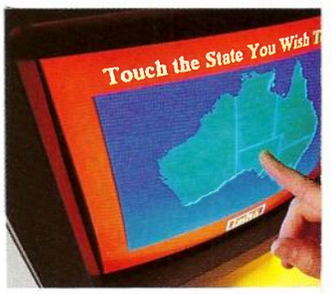
TRL is developing an "intelligent assistant" that will support the CAN design process. The software system uses geographical information and AI techniques to automate CAN design tasks including pillar placement, cable routing and joint location. It will produce CAN layouts that are cost optimised for the planned service life of the plant. The benefits resulting from the system are expected to be shorter design times, more uniformly optimised networks and increased opportunity for design staff to concentrate on strategic issues.

PUBLIC INFORMATION SYSTEMS

For any given topic there is a wealth of information available, the difficulty is in finding only that which is relevant and timely. Electronic systems can provide people with a user-friendly, attractive and interesting information source. For example, customers may touch a colour television screen to make selections of the data they wish to see. This data can then be presented as text, graphics or video complete with sound.

Fairly primitive examples of electronic information services that are already in use have proven to be very popular with the public. These systems typically display a variety of information including shopping centre tenant guides, timetables, locations of events at exhibitions and tourism guides.

TRL is bringing electronic information systems technology to maturity by improving their performance and making enhancements that take advantage of new telecommunications technology and advanced software techniques. A major undertaking is aimed at improving the quality and scope of information that the user is able to access through an information terminal. This can be achieved by providing access through high-speed communications networks to intelligent databases, electronic libraries and catalogues, and video repositories. Software advances would, for example, enable the user to plan itineraries or make detailed transactions using the system. Long term research is also examining ways in which methods for voice interaction and natural language understanding could be incorporated into the system.



New public information systems based upon easy-to-use touchscreen monitors will become commonplace during the 1990s

By making electronic information systems even more useful in this way, many more applications can be realised. For instance, a travel booking system would allow a prospective customer to look at video material of possible destinations and to choose between alternative accommodation quickly and confidently. While on holiday, the traveller will be able to discover and plan the sightseeing highlights each day using the tourist information system in the hotel lobby. It would also be possible for the traveller to perform transactions on the system to book activities in advance and then pay for them by interacting with a bank or credit card company.

Shopping centres, sports stadia, airports and central business districts are among the key sites targeted for Telecom's public information systems

The software package for the public information system that has been developed at TRL and is being used as a platform to aid the development of enhanced industrial and business services by incorporating into them techniques from AI research. In the near future, customers will be able to have access to easy-to-use multi-service terminals accessing a wide variety of information sources, customised to suit the needs of each individual user in any specific business environment.

NEURAL NETWORKS RESEARCH

Artificial neural networks, or neurocomputing, is the name given to a broad class of computational techniques that utilise large numbers of simple autonomous processors working concurrently and communicating with each other via a network of links. A recent avalanche of research in this area has resulted from progress in manufacturing parallel systems using VLSI technology, together with a growing awareness of the severe limitations of serial computers for applications such as pattern recognition.

The Neural Networks project in TRL has been running since July 1989 and has been aimed at exploratory development of basic neural network technology suitable for application in Telecom. The main technical effort has been in the development of algorithms for training a particular type of neural network known as multilayer perceptrons. Two new such algorithms have been implemented and extensively tested. Results demonstrate their ability to handle problems of a size one to two orders of magnitude greater than alternative techniques, taking hours instead of weeks or even months. With further possible improvements, one of the main impediments to the neural networks approach, that of long training times, may have been alleviated.

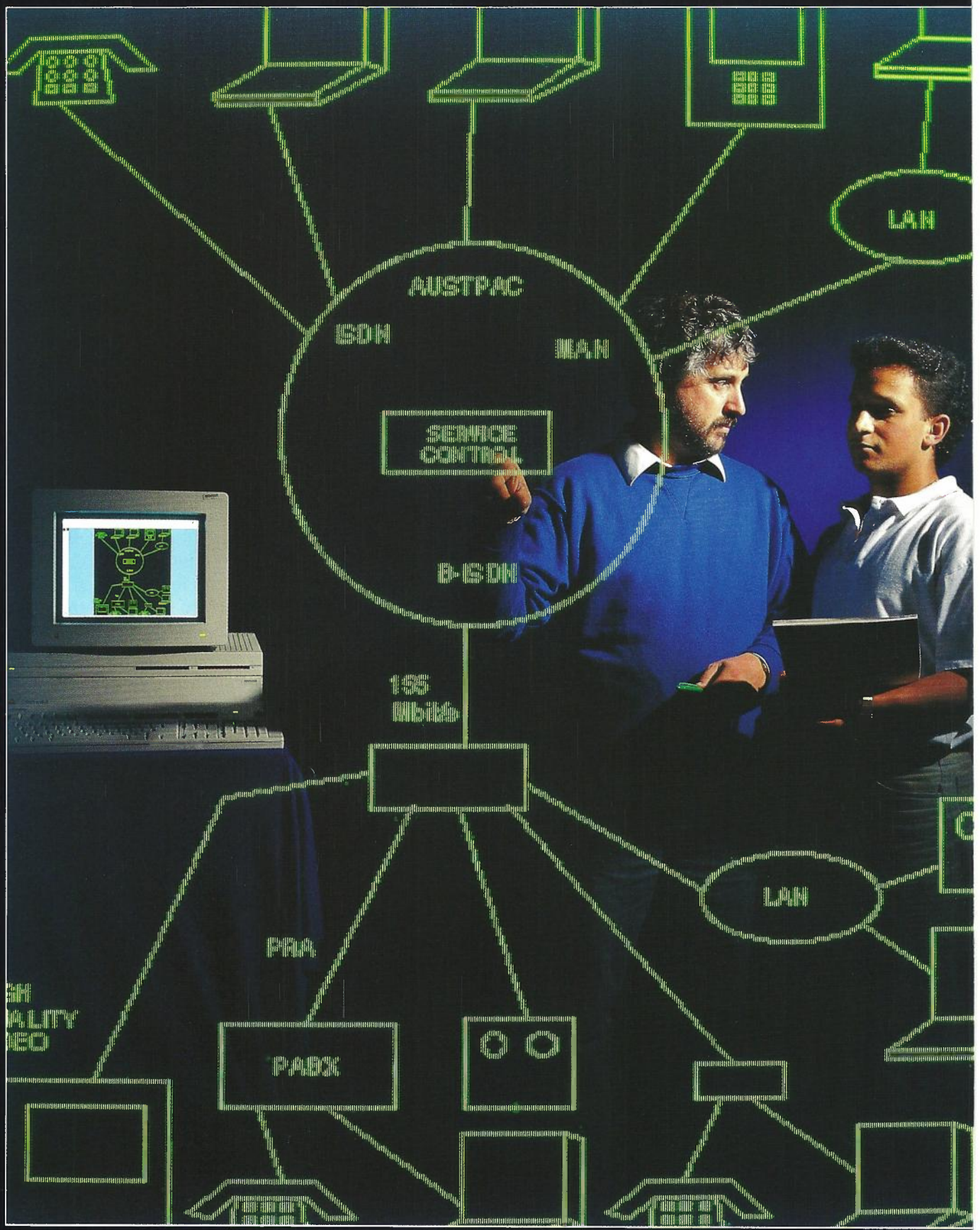
A hardware implementation for neural networks is crucial to their practical development in telecommunication applications, such as speech or data compression. Initial hardware implementation studies show that our training techniques lead to perceptrons with unique and exceptionally simple architectures.

On the application side, initial work on data compression shows that perceptrons provide an efficient implementation of data compression algorithms. Experiments with Huffman encoding for a dictionary showed that compression ratios exceeding those of existing techniques may be feasible. A number of other encoding schemes for digital voice and video are currently under investigation.

Natural language understanding, and speech recognition in particular, is another application being considered. For natural language understanding, a prototype system has been developed to analyse in parallel the role of each word in a sentence. Initial work has also begun on speech recognition. Phoneme recognition seems to be the most attractive application since alternative techniques currently available require complex programs running on large computers. Hardware neural networks, on the other hand, may be much smaller and cheaper, thereby greatly expanding the speech recognition capability.

Browsing and retrieval of information from very large data stores aimed at the demands of mass information services is yet another area in focus. A number of potential applications in the area of advanced transmission equipment have also been identified.

In summary, we have identified many business applications in telecommunications where neural networks may have a significant impact. While there is a continuing need to progress fundamental neural networks research, results to date indicate that there is merit in advancing some of these applications to the implementation phase. A number of potential applications in the area of advanced transmission equipment have been also identified.


LAN
AUSTPAC
ISDN
LAN
SERVICE
CONTROL
B-ISDN
16
Mb/s
LAN
PBX
PBX

SWITCHED NETWORKS

1989-90 has seen continuing high activity in relation to switched communication networks.

The international standards arena (CCITT and IEEE) has actively pursued broadband communication networks, using both Distributed Queue Dual Bus (DQDB) and Asynchronous Transfer Mode (ATM). Field trial equipment is now undergoing test for DQDB and a number of experimental ATM switches have been demonstrated in various laboratories, including Telecom Australia. The standards bodies have moved very quickly in this area with, for example, CCITT Study Group XVIII planning to use accelerated approval procedures for 13 Recommendations covering broadband ISDN by the end of 1990. In a remarkably short time, broadband switched networks have become a prime topic at many leading conferences and of interest to many potential users. (They were first mentioned in this publication in the 1985-86 issue).

IN A REMARKABLY SHORT TIME, BROADBAND SWITCHED NETWORKS HAVE BECOME ... OF INTEREST TO MANY POTENTIAL USERS

Signalling systems are the heart of network capabilities and the means by which users take advantage of them. In this area CCITT is also particularly active, with substantial additions to the capabilities of common channel signalling systems, data switching protocols, and Open Systems Interconnection. Users will see impressive new capabilities through such things as the Intelligent Network and Universal Personal Telecommunications, across networks such as ISDN, packet switching, and mobile.

With the switched network becoming markedly more complex and with users expecting continual enhancements in its capabilities and quality of service, network management has become a very important topic. Again, standards are a key element and both CCITT and ISO are very active. Users can expect to see sophisticated tools being applied to network design and analysis, and more capable management systems controlling the diverse range of network equipment and its interactions.

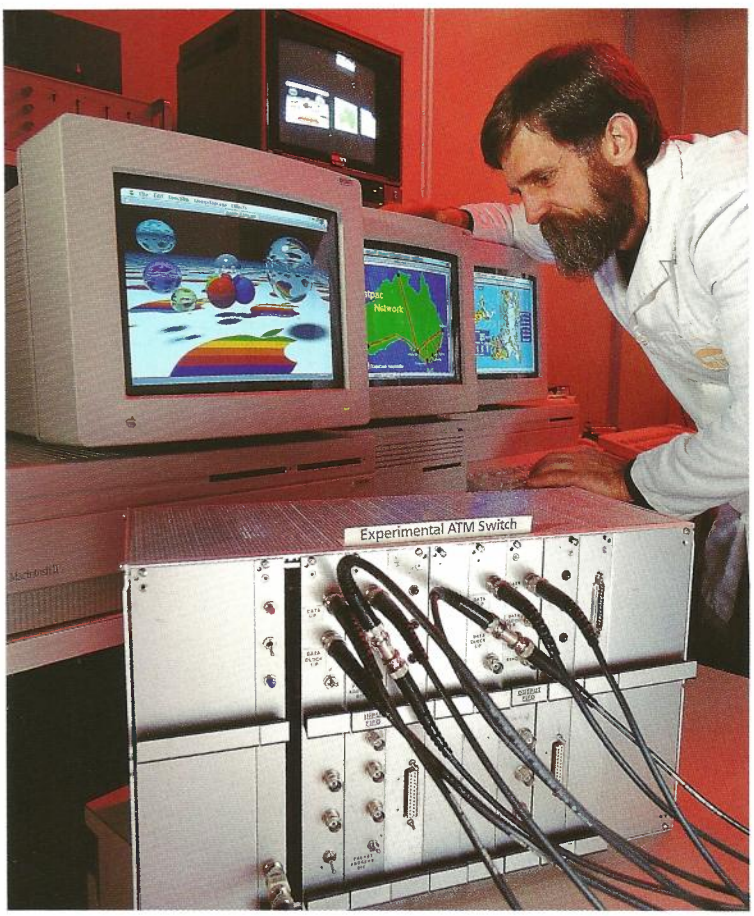
The next few pages illustrate how TRL is addressing these issues and others in order to provide Telecom Australia with timely advice and assistance relating to the future adoption of new technologies and operational practices in the Australian public switched networks.

LEFT: TRL researchers Peter Ellis and Joel Valadon, are at the forefront of developments in advanced Intelligent Networks (IN). Telecom's customers, especially businesses, will benefit from the control, flexibility and competive advantage that IN will provide

BROADBAND ISDN

Developments in optical fibre and fast packet switching technology are paving the way for the future Broadband Integrated Services Digital Network (B-ISDN) that will be able to support video and high speed data services. Some likely applications include video conferencing, video seminar distribution, high definition television, high speed image transfer and retrieval such as electronic clearing of cheques or title searches.

Before services can be introduced, international standards are required so that equipment from different manufacturers can interwork to achieve a global (B-ISDN) network. CCITT is currently developing the necessary standards. Some are expected to be available at the end of 1990 and further standards at the end of 1992. User interface rates will be at 155 and 620 Mbit/s. Information transfer will be by Asynchronous Transfer Mode (ATM) which divides user information streams into fixed length units called cells. The size and format of the cells has now been agreed. They will be 53 octets in length and include a 5 octet header. The header contains control information for connection identification and error control.



It takes just a split second for researcher Dave Hardwick to send high resolution images via a high speed, microelectronic switch

TRL has generated significant inputs to the CCITT. Many of TRL's technical results have been accepted as fundamental parts of the B-ISDN. These include the Virtual Path concept, where bundles of connections are switched together by the network, lowering connection handling costs. Other features include the use of a priority indication for some services, such as variable bit-rate video, a range of congestion control techniques to monitor and control traffic on connections to maintain quality of service to all customers as well as connectionless data support.

As part of its B-ISDN research, TRL has developed an experimental ATM switch. The switch has eight inputs and eight outputs each operating at 40 Mbit/s. The core of the switch is a custom designed very large scale integrated (VLSI) circuit that was designed in TRL. There is a range of terminal equipment connected to the switch to demonstrate broadband service integration. Services include 34 Mbit/s digital full motion video, high speed image transfer between personal computers at about 1 Mbit/s and digital telephones at 64 kbit/s.

Theoretical aspects being investigated, include broadband network resource management, network architecture, distributive service support, signalling and call control, congestion control and connectionless service support.

RESOURCE MANAGEMENT

The main resources of the B-ISDN will be the transmission and switching capacity used during information transfer and the control intelligence necessary to establish, manage and clear down connections. One area of concern as networks evolve towards the B-ISDN is the increased amount and complexity of the control intelligence needed to operate the network. Whilst technological advances in the capability of control processors are occurring, these are not keeping pace with advances in the capability of the traffic carrying capacity used in the network. Hence the cost of control is likely to become an increasingly significant component of the overall B-ISDN cost.

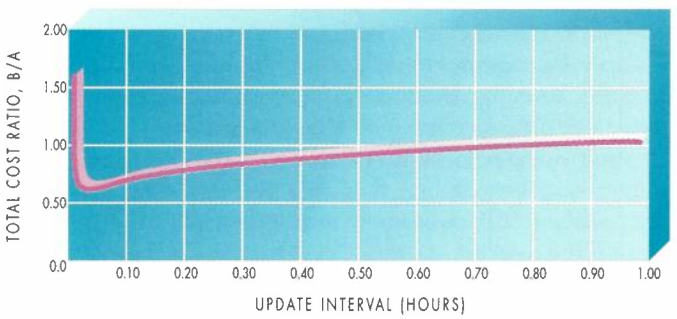
One way of reducing these rising control costs is to use virtual paths in the B-ISDN. The virtual path technique was developed independently and simultaneously by TRL and by NTT (Japan) in 1987. Telecom Australia holds a provisional patent on the technique within Australia.

Use of virtual paths in the network allows costly control decisions to be made once for groups of calls sharing common paths through the network. By reserving capacity on these paths, significant reductions in the call control load can be achieved at the expense of providing and managing this additional capacity. The amount of additional capacity

required can be reduced by updating the amount of reserved capacity on each virtual path to reflect changing demand.

A cost-benefit analysis has been performed to trade-off these capacity and control costs and determine the conditions under which it is economic to use virtual paths. This analysis has evaluated the core network cost for the case, where there are no virtual paths in the network and for the case, where capacity is reserved on all virtual paths in the network and updated at fixed intervals. The graph shows the ratio of costs B/A for these two cases as a function of the interval with which capacity reservations are changed.

Cost savings are achieved by reserving capacity on virtual paths, whenever the ratio B/A is less than one in the graph. This study shows that significant savings in the B-ISDN core network can result from use of virtual paths.



Total resource management cost ratio as function of update interval

DISTRIBUTIVE SERVICE SUPPORT

One of the key factors in the ultimate success of fibre to the home and businesses will be the ability of the system to deliver innovative services with high consumer appeal. In addition to familiar services such as voice and data, the B-ISDN provides a consistent framework for the integrated support of both interactive and distributive video and image services. This capability is a key factor in promoting the further convergence of the broadcast and telecommunications industries. Distributive services in the form of television entertainment, educational lecture distribution and business update services therefore represent a major new service type to be supported within the B-ISDN.

Unlike traditional telecommunications services, distributive services require a single information source to be simultaneously connected to many customers. For example, most television services are one-way, point-to-multipoint in nature and require network functions and attributes which match these characteristics. In contrast, voice and data communications is generally characterised by point-to-point, two-way service information flow. Entertainment video services are further characterised by very high service penetration levels (most homes have television sets), very long call holding times (comparable to programme run times) and fast call set-up requirements (to match the channel selection performance of existing television services). However while distributive services may be new to the telecommunications network, customer service expectations have been well established by decades of exposure to broadcast television and are continually modified by developments in related consumer products.

For the B-ISDN to meet the challenge of distributive service support requires expansion and enhancement of basic network functions. TRL is investigating the relevant technical aspects. Point-to-multipoint switching elements will be required to perform video channel selection functions, and perhaps also for the distribution of signals within the heart of the network. The signalling repertoire must also be expanded to allow customers channel selection choices to be made known to the switch. Similarly signalling will also be required to support the creation and deletion of multipoint service distribution paths across the network.

Of major importance in the planning and implementation of the B-ISDN is determining the extent to which it will be possible to physically integrate the transport, switching and control of distributive and interactive services. Different degrees of integration are possible depending on the service transport technology used, the type and level of B-ISDN switched service support assumed and the service access and control approach adopted. The resulting service support scenarios shape: B-ISDN network architecture, the distribution of exchange functions, the structure of the local loop, and service delivery options within customer premises. Distributive services are therefore a major influence on the form and function of, and final customer satisfaction with, the B-ISDN.

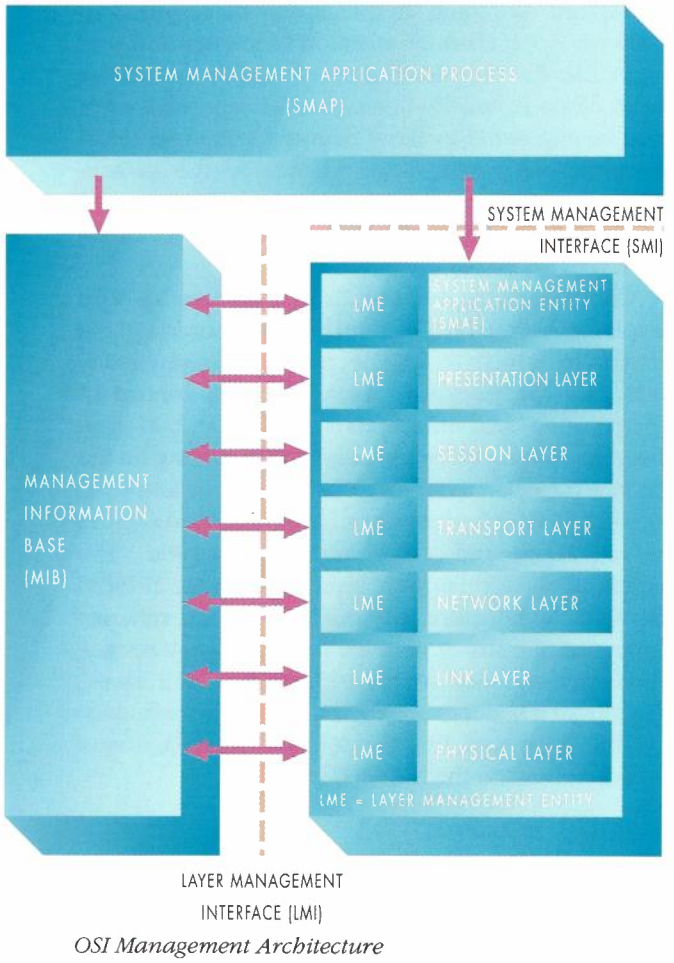
NETWORK MANAGEMENT STANDARDS

The Network Management and Information Systems used to operate, administer and maintain Telecom Australia's various networks are largely proprietary based (due to the absence of international standards) and oriented towards the management of specific networks/products. In the main, most of these management and information systems do not have the ability to interwork or provide a customer interface.

The standardisation issues are now being tackled by a number of groups, the foremost of these being

CCITT and ISO. The major output of CCITT in relation to network management has been Recommendation M.30 Principles for a Telecommunications Management Network (TMN) that presents the general principles for planning, operating and maintaining a TMN. A standardised architecture is defined for a network (a TMN) whose purpose is to allow for the transfer of management information between Operations Systems and the Network Elements to be managed. Functionality is designed into the architecture to allow the management of heterogeneous equipment and systems. M.30 also identifies a number of functions associated with Network Management. This Recommendation also states a preference for OSI communications and management protocols.

NETWORK MANAGEMENT STANDARDS



OSI Management Architecture

ISO has approached the issue from the viewpoint of managing OSI Systems. The OSI Management Framework is defined in Part 4 of the OSI Reference Model. The framework presents objectives and provides the necessary concepts and models for developing network management standards.

OSI management is achieved using functions of normal layer protocol operations, viz, layer management that operates within a layer to manage the activities of that layer only, and systems management that is concerned with the operation of the overall system (including management of all layers in all aspects including communications hardware, protocols, services etc.) and the adaption of that system to changing requirements or conditions.

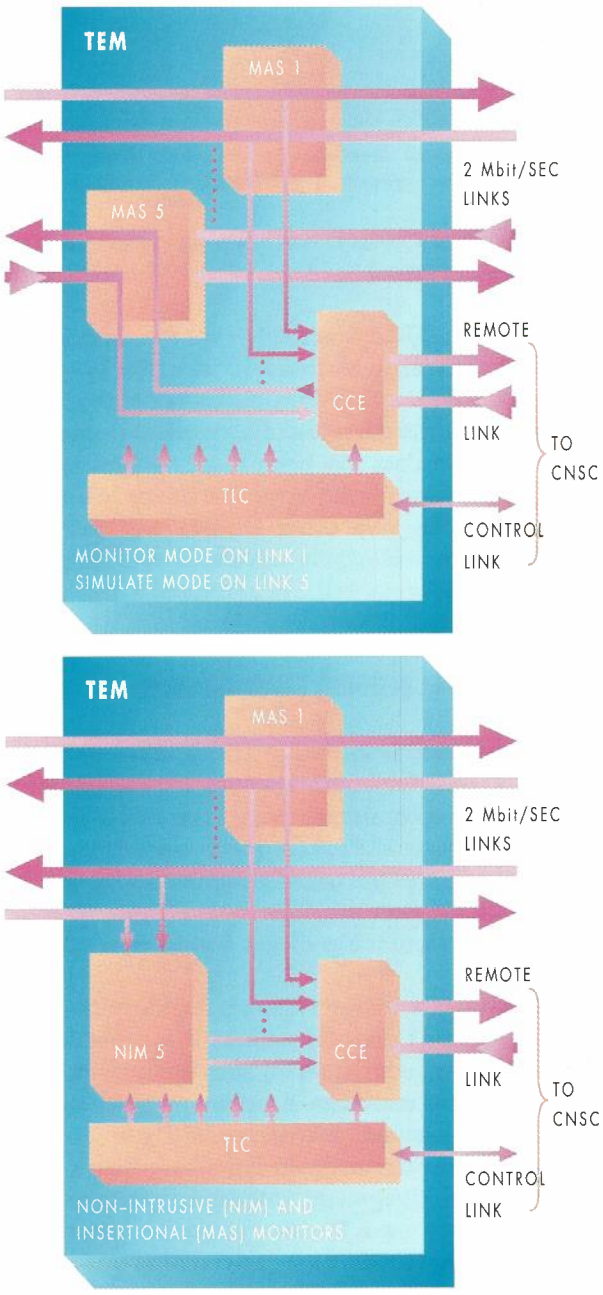
The management information base (MIB) in the figure is the information within an open system that may be transferred or affected through the use of OSI management protocols. OSI management standards are being formulated using an object oriented approach. In keeping with this, real resources are represented by managed objects. A managed object takes the form of information about the resource and forms part of the MIB.

OSI network management standards are associated primarily with the definition, transfer and operations that may be applied to management information within the MIB. In general network management can be broken down into five key functions. These are fault management, configuration and name management, performance management, security management and accounting management. In order to achieve effective network management these five functions must be able to interact.

Fault management is concerned with detecting, diagnosing, by-passing, repairing and reporting the status of network equipment and service failures; (ie what is the network doing). Configuration and name management is concerned with maintaining an accurate inventory of hardware, software and circuits together with the ability to change that inventory in a reliable and orderly manner in response to service requirements. Configuration and name management ensures the consistency and validity of operating parameters, naming and addressing tables, software images and hardware configurations of the network; (ie. what constitutes the network). Performance management is concerned with the utilisation of the network resources and its ability to meet defined quality of service objectives; (ie. how well is the network operating). Security management controls access to both the network and the network management system and may also protect information that is being transported by the network from either disclosure or modification; (ie. who is using the network). Accounting management measures network usage and computes the charges for that usage.

TRL is furthering its studies into Network Management Standards in order to develop strategies on how the evolving standards can be applied to the existing switched data network.

The TEM , designed and developed by TRL and manufactured by Telecom Industries



CARD FUNCTIONS

MAS: Monitor & Simulate
NIM: Non-Intrusive Monitor
TLC: TEM Logoc Controller
CCE: Channel Compressor & Expander

A TEST ACCESS NETWORK FOR ISDN

The introduction of Primary Rate Access ISDN in mid 1989 required the development of innovative strategies and tools for the testing and maintenance of the network. The available technology required the deployment of staff with ISDN protocol testing expertise at a large number of locations throughout the network. However each testing team will require a number of ISDN protocol testers. The shortage of suitable staff, the cost of training, and the expense of the protocol testers made this approach impractical.

The problem was solved by the development of the Timeslot Exchanger and Monitor (TEM) that makes remote and hence centralised testing of the network possible.

Speed of response has also been improved by this development because expert assistance is now immediately available.

The TEM provides the ability to transport signalling channels from 2Mbit/s customer access links to a remote diagnostic centre, the Customer Network Support Centre (CNSC), for monitoring and testing without interfering with the link traffic. Channels are transparently switched through the TEM, with a copy of the desired signalling channels being placed in selected channels of a 2Mbit/s system between the TEM and the CNSC. The TEM can be remotely configured to provide full testing access, including simulation and emulation, allowing the CNSC to test to the customer or the exchange. Thus a link can be fully tested in both directions remotely from the CNSC site. The diagnostic results are then passed to field service staff for remedial action.

An alternative input module to the TEM provides testing of live circuits without disturbing live traffic. This is useful for first-in checks as it does not require the link to be interrupted. It provides for examination of live faults, with no active testing (simulation) possible.

Up to five links can be connected to each TEM in its present form, but the architecture is modular and able to be extended arbitrarily.

The TEM has many other possible applications, and further development is being pursued. For example, it is being applied to reducing the costs of Telecom's Suppliers Development Assistance Scheme by enabling four or five Sydney-based PABX manufacturers to transparently and simultaneously access the Model exchange in Melbourne on a single 2Mbit/s connection. The problem posed by remote access to the Model is that to test a PABXs performance against the Model it is necessary to pass trial 'error' conditions back and forth and check responses. With a network between them, these 'error' conditions cause the intervening exchanges to react, and there is no way of indicating to them that the error conditions are tests only. TEMs at each end form a

TEM Modes - Simulation, Insertional Monitoring and Non-Intrusive Monitoring

complementary system that relocates these error conditions into data channels, transmits them through the network and then reinserts them back into their proper location. Hence the system behaves as though the PABXs and the Model are directly connected together. The TEMs allocate link capacity to each of the suppliers, and this can be varied according to test requirements.

The TEM, designed and developed in TRL and manufactured by Telecom Industries, has been highly successful. The time taken from the start of the design to the availability of the first production units was only six months. The equipment serves a very useful role in the support of the ISDN, and provides several million dollars in savings from its use.

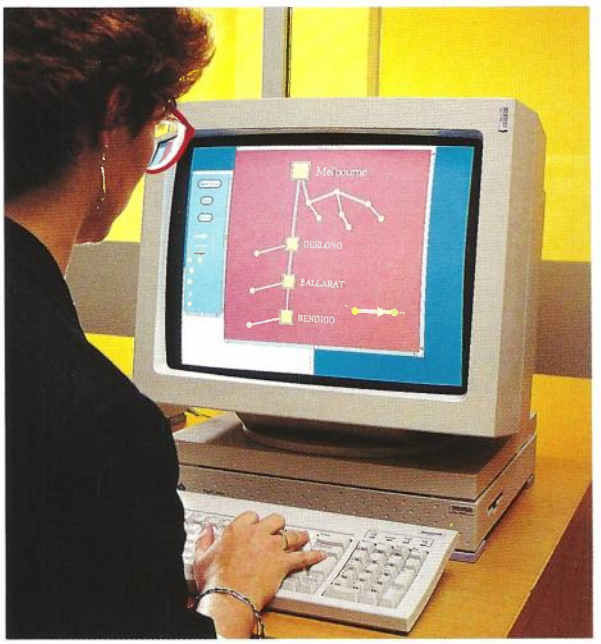
TELETRAFFIC RESEARCH

Teletraffic engineering is one of the enabling technologies that supports the construction and operation of large public switched networks. It enables the cost effective planning and design of networks so that they can carry present and future traffic loads. It also assists in the management of the network once the facilities have been installed. The increasing complexity of new technology options means that new methods and computer tools for teletraffic engineering are continually needed. The development of these methods and tools, as well as the modelling and analysis of new network options, is the work of teletraffic research.

TRL has strong expertise in this field. A particular emphasis of current work is in the performance and analysis of protocols and systems for future broadband networks. This encompasses traffic studies to permit design of these networks, performance analysis of proposed broadband protocols, and new methods for network management in a broadband environment.

TRL has been particular active in supporting the analysis and enhancement of the DQDB (Distributed Queue Dual Bus) protocol, which will be the basis for Telecom's future Fastpac network. The DQDB protocol is an Australian invention originally developed at the University of Western Australia under a TRL research & development contract. Its is now used by QPSX Communications Pty Ltd, a Perth-based company of which telecom is a major shareholder, to develop Metropolitan area Network products.

Teletraffic studies of the DQDB protocol have been necessary to support standardisation efforts for the protocol in the US. Several enhancements have been suggested to the basic protocol as a result of these studies. One important modification, for example, improves the performance of the protocol for large networks with heavy traffic. A modified protocol based on a time-variable cycle called CYREC (for CYclic REquest Control) has been proposed. A patent for this protocol has been filed in Australia and the US.



The NetCAD system developed by TRL allows Telecom to design complex communications networks for customers

A second modification to increase the capacity of a DQDB network with much local traffic has also been proposed. This introduces special 'eraser nodes' that permit the reuse of network transmission resources after data has been read. A provisional patent application for this invention has been filed in Australia. This and other studies will provide Australia with technically advanced and efficient broadband networks in the near future.

NETCAD NETWORK DESIGNER'S WORKSTATION

Telecom needs to design and analyse its own networks and Telecom's account executives and communication consultants need to be able to design and analyse networks for corporate customers. This inevitably requires the use of computer tools, which need to be the best available because they will in many cases create a significant commercial advantage.

NetCAD is a software system being developed at TRL that runs on Unix workstations. It will enable the user to specify, edit, analyse, simulate, and design communication networks. A preliminary version of this system is currently in trial.

NetCAD provides an environment in which a variety of network design and analysis applications can be conveniently used. The two important features of NetCAD are NetGraphEd that is a common user interface and EDL, a data description language.

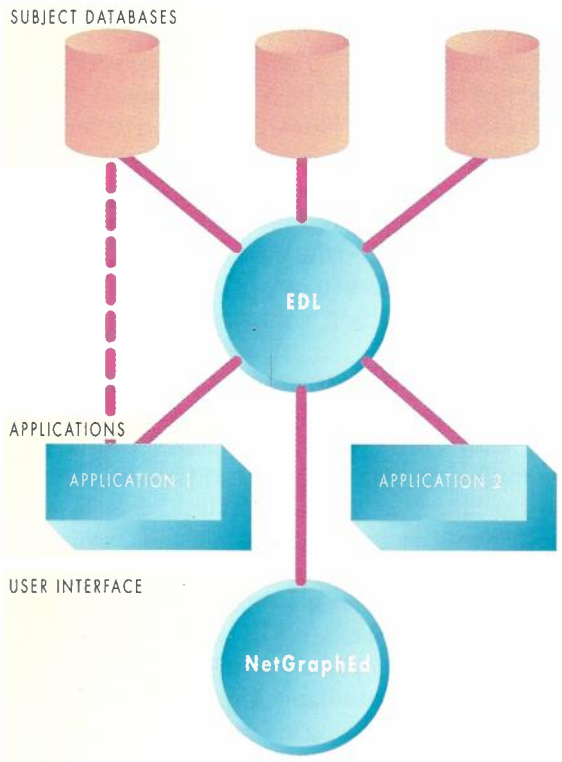
NetGraphEd is designed as a general purpose net-

work specification and editing tool. Users have at their disposal a collection of powerful graphical tools with which to generate small or large networks. These networks can then be submitted to a variety of application programs that may in turn modify the network and return it to NetGraphEd for examination by the user.

The other major feature of NetCAD is Entity Description Language (EDL), a data description language permitting easy reuse of data by several applications. EDL provides a standard interface between NetGraphEd and the other NetCAD applications. The EDL description of network data effectively contains some of the meaning of the data. For example, network routing information might normally be stored in a table, with nodes and links represented by numbers, or codes. The EDL representation of this routing information would contain explicit references to the *nodes*, and *links* of the networks, and all the applications that used this data would, in effect, know what a node and a link is.

In order to gain ready access to the large quantity of data in existing databases, an interface between standard SQL relational databases, and applications that are able to understand EDL will also be developed.

The list of applications that form part of NetCAD is open ended. Simple guidelines must be followed in order for an application to be able to read the network data generated NetGraphEd, and to generate data in a form that can be displayed meaningfully to the user by NetGraphEd. When developed, new applications can be easily installed in NetCAD.



NetCAD Architecture

Two major applications have been developed for use in the NetCAD environment so far, a network simulator, and an availability tool.

The simulator simulates a telephone network with non-hierarchical link-by-link routing of the type that we expect to see in place over the next five years. It allows for the simulation of network management actions in response to traffic congestion, overload, or equipment failures. In conjunction with NetGraphEd, the simulator provides an animated view of the network state during a simulation.

The availability performance tool calculates the end-to-end availability and mean-time-to-restore service between any origin and destination in the network. For large networks, calculating these measures of network performance is virtually impossible by hand, and quite difficult with the aid of a computer. The algorithm that has been developed for NetCAD is able to analyse large networks and is structured in such a way that it is able to take into account many important details that render the analysis more realistic. For example, routing is taken into account. Failures which prevent the network from successfully routing calls will contribute to the unavailability measure that the algorithm accumulates even if there are other paths, of which the routing is unable to make use of. Also, dependencies between items of network equipment can be accurately modelled.

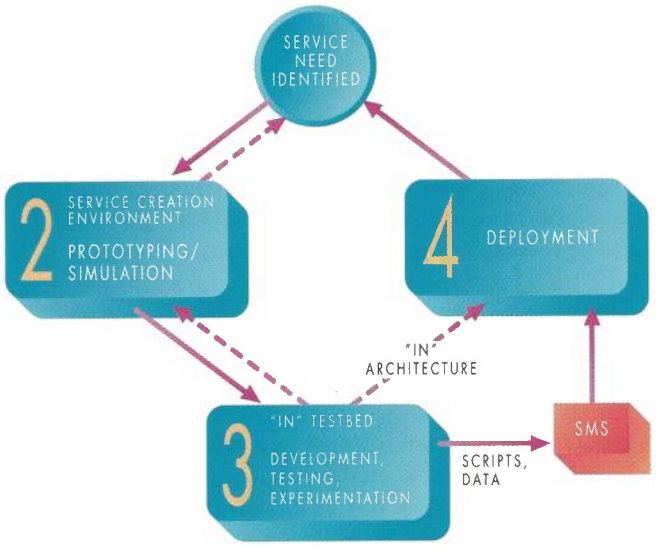
An extension of this availability algorithm that calculates a total performance measure is under development. This algorithm will compute the expected proportion of the time during which two telephone customers, at designated points in a network, will be able to communicate, taking into account failures, overloads, and congestion due to other telephone traffic.

SERVICE CREATION IN THE INTELLIGENT NETWORK

The Intelligent Network concept aims to provide greater service flexibility in public switched networks to quickly meet changing user needs. Among today's services that can benefit from intelligent network implementation are the enhanced 008 service, automatic calling card service, and wide area Centrex. These services have many features. To add a new feature by traditional means, which requires development, testing and deployment of new software to many exchanges, may take 3-5 years. In the Intelligent Network, the total time from initial feature definition to final availability in the network could be 6 months or shorter. Achieving this rapid response

will require software support across all stages of the service creation cycle. TRL has been active in defining the systems that will be required for this purpose.

Service creation begins with an idea for a new service or feature. The idea must be refined into a workable concept through experimentation and simulation. TRL envisage a service creation workstation for this purpose. The service designer would be able to define his or her idea using a very high-level interface construction from menus and icons. No detailed network knowledge would be required by the service designer in this process. Early prototypes of possible user interfaces have been constructed as a proof of concept. The designer will be able to use the service creation workstation to simulate the service and to evaluate it under various traffic conditions. TRL will be building these features into a future prototype workstation.



Service Creation Cycle

At the next stage of service creation, the service definition is installed on a testbed. At this point, the service actions may be examined on a network in relation to other services. TRL is developing an Intelligent Network testbed, conforming to international standards where they exist. The first Intelligent Network call in Australia was made on this equipment in May 1989. Since that time, a number of services and many service features have been installed, including an advanced credit card calling service with restricted number dialling, and a 008 service with calling line dependent routing. The close conformance to recognised standards, especially those for signalling, gives confidence to the service designer that new services on the testbed will work in the same way on the public network.

After testing, the service is passed to the service management system (SMS) for final deployment in the public network. At present, service management still involves many open issues, such as the management of distributed data, security and performance. TRL has been pursuing the requirements for this process and enhancing the service management capabilities of the testbed to demonstrate the key elements of the process. This has assisted the effort of defining Telecom's requirements for new network equipment.

After deployment, use of the new service or feature leads to new service ideas, and the service creation cycle begins again.

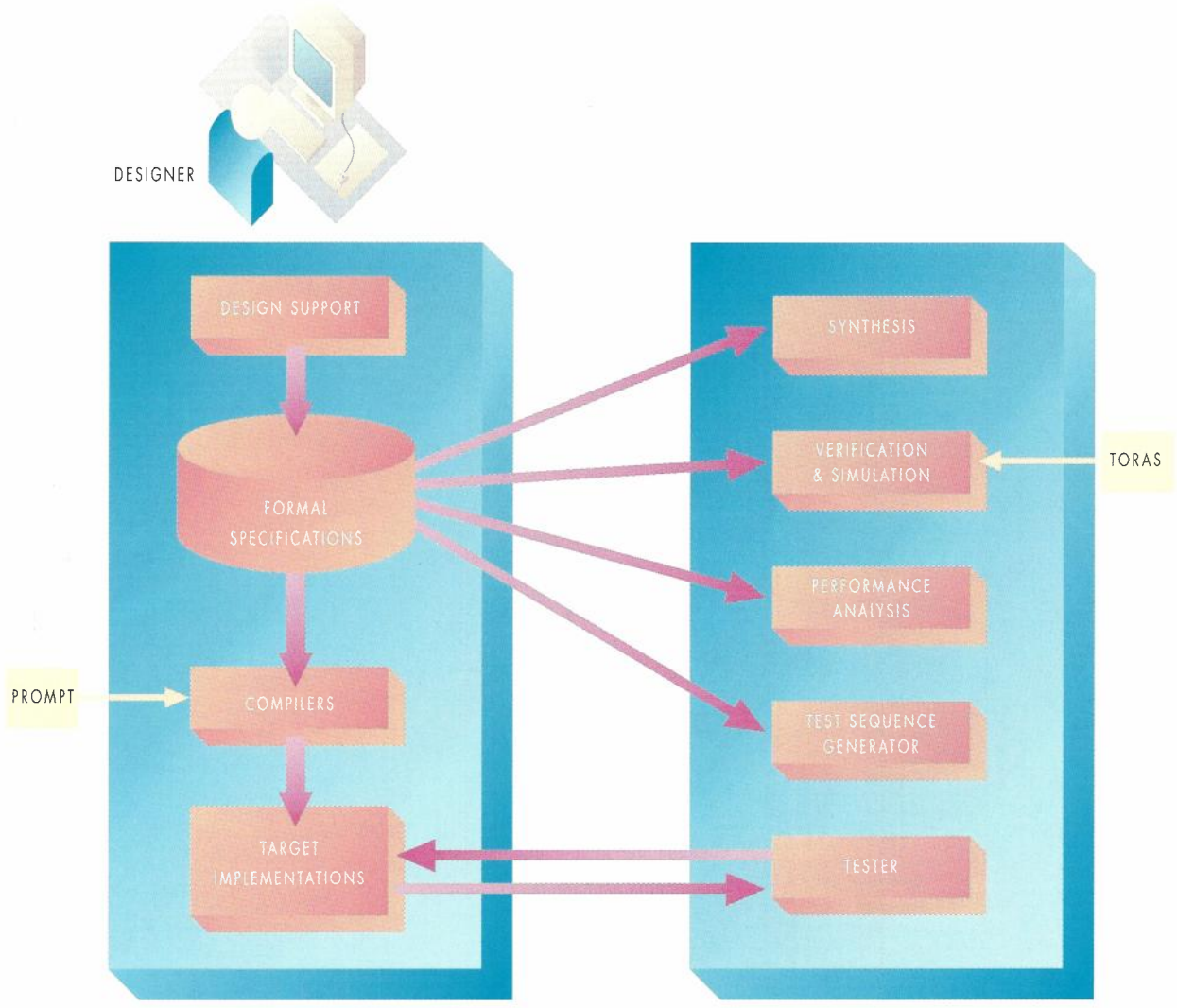
It is important that there be uniform software support throughout the service creation cycle. This is achieved by the use of a service logic program to define the service or feature and the definition of standard database updating procedures. As a major contribution to world-wide efforts in this area, TRL has defined a novel service logic programming language based on object-oriented programming. This language will be able to be standardised and efforts to have it accepted as a standard will be pursued in international forums. Further work in enriching the service logic program and its associated service logic execution environment is anticipated.

ANALYSING FORMAL SPECIFICATIONS WITH TORAS

The development of telecommunication system, services and networks is becoming increasingly dependent on software. To obtain quality products, it is essential to start from high quality specifications. An advantage of using formal description techniques for the specification of systems is the ability to analyse them. Systems which have been analysed are much more likely to be free of embarrassing and costly mistakes that reflect on the quality of products being provided to the marketplace. To analyse complex specifications, practical computer aided tools are needed.

An integrated environment for the development of systems, based on formal specifications, is the vision for the future. It is known as FORSEE (FORmal Systems Engineering Environment) and it could include tools for language sensitive editing, specification management, analysis, simulation and animation, performance analysis, automatic implementation, and implementation testing. TRL is currently developing a specification analysis tool called TORAS (TOol for Reachability Analysis of Specifications) and beta testing an automatic implementation tool, PROMPT, which are being integrated to form the core of FORSEE. An integrated environment will provide great gains in productivity for the development of quality software.

TORAS is a second generation analyser, devel-



FORmal Systems Engineering Environment (FORSEE)

oped out of experience gained with the PROTEAN system. The implementation is in the Eiffel object-oriented programming language and C on Sun Workstations.

TORAS has been designed to work flexibly with a number of formal description techniques. At present, it works with a simple Petri net language. It also has a very early prototype of an interface for accepting the XNL language (a Petri net based language used in the PROMPT system). It will be suitable for languages like high-level Petri nets, the standardised Formal Description Techniques LOTOS, Estelle and SDL, the automata-based languages and perhaps Z.

In order to analyse a specification of a system, TORAS generates the system's state space and either as a product of the generation algorithms or as a result of further processing, the properties of the system are revealed. If one simply generates the complete state space the approach is very simple and the algorithms required are not difficult. There is a problem, however, in that state spaces are often too large to handle.

The major advances with TORAS, are the employment of advanced algorithms to deal with large state spaces. These algorithms make it unnecessary to generate the complete state space, yet they can guarantee that properties like deadlocks, livelocks and equivalence of specifications are preserved.

Initial results have been encouraging. A resource sharing problem with a state space of 10^{47} states only required 32, 767 states to be generated, revealing a system deadlock. This was accomplished in less than 20 minutes of CPU time on a Sun 3/60. The algorithms have also been applied to a simple model of a distributed database system and an alternating bit protocol with considerable success.

TORAS is in the early phases of development and a number of features still need to be added to make it easy to use but it promises to be a very valuable tool.

TRANSMISSION NETWORKS

Optical fibre and mobile radio technologies will dominate transmission networks in the 1990s as telecommunications networks evolve to support increasing demand for broadband services and personal communications. Broadband networks will be optical fibre based and provide capacity up to Gbit/s rates. Personal communications will make increasing use of small hand-held personal terminals, together with more wide spread custom-design of access to the fixed network. These scenarios imply more customer control, supported by increasing network intelligence for rapid service definition and delivery.

Optical fibre is now well established in the inter-capital and inter-exchange networks, with transmission systems operating at up to 565 Mbit/s and it is planned to increase this rate to 2.5 Gbit/s in a few years time. By using optical amplifiers and coherent optical systems, various options for extending the capacity on the existing fibre network to even greater rates, as high as 10-20 Gbit/s, will become available from the mid 1990s. Optical fibre is hence well placed to handle the expected growth in network capacity especially as the customer demand for broadband services increases.

The use of optical fibre for customer access will initially be mainly for corporate customers. The fibre can be used to support services such as high-speed data, local area network interconnection and business video using QPSX Metropolitan Area Networks and also to provide high-speed integrated access based on Synchronous Digital Hierarchy (SDH). The use of fibre for smaller business and residential customer access requires the introduction of lower cost techniques such as the passive shared fibre architecture. In particular, it is expected that analogue modulation will be used initially to provide the large number of channels required for residential Pay Telecom.

In the longer term, probably in the next millennium, novel network architectures using all optical transmission, multiplexing and switching are expected to emerge.

OPTICAL FIBRE AND MOBILE RADIO COMMUNICATIONS WILL DOMINATE TRANSMISSION NETWORKS IN THE 1990s

The current spectacular growth in demand for mobile communications services illustrates the value that many customers place on being able to communicate wherever and when ever they choose. A number of technical developments will mature in the next few years to help satisfy this demand. Digital cellular mobile systems will be available in the early 1990s, promising better quality, higher capacities, and a wider range of services. The much higher user densities will also lead to the use of very small cells (micro-cells) that will require new design techniques and cell hand-over strategies. L-band mobile satellite systems will come on stream soon during 1992 to provide service to those in rural and remote areas. Telepoint services have been introduced thereby expanding network access economically for the mobile customer, and wireless PABXs and radio local area networks will enhance office communications technology to increase business productivity. All of these developments will lead to mobile services becoming a significant part of Telecom's business in the 1990s and beyond, adding a further degree of reality to what was once regarded as sheer speculation that the hand-held personal communicator will become as ubiquitous as the transistor radio.

LEFT: A future satellite-based mobile telephone service in the making. A van loaded with test equipment moves beneath trees in an experiment to measure the scattering that foliage causes to radio signals

INTER-EXCHANGE NETWORK EVOLUTION

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

At present, transmission over the long-distance optical network is provided using 140 and 565 Mbit/s transmission equipment with typical repeater spacings of up to 50 km. As the demand for increased transmission capacity grows, higher capacity 2.5 Gbit/s transmission equipment operating in the longer wavelength region around 1550 nm will be introduced into the network. By moving to the longer transmission wavelength it should be possible to maintain the current 50 km repeater spacings, provided that the effects of laser diode chirp which is the change in output optical wavelength as a function of modulation and time, in conjunction with the higher fibre dispersion in this region, can be adequately controlled.

In order to resolve any problems associated with laser diode chirp, particularly at high bit rates a research programme and field experiment is underway at TRL, in collaboration with Telecom Network Engineering. The aim is to predict the performance of these high capacity systems using computer simulations, then measure and quantify the effects of chirp for a range of laser diodes used in prototype high capacity transmission equipment. Transmission equipment specifications and acceptance tests will be developed to ensure that these systems can be introduced into the network with confidence.

In the longer term the transmission capacity of the long distance network could be increased in many different ways. Three possible scenarios which maintain 50 km repeater spacings are:

- Maintain the maximum bit rate at 2.5 Gbit/s per optical carrier and use wavelength division multiplexing (WDM, widely spaced optical carriers), and optical amplifiers.
- Change to coherent optical fibre transmission equipment and increase the bit rate to 5 or 10 Gbit/s.
- Use coherent optical fibre transmission equipment, frequency division multiplexing (FDM, closely spaced optical carriers) and optical amplifiers.

Two new technologies not used at present are required: optical amplifiers and coherent systems.

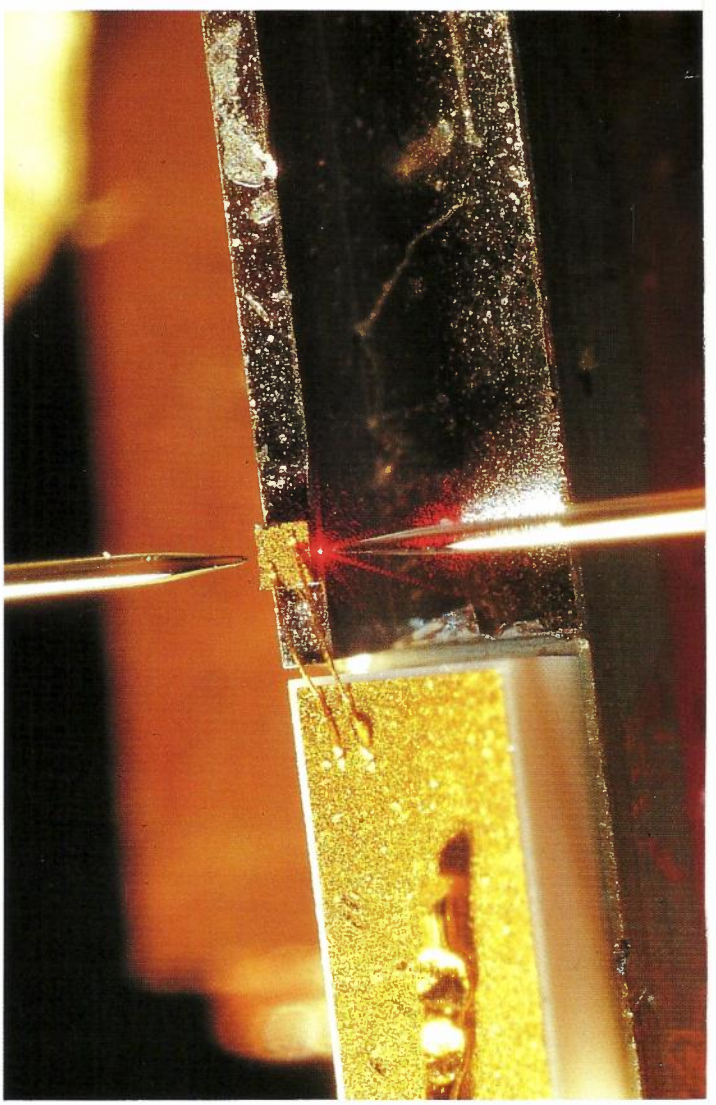
Optical amplifiers allow an array of optical signals each at a different optical wavelength or each at a different optical frequency as in (c) to be amplified in a single device. Optical amplifiers can also be used as power amplifiers to boost the transmit signal level and as pre-amplifiers to improve the sensitivity of optical receivers.

There are two main types of optical amplifiers; semiconductor and doped fibre and both are presently being investigated at TRL. An analytical model for semiconductor amplifiers has been developed exclusively for coherent system design and more sophisticated computer models of both amplifier types are being developed for possible applications in high capacity conventional and coherent long-distance system design.

Coherent systems employ optical sources with very high spectral purity and heterodyne or homodyne receivers. They achieve a 10 to 20 dB improvement in sensitivity compared to conventional systems and are frequency selective. Thus, it becomes possible to combine a large number of optical carriers onto a single fibre, and to choose a particular channel at the receiver by tuning the local oscillator laser.

A number of technological problems must be overcome before coherent systems can be employed in the Telecom network, and a great deal of work is being directed to resolving these. A programme of analytical and experimental work is being undertaken at TRL to establish the performance achievable from various coherent system options.

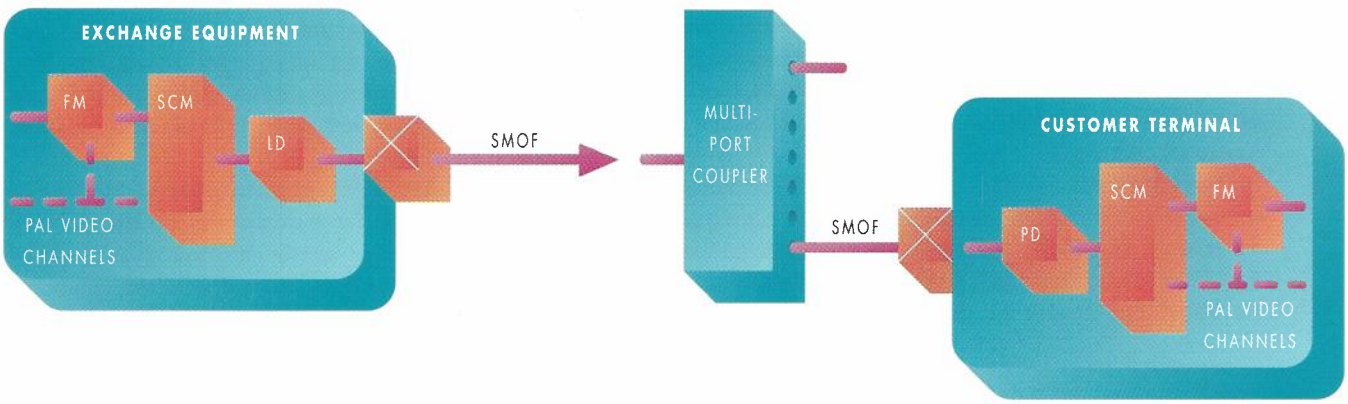
Experimental semiconductor laser amplifier



OPTICAL CUSTOMER ACCESS NETWORK

Video Transmission Over Shared Fibre Networks
Optical fibre network architectures for application in the customer access network (CAN) have been under investigation by TRL for a number of years. The emphasis has been to identify those architectures that will not only facilitate the introduction of new wideband customer services such as distributive and interactive video services but will also, in the near future, permit the cost effective delivery of the existing range of telecommunication services.

The passive shared optical fibre network architecture provides a flexible and potentially cost effective option. In its most basic form this architecture involves a double star topology, with the use of a passive multi-port optical fibre coupler located at a distribution point near a cluster of customers. This coupler acts as a splitting/combining element for the optical signals transmitted to and from the customers connected to it and is located in the street, possibly at a cabinet or pillar site in the existing external plant network.



The passive shared optical fibre network is ideally suited to the provision of distributive video signals (ie. Pay-TV) since information transmitted from the exchange end is inherently broadcast to all of the customer ends connected to the field located passive multi-port optical coupler. Furthermore, by using wavelength flattened couplers, the photonic transparency of the network is preserved over the full bandwidth of the single mode optical fibre. This allows a flexible provision of additional services and the ability to upgrade the network to accommodate an evolution to a future B-ISDN.

In the near term, video services (ie. Pay-TV) can be delivered over shared fibre networks using analogue modulation and electrical subcarrier multiplexing. With this approach, the input PAL video signals modulate a number of electrical sub-carriers to produce an FDM signal that intensity modulates a laser diode source. At each customer site appropriate channel selection and demodulation equipment is required to establish the video connection. The number of video channels that can be delivered using this approach depends on the type of modulation used (ie. AM or FM), the available loss budget, which is set by the transmit level of the exchange end optical source and the sensitivity of the optical receivers used at the customer sites, the optical loss introduced by the passive distribution network (this being dominated by the loss introduced by the multi-port passive coupler) and the video signal-to-noise (SNR) performance required.

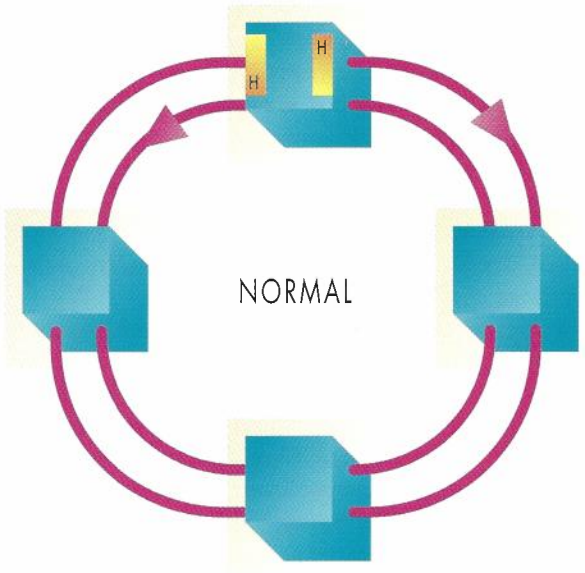
Studies have been carried out within TRL to determine the trade off between the above performance parameters. In particular, the maximum number of video channels that can be realistically transmitted over passive optical networks as a function of the number of customers fed from the network has been investigated. Because of the relatively high loss introduced by the passive coupler, (ie. 12-14 dB) for a 16-way split, amplitude modulation (AM) is not suitable. With frequency modulation (FM) a FM improvement factor, dependent on the frequency deviation used, leads to an increased SNR. The penalty with FM is the increased signal bandwidth required per TV channel. Further improvement in SNR can be achieved by deliberately clipping and amplifying the aggregate FM/FDM signal. This operation leads to a trade off between an increase in SNR, for a given receive power level, due to the increased modulation depth of the individual channels and a decrease in signal performance due to the clipping distortion introduced. The distortion can be minimized by constraining the sub-carrier channels to an octave frequency band and overall an optimum clipping level can be established that maximizes the number of channels for a given SNR. These theoretical studies have been complemented by measurements made with commercial multi-channel FM/FDM video equipment on a laboratory experimental passive optical network. This work will help Telecom with its planning for the introduction of new video services.

ASSESSMENT OF FASTPAC NETWORK PERFORMANCE

Telecom Australia will soon introduce the FASTPAC service for high speed packet data networking between computer mainframes, Local Area Networks (LANs) and other devices. FASTPAC will be a national network interconnecting major cities and metropolitan centres at backbone rates of 34 and 140 Mbit/s. Access rates will be 2 Mbit/s for connection of a single LAN, and 34 Mbit/s for multiple customer networks and devices. FASTPAC will be a switched service that enables each packet to be routed to any destination according to its address label. In this way, many of the features available on a customer's LAN may be extended to cover sites in all major centres, without the requirement for individual leased lines between sites.

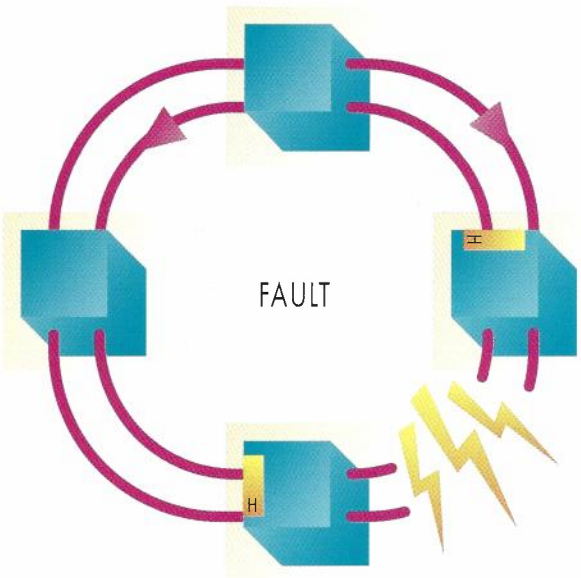
FASTPAC will initially be based on QPSX technology originated at University of Western Australia and now being developed by the Telecom joint venture company QPSX Communications. An initial engineering trial of this MAN technology will be operational in late 1990, for the interconnection of a number of Telecom buildings in the Melbourne metropolitan area. Extension to a national network with commercial service will follow. This national network will be based on a number of QPSX sub-networks interconnected by routers which filter and transfer the internetwork traffic.

Telecom's network designers require information on the reliability and performance of QPSX networks to ensure that high quality service is provided to FASTPAC customers. TRL has developed simulation packages that model the delay and throughput performance of individual sub-networks and of a number of sub-networks interconnected by routers. The configuration control algorithms, which control their configuration of sub-networks to bypass faults, have also been simulated.



Reconfiguration of QPSX

Studies of the delay performance of individual QPSX sub-networks have demonstrated the viability of the basic access protocol to carry a wide range of traffic types, such as data and variable rate encoded video-conference, at reasonable loading without in-



troducing unacceptable degradation of services. Several enhancements to the basic protocol have also been assessed. These include a bandwidth balancing scheme introduced by the IEEE P802.6 committee that is standardising the Distributed Queue Dual Bus (DQDB) MAN based on QPSX, and a guaranteed bandwidth scheme called CYREC developed and patented by TRL.

Routers that interconnect QPSX sub-networks are a potential source of congestion and hence of service degradation. TRL has developed a simulation package for the assessment of packet loss rates in routers due to network congestion at high loading. This package may be used for the assessment of congestion control measures, and will help Telecom to design the national network for the required service quality.

QPSX can reconfigure to bypass faulty transmission equipment or network equipment and maintain full connectivity and full capacity in the case of a single fault. TRL has also developed an interactive computer routine that simulates the operation of the configuration control algorithm and provides graphical output of the network states and control signals as reconfiguration proceeds.

This research has provided support for the FASTPAC product development and also indirectly for QPSX Communications Ltd in Perth, and for the standardisation of the technology within the IEEE P802.6 committee.

MOBILE COMMUNICATIONS SYSTEMS

Since early 1987, Telecom Australia has been operating a cellular mobile communications system, and since this time, customer demand has experienced explosive growth, a trend that has also been experienced world-wide. Also, a clear demand for small lightweight mobile communications terminals has appeared, which reflects the increasing demand for "personal communications", which describes the service idea of communications "person-to-person", rather than "location-to-location", as has traditionally been the case.

In response to this demand, public mobile communications is today undergoing rapid evolution. Considering the evolution of cellular mobile technology, one of the major technical hurdles to overcome is how to accommodate very high traffic demands within limited geographical areas, particularly in and around major city centres.

TRL is investigating cell design techniques to support high traffic densities, whilst still maintaining the required quality of service. The underlying objective is the achievement of a greater reuse of the radio channels over the service area, which requires the deployment of a large number of radio base stations, each serving a relatively small area, or radio cell. However, for very small radio cells or "micro-cells", the heights of the base station antennas will necessarily be low, in fact, ultimately below the heights of the surrounding buildings. This scenario raises a number of questions and potential problems that are not encountered with conventional cellular design. For example, the characterisation of the radio propagation loss from antennas of very low height, and also, the sudden loss of signal strength that may occur when turning a corner, and the implications this has on the ability of the system to "handover" such calls to an adjacent radio cell.

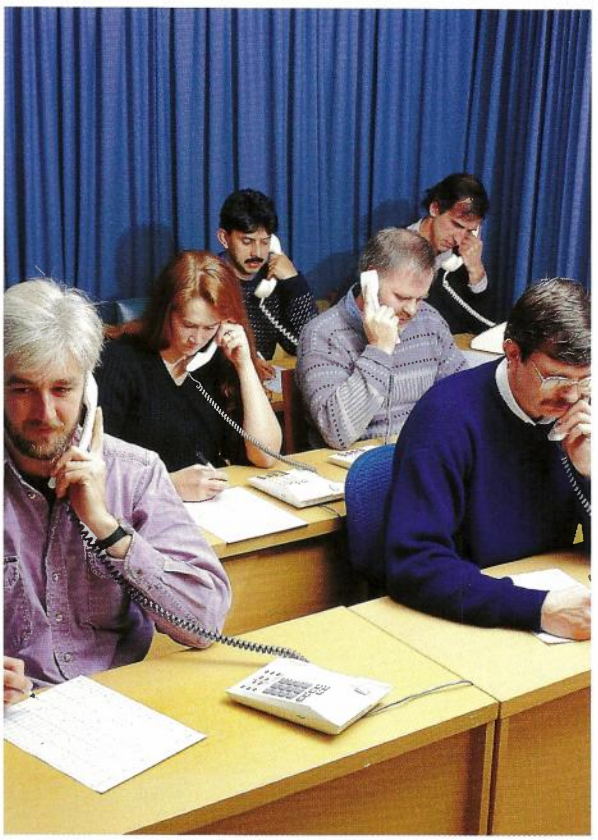
TRL is also investigating a more novel concept to support high traffic densities. In particular, utilizing a base station antenna that provides a large number of distinct beams, where each beam supports a separate radio cell. Part of this investigation involves measurements to determine the angle-of-arrival spread of the received signal at the base station. This will also provide valuable information for determining the requirements on antenna separations for reception diversity at cellular base stations, which is also being investigated.

The next generation of cellular systems will utilize digital encoding of speech and digital transmission technology. These systems ultimately provide more capacity than the current analogue systems. However, due to the "multipath nature" of the mobile radio channel, the pulses associated with the digital transmission technique are spread out, which can give rise to errors, even if the received signal power is high,

Radio signals that are reflected from buildings and other objects could affect the quality of a future digital mobile telephone system. TRL's Scientific Engineering Section designed and built this advanced multipath antenna to measure the angle of arrival of reflected signals

and thus must be considered in cellular design. TRL has designed and constructed a measurement apparatus to resolve the multipath components of the mobile radio channel, which will enable different environments, ie. urban and suburban, to be characterised for digital cellular operation.

The results of this work have enabled TRL to provide timely advice on cellular design techniques, and on the performances of the digital cellular systems that are likely to be introduced in Australia shortly.



Good listeners. Volunteers subjectively score the quality of several low bit rate voice codecs supplied to TRL by the world's leading codec designers. The pre-recorded voice signals processed by the voice codecs were scored for clarity and fidelity

A COMPETITION FOR CODEC MANUFACTURERS

The economic viability of the Telecom/ AUSSAT Land Mobile Satellite system will be dependent to a large degree on the power efficiency and robustness of the voice modulation scheme chosen. Various analogue single-sideband options for Mobilesat were examined at TRL during 1989 but these were finally rejected in favour of low bit rate digital voice coder-decoders (codecs).

Unlike traditional digital voice waveform codecs that operate at typically 16 to 32 Kbits/sec, low bit rate codecs are capable of achieving near toll quality performance at bit rates of around 5 Kbits/sec. This performance can be achieved using a number of computationally intensive algorithms that essentially model voice production in the human vocal tract.

These coding methods, apart from being more spectrally efficient than the waveform codecs mentioned above can also benefit from the use of powerful coding schemes. The value of these coding schemes is that they increase robustness against fading of the signal arriving from the satellite and will ultimately reduce the satellite power required per customer. Finally, encryption can be readily employed to provide security of both voice and data transmissions. Additionally, a mix of data and voice services can now be provided simultaneously on a single channel.

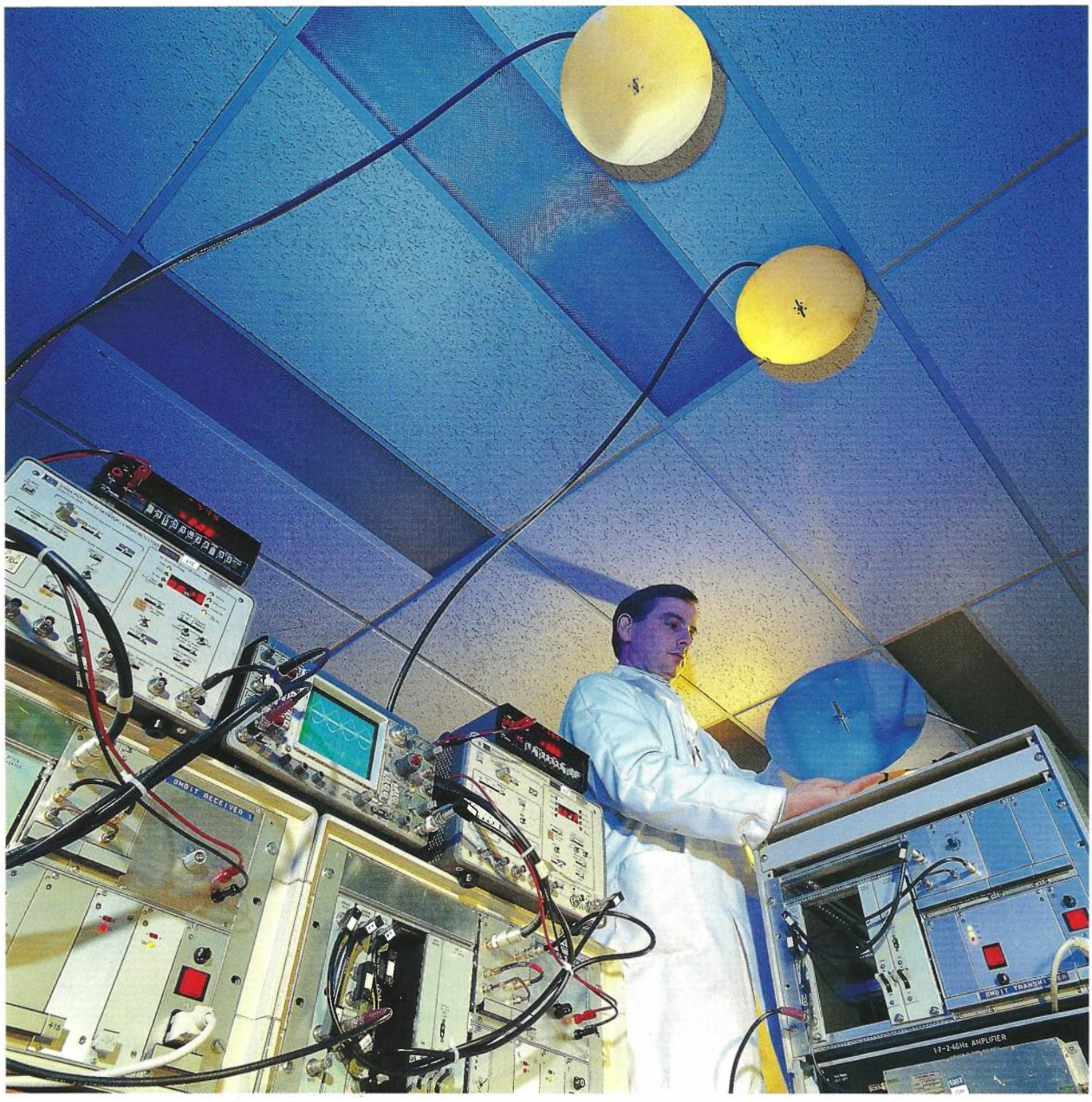
As a consequence of these perceived advantages, during late 1989 Telecom and AUSSAT invited codec manufacturers world-wide to participate in a contest. It was designed to choose the best voice codec algorithm available for the proposed Mobilesat system. It was also proposed that TRL would carry out subjective listening tests on these codecs to determine both the quality and robustness and rank them in order of merit. These results could then be used to further commercial negotiations with the codec manufacturers for the supply of the successful algorithm.

Fortuitously, around the same time International Maritime Satellite Organisation (INMARSAT) issued a similar invitation for its Standard-M system and also called for proposals from Laboratories interested in performing subjective testing. TRL responded quickly and was awarded a contract to carry out the work.

A detailed test procedure was developed using novel baseband channel error models based on both local and European propagation data. This was quickly made available to candidates during January. By February 26th, the final submission date, a total of 10 codecs were received. These were from Australia, Canada, USA, the United Kingdom and Japan.

An intensive series of subjective listening tests designed to evaluate speech quality and robustness against channel errors, caused for example by signal fading, or by background acoustic noise were made over a 12 week period. The final results of these tests were presented to INMARSAT in London. Commercial negotiations are currently underway with the successful candidate.

This TRL initiative, to combine the two contests, succeeded in securing a much larger number of candidate codecs than otherwise would have been possible and hence should increase the probability that the successful codec algorithm will be accepted as a potential world standard. This would lead to significant cost reductions in terminal equipment and facilitate interworking between mobile satellite systems.

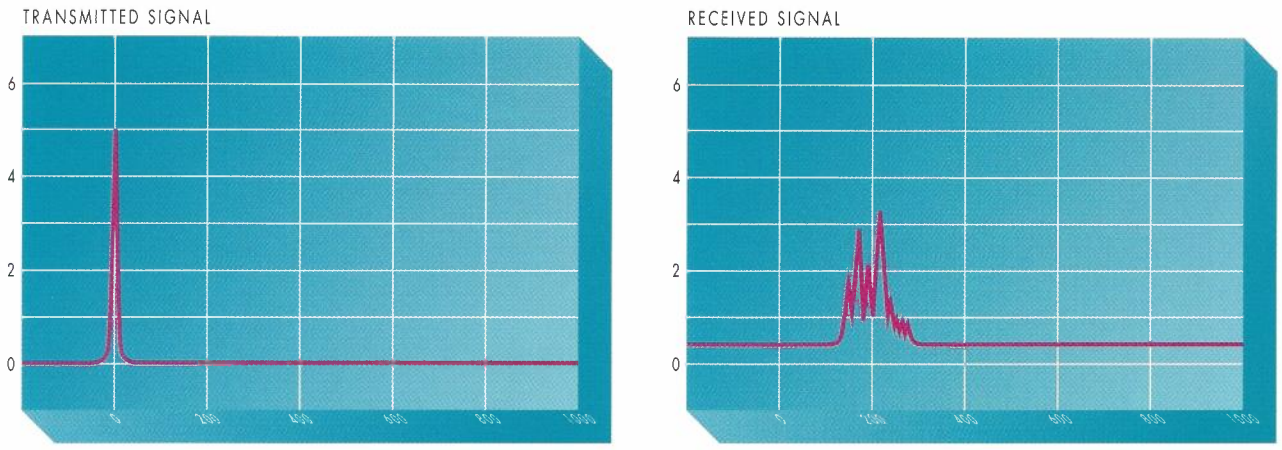


Ceiling mounted radio base stations. Gary Kay investigates advanced technology for the wireless office of the not-too-distant future

WIRELESS ACCESS SYSTEMS

Wireless access within buildings, can generally have two applications. Firstly, the narrowband access of public telephony network (PSTN), PBX and ISDN for voice and low bit rate data service. Secondly, the wideband access between computers, terminals and hosts for high speed data transfer of the order of few Mbit/s. So far as narrowband wireless access is concerned, new digital cordless standards such as CT2 are now available that offer limited radio access to the above mentioned narrowband services. In future, improved cordless standard called DECT (Digital European Cordless Technology) will be available for complete wireless access. In contrast, the standards for wideband radio access have not yet been developed and several research organisations in the world are in the process of specifying the system. TRL therefore has been studying the application and performance aspects of the cordless technologies and also working on the various technical aspects related to wideband access in order to take a lead in the specification and the standardisation process.

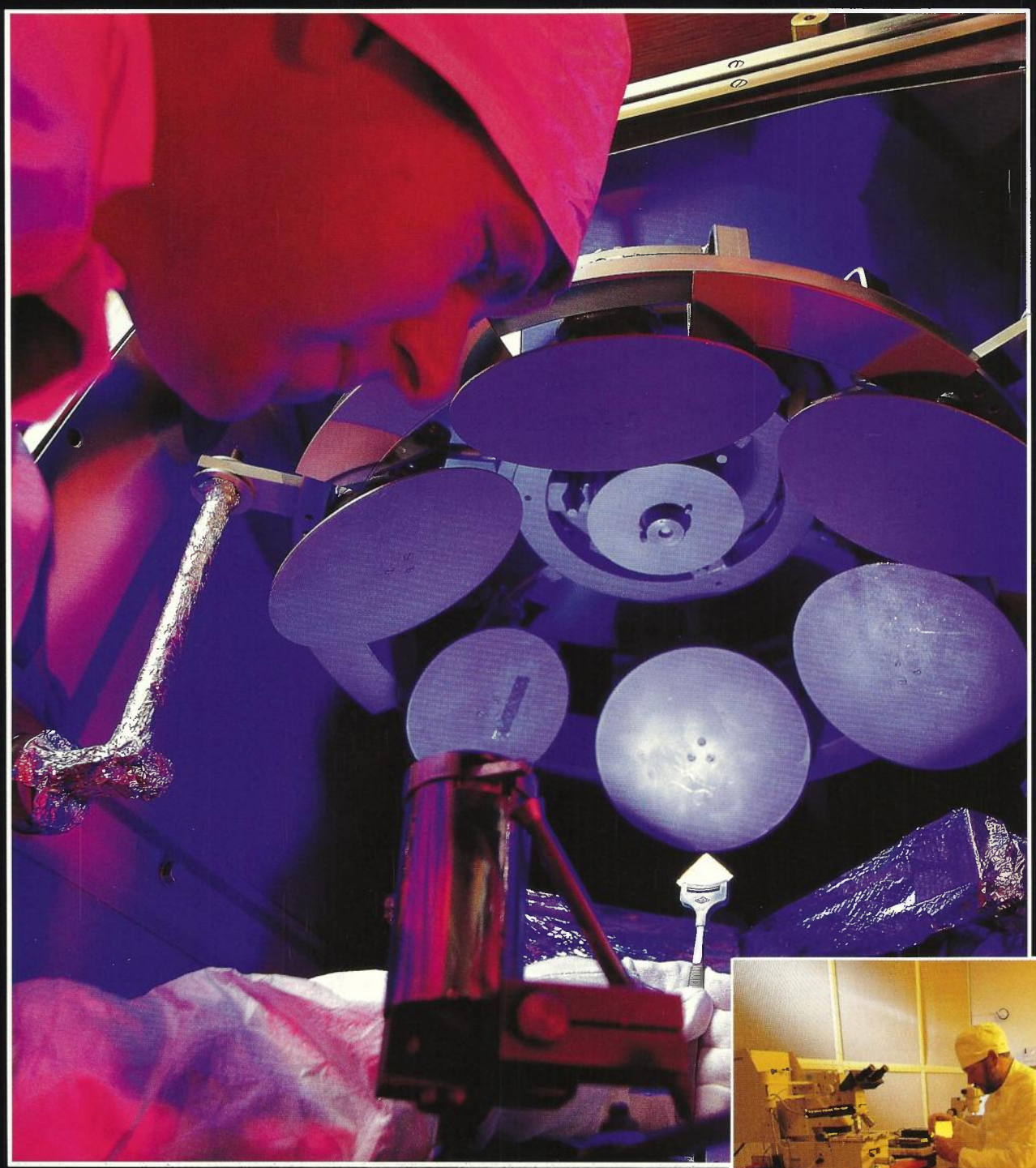
TRL has studied the application of CT2 cordless technology for public telepoint service, and in the wireless access to key systems and PBX. These studies have enabled the estimation of the capacity limits and determination of the appropriate architecture and interface for these two applications. A similar exercise is being undertaken for the upcoming DECT.

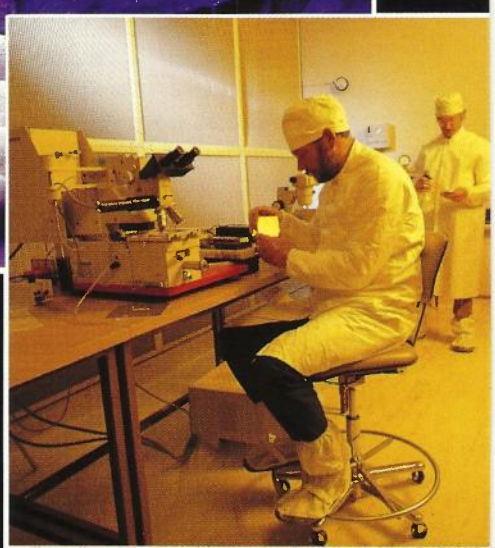


TRL researchers are working to overcome radio propagation problems inside buildings. One such problem is multipath propagation - the reflection of radio signals from obstacles. As shown in the above example, a narrow pulse transmitted inside a building (left) can become distorted at the receiving end (right) greatly limiting the systems capacity.

At the same time, TRL has kept a watching brief over a new narrowband wireless access system called PCN (Personal Communication Network). The PCN will allow customers to carry small pocket phones anywhere in the service area and be able to communicate via base stations networked with the switch using radio bearers.

The essential technical aspects of wideband access include determination of capacity requirements of such systems, the achievable capacity through the radio medium, appropriate protocols for the medium access and the radio network architecture. TRL has established the requirement of future wireless computer communications using a software monitoring technique on the ethernet available in TRL. To enable the estimation of capacity of wideband access, it is important to establish various radio propagation characteristics. The radio propagation within buildings is characterized by multipath transmission resulting in severe path attenuation of the signal, spreading of the transmitted signal and shadowing from metallic objects in the buildings. Using pulse sounding techniques, TRL has conducted wideband propagation survey of several buildings in Melbourne to obtain propagation statistics such as average path loss, variance of the delay spread and shadow loss within buildings. This survey included urban office type multi-story building, suburban office type building, a medium size workshop and a large manufacturing plant, each building representing its generic class. Studies are now being conducted to determine the optimum protocol and the architecture. An experimental wideband access system is currently being used to test the capacity, protocol and architecture for wideband access systems.





NEW TELECOMMUNICATIONS TECHNOLOGIES

Generally, it is at the fundamental level of research into new materials, components and techniques that the first indications occur of technology developments that will soon impact on telecommunications equipment, networks and services. TRL undertakes this research to maintain Telecom Australia's technological leadership, to generate strategic corporate advice on opportunities for exploiting new technologies, and to establish scientific and intellectual credibility and authority with local and overseas industry, academia and government.

OUR RESEARCH INTO AREAS SUCH AS ENERGY AND POLYMER TECHNOLOGIES, IS DRIVEN BY THE NEED TO MEET THE DEMANDS OF UNIQUELY AUSTRALIAN CONDITIONS

Current areas of materials and device research include optoelectronic devices, based on the Gallium Arsenide and Mercury Cadmium Telluride compounds, and fibre materials and devices using fluoride glasses as host. This work is in strategic technology areas vital to future optical communications developments.

Other research, such as that into energy and polymer technologies, is driven by the need to meet the demands of uniquely Australian conditions.

The selection of research activities described in the next few pages illustrates some the work of TRL, seeking to harness new technology so that Telecom Australia will continue to evolve a modern, efficient and reliable national telecommunications network.

LEFT: Researchers prepare experimental optoelectronic devices for treatment in TRL's Metal Evaporation System. The system deposits thin layers of gold and other metals which provide circuit connections

HARNESSING ENERGY FROM THE WIND

With solar energy being used so successfully to supply power to telecommunications equipment in remote areas, the question often asked is why is Telecom interested in harnessing energy from the wind. One reason is that solar modules are still expensive, even though their cost has decreased enormously since Telecom started using them in 1974. The present day cost of a solar module is about $6 per watt, whereas for wind machines, it ranges from around $4 per watt for very small units of less than 1 kW to around $1 to $2 per watt for medium size units (1 to 20 kW) and even lower for larger machines. Another factor is that some remote locations have large differences in solar energy input between summer and winter. At sites where the winds are predominantly in winter, a hybrid solar/wind power system that exploits the complimentary between the solar and wind energy sources may be an attractive option, particularly for supplying larger loads (500 kW).

A solar/wind/diesel hybrid power system is under study on French Island in Westernport Bay. This is a collaborative project with CSIRO and the Renewable Energy Authority Of Victoria. Telecom's main interest is the performance of the wind machine. System parameters, such as the amount of energy from each source and the battery charge/discharge cycling profile are also being monitored.

Another project is evaluating a low speed generator and wind turbine that has been developed by a local manufacturer. Five units are being installed in remote locations with diverse wind conditions. Correlation of wind speed data with generator energy production will provide a basis for sizing such systems for telecommunications applications.

A third project has two identical wind machines co-located at the Caldermeade Antenna test range. One machine has an optimally matched resistive load while the other has an electronic equivalent of a battery load. Results will indicate whether an electronic interface is needed between a wind machine and a battery and load for maximum energy collection.

Solar energy will continue to be the preferred energy source for most remote applications. However, at certain sites and for larger loads using wind as an energy source, either alone or in combination with other energy sources, appears to be an attractive option.

Telecom Australia is already the worlds biggest user of photovoltaic (solar module) technology. TRL is now researching the use of hybrid solar/wind energy systems to power repeater stations in remote locations

RIGHT: Researcher Chris Byrne setting up a test measurement of fluorescence in erbium-doped ZBLAN optical fibre, to assess the fibre's suitability for a fibre amplifier

NEW COMMUNICATION FIBRE AMPLIFIERS AND LASERS

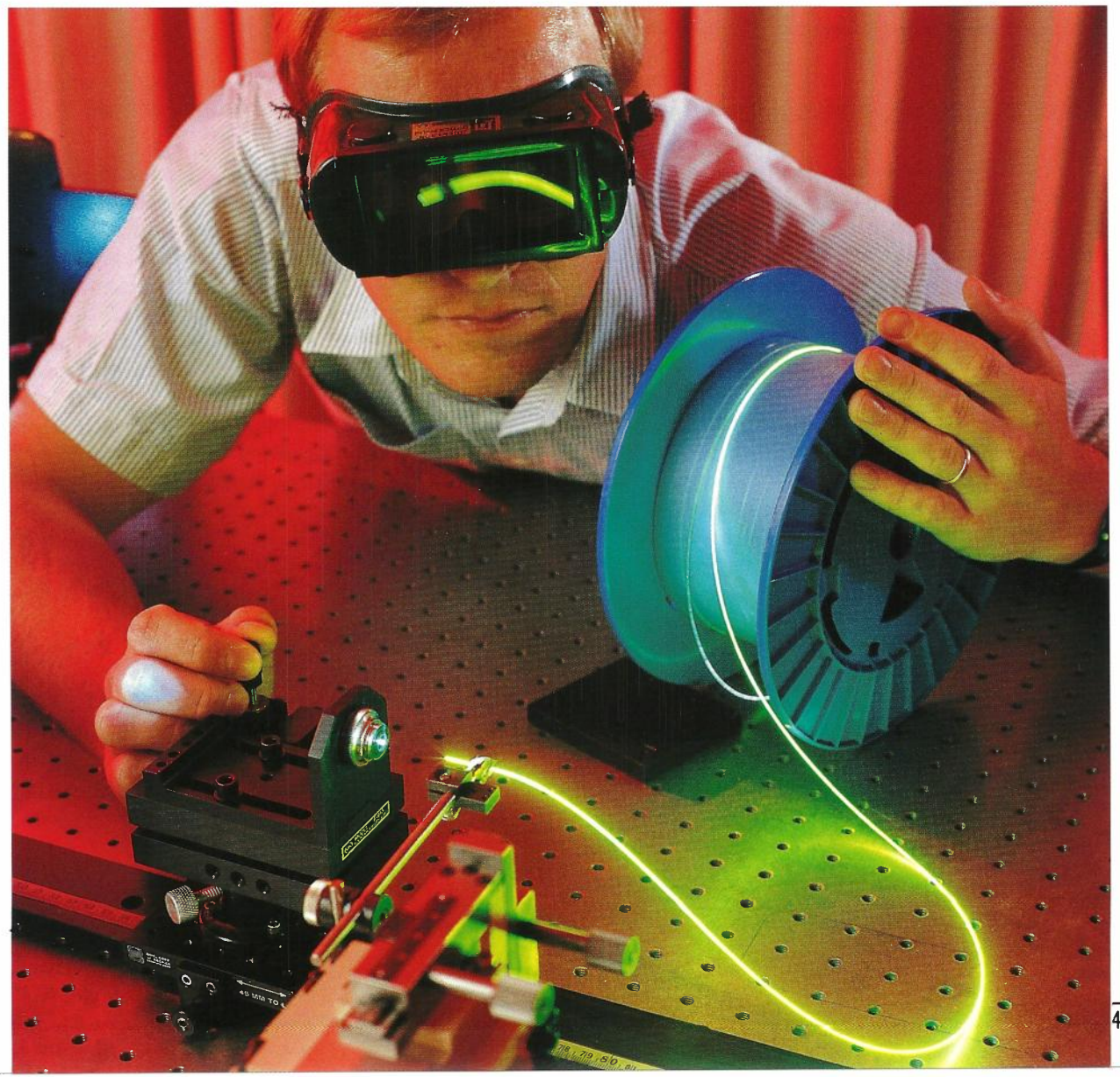
Fibre laser sources and amplifiers (FLSAs) are a relatively new class of system components constructed from specially prepared optical fibres. Physically they have a core/cladding structure like a conventional optical fibre used for transmission, except that in the core is added a small amount of one or more dopants that render the glass there optically active under some prescribed conditions. FLSAs could find an important niche in future telecommunications networks because:

- they are compatible with optical fibre transmission media,
- they provide all-optical amplification without the need for electronic conversion, and
- they are mass-producible hence potentially low cost.

A typical FLA requires a few metres of fibre from a single draw-length of perhaps one or more kilometres. Conceptually, a FLA may be simply spliced into an optical fibre system where optical gain is required.

However, there are many options to consider before FLSAs can be implemented into the telecommunications network, which is why there is significant research in this area by many laboratories at present. Invariably these devices are optically pumped, so in order to utilise their 'in-line' advantage, optical couplers are important associated components. Optical resonance is desirable as a means for controlling wavelength selection within a broader fluorescence spectrum, whilst for best efficiency the main fibre should support only the fundamental mode at both pump and signal wavelengths. Inexpensive pump lasers are required at the appropriate wavelengths with power to match low thresholds of efficient FLA design. The type of host glass and glass quality (transparency) are also critical factors.

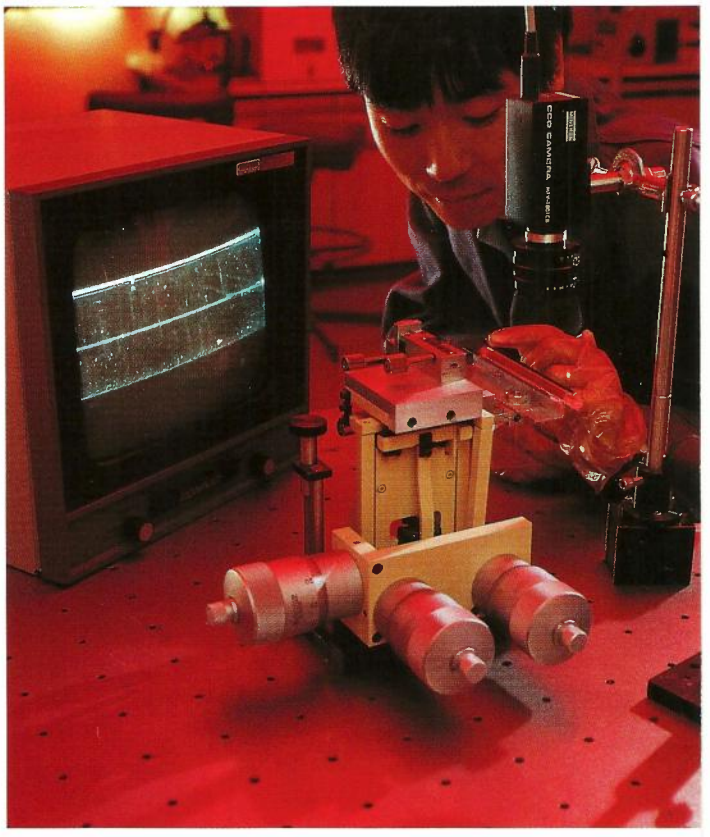
At TRL fibre lasers have been fabricated from ZBLAN, a glass comprised of heavy metal fluorides of a particular composition, and doped with either neodymium (Nd) or erbium (Er). A Nd-ZBLAN fibre laser operating at 1050 nanometres has been demonstrated using glass, preform and fibre made from fluoride starting materials. Success of this demonstration has



depended in no small way on a number of techniques developed to this end, and achieving low scatter glass has been an important milestone in meeting our objective. Nd-ZBLAN is expected to operate near 1300 nm, a strategic communications wavelength having low loss and zero dispersion in silica. When ZBLAN is doped with Erbium it fluoresces in the visible and also at 1500nm, the lowest loss wavelength for silica.

Turning to optical couplers, a new class of device has been investigated for application to FLSAs. In one configuration the new devices have two resonance wavelengths (which may be extended to several) at which the device looks like a reflector or mirror in the main fibre, yet allows a pump wavelength to couple efficiently at a third, shorter wavelength, all the time preserving the basic in-line fibre configuration.

There can be little doubt that the application of specialised optical fibres, in which FLSAs are but examples, to signal processing functions as distinct from transmission ones will continue to grow in the 1990s. The exciting prospect of addition of other dopants designed to enhance magnetic and nonlinear effects serves to support this view.

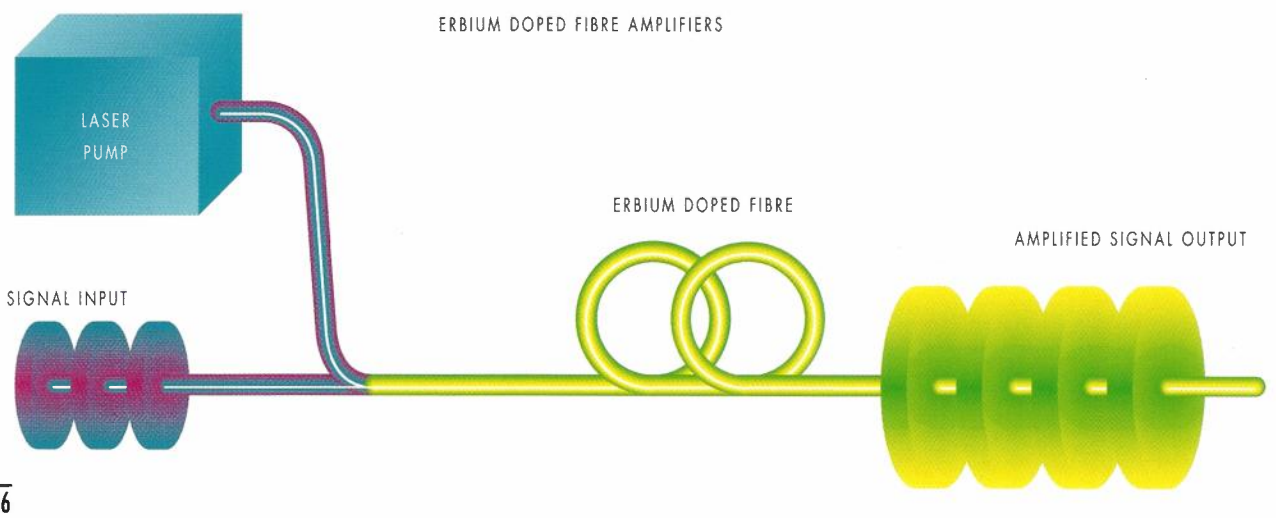


Researcher Yasuo Ito inspects the scattering of laser light in a fluoride glass preform, with the aid of a high sensitivity camera

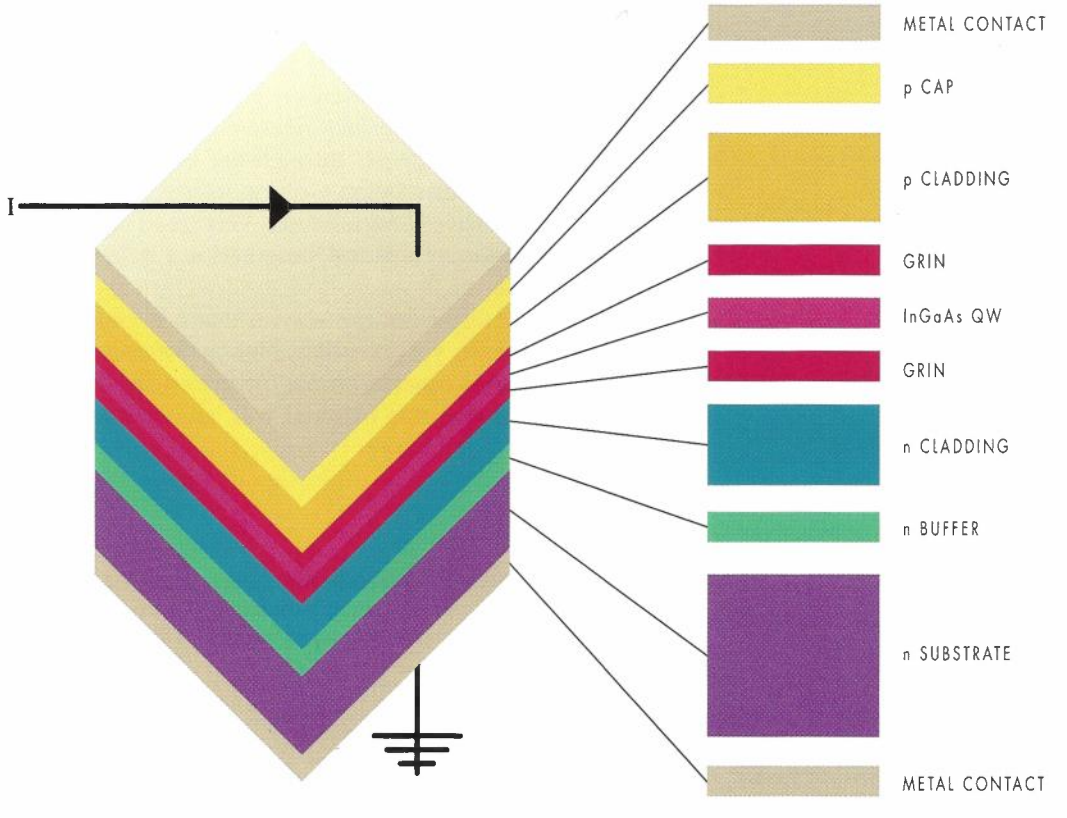
EXCITING DEVELOPMENTS IN OPTICAL COMMUNICATIONS

One of the most exciting developments in optical communications in the last two years has been the progress of fibre optical amplifiers. For the first time there would appear to be a way of amplifying an optical signal in a fibre with the ease that we take for granted when amplifying electronic signals. Before this is achieved, considerable development of the components of the amplifier, particularly the optical pump, is needed. Although the fibre amplifying medium is nearly perfected, critical parameters such as the overall cost, power consumption and lifetime depend on the optical pump. Hence the development of an optimum pump is one of the major advanced material and device research projects in TRL.

The way the amplifier works is shown in the figure. The optical signal passes from the normal silica fibre and through a few metres of erbium doped fibre. Light is also coupled in from a laser pump, which excites the atomic levels of the erbium atoms. The incoming light "discharges" the excited states and the fibre emits at 1.5 micron in synchrony with the output. One of the most attractive features is that the amplifying fibre can be made to match the signal fibre exactly, eliminating coupling problems such as reflections. The amplifier should eventually consist of a small box that is simply spliced into a fibre wherever 24dB of clean GHz amplification is needed.



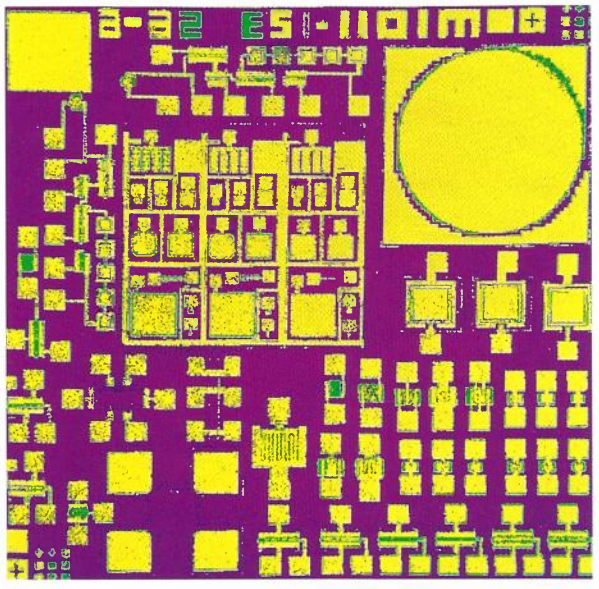
The aim of the research is to design and develop a laser diode to act as a pump. The optimum pump wavelength for the 1.5 micron signal region is 0.98 micron and there are no commercially available laser diodes at this wavelength. As well, the lasers that are certainly being developed for this application are based on expensive indium phosphide technology. An alternative is a potentially much cheaper and more efficient gallium arsenide technology using strained layer materials. This technology has only been researched recently in a few institutions world-wide, including TRL. Its application to the laser is shown in cross-section view. The laser is grown on a gallium arsenide substrate by molecular beam epitaxy and consists of a number of different layers designed to confine the electrons and photons. If the materials were conventionally grown, the laser would emit at 0.85 micron, too low for efficient operation. In this laser, the active layer is made of indium gallium arsenide that emits at longer wavelengths. The problem is that its atoms are further apart than those of gallium arsenide and it must be "persuaded" to fit the gallium arsenide and to form a highly strained defect free layer with a thickness measured in atomic layers. The first such lasers have now been made and wavelengths in excess of 1.1 micron have been measured. Work is now continuing on optimising the design with particular attention to high efficiency operation.



A TRL laser structure grown on Gallium Arsenide by molecular beam epitaxy

MID INFRARED OPTOELECTRONICS

For just over 2 years TRL has had a project covering the development of optoelectronic devices from the compound semiconductor, mercury cadmium telluride (MCT). The chemical formula for this material is $Hg_{1-x}Cd_xTe$ where x is related to the ratio of the number of cadmium to mercury atoms in the crystal lattice. As x is varied from 0 (HgTe) to 1 (CdTe) the wavelength range of detectors made from this material moves to shorter wavelengths. Consequently, this is a very useful material since devices can easily be made to work at any optical communication wavelength of interest, particularly at the currently used 1.3 and 1.55um and also at 2.5um where future generations of very low loss fluoride fibres will work.

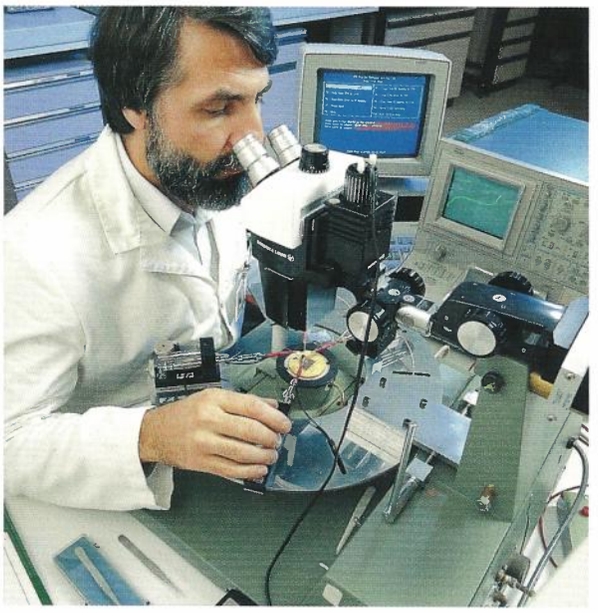


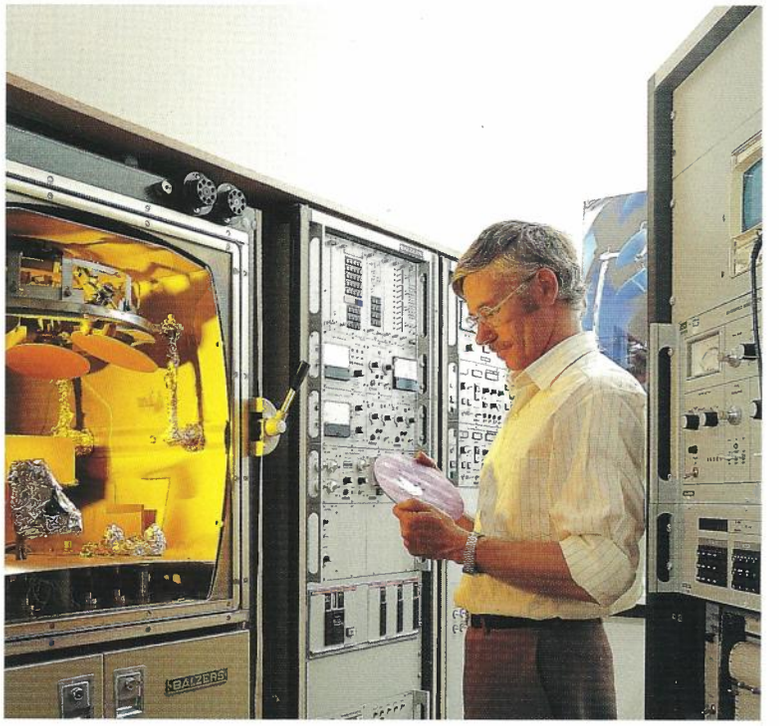
An experimental optoelectronic device produced at TRL as seen through one of TRL's scanning electron microscopes at very low magnification (33x)

During the year a number of significant achievements were made in the development of the technology for making communications quality devices from MCT. These principally involved the development of a metallisation system that allowed both ohmic and Schottky barrier (rectifying) contacts to be put down on the same material. Out of several evaluated, two metals were found to have contact characteristics suitable for the fabrication of a particular type of transistor called a Metal-Semiconductor Field Effect Transistor (MESFET). Two types of these devices were made and were found to have good electrical characteristics. This success was followed by the fabrication of working 1.3um detectors called Metal-Semiconductor-Metal (MSM) devices that use much the same materials and technology as the FETs. Both device types promise very high performance and simple integration to form an optoelectronic receiver chip. A design for the realisation of a prototype receiver has been completed. Such receivers are less complex and hence of lower cost than equivalent gallium arsenide devices. Also, the technology developed, has the feature that the MCT devices can be placed directly on top of complete gallium arsenide circuits if desired to take advantage of that technology's greater maturity.

None of this would be possible without a source of good quality material of the right properties. Excellent quality material is being made, using the Metal Organic Chemical Vapour Deposition Process (MOCVD). The MCT is grown by first depositing a stack of CdTe and HgTe layers of carefully chosen thicknesses and interdiffusing them under controlled conditions after the deposition has ceased. A problem faced in developing this method was in being able to predict the exact growth and annealing conditions to give the desired compositional profile. This is very desirable so that different materials can be used in different parts of the device. This problem was solved with the introduction of a unique computer model, developed in conjunction with CSIRO, which can accurately predict the material compositional profile (variation of x ratio with depth). The model has been tested by cross sectioning the materials grown and making measurements of composition at several points through the layer using high resolution transmission electron microscopy and energy dispersive X-ray analysis. Very good correlation between theoretical and measured results have been obtained.

So far this work has shown that it is possible to make simple, yet potentially high performance, communications optoelectronic integrated circuits from MCT and that this material will have a role in the systems of the future.



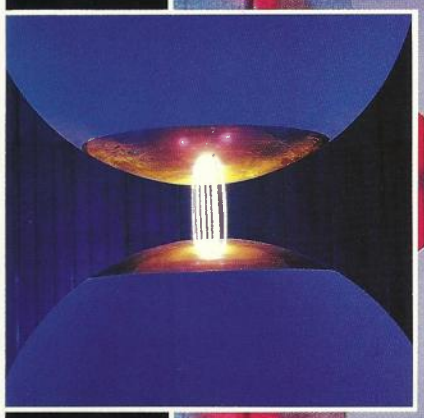


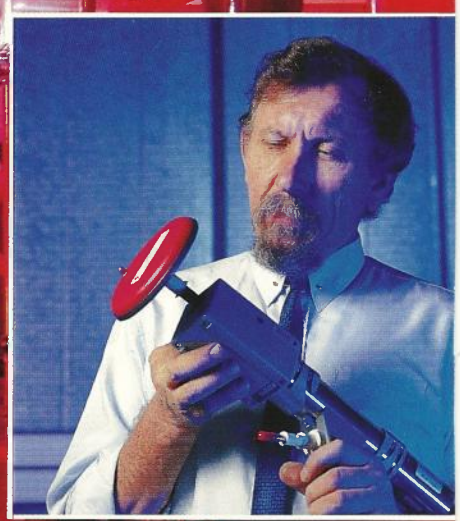
Gerry Brinson with TRL's Metal Evaporation System

TOP LEFT: Measuring the electrical performance of optoelectronic devices. Novica Petkovic probe tests devices on a wafer of Mercury-Cadmium-Telluride (MCT)

MIDDLE: Andrew Doherty operates a mask alignment system as part of the photolithographic processing that will produce optoelectronic devices from a wafer of novel semiconductor material

BOTTOM: Using liquid nitrogen as a coolant, Russell Anderson prepares to make low temperature measurements of the carrier properties of MCT devices





RELIABILITY ASSESSMENT AND STANDARDS

Telecom Australia aims to provide its customers with reliable and affordable telecommunications services.

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

TELECOM AUSTRALIA AIMS TO PROVIDE ITS CUSTOMERS WITH RELIABLE AND AFFORDABLE TELECOMMUNICATIONS SERVICES

Reliability assessment should preferably occur during the product design phase. Thus, while performing reliability assessment and failure analysis, TRL interacts closely with manufacturers and suppliers of materials and equipment to Telecom. Laboratory-based testing and evaluation often requires simulation of the stresses and conditions to which a product may be exposed during its service lifetime. Problems in the field can be widespread and costly to rectify. Thus it is imperative that TRL quickly determines the cause and finds the most expedient solution.

The electromagnetic compatibility of modern semiconductor-based equipment is an increasingly important aspect of equipment performance and reliability. Bio-electromagnetic hazards are also of concern particularly in relation to the work practices Telecom adopts.

The Reference Standards maintained by TRL provides traceability to the Australian National Standards and contribute to the efficient operation of the network. TRL operates, develops and disseminates electrical, optical, time and frequency standards to meet Telecom's needs.

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

LEFT: Ed Bondarenko (insert) is one of a team of experts whose work in TRL's high voltage laboratory is aimed at protecting equipment from high voltage surges

ELECTROMAGNETIC COMPATIBILITY OF INFORMATION TECHNOLOGY EQUIPMENT

Electromagnetic compatibility (EMC) of information technology equipment (ITE) embraces a multitude of activities. Not only are the potentially disturbing electromagnetic emissions from ITE of concern to Telecom, because of the interference they can cause to the operation of other electronic systems, but the susceptibility of ITE to natural or man-made electromagnetic disturbances must also be considered.

SITING OF TELECOMMUNICATIONS INSTALLATIONS

When planning the siting of telecommunications installations, considerations of environmental factors can play a significant part. Not least amongst those factors is the possibility of man-made radio-frequency electromagnetic interference to the operation of the telecommunications equipment that is to be installed at the site.

Guidelines have been prepared to allow the network planner to select a telecommunications site so that electromagnetic interference (EMI) to the telecommunications equipment by man-made radio waves will be minimised.

The guidelines are not concerned with natural sources of Radio-Frequency (RF) radiation, like lightning.

Intentional radiators of radio waves, such as RF transmitting antennas (AM broadcast, FM, TV, microwave dish, radar, etc.), and some unintentional transmitters of radio waves, in particular those fixed sources described as Industrial, Scientific, and Medical (ISM) radio-frequency apparatus, are within the scope of the guidelines.

The guidelines give methods of calculating the effective field strengths of man-made radio waves, and give an indication of how and under what circumstances RF electromagnetic site surveys should be undertaken.

INTERNATIONAL STANDARDS FOR ELECTROMAGNETIC COMPATIBILITY

One way Telecom can ensure that ITE, particularly customer premises equipment, will have acceptable EMC performance is to require that the ITE that Telecom operates, complies with accepted EMC standards. From an economic and trading point of view, the adoption of international EMC standards is the most sensible course.

To ensure that the international standards provide the EMI limits and methods of measurement that Telecom requires, technical inputs have been made to the Working Groups of the International Special Committee on Radio Interference (CISPR) and the Study Groups of the International Consultative Committee on Telegraphy and Telephony (CCITT).

EMI limits for the basic access Integrated Services Digital Network (ISDN) have been proposed by TRL to the CISPR and have been provisionally accepted for inclusion in the revision of the current CISPR standard for EMI of ITE. Contributions have also been made on the levels of EMI immunity required by ITE.

Potential EMI problems of interference to AM broadcasting services, arising out of the existing CCITT recommendations for the transmission characteristics of the basic access ISDN, have been represented to the CCITT, and form part of the continuing contributions being made during the present CCITT study period.

COMPLIANCE TESTING AND CONSULTANCY FOR ELECTROMAGNETIC COMPATIBILITY

EMI tests and measurements for compliance with the EMI limits of the present CISPR EMI standard have been carried out for several Telecom products - the QPSX Cluster, Commander E, Datagate, Emergency Recall Device, and the Timeslot Exchanger and Multiplexer.

Where non-compliance with the limits or other potential EMI problems have been detected, consultancy and advice have been provided to the product groups.

THE NUMERICAL ELECTROMAGNETICS CODE

In the study of EMC problems involving the interaction of conductors and electromagnetic waves close to real ground, as opposed to an idealised perfectly conducting ground plane, it will be very useful to have available a computer code that can be used to accurately calculate the electric and magnetic field strengths. This will be particularly so for problems involving the near-fields of wires and cables, acting as inadvertent radiators or receivers of EMI near the surface of the Earth.

A computer code in world-wide use, which seemed to offer such convenience was the Numerical Electromagnetics Code (NEC2), which was released for public use in 1981. It is a very large code that is built around the numerical solution of integral equations for the currents induced on metal structures by sources or incident fields.

Experimental investigations at TRL into the accuracy of the code's calculations of near magnetic fields close to real ground demonstrated that the calculations were seriously in error, and led to the disclosure

that a section of the code vital to the calculation of near magnetic field strengths close to a real ground was missing when NEC2 was released for use in the public domain.

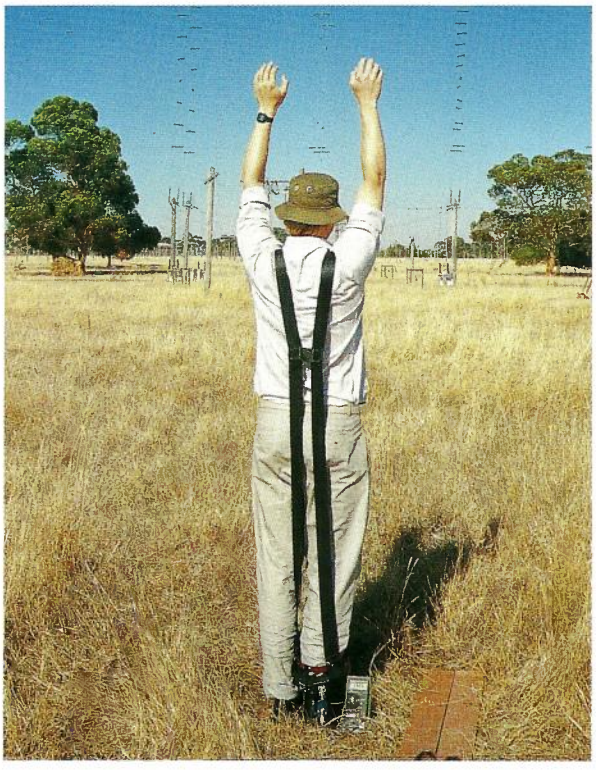
The missing section of code has now been supplied to TRL by the code's developers, and the use of NEC2 - with the missing section of code restored - is now being investigated further for its usefulness in the solution of EMC problems.

Mike Wood sets up an antenna for testing in one of TRL's two anechoic chambers. By absorbing Radio Frequency Radiation (RFR), the chambers allow measurements to be taken in a non-reflective environment. Apart from antennas, electronic equipment is measured to ensure that it will not be susceptible to RFR interference, and that its RFR emissions are within limits

INDUCED RADIO FREQUENCY CURRENTS IN HUMANS

When a person is exposed to radio frequency (RF) radiation, currents are induced in tissue through the action of the electric field of the incident radiation and energy is deposited. Ultimately this energy ends up as heat and a measure of how much heat is generated is the magnitude of the induced RF current. Maximum currents are induced when the body is resonant and the electric field of the incident radiation is vertical. For an upright male of 1.75 metres height, resonance occurs at around 80 MHz for the free space condition and at around 40 MHz when good electrical contact is maintained with the ground.

TRL has been investigating methods of measuring these induced RF currents and has devised two independent measurement methods. In the first method a RF current transformer is clamped around the ankle of a test subject and the output voltage measured. The induced RF current flow leaving the body through the leg is then calculated. In the second method the test subject stands on a resistive plate and the voltage developed across the plate is measured. The induced RF current flow leaving the body through both legs is then calculated. The agreement between two methods of measurement is within 10 percent.



Recent reviews of Australian and International RF exposure standards have recommended limits for the magnitude of the induced RF current flow. Therefore, this work is of significant value and is timely in that Telecom is now in a position of establishing compliance with the new exposure limits.

FOETAL PROTECTION IN THE WORKPLACE

Since Telecom maintains and operates high powered sources of radio-frequency (RF) radiation, eg. the transmitters of the Australian Broadcasting Corporation (ABC), special consideration must be given to young women working in such an environment so that in the event of a pregnancy both mother-to-be and foetus are protected from excessive exposure to RF radiation.

TRL is presently providing assistance to the Director, Occupational Medicine, in the formulation of guidelines to protect the unborn child. The Australian RF radiation exposure standard, AS2772-1985, requires that occupational exposures (the mother-to-be) be limited to 0.4 W/kg when averaged over the whole body, while RF exposures of the general public (the foetus) must not exceed 0.08 W/kg. Because of the difficulties of direct investigation of the deposition of RF energy in the human body, numerical simulations are being utilized to estimate the absorption of RF radiation at the foetal site.

One important question being studied is whether or not absorption by the foetus exceeds the non-occupational limit if the mother is exposed to the occupational limit level. Preliminary results indicate that at certain stages of pregnancy and at certain frequencies - around 80 MHz (body resonance) and in parts of the microwave frequency band - the foetal exposure may exceed the non-occupational exposure limit.

Research for a safer working environment. TRL's Vitas Lubinas takes part in an experiment to measure induced radio frequency currents in the human body

EXPERTISE PROVIDES SAFETY THROUGH PREVENTION

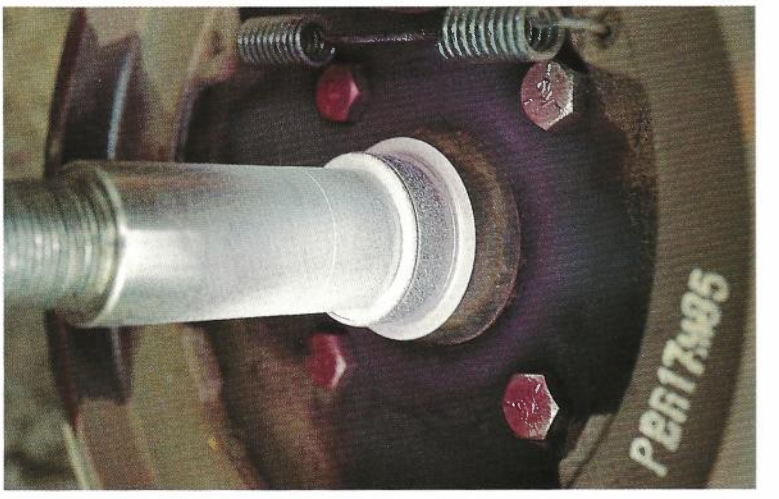
Metallurgical consultancy plays a vital part in ensuring that Telecom equipment remains reliable and continues to operate safely for its life expectancy.

A recent example of the importance of this role was seen when an investigation into the loss of a wheel from a 3 tonne tandem trailer, because of breakage, lead to the correct prediction that other trailer axles would also be at risk. Unskilled examination is inadequate when ascertaining the extent of deterioration or faults in metals.

As a consequence the skills of TRL staff were called upon and using their expertise in non-destructive testing techniques, a survey of suspect trailers was conducted. The Dye-prenetrant technique, was just one of the methods of non-destructive tests used in this case.

Although several axles had been previously inspected by workshop personnel and declared crack-free, the TRL survey found fatigue cracking, as initially suspected, in all axles inspected.

There is no doubt that the consequent replacement of nominated axles has prevented in-service failures, and possible serious personal injury.



Using special dye penetration techniques, TRL metallurgists revealed these otherwise unseen cracks (above) in the axles of 3 tonne tandem trailers (below). If the cracks had remained undetected, the safety of the public and Telecom staff could have been jeopardised

CHRISTMAS TREE ATTACK ON TELECOMMUNICATION CABLE

In the design of telecommunication cable for external plant use, significant emphasis is placed on the ability of the cable to withstand the harsh environmental conditions, particularly those of extreme thermal and solar radiation, quite often encountered throughout Australia.

Over the years, a range of extraordinary environmental situations have also threatened Telecom's cables. These include attack by predators such as termites, parrots, wombats and the more recent infamous Western Australian Christmas Tree (*Nuytsia floribunda*) which through the parasitic behaviour of its root system has penetrated and on occasions severed small sized copper conductor cables.

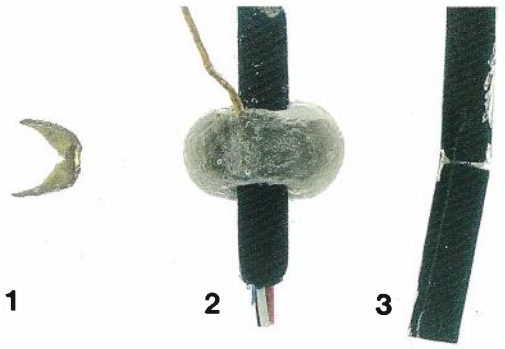
With the proposed introduction of an alternate major trunk single mode optical fibre (SMOF) cable link between Perth and Adelaide, West-East SMOF No.2, which will traverse areas of known Christmas Tree root activity, there was concern about the cables security because attacks on this cable would create a major disruption to network services.

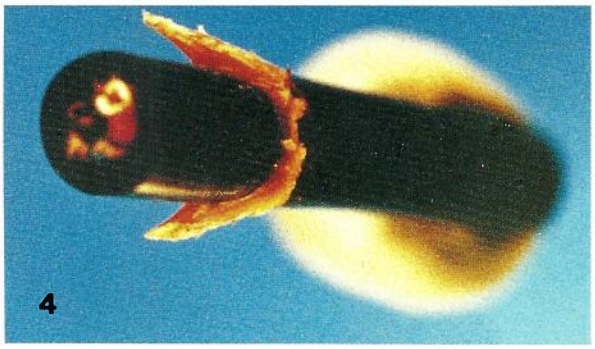
The Christmas Tree is a member of the mistletoe family, *Loranthaceae* and is only one of many mistletoe species found in Australia that exhibits various forms of parasitism, either through attachment to branches or roots of neighbouring plants. The majority of these are aerial (borne on branches of a host plant) and small terrestrial shrubs. The Christmas Tree differs in that it is a small multi-trunked tree (3-4 metres) and is classed as the largest of the terrestrial root parasites in the world. It is known colloquially as a Christmas tree because of its spectacular orange/yellow floral display from October through to January.

The plant, which is endemic to Western Australia, has developed a unique and extensive parasitic root system that extracts the majority of its water and nutrient requirement from the roots of other plants. The parasitic adaptation consists of a conical swelling on the extremities of the plants' smaller roots which, when in contact with a host root, expands into a rounded body, known as a haustorium, which encircles the host root. In the inner structure of the haustorium, a 'horn-like' structure develops and as a result of its growing process and possible radial pressure exerted by the haustorium, the 'horn' mechanically slices into the host root.

Due to the non-specificity in host selection, the roots also attach to any inert objects resembling plant roots, such as telecommunications cables.

TRL's investigation into the behaviourial characteristics of this plants' root system did not provide a comprehensive solution to the problem of root attack. However, it revealed a number of options that would minimise the risk of attack based





TOP: The unassuming West Australian Christmas Tree

ABOVE: The Haustorium 'Horn'- showing 1. the 'Horn,' 2. Haustorium encircling a cable, 3. the damaged cable and 4. Haustorium removed revealing the 'Horn' embedded in a copper cable

on modification of cable design and isolation of cable from the threatening environment, such as route selection, cable-laying depth, increased cable diameter or use of sub-ducts. Common practices such as clearing or the use of herbicides were not feasible as the Christmas tree is an indigenous plant protected under legislation.

The testing of semiconductors and other network components avoids costly network failures and customer dissatisfaction

HUMIDITY TESTING OF SEMICONDUCTOR DEVICES

Plastic encapsulated integrated circuits (ICs) are now commonly used in high reliability applications, because they have overcome their earlier image of poor reliability. These ICs were susceptible to moisture permeation, which resulted in parameter drift and failure due to corrosion of the chip metallisation, often within a few years, but improvements in chip processing and encapsulation have mostly resulted in devices in which moisture ingress is unlikely to cause problems.

For corrosion to occur in an IC, ionic carriers must be present; either leached from the plastic as the water permeates through, from the passivation as in the case of some phosphorus doped silicon dioxide passivations, or from process residuals on the chip. As it is not possible to reduce the permeability of the encapsulant to a suitably low level, manufacturers have concentrated on improving the chip cleanliness, reducing the moisture permeation through the passivation system, reducing the hydrolysable ionic content in the encapsulant and increasing its adhesion to the lead frame and chip.

Because no appropriate parameter measurement test has been developed, high humidity testing is necessary to ensure devices meet requirements. The industry standard accelerated test conditions are biased 85C/85% relative humidity (RH). Lifetimes of several thousand hours (several months) at these conditions are now common, necessitating a shorter test for batch acceptance testing before assembly, and highly accelerated tests using an autoclave to produce unsaturated conditions above 100C are gaining popularity.

The good resistance to moisture-related degradation generally found in ICs from reputable suppliers is demonstrated by a recent test at TRL on static random access memories (SRAMs) from Japan, West Germany and Korea. These survived for greater than 1000 hours at 120C/85%RH without failure. This is equivalent to over 5500 hours at 85C/85%RH, and roughly approximates better than 40 years in a high humidity environment, such as tropical Queensland, indicating that this failure mode should not occur in a typical equipment design life, in other than extreme environments.

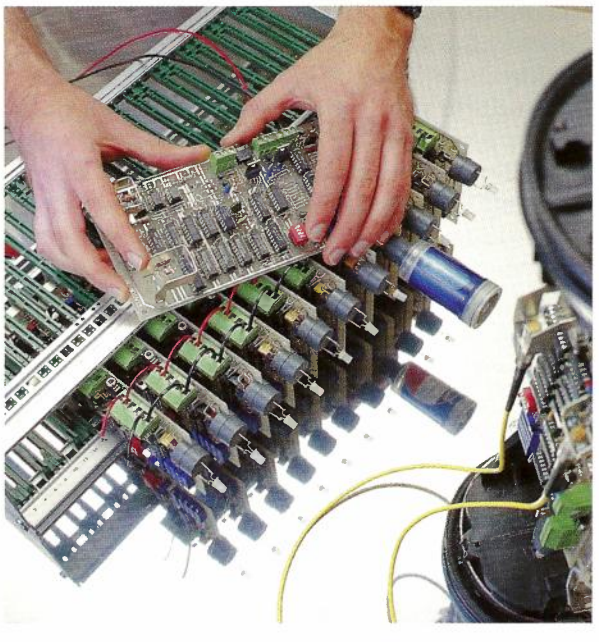
However, some types of surface mountable ICs can still be susceptible to moisture induced degradation. During wave soldering, moisture absorbed in the encapsulant evaporates explosively on contact with the solder, which can damage the passivation/encapsulant interface, particularly for larger die sizes. Very large ICs are susceptible to passivation or die damage due to thermal expansion coefficient mismatches. In both cases the integrity of the die/passivation/encapsulant interface is lost, leaving the devices susceptible to subsequent moisture ingress.

HUMIDITY SENSOR FOR OPTICAL FIBRE JOINT ENCLOSURES

With the increasing use of optical fibres for communications, it is necessary to evaluate the various possible failure mechanisms for fibre junctions. One such mechanism can be caused by excessive moisture, which can result in poor adhesion between the fibre and its protective jacket, resulting in severe signal attenuation or loss.

To monitor the possible ingress of moisture into optical fibre junction enclosures, a humidity monitoring system has been developed. It allows the humidity level inside an enclosure to be read periodically from a remote location. The acquired data can then be used to determine the rate of increase of humidity inside the enclosure.

A capacitive humidity sensor is used to provide an electrical signal, which is proportional to the ambient humidity level. As the humidity increases, the capacitance of the sensor also increases. This capacitance is converted to a DC voltage and then to a digital signal in the sensor unit. When requested by a remote controlling computer, the sensor transmits this value along a fibre to the serial port of the controller. To allow a number of enclosures to be monitored, each sensor has a unique internal address and will only transmit when this address is selected. Each sensor responds by continuously transmitting its address, humidity level, ambient temperature and current state of its internal batteries until another sensor is selected. When all sensors have been interrogated the controller turns off all sensor units to conserve battery power.



Optical fibre humidity sensors undergoing environmental testing

To simplify the design of the sensor units, a very simple pulse width coding scheme is used for all external control. Power consumption is minimised by using CMOS circuitry where possible, standby current consumption is less than 20A. Long life Lithium batteries are used to give a service life of approximately ten years.

The complete system is controlled by a PC via a single serial port. The data received from the sensors is sampled by the control program and stored in an array before processing into an actual humidity level. The resulting data is then stored on disk for future reference and further processing. The control program also incorporates a number of checking procedures to prevent the system from locking up should a fault in one of the sensor units occur. An inbuilt testing facility can also be used to allow a simple examination of the functioning of the sensor units by direct connection to the control unit.

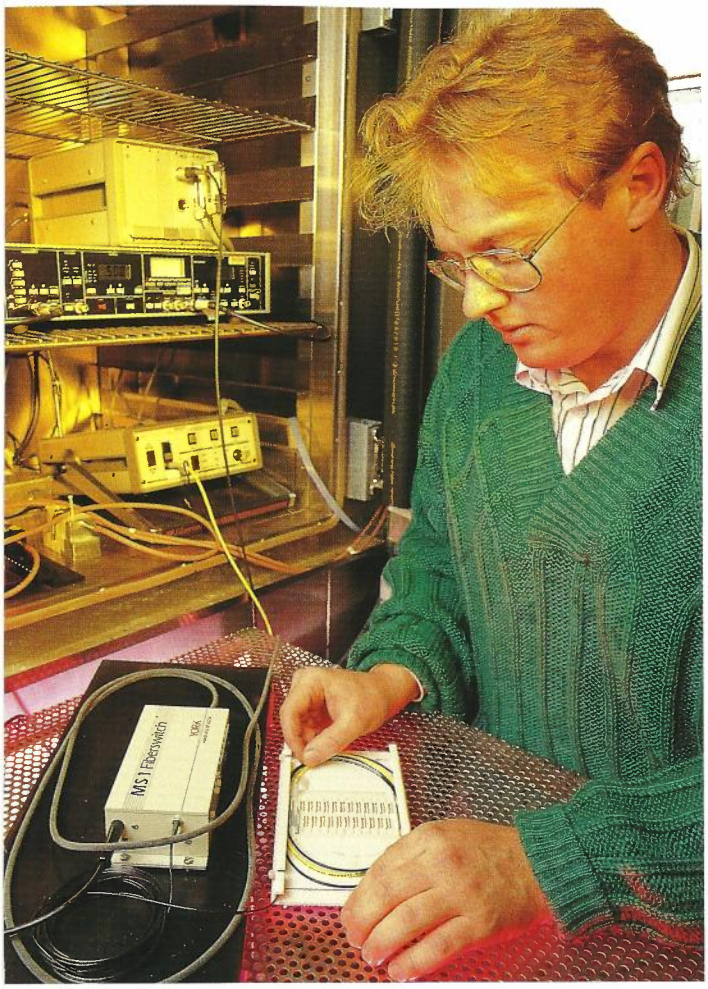
NEW MEASUREMENT SYSTEM FOR TESTING OPTICAL FIBRE COMPONENTS

The reliability of passive optical fibre components such as couplers, connectors and mechanical splices is becoming increasingly important as the rate of introduction of this technology into the Telecom network accelerates.

TRL has developed sophisticated new measurement systems using state of the art single mode optical fibre switches. These computer-controlled switches make possible efficient automatic measurement of multiple parameters throughout accelerated lifetime tests on a pseudo-continuous basis through rapid scanning between a large number of test specimens. This offers many significant advantages over existing methods, which use manual connections or access specimens connected in series using an optical time domain reflectometer.

In order to make full use of the optical fibre switches, many details of measurement system design had to be taken into account. Sources were chosen with regard to signal power, wavelength definition, coherence length and output polarisation. Detector selection depended on both signal-to-noise ratio and fibre to detector coupling considerations. For many system components both polarisation sensitivity and reduction of back-reflections were design issues. For maximum accuracy, switch co-ordinates were optimised during some measurements and many components required thermal stabilisation. The overall designs include suitable reference fibres so that the systems are self calibrating.

The first of these switch based systems is already being applied to an investigation into the stability of optical fibre couplers. This work is of particular significance, because couplers are required in large

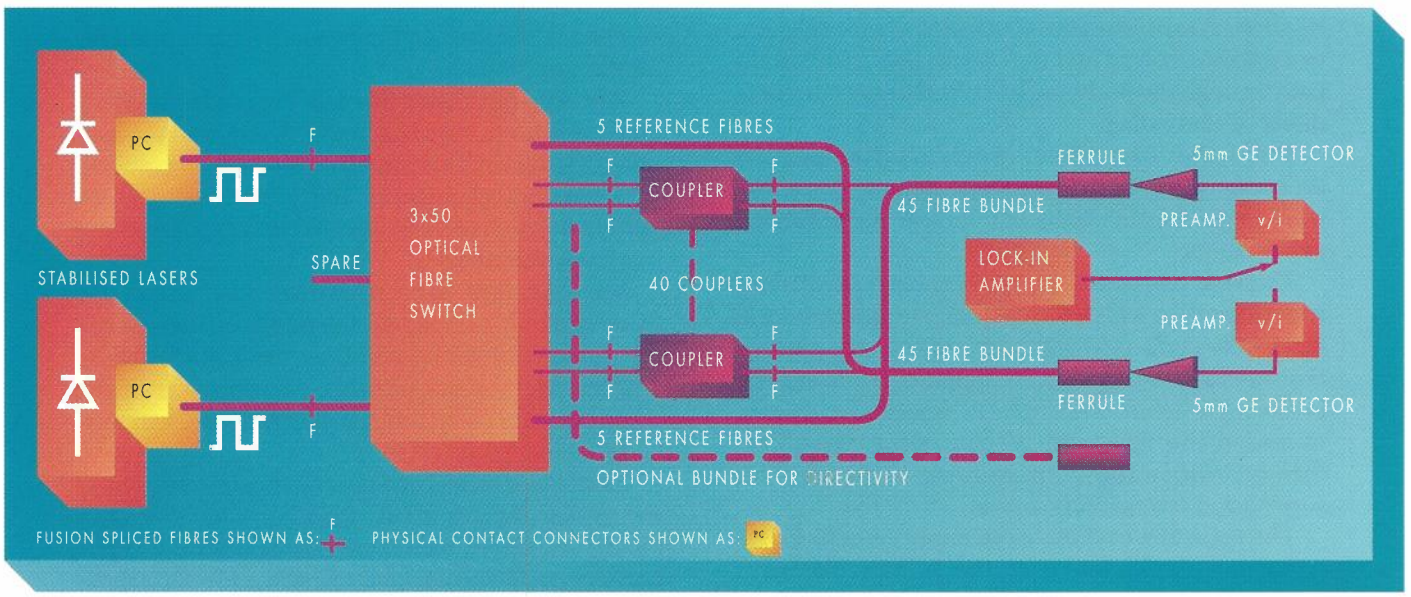


numbers as key elements in shared fibre architectures for economical customer access, such as the TRL MACNET design. In such systems, optical fibre components are widely distributed throughout the network, in often harsh environmental conditions, and it is essential that these function reliably over decades with little or no maintenance.

In this project, couplers from Australian and overseas manufacturers are being subjected to accelerated lifetime tests in environmental chambers in accordance with Australian, IEC, and international industry standards. During the test all ports of the couplers are utilised in continuous measurements to determine coupling ratio and excess loss, thus providing detailed information on any degradation affecting optical performance.

Initial tests found significant differences in performance between certain couplers, showing this work to be essential for Telecom to be able to select only reliable products in building its fibre optic network. Information about coupler ageing is fed back to the manufacturers, enabling product modifications that will ultimately result in better couplers becoming available to Telecom.

Tony Neilson prepares an optical switch for use in the environmental test programme on optical fibre couplers



Measurement system for testing optical fibre couplers

THE ELECTRICAL SAFETY OF POWER FEED SYSTEMS

The recent introduction of pair gain systems with floating and current limited 300 V, 50 mA d.c. power feed circuits led to an investigation of electrical safety criteria that could be applied to these systems.

The criteria were considered in terms of the electrical parameters of the power feed circuits, the most likely conditions under which an electric shock incident could occur, and in terms of the body's responses to electrical stress.

The effect of an electric shock on a person varies from just a perception of the shock, through a range of injuries, to death. At the perception stage the person in contact with a live object can break the contact either voluntarily or involuntarily, depending on whether the shock was expected or not, the nature of the contact, and various physiological and psychological predispositions of the person to electric shocks. As the severity of the shock increases, the response to it becomes involuntary and subject to muscular overreaction. This overreaction can injure the muscles, may cause the person to lose balance and fall, or may cause injuries through violent body or limb contacts with surrounding objects.

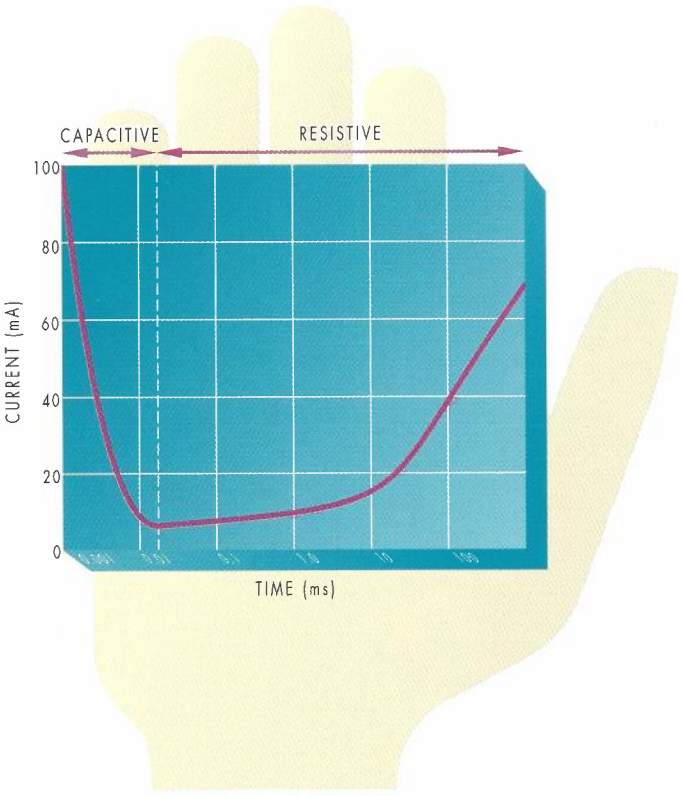
When the current reaches a certain value muscular contractions can prevent the person from releasing the live object. Further increase in the current and in the duration of the shock may arrest breathing, cause transient cardiac arrests, cause auricular fibrillation and eventually ventricular fibrillation or permanent cardiac arrest, either of which can cause death. Death can also result from current caused damage to the nervous system, from burns, or from other complications.

The magnitude of the current at which the above effects begin to occur depends on the person's constitution, the nature of the contact ie. whether a touch or a grip is involved and the contact area, the current path through the body, and on whether the current is direct or alternating.

Due to the unavailability of published information on some of the body's electrical parameters, these were derived from results of in-house electric shock experiments.

To avoid the possibility of ventricular fibrillation, experiments in which the current path involved the heart were performed with currents up to the perception values only. Tests with higher currents did not involve the heart, and tests in which the current exceeded the threshold of pain value were performed under local anaesthetic with medical supervision at a medical centre.

The main aim of these experiments was to investigate the dependence of the body's electrical impedance, and, in particular, the impedance of the skin, on voltage, the contact area, and the duration of the electric shock.



Variation in the capacitive and resistive current in the palm of a hand with the duration of shock at a test potential of 200 volts.

ered to be made up of resistive and capacitive components and sub-divided into internal and skin impedances.

The internal impedance involves the blood, the flesh, muscles, other body tissues, joints etc.. It is essentially resistive and its value depends primarily on the current path. .

The skin impedance involves the partly insulating epidermis layer, the conductive dermis and the sub-oriferous ducts. This impedance can be considered as a network of resistors and capacitors, and the current through the skin divided into capacitive and resistive components.

Measurements have shown to what extent the value of the skin impedance depends on the voltage, the duration of the current flow, the surface area of contact, the contact pressure, the location of the contact on the body, and the skin moisture and temperature.

From these results and the electrical parameters of the power feed systems, together with the likely conditions under which an electric shock incident could occur, it was concluded that the electric shocks from these power feed systems could be considered as safe in the sense that they are not expected to

produce harmful and irreversible physiological damage even under the most unfavourable incident conditions.

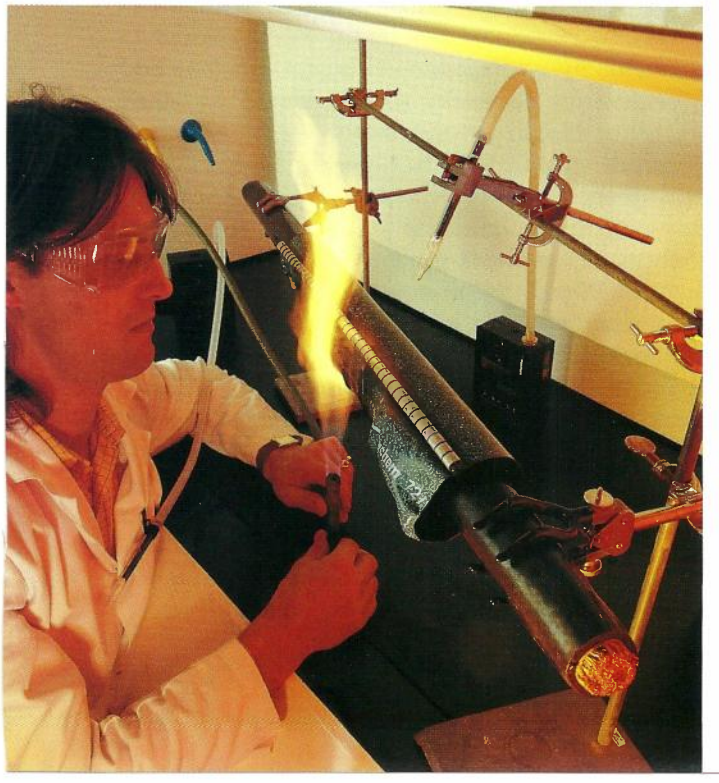
The nature of the contacts, the small contact areas, and the division of current between the load and the person, which will be occurring in the majority of the accidental contacts with the power feed conductors, will further reduce the effects of the electric shocks, and adherence to work practices should reduce the frequency of their occurrence.

ASSESSMENT OF HAZARDS ASSOCIATED WITH THE USE OF THERMO-SHRINK SLEEVES FOR CABLE JOINTING

Thermoshrinkable polyethylene sleeves are used extensively by Telecom field staff as part of a kit for jointing and repairing cables. The sleeve components, as supplied, are manufactured from polyethylene that has been lightly cross-linked by either irradiation or chemical means and then expanded in diameter. Upon application of heat from a propane gas burner the sleeves soften, relax and shrink down onto the cable and/or joint closure to provide a water tight seal.

In recent times, questions have been raised regarding the nature and level of gaseous emissions whilst heating and shrinking sleeves and the impact, if any, on field staff involved in the process. Telecom is committed to ensuring that the working environment is safe for its personnel. To help Telecom's Occupational Hygienists in resolving this question, TRL participated in a series of field trials followed by extensive laboratory work to develop analytical techniques and generate data from which conclusions could be drawn.

David Holding seals a cable join with a polyethylene thermo-shrink sleeve



Experimental sampling of the work environment took place at the External Plant Training School at Chermside, Queensland. The personal breathing space of trainee jointers, working under the supervision of their instructors, was monitored when using two types of commercially available thermoshrinkable sleeves. Breathing zone air was drawn through an adsorbing medium at a constant flow rate, thus allowing subsequent identification and quantitation of any organic emissions from the jointing procedure.

Analyses of the adsorbed media were carried out at TRL using a gas chromatograph - mass spectrometer (GC-MS0), which separates, detects and identifies organic species at the parts per million level. The results of these trials so far, have demonstrated that total organic emissions from the use of thermoshrinkable polyethylene sleeves are minimal, and far below any currently accepted permissible levels in the workplace, and that no change in work practices is necessary.

ELECTRICAL AND OPTICAL STANDARDS

Any measurement made in Telecom must be traceable to the Australian National Standards. TRL is charged with providing and disseminating the reference standards necessary for Telecom's operations. These standards are directly traceable to the National Standards and provide a sound basis for determining and maintaining the performance of the Telecommunications network and other services.

TRL has been developing and disseminating standards for electrical quantities since the Laboratories began in 1923. With Telecom's strong commitment to optical fibres in the network, it has become necessary to establish a similarly traceable system for optical quantities. A new system of optical standards is now in operation and growing alongside the continually developing electrical standards.

Activities over the past year in the electrical and optical standards area have included:

- development of a more precise method for calibrating high resistance standards to 100 T and the calibration of several sets of high resistance standards for various areas of Telecom:
- continuing advice to areas in Telecom for establishing additional NATA registered calibration laboratories, and in upgrading NATA registrations to include optical calibration capabilities:
- assistance for measuring impedance characteristics of 75 coaxial cable up to 100 MHz. Specialised screening methods were needed to minimise the coupling of spurious signals into the detection system:

• advice to optical calibration areas in Telecom on the difficulties associated with performing meaningful measurements despite the disturbing effects of wavelength dependence and optical connector performance. This has included visits to those areas where techniques, pitfalls, solutions, and procedures have been discussed and demonstrated:
• reassessment of TRL by NATA, including registration for a range of tests related to optical fibres, and
• development of computer controlled calibration systems to assist in performing optical power measurements. These will be expanded to include other optical quantities that are important for the operation of the optical fibre network.

The Comitè International des Poids et Mesures has recently sanctioned changes to the standards for electric potential (volt) and resistance (ohm). These changes have been adopted in Australia from 1 January 1990 and have the effect of changing the maintained value of the volt by +8.1 ppm and the ohm by +0.1 ppm. This also affects all other quantities derived from these standards, ie. current (ampere), electric power (watt), and electric field strength (volt/metre). Temperature measurements have also been affected with the introduction of the International Temperature Scale (ITS-90) to replace the International Practical Temperature Scale (IPTS-68) with the greatest change being 0.3 at 800C in the range -200 to 1000C. These changes are being disseminated throughout Telecom.

The future requirements for an increasingly sophisticated telecommunications network means that new techniques and procedures have to be rapidly developed to satisfy these new needs. Much effort is devoted to analysing and determining the needs and the means of producing suitable working standards. A system of standards is operating in TRL and is growing as needed to ensure that Telecom fulfils its obligations of cost efficiency and to allow for future growth with high reliability.

STANDARDS OF TIME AND FREQUENCY

TRL provides Telecom with its frequency and time standards that are the basis of many customer services as well as playing an ever increasing role in the day to day operation of Telecom's modern and expanding networks. A modern telecommunications network must incorporate accurate frequency and time standards to ensure efficient network operation and to make possible many of the newest network facilities that will become available when synchronous transmission is introduced.

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

The development of standards for optical fibres ensures cost efficient and reliable network growth. TRL is a major contributor to standards both in Australia and internationally

Distributions from the Time and Frequency Standard include:
• provision of synchronising signals from the National Reference Clock that directly control the clocks at every node of the IDN, ISDN and DDN networks to ensure optimum performance is obtained. By synchronising its digital switching and transmission networks to this world standard reference clock, several important benefits are derived, including minimised digital slip performance with other networks, nationally and internationally, and the capability to deliver sophisticated network facilities and features as part of the ISDN and synchronous digital hierarchy,
• precise frequency is also distributed throughout the analogue network for a range of applications including the control and calibration of master oscillators in the trunk network and also to provide standard frequencies for use as master clocks for timing, and in equipment service and calibration areas. Many of Telecom's customers in Government agencies and instrumentalities also utilise this distribution as a source of accurate frequency traceable to the Australian National Standard, and

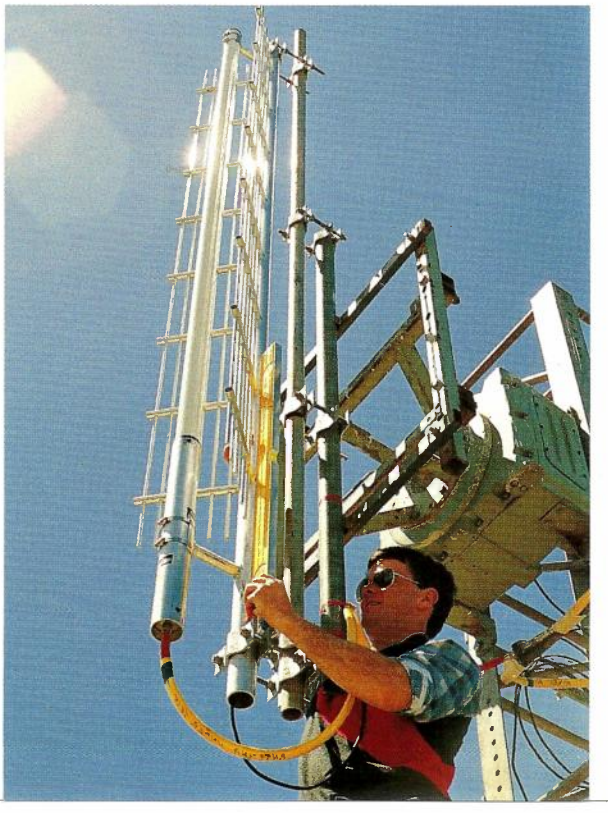
• provision of accurate and traceable time of day for the Speaking Clock network to the capital cities and many of the larger provincial cities, and distribution of the Civil Time Code signals transmitted in a binary coded decimal (BCD) form over a voice channel. The Speaking Clock also provides the ABC and a number of commercial radio stations with timing signals, which are broadcast as six pips to mark the hour.

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

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

MOBILE BASE STATION ANTENNA MEASUREMENTS

The Cellular Mobile Radio Telephone System (CMTS) was launched in February 1987 to meet the expanding demand for mobile telephone services. It makes use of a cellular layout that allows frequency re-use and cell splitting in order to achieve greater customer capacity and more efficient use of the radio spectrum.



To implement this cellular concept, a range of base station antennas are employed. These include antennas designed to have sectoral coverage for cells in metropolitan areas and omnidirectional antennas for use in non-metropolitan areas.

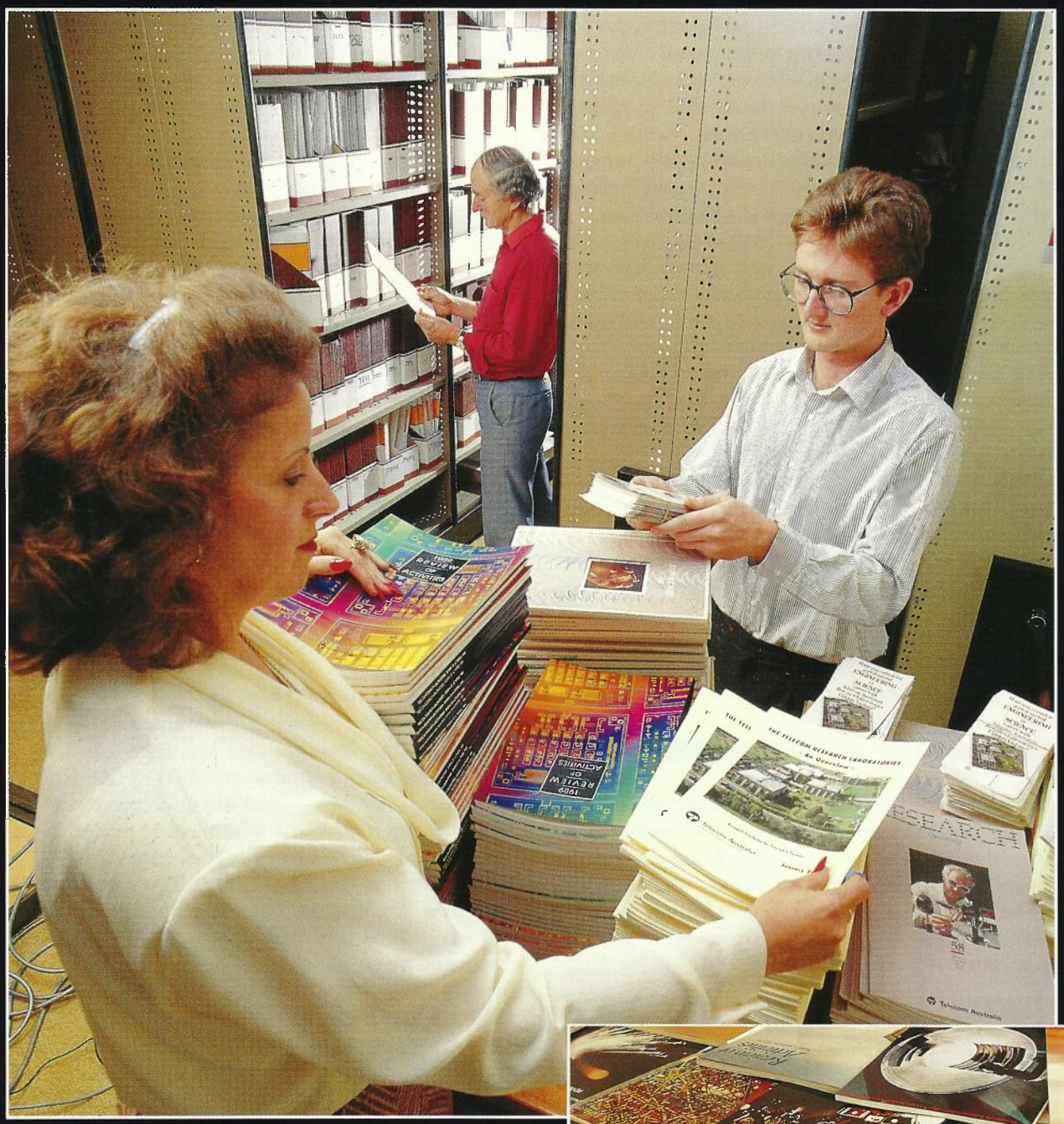
Base station antenna characteristics are important in achieving CMTS network performance standards and to this end twelve commercially designed antennas were assessed. Testing of the base station antennas was aimed at ensuring that these meet Telecom operational specifications and were suitable for installation in the CMTS network. In particular, the information provided will ensure the purchasing of appropriate antenna types. As well, the characterisation of the antennas provides additional information not previously available or not available in such detail. For example, the information from azimuth patterns measured with down-tilted antennas-under-test will allow planning of smaller coverage areas as would be required when cell-splitting occurs. Finally, an examination of antennas that have failed in operational service or are having difficulties in maintaining performance specifications has provided useful information for assessing the suitability of antennas.

The antennas tested varied in type and also in the stage of their development or manufacture. In terms of broad classifications, they are either omnidirectional antennas or sectoral antennas of one type or another. They varied from the prototype to the in-service antenna. Their manufacture varied from being local, part local, or wholly overseas.

Testing was carried out at the Telecom Australia Antenna Test Range at Caldermeade, which is some 72 km south-east of Melbourne. This test facility is operated as an out-door far-field range. For these tests it was configured as a ground reflection range. The range is made up of transmit and receive sites that are separated by up to 2500 metres. A computer based measurement and control system allows the transmit-end antenna position and transmit signal parameters to be set or altered. The mobile radio base station antennas-under-test were mounted on a 30 metre tower at the receiver end of the range.

Direct measurements of voltage standing wave ratio (VSWR), antenna gain and elevation and azimuth radiation patterns were carried out on the base station antennas across the 825 to 896 MHz band. From these results, beamwidths and front-to-back ratios were derived. The results were compared against Telecom specifications. As well, observations on the mechanical design and construction of antennas and their finish provided useful information about their long-term reliability.

Checking the quality of supplied equipment. Geoff Bail prepares a mobile base station antenna for testing at TRL's antenna test range


1989
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Telecom Australia

TECHNOLOGY AND INFORMATION TRANSFER

The primary role of TRL is to ensure that Telecom Australia has timely and relevant advice regarding new and existing technologies. TRL's Business Plan is guided, established and reviewed by corporate processes to ensure its relevance to Telecom's needs for such advice. It comprises a number of R&D projects which generally seek to develop technical know-how across the spectrum of evolving telecommunications science and technology. TRL transfers the know-how to clients units in the Customer Divisions and other Shared Resource Units of Telecom Australia, where it is applied in specific projects relating to the planning, implementation or operation of services and networks. These processes of technology and information transfer are ongoing and multi-faceted. They occur through day-to-day working interactions between TRL staff and those of the client units and through other formal and informal technology and information transfer mechanisms.

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

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

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

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

The following pages illustrate some of the more noteworthy examples of technology and information transfer from and to TRL that have taken place over the past year.

TRL TRANSFERS THE KNOW-HOW TO CLIENTS UNITS IN THE CUSTOMER DIVISIONS...

LEFT: Knowledge is the foundation of quality, and the fuel that drives business success. TRL's information and communication experts ensure that the knowledge won through research is well protected, and is efficiently communicated to Telecom's business and technical divisions

FAREWELL, FRANK...

Frank W. Arter went into retirement during 1990 after 37 years working for Telecom Australia and the former Post Master General's Department.

Frank began his career as a cadet engineer and in 1958 joined TRL where he made many significant contributions in the areas of semi-conductor switching and data communications. At the time of his retirement Frank had risen to the post of General Manager, Intellectual Property & Information Branch.

Of his many achievements, Frank will perhaps be most widely remembered as the chronicler of TRL, having been Editor of TRL's annual 'Review of Activities' through 17 editions.

Regular readers of 'Review of Activities' can thank Frank for keeping them abreast of the changes and highlights that have occurred in Australian telecommunications R&D over the past few decades.

As Editor, he became adept at transforming the often convoluted tracts of text written by research staff into concise and readable articles. His incisive use of a red pen to edit drafts became infamous at TRL, yet few could say that he had not improved their writings. Today, the work of TRL is better understood and better appreciated by a wider audience as a direct result of Frank's editorial efforts.

Frank also possessed sound negotiating skills and, although an engineer and not a lawyer, he was particularly talented at unravelling the complexities of contractual and patent law - a skill which led him to negotiate many of Telecom's important R&D contracts and collaborative agreements. Over the years, many sharp young lawyers in outside organisations cut their teeth on erudite drafts prepared by Frank W. Arter, and he retired having earned the respect of many senior professionals not only within Telecom Australia, but in industry and government.

In a farewell letter to Frank, Telecom's Managing Director, Mel Ward, wrote: "It was always a comfort in dealing with a complex aspect of research activities to see the signature 'F.W. Arter' on the correspondence, and to know the care and consideration that had been devoted to the subject."

Frank also pioneered the establishment of the Intellectual Property Section at TRL during the mid 1980s. His aim was to protect Telecom's ownership rights to software and other Telecom developments in what was then becoming an increasingly competitive environment.

He succeeded in forging a group of highly skilled professionals who today provide all of Telecom with expert advice on patents, copyrights and trademarks. His early recognition of the need for this service was typical of Frank in that it was an idea ahead of its time.

Also typical of Frank was his generosity, and his tolerance of those who shared different views. He will be warmly remembered by his colleagues at TRL and throughout Telecom Australia. On their behalf, 'Review of Activities' bids Frank a peaceful retirement, and wishes him every health and happiness in the many years that lie ahead.

Wielding his red pen for the last time, Frank W. Arter surveys the results of his editorial work after 17 years as the editor of TRL's 'Review of Activities'.

POSTHUMOUS HONOUR FOR ERIC CRAIG

The International Radio Consultative Committee (CCIR), a permanent organ of the International Telecommunications Union, has bestowed a special award on a former TRL researcher.

The late Eric Ramsay Craig was awarded a Diplome D'Honneur during a commemorative program to mark the 60th Anniversary celebrations of the CCIR. Similar awards were made to others who had provided the CCIR with outstanding technical contributions or leadership over many years.

Eric Craig was the Assistant Director of TRL's former Telecommunications Technology Branch. He died in 1983 having played a leading role in the activities of CCIR's Study Group 4 for over 20 years. The Group is responsible for technical aspects of providing satellite communications to fixed Earth stations.

Eric's award was both for his outstanding technical contributions to Study Group 4 between 1961 and 1983, and in recognition of his leadership during his term as Vice Chairman of the Group from 1970 to 1978 and as Chairman from 1978 until his death.

The award was officially made in Geneva by the Secretary General of the ITU and the Director of CCIR. It was accepted on Eric Craig's behalf by Telecom Australia's George Hams who recently retired as Senior Executive General Manager of Metropolitan Division.

Later in Australia, a special ceremony was held at TRL before an audience of research staff and members of Eric Craig's immediate family. His widow, Joyce, attended to receive the Diplome D'Honneur from Telecom's Deputy Managing Director, Doug Campbell.

Joyce Graig the wife of former TRL satellite researcher Eric Craig, receives the CCIR Diplome D'Honneur from Telecom Australia's Deputy Managing Director, Doug Campbell.

NEW CENTRES OF EXPERTISE

TRL has let contracts for two new Centres of Expertise in universities to augment TRL's research work in two strategically important fields.

The new Centres are the Switched Networks Research Centre at the University of Wollongong and the Centre of Expertise in Geographic Information Systems and Analysis at the University of Tasmania. The contract for each Centre will run for three years.

SWITCHED NETWORKS RESEARCH CENTRE

The Switched Networks Research Centre (SNRC) at the University of Wollongong will conduct specialist research studies in two evolving network technologies, namely the Intelligent Network and the Asynchronous Transfer Mode (Fast Packet) network.

The Intelligent Network (IN) studies will include an investigation of how IN architectures will perform in current telephony networks. This will be done by simulation and analytical modelling of the switched telephony network so that performance changes caused by the introduction of an IN overlay can be predicted. This work will also lead to the design of test and performance measurement instruments for use in the actual IN network.

The Asynchronous Transfer Mode (ATM) studies will examine the effects of protocol design on signalling performance and determine the optimum location of signalling transfer points in the network. Other studies will determine the placement of IN call control functions in the ATM network for enhanced supplementary services (such as call forwarding) and the design and implementation of an ATM signalling point.

Related studies will examine the techniques required to enable a single call to use the public telephony network, the ISDN network, AUSTPAC, Mobilenet and the ATM network.

The Switched Networks Research Centre will draw upon the skills of the University's Departments of Electrical and Computer Engineering, Computing Science and Mathematics, and will be assisted by researchers from the School of Electrical Engineering at the University of Technology, Sydney. The Centre will be directed by Professor Hugh Bradlow, Professor of Computer Engineering and the former Head of the Department of Electrical and Computer Engineering, who will share his time between the SNRC and the newly formed NorTel Technology Centre.

The Vice Chancellor of the University of Wollongong, Prof. Ken McKinnon (LEFT), with Harry Wragge (CENTRE), at the openning of a new Telecom Centre of Expertise. TRL's head of Switched Networks Research, Jim Park (RIGHT), will guide the direction of the Centre's research

CENTRE OF EXPERTISE IN GEOGRAPHIC INFORMATION SYSTEMS AND ANALYSIS

The Centre of Expertise in Geographic Information Systems and Analysis (CEGISA) at the University of Tasmania will undertake a research program in the fundamentals of geographic information system (GIS) technology and its application to strategic studies, policy development and telecommunications planning.

GIS technology is a computer-based method of presenting geographically-related information in diagrammatic form. For example, by combining telephone exchange boundaries with telephone customer information, one can present maps of the geographic concentration of particular services, customer types, revenues, etc. Such tools will help Telecom's planners by identifying the location of future telecommunication services, the means of delivering such services, and the necessary network infrastructure.

Researchers in the Centre will undertake studies of generic GIS methodologies and will develop particular applications of this technology for Telecom's business divisions, study the capabilities of various software and hardware options, and develop demonstration systems.

The Centre will be directed by Mr Peter Zwart, Reader in Surveying, and will draw upon skills from the Departments of Surveying and Computer Science. The work of the Centre will be augmented by skills from the CSIRO's Division of Building, Construction and Engineering under the leadership of Dr Peter Newton, Senior Principal Research Scientist.

EXISTING CENTRES

These two new Centres of Expertise bring the total number of Centres funded by TRL to five. The three existing Centres are the Teletraffic Research Centre at the University of Adelaide, the Centre of Expertise in Distributed Information Systems at the University of Queensland, and the Centre for Communications Security Research at the Australian Defence Force Academy in Canberra (part of the University of New South Wales). The contract for the Teletraffic Engineering Centre was renewed during 1989 to reflect changes in personnel at the University and to redefine some of the research activities. The new contract extends funding of the Adelaide Centre through to 1994.

The Centres of Expertise scheme seeks to identify tertiary education institutions having a nationally recognised expertise in a technology or field of research of relevance to Telecom, where several academics and several research students are involved in the study of the topic. This ensures continued viability against changes in personnel, where research work is organised in a mutually supportive way for maximum synergy, and where there is scope for support from other organisations.

Harry Wragge and the Vice Chancellor of the University of Tasmania, Prof. Alec Lazenby seal a contract to establish a new Telecom Centre of Expertise.

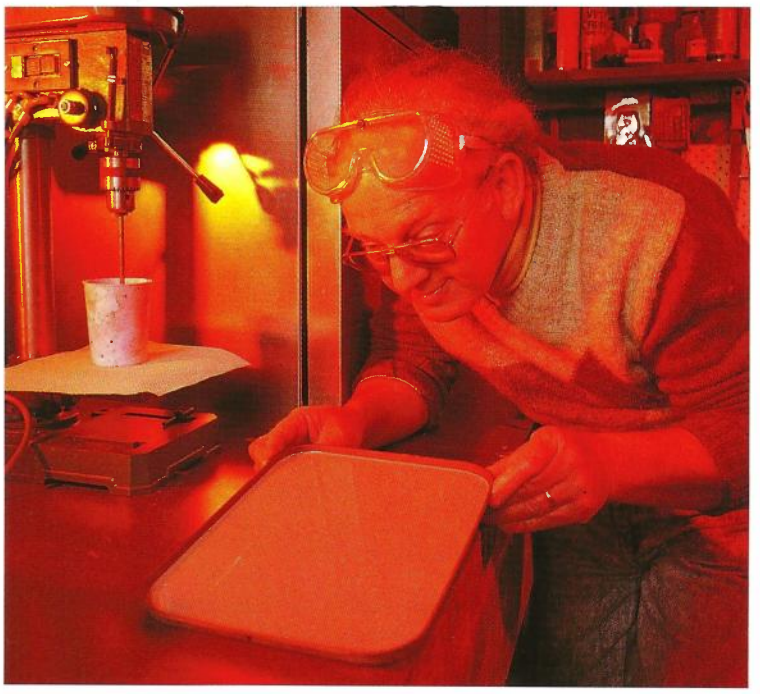
TELECOM AUSTRALIA'S PRODUCT DEVELOPMENT FUND

Telecom Australia has undertaken a number of initiatives, particularly since 1984, to encourage Australian design and development of telecommunications-oriented products. To further increase its commitment to local industry, Telecom proposed the establishment of the Product Development Fund (PDF) in a submission to the Inglis Review Committee on Government Technology Purchasing Arrangements. The Fund was launched on 27 January 1987, and is specifically aimed at small and middle sized Australian companies.

The Fund provides financial assistance to selected local entrepreneurs and inventors who wish to promote ideas, concepts or developments for possible adoption within the Australian telecommunications network, or for export. In addition to such financial assistance for new product development, Telecom will, on occasion, lend some projects the benefits of Telecom's engineering knowledge and facilities as development aids. In return for these funds and assistance, Telecom seeks intellectual property rights in a particular product commensurate with its inputs to the project.

The PDF is controlled by a Committee of Senior Management under the Chairmanship of the Executive Aide to Telecom's Deputy Managing Director. The full-time Manager of the fund is located at TRL, but co-opts resources from throughout Telecom to help in the assessment of applications for funding. In particular, the Technical Liaison Office (Network Engineering SRU) and the Intellectual Property Section (TRL) play significant roles in the operation of the Fund. All TRL Branches have, on occasion, been involved in technical aspects of the assessment procedure, and several are now involved in continuing liaison with successful applicants during the product development phase.

Inventor Stan McTighe developing anti-static mats for computers in his home laboratory following PDF funding.



To date Telecom has committed nearly $5 million in support of 27 Australian companies. Products which received support include a linesman's test instrument that has now been exported to many countries and a process for recycling used telephone books into home installation material.

SPONSORED EXTERNAL RESEARCH AND DEVELOPMENT

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

TRL acts as one channel for the provision of such support by Telecom, in particular, for research studies on telecommunications topics having potential application in the longer term development of Telecom's networks and services. In some cases, TRL also contracts out development projects in specialised fields to meet technical needs that cannot be satisfied through normal sources of supply.

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

During 1989/90, TRL managed a portfolio of five R&D contracts for Centres of Expertise (total value $5.1 million), eight R&D contracts with industry (total value $0.6 million) and a further 36 R&D contracts with academia and other R&D institutions (total value $5.6 million). In addition, TRL managed a further seven R&D contracts on behalf of other Divisions within Telecom (total value $1.1 million). The duration of the contracts vary from less than one to several years.

Total expenditures on extramural R&D by TRL in 1989/90 was approximately $2.25 million. Of this total, $0.25 million was disbursed to academia via ATERB for R&D on telecommunications topics. The remainder comprises direct payments made to R&D contractors and occasional specialist consultants.

MILLIMETRE WAVE CONTRACT WITH DEAKIN UNIVERSITY

Deakin University has completed a contract on the 'Feasibility of millimetre wave systems for indoor wireless communications' let by TRL in late 1985. As part of the contract, the university has characterised the propagation of millimetre waves within buildings both by theoretical and experimental techniques, and has surveyed a market for such systems and determined the data throughput requirements. This characterisation has enabled the determination of capacity of such systems to be around 2 Mbit/s. This study was followed by an experimental demonstration of a simple one way transmission of signals at 24 GHz at 2 Mbit/s, using microwave GUNNPLEXOR trans-receivers. In the final stage of the contract, Deakin university has simulated an indoor wireless network using the results of the propagation study and the results of the experiments with 2 Mbit/s. This simulation has enabled the analysis of technical issues pertaining to a radio network such as access protocols, inter systems interference and network architecture.

MOBILE COMMUNICATIONS LABORATORY

TRL has awarded the South Australian Institute of Technology (SAIT) and the University of Adelaide a three year contract to establish a mobile communications research laboratory. The function of the laboratory is to help Telecom with its investigations into the timely adoption of new and emerging mobile communications services, networks and standards by conducting a coordinated programme of relevant research and development. The program will be implemented by pooling the resources of the two institutions.

The suggested research areas for the Laboratory are:

- Mobile channel modelling and simulation,
- Modulation, coding and detection for mobile radio channels,
- Access protocols for mobile communications, and
- Development of advanced mobile communications terminals.

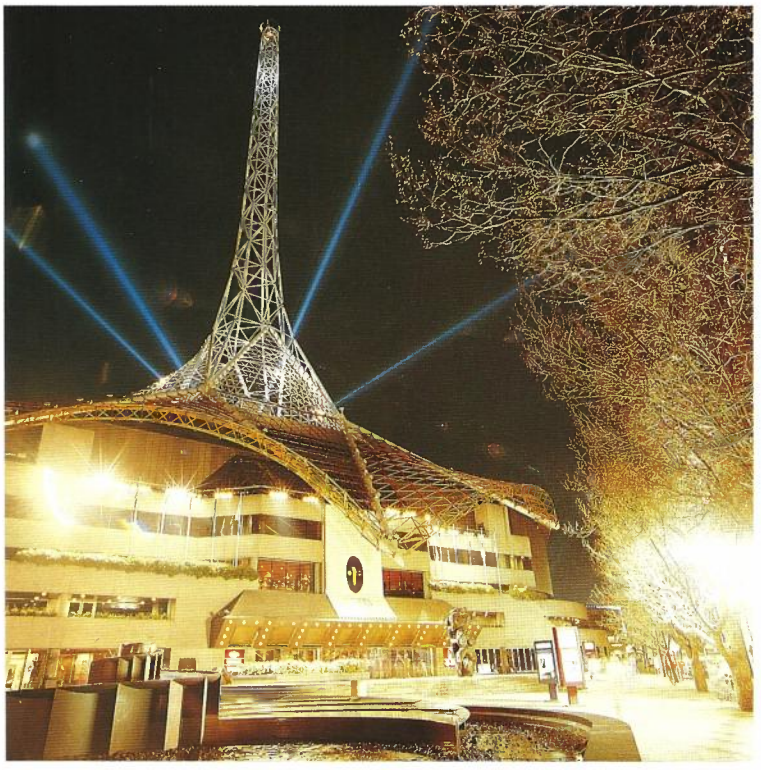
The Laboratory should also generate increased awareness of the challenging mobile communications issues confronting Australia and attract young scientists and engineers at both undergraduate and postgraduate levels towards a career in communications research. The timely availability of this human resource is of major importance to Telecom and the Australian communications industry.

Ringing in the new - Harry Wragge and Professor Michael Miller, head of the Digital Communication Group at the South Australian Institute of Technology at the opening of the Telecom-funded Mobile Communications Research Laboatory.

SPRING SEMINARS - "QUALITY IN COMMUNICATIONS"

Over 400 Telecom customers, industry suppliers and media reporters attended TRL's third annual Spring Seminars in late 1989.

The seminars were entitled "Quality in Communications - an imperative for the 1990s" and were held at the Hilton International Hotels in Sydney and Melbourne. In addition, seminars exclusively for Telecom staff were held at other venues.



The Melbourne venue for TRL's Spring Seminars for Telecom staff was the Victorian Arts Centre

Delegates heard research staff from a diverse range of specialisations discuss TRL's role in building and maintaining a quality network - one that is capable of providing customers with modern, reliable and cost effective services.

Topics ranged from the reliability of network components and energy systems to the latest advances in photonics, Broadband-ISDN and mobile/cordless technologies. Researchers from TRL's Human Communication Section also provided insights into the human and social factors that can impinge upon quality in communications.

Telecom's Corporate Customer Division used the high public profile generated by the seminars to formally announce to the media the advent of a new network service to be known as FASTPAC.

FASTPAC will be the first Metropolitan Area Network (MAN) service of its type in the world when it is launched in 1992. It will provide Telecom's corporate customers with a high speed, optical fibre-based communications service that can link Local Area Networks across the country. It can also provide the basis for new high speed image transfer services and for distributed information systems.

FASTPAC is Telecom's implementation of the revolutionary Distributed Queue Dual Bus (DQDB) technology that was conceived at the University of Western Australia in the early 1980s. From the beginning, TRL provided support for the DQDB concept, and FASTPAC will provide the realisation of many years of development work that has led the world in MAN technology.

At the Sydney seminar the Deputy Premier of NSW, the Hon W.J.T. Murray MP, announced the establishment of the new Telecom-sponsored Customised Software Solutions Centre at the University of Wollongong. The Centre will be staffed by Telecom computer experts who will develop communications software to address the specific requirements of Telecom's corporate customers.

To gain feedback on the usefulness and value of the seminars, professionally prepared questionnaires were given out to the delegates and their reponses were analysed to gauge their perceptions. The questionnaires established that seminars of this type should continue to be held. In particular, customers and suppliers found the seminars to be a valuable source of knowledge and ideas that could be usefully applied in the formulation of their business strategies.

SATELLITE MOBILE TERMINAL WORKSHOP

A one day Satellite Mobile Terminal Workshop was hosted by TRL during August 1989. The aim of the workshop was to provide a forum for the discussion of mobile terminal specification and design issues relating to the proposed land mobile satellite telephone service (Mobilesat) that is due to be placed in operation in 1992 with the launch of the AUSSAT second generation B-series satellites. Over 30 representatives from Telecom, AUSSAT, Industry and Academia attended the meeting.

A number of issues critical to the success of Mobilesat were discussed in detail. These included spectrum allocation, vehicular antenna design criteria, voice modulation schemes and L-band channel characteristics. The latter discussion was based on the results of field propagation measurements conducted by TRL in Melbourne and neighbouring country areas using a helicopter as a simulated satellite. These measurements were designed to characterise the L-Band channel under Australian conditions.

A highlight of the workshop was a presentation by technical staff from NASA's Jet Propulsion Laboratory who were conducting trials in Australia of prototype terminal equipment designed and built in the United States for NASA's MSAT-X experimental mobile satellite program. These trials were carried out in conjunction with the Japanese ETS-5 satellite and INMARSAT's Pacific Ocean Region satellite. A sophisticated low bit-rate digital voice coder-decoder suitable for use in mobile terminal equipment was also demonstrated at the workshop, using TRL's mobile satellite channel simulator.

The workshop was successful in bring together a wide range of design and research expertise to focus on the challenging technical issues that are a part of Mobilesat. Such activities will be continued and intensified over the next two years to ensure that Telecom will be able to provide the best possible mobile satellite telephone service to Australians in 1992. This service will be the first of its kind in the world.

INTERNATIONAL TELETRAFFIC CONGRESS SPECIALISTS SEMINAR

In September 1989, the University of Adelaide hosted an International Teletraffic Congress Specialists Seminar, sponsored in part by TRL. These seminars, attended by invitation only, bring together the leading researchers in teletraffic studies for detailed discussion of state-of-the-art methods. The fact that so many recognised experts from around the world chose to attend the Adelaide seminar, was a tribute to the strong international reputation in this field of research that the centres of teletraffic expertise at Adelaide and Bond Universities have.

Topics addressed by the 90 attendees during the week of the seminar included Network Standards, Computer Networks, Teletraffic Models, Quality of Service, Network Architecture, Network Management, and the Broadband ISDN.

One of the main topics was the design, architecture, and management of the future Broadband ISDN, which is expected to carry broadcast TV, interactive video, high-speed image services, computer data, and ordinary telephone conversations, all on the same network. Another important topic addressed was the performance of Metropolitan Area Network protocols, such as the DQDB protocol upon which Telecom plans to base a preliminary Broadband ISDN-like service in the near future.

NETWORKING SPATIAL INFORMATION SYSTEMS

The introduction and development of new telecommunication services during the 1990s is expected to revolutionise networking opportunities for users of spatial information systems. With this in mind the Geographical Information Studies Group at TRL held a two-day seminar in Melbourne, on May 30 & 31, 1990. The seminar, entitled "Networking Spatial Information Systems", was aimed at users from a wide range of fields employing spatial information systems, including those involved with GIS (Geographic Information Systems), LIS (Land Information Systems), Remote Sensing and CAD (Computer Aided Drafting).

The aim of the seminar was to encourage greater exchange of information within the broad community of spatial information system users. The major benefits for Telecom were three-fold:

- Telecom personnel gained valuable insights into the potential applications of spatial information system technology and the scope of the networking needs of the spatial information community,
- The spatial information community was introduced to Telecom's high-speed broadband networks in the context of their own existing and future networking requirements, and
- Telecom personnel had an opportunity to assess the GIS/LIS/Remote Sensing/CAD markets for high-speed broadband networks and the likelihood of adoption of such networks by spatial information users in the short term (2 to 5 years).

The seminar attracted a wide range of attendees from government, private industry and educational establishments, as well as a variety of senior Telecom representatives. In addition to the formal presentations and technical sessions, seminar attendees were able to view demonstrations of high speed data and image transfer at a variety of network speeds.

Speakers were drawn from the various user communities and from within Telecom. The formal programme covered the following fields:

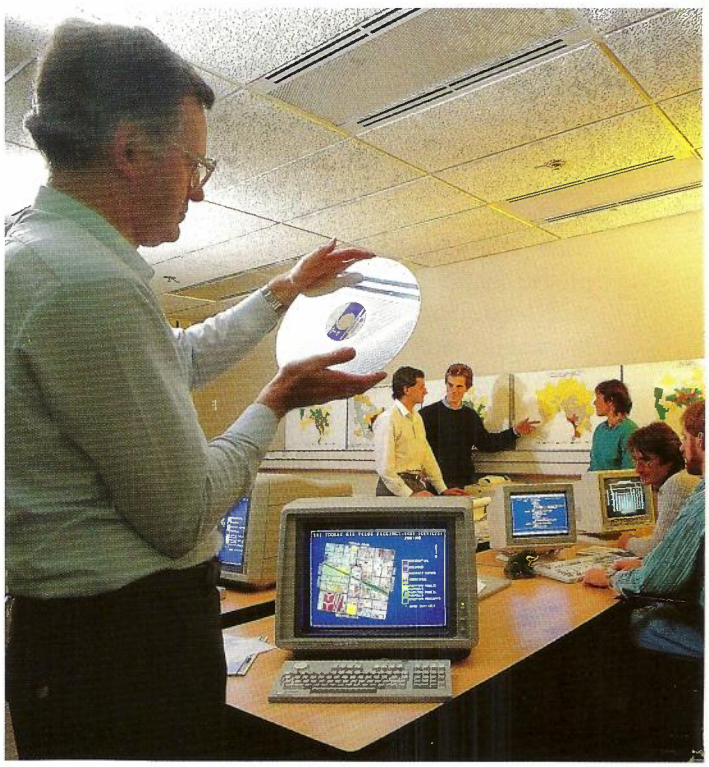
- an overview of telecommunication networks,
- standards in graphical data interchange and telecommunications,
- public broadband networking solutions, and
- security in telecommunications.

In addition, a technical session entitled "The use of telecommunications by the spatial information community" was held on each day which provided the opportunity for representatives of each of the user communities to discuss the present and future networking needs of their organisation. Day 1 concluded with a panel discussion and day 2 with a feedback session, where speakers and audience were able to discuss matters arising from the presentations.

The seminar was opened by the Executive General Manager, Corporate Customer Division, who gave a brief overview of Australia's role in Spatial Information Systems development. He also noted the unique lead being taken by Telecom in hosting a Spatial Information Systems seminar.

Dr Andrew Frank of the National Centre for Geographic Information and Analysis at the University of Maine presented the keynote address on the role of telecommunications in GIS development and applications. Dr Frank's address included a review of developments in telecommunications technology, and of recent trends in GIS development, applications and use. He also discussed the use of new telecommunications technology in database design, networking, data transfer and storage, systems design and user access and forecast what the future GIS community might expect from telecommunications.

There was a positive audience response to the seminar, resulting in many constructive comments relating to matters of content and organisation. A "post-seminar" survey indicated a high level of interest in the new telecommunications technology, and highlighted potential application and marketing opportunities for Telecom. The success of the seminar is expected to encourage further discussion on networking of spatial information systems, and has established new links between Telecom and the user communities.



Trevor Long uses Geographical Information Systems to plot the spatial distribution of customer groups. Data is stored on laser disc

TRL AWARDS FELLOWSHIPS TO TOP STUDENTS

As in past years, the best of Australia's future scientists and engineers in telecommunications research were honoured with Fellowships awarded by TRL.

twenty-one students, from tertiary institutions around Australia, received Fellowship stipends totalling $168,000 in 1990, in recognition of their outstanding academic achievements in telecommunications-related studies.

Additionally, the students had the opportunity to undertake leading edge research work at TRL where, for a short time the students experience life as researchers in a world class R&D environment, and gain an early exposure to the career opportunities that lie ahead.

The Fellowship awards were presented by Telecom's Deputy Managing Director, Mr Doug Campbell, at a ceremony attended by the students, their parents and mentors, and eminent academic researchers from Monash University and the University of Melbourne.

"The recipients of these Fellowships are beginning careers that will lead Australia towards the 21st century and beyond", Mr Campbell said. "It will be upon their shoulders, and those of other young people like them, that Australia's future prosperity will rest. Telecom is very pleased to be able to encourage and support them in their endeavours."

Mr Harry Wragge, the Executive General Manager of TRL, said it was pleasing to see two outstanding women amongst this year's recipients.

"They have shown, especially to other young women contemplating careers in science and engineering, that women can achieve the highest success and recognition in what have traditionally been male-dominated fields," Mr Wragge said.

"As pioneers of change, Roberta Sargent and Alison Payne deserve the special praise, and indeed the thanks, of the science and engineering professions. I hope that many other young women will follow their lead in the years ahead."

By awarding Fellowships, TRL aims to promote Australian research excellence in telecommunications by rewarding those students who have achieved outstanding academic results in areas relevant to the research interests of Telecom.

Two types of Fellowship are offered to university students every year. 'Telecom Australia Education Fellowships', worth $7,500 each, are awarded to undergraduate students who are about to commence their final years of tertiary study.

Australia's best tertiary students in telecommunications related fields, were awarded Telecom Fellowships in 1990. The Fellows are studing undergraduate and postgraduate courses at universities across Australia

Postgraduate students about to embark on Masters or PhD courses relevant to telecommunications receive the 'Telecom Research Laboratories Postgraduate Fellowships' worth $11,000 per year for up to four years. Selection of all Fellows is based upon academic merit and the recommendations of a selection panel.

OVERSEAS VISITS BY TRL STAFF

It is an important responsibility of any viable research organisation to keep abreast with developments and changes in particular fields of interest to Telecom Australia. To this end, TRL arranges an annual programme of overseas, enabling TRL staff to interchange experience, technical knowledge, opinions and ideas with research personnel of other organisations. The visits are normally to other telecommunications administrations, universities and industry. In addition, TRL staff undertake overseas visits to participate in the standards development and other activities of international forums and conferences of world telecommunications bodies and related organisations.

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

M.O. Andrews
R.W.A. Ayre
G. Bharatula
R.J. Boast
A.J. Bundrock
L.H. Campbell
M.E. Cavill
S. Charles
J. Cheong
J. Cybulski
N. Demytko
B.T. Dingle
J.C. Ellershaw
R. Exner
A.J. Gibbs
R.W. Harris
P.R. Hicks
G.F. Jenkinson
I.P. Macfarlane
I. McGregor
J.L. Park
P.G. Potter
D.J. Richards
P.J. Richardson
T.P. Robbins
B.M. Smith
R. Smith
J.L. Snare
G.O. Stone
S.L. Sutherland
E. Tirtaatmadja
E.A. Zuk
M. Zukerman

During the year, many overseas visitors were interested in discovering how TRL's MACNET prototype can deliver optical fibre to the home and office

TOP (L to R) - David Twyver, Managing Director of Northern Telecom UK; John Semple, TRL optical networks researcher; Desmond Hudson, President of Northern Telecom World Trade, Canada; and George Smyth the President of Bell Northern Research Ltd, Canada

BOTTOM (L to R) - His Excellency Mohamed Jamil Mulla, the Assistant Deputy Minister for Operations & Maintenance Affairs of the Ministry of PTT, Saudi Arabia, examines a passive optical fibre splitter with Dr Bernard Smith and Dr Alan Gibbs of TRL

VISITORS TO TRL

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

TRL activities are also demonstrated to specialists and non-specialists groups from business, industry, professional societies, Government Departments and academia. This is achieved through arranged discussions, inspection tours and demonstrations.

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

NATIONAL INFORMATION RESOURCE CENTRE

Information has the potential to be a vital strategic resource in a technically and commercially oriented organisation such as Telecom. To be truly useful, information needs to be in the right place, at the right time, and in the appropriate format. It must be effectively collected, managed, analysed, packaged and delivered. It is this management of information on behalf of Telecom which is undertaken in the National Information Resource Centre throughout Australia.

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

The National Information Resource Centre is a corporate facility, provided by TRL on behalf of Telecom Australia. Centres are located in the major metropolitan areas throughout Australia, to help Telecom staff with their information requirements.

The National Information Resource Centre has a staff of information professionals who have a wide range of expertise in many aspects of information handling. These people have an excellent understanding of Telecom, and of its likely current and future information needs. They are skilled in identifying, analysing and packaging information, so that it is of immediate benefit to particular client groups. In these ways, the National Information Resource Centre provides value added products and services to Telecom.

A comprehensive collection of information forms the basis of the products and services provided by the National Information Resource Centre. This information base includes:

- access to an exceptionally wide range of on-line information sources, including bibliographic and statistical sources, and many full text services,
- access to an increasing range of information available via CD ROM,
- access to a wide range of business information, including business intelligence files,
- comprehensive collections of standards, integrated circuits and semiconductor files,
- an excellent collection of hard copy reference tools, journals, newspapers reports and conference proceedings, which has been developed over many years, and reflects both the new and traditional interests of Telecom Australia. and
- in-house data bases that include details of:
  - Telecom Australia publications;
  - annual reports from many Australia and overseas organisations;
  - market research reports commissioned by Telecom;
  - details of forthcoming conferences, both Australian and international in science and technology and in management and marketing.
  - current journal articles, and items of interest to Telecom, selected from the daily press.

Specialised products and services, based on this information, are the main focus of the activities of information professionals from the National Information Resource Centre. Increasingly, their work involves the provision of enhanced, value added information, to Telecom's senior executives and key decision makers, throughout Australia.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