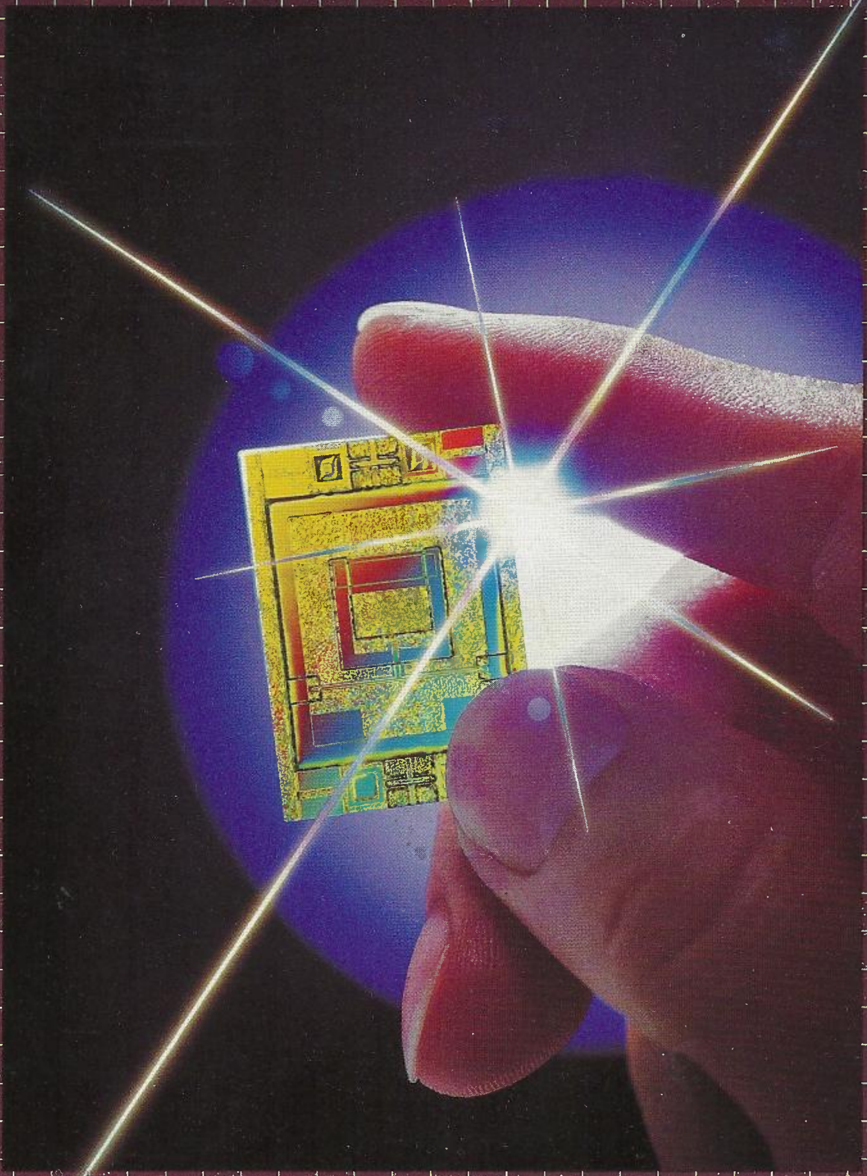
DARE TO DISCOVER



RESEARCH DEPARTMENT OPEN DAYS 1985

Telecom Australia

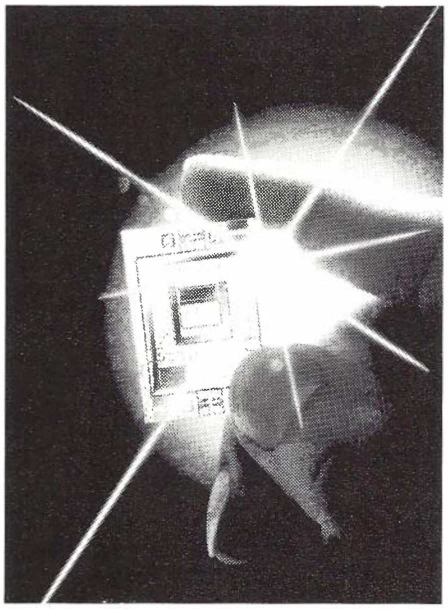
DARE TO DISCOVER

To discover is the essence of research. Discovery is the realization of vision.

Research can be expensive and achievement of a favourable outcome cannot be guaranteed. However, benefits from successful research can enormously outweigh the cost. Judgement in the choice and direction of research is crucial if the proportion of successful work is to be rewardingly high.

RESEARCH DEPARTMENT OPEN DAYS 1985

Telecom
Australia



COVER PHOTOGRAPH:

A 100 times magnification of a two-dimensional, electron gas, field effect transistor (TEGFET) made in the Research Department. Telecom's Research Department is the only Australian laboratory capable of producing this revolutionary semiconductor device. Laboratory exhibit TT06 provides full details.

FOREWORD

To meet Telecom Australia's objective of efficiently providing communities and businesses in Australia with the increasing variety of world-standard telecommunications services they are requiring, particularly in non-voice services, the Research Department maintains a high level of expertise in the most recent developments of the new technologies and techniques involved.

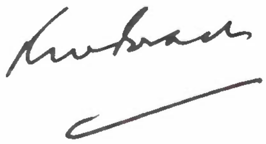
The Research Department has played an important part in the growth of Telecom's reputation world-wide as a leading telecommunications administration. The Department is regularly involved in international technical conferences and standardization activities and its staff contribute frequently to international scientific and technical literature.

In addition to the challenges of this continual development of the national telecommunications system, there are those presented by the particular circumstances of Australia's size, its environmental characteristics and its uneven distribution of population.

This booklet, a guide to the 1985 Open Days, gives overviews of six principal themes in the Department's current work towards Telecom's objectives and also lists and briefly describes each of the many exhibits on view. These will enable all those people and organizations interested, to explore with us the future of telecommunications in Australia.

In 1978 a substantial part of the Research Department, including its Head Office, was relocated to its present site at Clayton where these Open Days are being held. The improved accommodation has greatly facilitated the work of the Department.

I have pleasure in welcoming you to the Research Department's 1985 Open Days.



R.W. Brack
Chairman,
Telecom Australia.

CONTENTS

GUIDE FOR VISITORS

TIMES FOR VISITORS

Monday	1st July,	1985 :	9.30 a.m. — 5.00 p.m.	Mornings — Telecom staff
Tuesday	2nd ,, ,	1985 :	9.30 a.m. — 5.00 p.m.	Afternoons — Invitation only
Wednesday	3rd ,, ,	1985 :	9.30 a.m. — 9.30 p.m.	
Thursday	4th ,, ,	1985 :	9.30 a.m. — 5.00 p.m.	Public Days
Friday	5th ,, ,	1985 :	9.30 a.m. — 5.00 p.m.	

FIRST AID

First aid facilities are available in all buildings. Any staff member will be able to assist you in this regard.

REFRESHMENTS

Light refreshments are on sale on the ground floor of the central exhibit area.

Extended facilities are offered in our cafeteria located on the 1st floor of Building 5. The menu includes a wide selection of hot meals, light snacks, tea/coffee and a vartiety of soft drinks and fruit juices.

HOW TO IDENTIFY AND LOCATE LABORATORY EXHIBITS

Using this Booklet

Details of laboratory exhibits are set out in the 'List of Exhibits' at the back of this booklet. The exhibit Title, a brief synopsis and location code are included.

A further listing, 'Exhibits by Subject', will assist selection of exhibits on a subject basis.

The location of most exhibits is indicated by a four character 'Location Code'. The first digit of the 'Location Code' denotes the Building No. (refer Site Plan). The remaining three characters denote the Floor and Room No., e.g.:
2G09 = Building 2, Ground Floor, Room 9
6L01 = Building 6, Linkway, Room 1
5229 = Building 5, 2nd Floor, Room 29

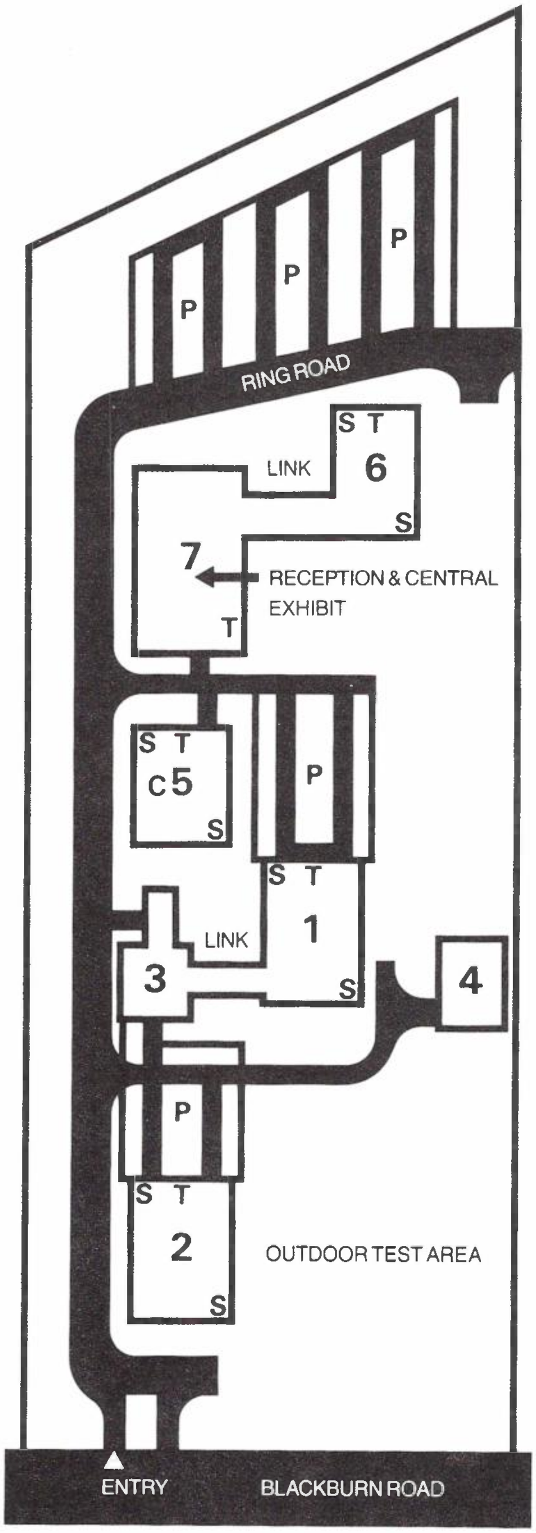
Some exhibits are located in common areas such as foyers. These locations are indicated by a two-character risk/letteletter) code, e.g., *A. An explanatory note is provided at the foot of the page.

It is suggested that you use the 'List of Laboratory-Based Exhibits' to select exhibits of interest following your inspection of our central exhibition.

Using the Viatel Terminals

As a further aid to selection of laboratory exhibits, computer type terminals linked to Telecom's electronic information service, 'Viatel', are available for your use, both in the main exhibition hall and the ground floor foyer areas of each building. Using these terminals is very straightforward, — simply select the option you want from the menu displayed on the screen by entering it's associated number via the numerical keyboard. Repeat this selection process until the detailed information you seek is displayed.

SITE PLAN



Telecom Australia Research Department
770 Blackburn Road Clayton, Victoria

Telephone: 541 6444
Telex: AA 33999

Postal Address:
P.O. Box 249,
CLAYTON. VIC. 3168.

LEGEND:

- **2** Building Number
- **P** Parking
- **S** Stairs
- **T** Toilets
- **C** Cafeteria (1st Floor)

0 25 50 75 100M

◀ NORTH

A BRIEF HISTORY OF THE RESEARCH DEPARTMENT

The Research Department of Telecom Australia owes its origin as a special unit of Telecom to the need, after World War 1, for the then Australian Post Office (APO), from which Telecom was formed, to introduce new technology into the telephone and telegraph networks to improve their capacity and quality of service while maintaining their economic viability. This called for specialists that would carry out investigations into the technical aspects of new systems and give timely advice to the APO on their benefits to its operations.

THE EXTRAORDINARY IMPETUS OF THE VACUUM TUBE

World War 1 had advanced Lee de Forest's vacuum tube triode from a laboratory device to a commercially available component. Its potential application as an amplifying device for small electrical signals was recognized quickly and this was to lead to telecommunications links successfully spanning greater and greater distances.

Prior to 1920, Australian telecommunications activities centred upon the provision of telephone services in capital and provincial cities, with an infant trunk network of aerial lines linking them rather tenuously. The overseas use of vacuum tube VF (Voice Frequency) repeaters had by 1920 demonstrated their potential in extending the distance of trunk routes. The APO, realizing this, introduced the first 2-wire VF repeaters into the Sydney-Melbourne route on an experimental basis in 1922, after the then Chief Engineer, accompanied by a Mr Sidney Witt, had visited the U.S.A., U.K. and Europe to assess their use.

BIRTH OF THE RESEARCH DEPARTMENT . . . WITH NO OVERHEADS!

The activity led the then acting Chief Engineer, Mr R.N. Partington, to propose, on 19th March, 1923, the establishment of a Research Section to provide specialist technical advice on the introduction of these new devices into the Australian network. The proposal was approved and in about June 1923, Mr Sidney Witt, Engineer, was set to work as a one-man Research Section — with little equipment and about 30 m^2 of space in the then Postmaster-General's Department Headquarters building in Treasury Place, Melbourne, Victoria.

The Research Department, then known as a Section, increased to two engineers on 11th February, 1924, when a Mr Wright was transferred from the Victorian Administration to assist Mr Witt. During 1925, the tiny Research Department moved into a larger area of 160 m^2 in Melbourne House, 360 Post Office Place, Melbourne.

By 1925, the Section had been formally established with Mr Witt as the Supervising Engineer, assisted by Messrs Eric Wright and Alan Lorimer, Engineers, Mr G.G. Robb, Mechanic and Miss F. Terrell, Typist and Clerk.

The infant Department was charged with the task of establishing expertise in the field of telephone and telegraph transmission by studying 'the latest discoveries, inventions and developments in electrical communications' and advising the Chief Engineer of those that were promising and likely to benefit the nation's telephone and telegraph services. That early purpose of the Research Department still applies today. The list of Heads of the Research Department since then, is shown *above right*.

HEADS OF THE RESEARCH DEPARTMENT 1923-85

1923-45	Sidney Herbert Witt
1945-53	Eric Percival Wright, B.Sc.
1953-60	Norman James McCay, B.Sc.
1960-64	Leonard Michael Harris, O.B.E., B.Sc.
1964-75	Percy Rollo Brett, O.B.E., B.Sc.
1975-85	Edward Francis Sandbach, A.M., B.A., B.Sc.
1985-	Harry Stuart Wragge, B.E.E., M.Eng.Sc.

EARLY ACTIVITIES IN THE NATIONAL TRUNK NETWORK

The early years were spent mainly in the conduct of transmission measurements, the determination of transmission standards and the study of evolving transmission theory and practice as required by the application of VF repeaters and early carrier systems in the trunk network. The year 1925 saw Mr Witt installing the first 3-channel carrier system in Australia on the Sydney-Melbourne route, Mr Wright installing VF repeaters and later the first single-channel carrier system in Western Australia and Messrs Lorimer and Mair developing transmission test equipment, practices and transmission standards. The study of problems and advances in telegraph and telephone transmission continued to occupy the growing Research Department, by then known as the Research Laboratories, as time and technology led from VF repeaters to single and three-channel systems in the late 1930s.

This work required the development of technical expertise in telephone performance standards, telephone transmission measurements and standards, transmission systems evaluation and in the study and characterization of transmission media. The growth of these specialities has continued since and a significant number of present-day activities, as reflected in the current organization chart and work program of the Department, can be traced back to these modest beginnings.

CONTRIBUTIONS TO RADIO BROADCASTING

From 1925 onwards, the Department's staff became involved in the transmission of radio broadcast programs over the trunk network, engineering in 1925 the first simultaneous interstate broadcast in Australia. The occasion of this broadcast was a promotion of a Commonwealth Conversion Loan by the Secretary to the Treasury, Mr. J.R. Collins, via a network hook-up of six radio stations — 2FC, 2BL, 3LO, 3AR, 4QG and 5CL. The Department went on to arrange the nation-wide broadcast in 1927 of the first opening in Canberra of the Commonwealth Parliament, by manning a similar transmission network for the radio broadcast stations of the day.

Between 1925 and 1927, the Department was equipped to conduct radio frequency field strength measurements and was carrying out these measurements on the medium frequency broadcast transmitters. At this time, decisions were made to extend and upgrade the National Broadcasting stations to provide a reliable service to 90% of the population and, in 1927 Mr Witt and several other of the Department's staff were seconded to plan the present National Broadcasting System. Following the planning phase, which lasted several years, the Department was closely involved with the implementation of the plan, going on to design broadcast transmitting equipment and antenna systems, evaluating studio equipment and the like during the years prior to World War II.

This direct involvement with the implementation of radio broadcasting has since ceased but it is of note in that it led from medium to high frequency (HF) broadcasting, the Department setting up the first Australian HF transmitter on an experimental basis at Lyndhurst, Victoria, in 1928 and later developing it until it provided a regular service. This early involvement with radio built up the expertise in transmitter design, antenna design, radio field strength measurements and propagation theory that was turned to VHF (very high frequency) radio telephony applications and investigations in the late 1930s. In 1938, when the submarine cable link to Tasmania was under repair, the staff of the Department were instrumental in establishing the first APO radio telephone system from Mount Tanybryn in Victoria to Stanley in Tasmania, a distance of 270 km across Bass Strait.

THE 1932 MOVE INTO SPACIOUS ACCOMMODATION

By 1932, the staff had increased to 35 and they had outgrown the 500 m^2 they then occupied in Melbourne House. (As another indicator of growth, the value of the Department's test equipment had risen from 3000 pounds in 1925 to 16 000 pounds in 1932). In this year they moved into what was then a spacious area of 2400 m^2 at 59 Little Collins Street, Melbourne, which remained the Head Office of the Research Department until 1978 when it was relocated to its present site at 770 Blackburn Road, Clayton. Before the complete relocation of the Department at Clayton at that time, the Department's activities had spilt over into a further six buildings at the eastern end of central Melbourne, and one at North Carlton.

THE 1940s — AND THEIR LINKS WITH CURRENT RESEARCH

The years of World War II saw the Department assisting in the development of radar systems and engaged in other work for the armed services. Following the war, the radio frequency activities of the Department turned more towards radio telephone systems. However, for a period after the war and as a preliminary to the introduction of television broadcasting into Australia, the Department was engaged on television propagation studies, as well as on a series of studies to determine the optimum parameters for a working television broadcast service. This latter work has now changed emphasis and is directed at studies of the coding of television signals for optimum bandwidth utilization, with particular attention being given to broadband digital systems of the future.

The extension of the radio telephony work at VHF and UHF has naturally involved the Department in the investigation of satellite systems and staff of the Department have participated in studies on the use of satellites for telecommunications purposes since 1960.

The post-war years have also seen an expansion of the Department's interest in broadband systems and guided transmission media — as might be expected with the addition of the newer video and high-speed data services to the older telephony and telegraphy services provided by the APO. The expertise developed by the Department in the late 1940s in the microwave systems and media fields extended through the coaxial cable phase of the 1950s and was used for investigations of the potential of optical devices and optical fibre media in the 1960s.

THE 1950s AND 1960s — SEMICONDUCTORS AND SYSTEMS

The invention of the transistor in 1948 led soon afterwards to the increasing use of these (and later generation) semiconductor devices in experimental systems in the Research Department. This was particularly evident in the growth of expertise and activity in the Department in the investigation and development of digital electronic switching and transmission techniques and systems. In particular, this advance was responsible for the Department becoming heavily committed in the technology of future generation all-electronic exchange systems. The Department set up its own facility for manufacturing micro-electronics prototypes in the early 1970s.

By contrast with the early preoccupation of the Department with the trunk network's individual transmission links, the evolution of Stored Program Controlled telecommunications networks since the late 1950s (and the evolution of mathematical systems theory since the 1940s) led, by a shift in conceptual emphasis, to the examination of the total network and its capacity to provide integrated services, telephony, data, facsimile, perhaps video — through a common network. Through research into Stored Program Controlled systems and networks and into advanced transmission, switching and signalling techniques, the Department was able to give informed advice to Telecom network planners on costs and facilities of networks and systems of the future.

THE 1970s AND EARLY 1980s — DIGITAL TECHNOLOGY AND THE CONVERGENCE OF COMMUNICATIONS AND COMPUTING

The shift that began in the 1960s towards integrated services to be provided through a common network took shape in the 1970s as the ISDN (Integrated Services Digital Network) concept. As the title of the concept suggests, digital technology is crucial. It has been applied in the achievement in service of integrated optical fibre, microwave, switching and other systems that all depend on digital technology and together have been designed to facilitate communications, computing and their convergence.

Studies of telematique services and human factors in communications have enabled development of message handling systems, teleconferencing and computer use.

Satellite Communications work has led to the business, remote and mobile links to be provided by Telecom's Iterra satellite service.

Materials research, such as investigation of semiconductors and solar cell modules, has also been important.

Most of the above areas require increasingly extensive participation in the work of international standardization organizations.

ROLE OF SPECIALIST GROUPS

The Department also contains certain specialist groups. The Applied Science Branch, from a modest beginning in 1931, has grown to comprise physicists, chemists and metallurgists capable of conducting a wide variety of material investigations and evaluations and equipped with advanced analytical and environmental test facilities. This group played an important role from the 1940s onwards when it provided specialist advice and investigational facilities to assist with the many problems encountered by the infant telecommunications equipment and cable manufacturing industries. Other specialist groups include psychologists, librarians and a group that maintains, develops and applies Telecom's reference standards of time, frequency and electrical calibration with the precision required of national verification bodies.

VITAL STATISTICS — 1985

The Research Department has kept pace with the expanding frequency spectrum, digital technology, satellites and the increases in Telecom services. It now employs some 500 staff comprising approximately 140 professional engineers, 40 professional scientists and 8 professional librarians, together with 170 supporting technical staff in both the scientific and engineering disciplines. The administrative staff totals 80.

One measure of the effectiveness of a Research organization is the eagerness of its staff to communicate the results of their work, both in its own publications and in outside journals. In the sixty-one years of its existence, the Research Department has published nearly 8000 Research Laboratories' Reports. These form the official record of the work of the Department. The number of contributions to journals of learned societies, both national and international has run into many hundreds. This is evidenced, for example, by the continuing role the Department's officers have played in the Telecommunication Society of Australia and by their frequent contributions to its publications, 'The Telecommunication Journal of Australia' and 'Australian Telecommunication Research' (ATR). The Department's staff have been prominent editors and contributors to the Journal since it was first produced in 1935 and the Society's more recent publication, ATR, was started in 1967 following initiatives taken by the Department.

FUNCTIONS OF THE RESEARCH DEPARTMENT

The Department provides the technological research and development support needed to allow Telecom Australia to carry out its day-to-day activities and to prepare for the technological demands of the future. In general terms the research and development objectives of the Department are :

(a) to ensure that research and development are undertaken at an adequate intellectual level and in sufficient fields of work to satisfy its needs for new knowledge, new expertise and new developments,

(b) to assist the Australian telecommunication manufacturing industry in maintaining the required level of innovation and up-to-date manufacturing technology and

(c) to encourage universities and other tertiary education institutions to accord telecommunications research a prominence that will attract talented engineering and science students in sufficient numbers to meet future national needs.

CHARTER

With these objectives in mind the Research Department operates to the following charter:

(a) to conduct research and development in telecommunications theory and practice, particularly as applying to the Australian region,

(b) to appraise new developments in telecommunication equipment and in appropriate cases to conduct field trials,

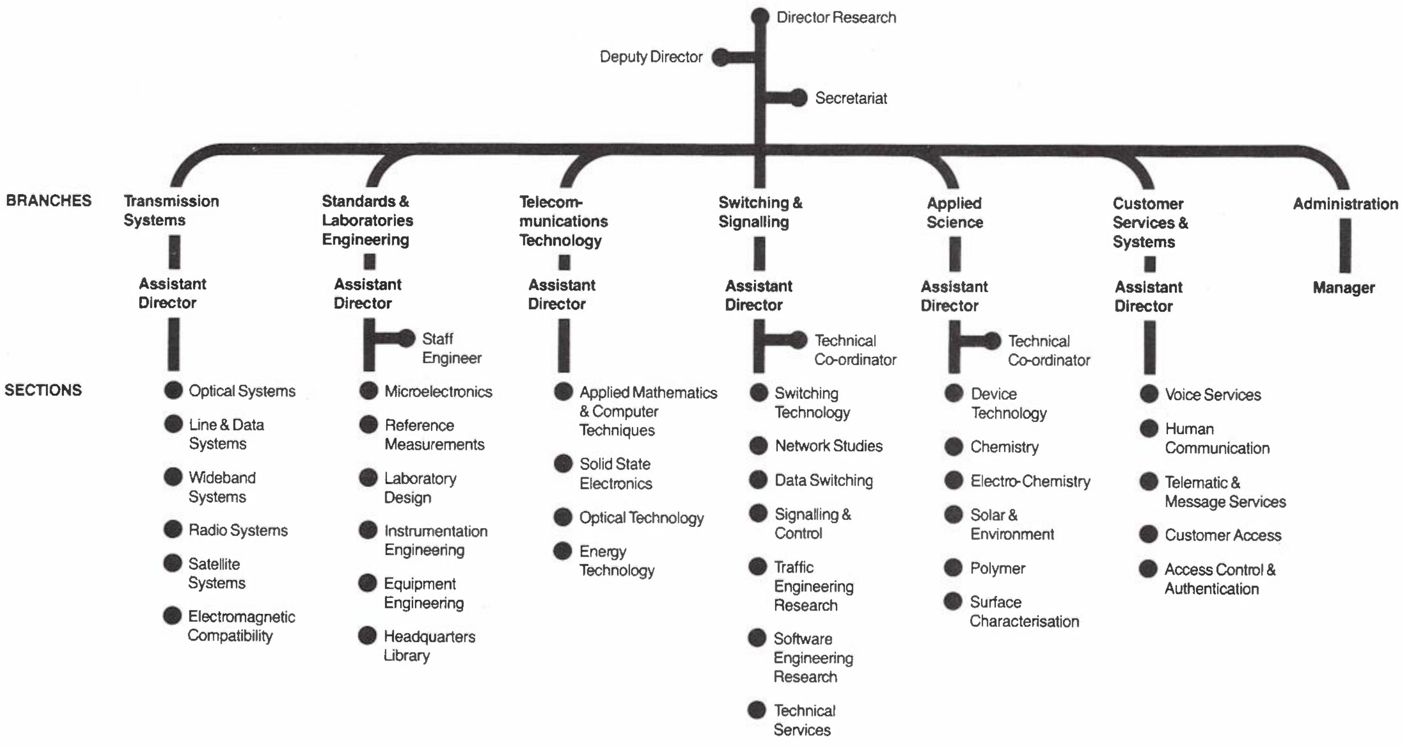
(c) to develop apparatus and systems that are required in the Australian communications network and are not available from commercial sources,

(d) to act as consultant on scientific and engineering matters to Telecom Australia,

(e) to participate in the work of national and international organizations associated with telecommunications research and to be represented on their committees and

(f) to encourage research and development in telecommunications and allied disciplines in tertiary education institutions and industrial laboratories.

RESEARCH DEPARTMENT ORGANIZATION



PRINCIPAL THEMES OF THE 1985 OPEN DAYS

The work of the Research Department is summarised in six themes, viz:

Human Factors in Telecommunications

Integrated Services Digital Networks

Materials Science

Optical Fibre Communications

Satellite Communications

Telematique Services

Elements of these themes will emerge as you visit selected exhibits.

The following pages will be of interest should you wish to explore one or more themes further.

HUMAN FACTORS IN TELECOMMUNICATIONS

Introduction

People and their need to communicate provide the only reason for telecommunications. The need to communicate explains why huge resources have been spent to build a worldwide telecommunication service. Now people can communicate to almost anywhere using the spoken word, text or moving and static images. With telecommunications, people can seek information stored remotely in computer data banks or they can monitor the performance of some distant physical process. Telecommunication options are already numerous and more will eventuate as knowledge grows with research and experience.

However, there is a hidden cost to this proliferation of telecommunication possibilities. The cost lies in the increased complexity of the telecommunication service. People could face considerable difficulty in the choice and easy use of telecommunications, unless services are designed and implemented to match human capabilities.

The study of human factors in Telecom's Research Department aims at understanding the requirements placed on telecommunication facilities to enable human users to communicate easily and effectively. Human Factors research generates guidelines for designing services and systems that people find easy to use whatever their level of experience might be.

What is Human Factors Research in Telecommunications?

The term 'Human Factors', for the Research Department's purposes, refers to those attributes of people that are important when using telecommunication services. They are the factors that should be considered when designing the terminal equipment and procedures that people use for telecommunication and when specifying the desired overall performance of the communication service.

The factors of concern may be physical. The shape and dimensions of the human skull affect the optimal design of the telephone handset. The factors may be psychophysical. The human ability to understand speech depends upon both hearing — the level of sound in the telephone receiver — and on the ability to interpret the sounds heard as speech. The last factor determines the limits to the ways in which the speech signal can be processed for cheapness and ease of transmission between telephones. For some types of telecommunication the important human factors may be cognitive; the procedures for using text messaging services require the user to read and understand instructions written on a video display screen and to act upon them. The written instructions and the procedures they describe must be carefully matched to the human abilities in this type of performance.

An Historical Overview

The need for human factors studies has grown over the years, slowly at the start, but more recently with increased rapidity. For 100 years, telephony was the only telecommunication service used directly by a general population. (Telegrams required the intervention of the telegraphist, who actually used the technical system.)

At first, the telephone was a magical device but the customer had a simple procedure — just pick up the receiver, turn the handle and listen for the operator. The expert operator would use the complicated switchboard to connect the customers. The main human factors problem with telephony was, and is, ensuring that people can hear and understand speech correctly. The Research Department, since its foundation in 1923, has worked on this problem and has contributed much to the international understanding in this area of knowledge. The result is an Australian telephone network that is equal to any other in its quality of speech communication.

During the last two decades, new technology, made possible by semiconductor devices (the transistor and its offspring, the microchip), has opened the door to a vast range of new services for general use in the community. The new possibilities have brought with them a new set of human factors problems, some of which have been studied by the Research Department, but many of which have still to be solved.

Video and audio teleconferencing received considerable attention in the 1970s and early 1980s. Psychophysical studies of human vision produced information on the performance that would be required of television systems if they were to be suitable for video-conferencing. Research into the human factors of group communications led to several exploratory developments in audio teleconferencing, some of which have been offered commercially.

The advent of computers into telecommunication in the most recent years has brought about a new direction in human factors studies in the Research Department. The cognitive capabilities of humans to understand and operate computer based telecommunication services, such as telematique and message services, is an important area of study. It has been the focus of human factors research during the last two to three years and mirrors a growing concern in international laboratories. The demands of Telecom's customers for 'user friendly' telecommunications will lead to greater emphasis on this research in the future.

Telecom's Interest in Human Factors Research

The application of the results of the human factors research is an essential element in meeting Telecom's paramount commitment to provide up to date, affordable and efficient communications throughout Australia (Telecom Annual Report 1983-84). This is clearly seen in telephony, where the goal is that all telephone connections must enable speech communication to take place to a satisfactory standard. Human factors research aims at determining what is a satisfactory standard as seen by the Australian population in Australian conditions.

However, Telecom's commitment to providing up to date services means that our knowledge must grow beyond the human factors relevant to telephony and into the field of computer based telecommunications. The value added network services that telecomputing makes possible must match the users' capabilities if these offerings are to be acceptable to Telecom's customers.

The Research Department's Role and Contribution

The Research Department will continue with its human factors studies on speech. The future emphasis in the digital environment will be on the use of speech signal processing techniques, such as adaptive differential pulse code modulation encoding, the acceptability of their use in the telephony network and the acceptability of different types of synthetic voice used for voice announcements.

However a significant proportion of the Research Department's resources in human factors research will be directed to studies of the issues related to computer based telecommunications.

This is a new field that has been recognized as a significant problem area by the International Telegraph and Telephone Consultative Committee (CCITT). The VIIITH CCITT Plenary Assembly Meeting in October 1984 agreed to study a new set of questions dealing with the problems during the 1985-88 study period. The same problem area has arisen in computing where the spread of personal computers has brought untrained people, whose business is other than computer programming, face-to-face with the difficulties of controlling a complex logic machine.

Current understanding of human factors in computer based telecommunication is very pragmatic and based on experience of what works, particularly the experience and preferences of the expert software designer. Some general principles are agreed as being necessary but many questions still exist. Much of the knowledge reported in the literature is valuable for the designer and service provider, who must get services into the market place; however, more and better knowledge will help ensure that the most usable services become available to the customer.

The Research Department has built up a small, skilled, interdisciplinary team of psychologists, engineers and technical officers to investigate the area. This team is well equipped to contribute to developing our understanding of what will make Telecom's new computer based telecommunications easy for our customers to learn to use and to continue to use efficiently.

It is worth noting that the research does not take place exclusively in the laboratory. The results of laboratory experiments are as far as possible further tested in the field, with strong attempts being made to duplicate real life conditions.

The Benefit to the Customer

Most telecommunications users have had experience with modern products that are complicated to use. Many people have difficulties with the range of options available on some washing machines or the time clock mechanisms on stoves or video recorders. Hence it is fairly obvious that considerable effort is worthwhile in designing telecommunications to be readily usable. Most people want their telecommunications service as a tool, not a challenge. They want services that enable them to get on with their main business efficiently and effectively. Telecom's human factors research effort is aimed at providing just such a tool.

INTEGRATED SERVICES DIGITAL NETWORKS

Introduction

An Integrated Services Digital Network (ISDN) is a network able to support a wide range of services, including voice and data services, to which users have access by a small set of standard multi-purpose customer interfaces. Establishment of these interfaces then allows independent developments in the customer's premises, such as terminal equipment, and in the network itself, such as transmission, switching and signalling equipment, within a common framework. The ISDN approach is increasingly being viewed by telecommunications network administrations worldwide as the long term solution to the problem of providing for the diverse range of communication services expected to be required in coming years.

Work in many areas of the Telecom Australia Research Department is either directly or indirectly concerned with the definition of this future ISDN.

Background

Telecom Australia, like most other network administrations, has adopted a strategy of using digital technology for most future network development. Recent cost trends favour this approach but the real impetus comes from the accelerating customer demand for new services based on digital techniques. Accordingly, large investments are being made to introduce digital transmission and digital switching systems to meet increased demand or to replace obsolete equipment. At currently forecast rates of development and equipment provisioning it is expected that approximately 50% of the network will consist of digital equipment by the year 2001.

Most of the initial investment in digital technology is being used to construct a fully digital 'overlay' network of digital exchanges interconnected by digital radio and line transmission systems (twisted pair, coaxial cable and optical fibre). This network is known as the Integrated Digital Network (IDN) and will provide for circuit switched 64 kbit/s connections between local exchanges. A powerful inter-exchange signalling system based on packet switching techniques known as CCITT Signalling System No. 7 will also be introduced with the IDN, providing faster call set-up and considerable flexibility for future enhancement.

The IDN will not initially be directly accessible by the customer but rather will enable significant cost and performance advantages to be realized in the inter-exchange part of the network. The IDN will also provide the transmission capacity for a number of specialized data networks meeting particular needs of the business customer. These include the Digital Data Network (DDN), which provides high performance leased-line data services at rates up to 48 kbit/s and AUSTPAC, Telecom Australia's packet switched public data network.

The final stage of network digitalization is the introduction of digital technology into the link between the customer's premises and the local exchange. The resultant network providing digital connections end-to-end between customer terminals forms the basis for the Integrated Services Digital Network (ISDN). The ISDN differs from existing voice and data networks in its potential to support a range of voice and data services on a single 'multi-service' digital network. This unified approach offers significant advantages in cost and convenience to both the customer and network administration.

The international Telegraph and Telephone Consultative Committee (CCITT) is playing a central role in the setting of standards for the ISDN, particularly in the area of customer-network interfaces. Representatives from Telecom Australia, including representatives from the Research Department, have regularly attended the CCITT working party meetings dealing with ISDN and have contributed to the development of these standards.

Various Research Department activities are discussed below.

Customer Access

A key element of the ISDN will be the ISDN customer-network interfaces being developed within CCITT. The major thrust of the ISDN customer access standardization activities has been to develop an interface structure that can be produced at sufficiently low cost to allow widespread deployment in both business and domestic markets but with the flexibility to handle a wide range of present and future communication needs. This has led CCITT to adopt a basic interface structure that provides each customer with two 64 kbit/s channels suitable for either voice or non-voice information and a 16 kbit/s channel reserved primarily for carriage of signalling to control the use of these 64 kbit/s channels. This high capacity signalling channel uses a packet mode protocol and allows for fast call set-up but also provides spare capacity, which can be used to carry other packet mode information (e.g. data or telemetry). Hence, the future ISDN user will, through the one interface, be able simultaneously to operate several independent communications that would otherwise require the separate provision of a number of individual access lines.

Current research activities include investigation of the way an ISDN user can best use this 'multi-media' capability and studies of the complex interactions between the customer access signalling and the inter-exchange signalling within the network. Formal description of the customer access protocols and experimental verification of their correctness are also current research topics. In addition, an experimental ISDN terminal is being developed to investigate the integrated delivery of multiple services.

Digital Transmission

The development of a two wire, full duplex, digital line transmission system that can provide basic ISDN access to almost all customers, over the existing local copper pair cable network, is a necessity for achieving a viable ISDN capability. This task has received considerable worldwide attention and many telecommunication administrations and companies are currently at various stages of finalizing national system specifications and equipment designs to achieve this end. The various design approaches being pursued involve different trade-offs between system complexity and transmission performance.

Since most customers have only a single cable pair to their local exchange, the line transmission systems used to provide basic ISDN access must separate the go and return transmission signals. The system most likely to be used by Telecom will achieve the directional separation by using a hybrid with echo cancellation circuitry to remove any residual transmit signal that appears in the receiving direction owing to both finite trans-hybrid loss and reflected signal power from impedance discontinuities along the cable pair (i.e. owing to gauge changes and bridged taps). Since on long cable pairs the receive signal can be attenuated by perhaps 40 dB, the successful operation of echo cancellation systems relies on their ability to achieve 50–60 dB echo cancellation. This can only be achieved with complex circuitry, which must be implemented in LSI technology to be cost effective. However, this complexity also makes the process of converting prototype designs into production LSI chips a difficult task. Other factors, such as the choice of line code and the various adaption algorithms adopted to automatically control the echo cancellation operation and signal detection process used in the receiver, also have a significant impact on the performance and operation of a system design.

Before any particular transmission system can be adopted by Telecom its suitability for operation in the Australian customer network must be assessed. To facilitate this task the Research Department has developed a wide range of analytical skills and computer simulation tools to model the system's operation and the transmission impairments and noise processes that limit the achievable cable loop length. Appropriate studies are also under way into the implementation aspects that impact on the design and operation of the line transmission systems. The results of Research work are used to predict system limitations and the restrictions that these would impose on the number of customers that can gain direct basic access to Telecom's future ISDN.

Network Structure and Interworking

Whereas the customer-network interface will be subject to detailed international standardization, the internal structure of the ISDN will be much more a national matter, strongly influenced by the existing network structure. Possible approaches range from a number of distinct internal sub-networks each handling a single service (voice, circuit-switched data, packet-switched data, leased-lines etc.) available to the user by a common access arrangement, to a single integrated network that supports all the ISDN services. In Australia the ISDN will develop from the IDN, using the IDN to provide 64 kbit/s circuit switched connections between customers for both voice and data. Leased line services will also be able to be supported as semi-permanent connections through the IDN. Related research activities include detailed studies of the signalling requirements, technical characteristics of interfaces between equipment within the network and facilities for fault detection and location.

The role of packet switching in the ISDN is receiving special attention in studies by the Research Department. The CCITT identified packet switching as a service to be provided by the ISDN. Initially the ISDN will probably not handle packet traffic directly but will act as a circuit switched access network to the specialized packet switched data network (AUSTPAC). If packet switching develops as a major ISDN service, this approach may prove inefficient and some more integrated approach may be required. The impact on future exchange design could be profound. Present research activities include identification and evaluation of some of these alternative approaches.

Initially the emerging ISDN will need to coexist with the existing single service networks. Interworking between the new ISDN and these existing networks is a necessity for orderly growth of the ISDN. Network interworking is a many faceted problem that includes signalling and protocol conversion, addressing considerations, tariff considerations and network operations and maintenance. In collaboration with other Telecom Departments, the Research Department is investigating aspects of this problem relating to particular network interworking situations and to a general approach to network interconnection based on the Open Systems Interconnection (OSI) work of ISO and CCITT.

Experimental ISDN Exchange

To facilitate further experimental investigations to ISDN the Research Department is purchasing an experimental model of an ISDN exchange and associated terminal equipment, which is scheduled for installation during the second quarter of 1985 and will then provide a valuable test bed for trialling signalling protocols and ISDN services. Experience gained from the experimental ISDN exchange will assist in the later introduction of ISDN as a public service.

A range of representative ISDN terminal equipment will also be connected to the experimental ISDN exchange, to provide a realistic small-scale demonstration of the eventual capabilities of a public ISDN.

MATERIALS SCIENCE

Importance of Materials Science Activities

Materials science plays an important part in Telecom's R&D (Research and Development) activities. The bulk of this work is applied research aimed at ensuring that the materials Telecom uses are the most effective available in terms of both cost and performance. This investigative work is mainly performed at the design and prototype stages of equipment production. The Research Department is also engaged in basic research into the production and characterization of new materials that may be used in telecommunication equipment in 5 to 10 years' time.

As Telecom buys the overwhelming majority of its material requirements from private industry, it is sometimes argued that the choice of material should be left to the manufacturer. In fact, most such decisions are made by contractors, certainly those that maintain substantial R&D and quality control organizations. Some products do fail prematurely, however, especially when a material has been chosen without a full understanding of Telecom's operational practices, the range of Australian climates or the interaction of one material with another. There can also be subtle changes in properties due to variations in process technology. Such changes are not always detected by conventional quality control procedures. In equipment that is often at the forefront of the telecommunications state-of-the-art, it is also not uncommon to find that a material or component choice has had to be made without a full knowledge of all facets of its behaviour or before production processes are truly stabilized. Hence Telecom has for many years found it advantageous to be able to assess products, to solve materials-based problems and to make informed proposals for the improvement or modification of manufacturing processes. In a capital expenditure program of more than 1400 million dollars annually, such work results in considerable savings by minimizing replacement or maintenance, reducing equipment outages, improving the grade of service to customers, protecting the safety of staff and ensuring that the best product for a given price is bought.

Range of Materials Science Activities

Examples of a few recent investigations, which illustrate the range of materials science activities in Telecom, are:

- kinetics and interaction in polymer stabilizer systems,
- study, by voltage contrast, marginal voltage or electron beam induced current techniques, of materials defects in integrated circuits,
- effects of organic acid contamination in battery electrolytes,
- hydrogen evolution from optical fibre cable materials,
- surface characterization of contact materials,
- telephone keypad elastomers,
- fire-resistant plastics cable,
- characterization of solder fluxes,
- field trials of paint systems,
- plastics for packaging of integrated circuits,
- electrical insulating mats and protective clothing,
- amorphous silicon for solar cells,
- photovoltaic solar modules,
- cellular polyethylene,
- fibreglass laminate materials for radomes and
- III-V semiconductor compounds for optoelectronic devices.

III-V Semiconductors

The last item listed is one of the current basic research projects. III-V semiconductors are compounds of elements from columns III and V of the periodic table of elements. The best-known compound is gallium arsenide (GaAs) but more complex alloys such as indium gallium arsenide phosphide (InGaAsP) are widely used in telecommunications.

The III-V semiconductors have the fastest operating speeds known. They can exchange carriers, i.e. they can switch between electrons and photons as carriers of a given train of information and they can operate at light wavelengths that perfectly match silica optical fibres. Thus III-V semiconductors can provide an interface between the optical fibre and the outside world via devices such as solid state lasers and detectors.

The development of these materials and of the devices made from them is recent and relatively immature when compared with that of silicon. It is thought that many potential properties and applications of these materials remain to be discovered and the rate of advance of this technology is a major factor in the speed of the development of telecommunications as a whole. These reasons motivated the Research Department to establish a III-V materials growth and device fabrication capability using the Molecular Beam Ipitaxy (MBE) technique.

In this technique the elements are evaporated under stringently clean conditions, e.g. the vacuum used is 10–13% atmosphere, and are condensed onto a crystalline substrate. The resulting compound takes up the crystalline structure of this underlying substrate. The growth is slow — one atomic layer a second — so it can be controlled with atomic precision. A resulting single crystal can consist of different materials that, on an atomic scale, have near perfect interfaces. The focus of this work in the Research Department is on the exploitation of these heterostructures for optical and electronic communications. The devices that have been fabricated here include double heterostructure lasers, waveguides, optical modulators and GaAs field effect transistors. Of particular interest was the successful fabrication of the two-dimensional electron gas field effect transistor. Present and future work is concentrated on developing the technology required to integrate optical and electronic devices onto GaAs substrates.

Amorphous Silicon for Solar Cells

Amorphous silicon is a disordered assembly of silicon atoms, which can be made semiconducting by the addition of hydrogen. The hydrogen absorbs unpaired silicon valence electrons giving a low carrier state density that can be modified by conventional p- or n-type dopants. Hydrogenated amorphous silicon (a-Si:H) has a major advantage over its crystalline counterpart in that it absorbs light over much shorter distances. The light absorbed creates electron-hole pairs that can be separated across a potential barrier in a p-n junction structure to convert incident solar radiation into electrical energy. The a-Si:H layer need be no thicker than 500 nm allowing the use of cost-effective, thin film, mass production technology for manufacturing solar cells. The small quantities of material required can be directly deposited from silane (SiH^4) gas at low temperatures, further reducing costs. These advantages make a-Si:H a prime candidate to eventually become a serious competitor with conventional sources of electricity. The Research Department is investigating amorphous silicon as a possible power source for telecommunications equipment in remote locations. The Department has established amorphous silicon solar cell processing facilities incorporating the technologies that are those most likely to be used in industry. In this way it will be in a position to assess the characteristics of amorphous silicon solar cells in a quite fundamental manner and also have the flexibility to optimize process parameters with a view to improving efficiency and lifetime.

Failure of Polyethylene Insulant

An example of a major investigation into the cause and rectification of an important materials-related plant failure problem is the work being done on premature embrittlement of solid, medium density, polyethylene insulation of cables installed in above-ground joint enclosures. This problem has been shown to be confined to cables manufactured in the period 1965-74 and to be caused by oxidative degradation due to the early depletion of an initial low concentration of antioxidant. The rapid rate of depletion has been proved to be caused by a number of competing and interacting factors such as losses during processing; interaction between antioxidant, metal ions, pigments and opacifiers; high temperatures in the jointing enclosures and the migration of antioxidants to the polymer surface. To demonstrate the causes and effects associated with these and other factors has required a major investigative effort, in particular in devising novel analytical and test methods for determining the various reactions taking place in the polymer system. The work has already resulted in the specification of new stabilizing systems and hence far greater cable life expectancy. Most importantly it has led to a better fundamental understanding of the role of metal deactivators and of the behaviour of antioxidants, how they interact with other polymer additives and the quantitative relationship between their concentration levels and the life expectancy of polymers.

Conclusion

To cover this wide diversity of applied and basic research, the Department has installed a comprehensive range of analytical, mechanical, electronic and environmental test and measurement equipment. A staff of chemists, metallurgists, physicists and other technically qualified staff work individually in particular areas of expertise and also in multidisciplinary teams. Using a highly interactive and co-operative approach to solve materials-related problems they are making a significant contribution to the continuing efficiency of the Australian telecommunications network.

OPTICAL FIBRE COMMUNICATIONS

Introduction

The history of optical fibre communications is brief but includes an impressive series of developments. The optical fibre was conceived as a transmission medium in 1966 and the first practical all-glass fibre was made only in 1973 yet, by the end of the 1970s, telecommunications cable manufacturers around the world were closing their coaxial cable manufacturing facilities and setting up optical fibre manufacturing and cabling plants.

The high transmission capacities and long repeater spacings offered by modern single-mode optical fibre systems make them very attractive in planning the expansion of the telecommunications network. The cost of optical fibre cables and transmission equipment is competitive with other media and the use of optical transmission systems offers a number of other advantages. For example, an optical fibre cable need not contain metal elements and can thus be immune from lightning-induced damage.

In Australia, optical fibre cables are being installed between telephone exchanges in the major cities and are soon to be installed on major trunk routes linking those cities. With the growing sophistication of customers' equipment and the growth of customer wideband services, optical fibres may in the future be used to link a customer's premises to the telecommunications network.

Despite the impressive progress made to date in optical fibre communications, there are a number of further developments that will, over the next decade, greatly influence planning of long-distance communications networks. These include increasing sophistication of transmission techniques and the use for optical fibres of new materials that offer extremely low losses.

Both developments allow greatly increased transmission distances for high capacity systems, to the extent that the ideal of trans-continental or trans-oceanic communications systems without intermediate repeaters is no longer considered an impossibility.

History

The development of the laser in the early 1960s led communications engineers to consider the possibility of using light beams for signal transmission. The very high frequency of an optical signal allows, in theory, an enormous information transfer rate. Early experimental systems using free-space transmission proved to be as unreliable as the weather but it was not until 1966 that the use of an optically transparent guiding structure was proposed and the concept of the optical fibre was established.

Techniques for fabricating the extremely pure silica glasses required to achieve low transmission losses and for drawing those materials into strong fibres that could be used in communications cables were developed in 1971. In that year, fibres with an attenuation of only 20 dB/km were reported. The achievement of this attenuation level was significant because it marked the point at which optical fibre systems could begin to seriously challenge the established coaxial cable technology.

Early optical fibres were based on single-mode designs. However in 1971, attention shifted from single-mode fibres to multimode fibres, for which fabrication problems were not so critical, and for which useful, although lower, transmission capacities could be achieved. In 1973, attenuation levels of only 2 dB/km were reported. Continuing improvements in materials and fabrication techniques since that time have enabled large scale production of good quality multimode and single-mode fibres. For multimode fibres, an attenuation of 0.6 dB/km and a bandwidth of approximately 800 MHz at 1 km are now achieved routinely. Single-mode fibres with an attenuation of 0.4 dB/km and over 100 GHz bandwidth at 1 km are readily available from most competent manufacturers. Laboratory-made fibres have been reported with the ultimate low loss, for silica-based fibres, of 0.16 dB/km.

In parallel with the optical fibre developments outlined, a similar effort was being made in optical source development. Semiconductor laser diode sources capable of continuous operation at room temperature were first reported in 1971. Because of their high output power, ease of modulation and small size, which is compatible with optical fibre dimensions, laser diodes are a most attractive source for optical communications systems and are used almost exclusively.

Continuing developments have led to greatly improved lifetimes and have allowed operation at the longer wavelengths at which silica optical fibres offer minimum attenuation and dispersion.

Laboratory trials of multimode optical transmission systems commenced as soon as the first optical fibres became available but it was not until 1976-77 that large-scale field trials of non-commercial transmission systems took place. Since late 1979, many countries have begun to install multimode optical fibre cables between urban telephone exchanges in preference to using other media. As the use of optical fibres has increased, advances in manufacturing techniques have improved production volume and yield. Consequently optical fibre prices have decreased dramatically.

The manufacturing technology improvements needed to fabricate good quality single-mode fibres on a large scale were also made quickly and trials of prototype single-mode systems suitable for long-distance transmission commenced in 1982.

Current Optical Technology

The use of multimode optical fibre systems in urban areas is now well established. A useful span of 15 km or more, depending on the transmission capacity required, can be achieved between repeaters. This means that most repeaters can be located in exchange buildings. Multimode fibre systems are used where medium capacities are required, principally at 34 and 140 Mbit/s (equivalent to 480 and 1920 voice channels respectively), although lower capacity systems are also used in many countries.

The use of single-mode optical fibre systems is becoming established for routes where high traffic capacities or very long repeater spans are required. In general, those systems operate at rates of 140 Mbit/s and higher and at these rates offer repeater spans of over 30 km. Perhaps the most ambitious of the early single-mode trunk networks is that commenced in 1982 by NTT in Japan, which consists of a link operating at 400 Mbit/s running the entire length of the chain of islands and connecting every major city. When completed in 1985, this will include over 2000 km of cable and 70 000 km of single-mode fibre.

Australian Developments

The Research Department first became involved with optical fibres in 1971, when the Commonwealth Scientific and Industrial Research Organization (CSIRO) produced a liquid-filled fibre with what was then a world record minimum attenuation performance of 10 dB/km. The Department carried out transmission performance measurements on these fibres and demonstrated the transmission of analogue video signals over kilometre lengths of fibre early in 1972. Over the next few years a variety of laboratory experiments were performed on liquid-filled and later all-glass fibres, calculations were performed on transmission characteristics and source-coupling efficiency, techniques were established for optical measurements and experimental light-emitting diodes were fabricated.

Telecom Australia's first field experiment began in 1978 with the laying of a 1.6 km step-index fibre cable in cable ducts near its Research Department at Clayton. Transmission systems for analogue video and PCM telephony signals at 2 and 8 Mbit/s (30 and 120 voice channels) were designed and built by Research personnel for use on that cable. A second field experiment involving the linking of the Clayton and Springvale telephone exchanges with the two Telecom Research Department sites in Clayton began in 1980.

Investigations at the Research Department were complemented by research and development work sponsored by Telecom in Industry and the Universities. AWA Ltd. established a pilot plant for the manufacture of optical fibres under a series of contracts that commenced in 1976. The first wholly-Australian optical fibre cable was delivered to Telecom in 1979. Extensive theoretical studies of optical fibres have been undertaken at the Australian National University and other optical fibre device work and development of optical fibre equipment has been carried out at the Universities of Western Australia and New South Wales. Two companies received contracts to investigate optical fibre cable design strategies and the University of Queensland has also been involved in the development of optical fibre test equipment.

In 1983 Telecom commenced its optical fibre Engineering Field Trials involving installation of commercial cables and transmission equipment in Melbourne, Brisbane and later Sydney. Cable for one of the two Melbourne systems was made in Australia from Japanese fibre and both fibre and cable for the Sydney trial were Australian-made. Since 1984 Telecom has been installing multimode optical fibre systems on a routine basis in urban areas.

Telecom's single-mode fibre field trial linking Melton and Ballarat in Victoria is under way and will be completed by mid-1985. This will be soon followed by work on a system to link Darwin and Katherine in the Northern Territory and by the Australian Bicentennial Project being undertaken by Telecom, which is a large cable linking Melbourne and Sydney via Canberra to go into service late in 1987.

Telecom's plans for the use of single-mode optical fibre on inter-capital trunk routes and rural routes are ambitious. These plans, coupled with Telecom's acknowledged preference for local manufacture, have prompted two companies to set up large-scale optical fibre manufacturing facilities in Australia to meet the expected demand.

It is interesting to note that Telecom appears to be a world leader in the implementation of high-speed, long distance optical transmission systems. This arises in part because of Australia's unique geographic characteristics and it means that Telecom will need to play an increasing role in the setting of standards for these systems by the appropriate world bodies.

Current Research and Future Developments

There are two clear trends in current research worldwide and these are mirrored by work being undertaken in the Research Department. The first recognizes that present optical techniques, whilst they offer transmission capacities and repeater spans unimaginable a decade ago, are unsophisticated and that considerable improvements in the sensitivity of optical receivers can be made through the use of heterodyne or homodyne receivers and frequency or phase modulation techniques. These require a number of advances in semiconductor lasers and stabilization techniques but work in these areas is progressing and a number of laboratories have reported experimental systems offering improved performance over conventional systems. Experiments in laser stabilization are being undertaken at the Research Department, in preparation for the construction of an experimental system.

The longer term trend in optical fibre studies recognizes that the ultimate attenuation limit in silica-glass optical fibres has been reached and that further attenuation reductions are not possible. However, other materials, especially the heavy-metal fluoride glasses, may be used at longer wavelengths where they offer the potential for very much lower attenuation levels. In theory, it should be possible to achieve losses of 0.01 dB/km and below and this raises the possibility of trans-continental or trans-oceanic systems without intermediate repeaters.

Considerable advances in a number of areas, including material purification, fibre manufacturing and optoelectronic device technology are required before such systems reach the field trial stage. Progress in the material technology area in particular has been impressive and it is expected that the performance of present silica-based fibres will be exceeded by laboratory-fabricated fluoride glass fibres before the end of this decade. Fully engineered systems for such very long wavelengths may become available in the mid-1990s.

SATELLITE COMMUNICATIONS

Introduction

Satellites are now finding widespread application in national communication networks. Satellites are placed in geostationary earth orbit so that they remain fixed in the sky and can be used to relay radio signals between any points within the satellite coverage area. By suitably designing the satellites and associated earth stations, satellite networks can meet users' needs for public and private communication services.

Telecom is including satellites in the range of technological options it uses to provide services to its customers. As with all such options, there is a range of situations where satellites are a practical and cost effective solution to customers' communications requirements. Satellite based systems are well suited to the provision of services at short notice, the provision of facilities that may require frequent rearrangement, the provision of services to remote areas and the provision of services to customers that need to own and control their own communications facilities. Telecom's range of satellite based services is structured around these applications.

Telecom Satellite Services

ITERRA Satellite Services (ISS) has been chosen as the collective name of the range of satellite services to be provided by Telecom. These services will use satellite transmission capacity leased from Aussat Pty. Ltd., which is the government-owned company that operates Australia's national satellite system. Telecom is a 25% owner of Aussat and the two organizations co-operate closely.

The first service via the domestic communications satellite to be offered by Telecom is the ITERRA Network Service (INS), which will provide telephone, data (up to 4.8 kbit/s) and text facilities connected to the national switched telephone network. This service will give Telecom the ability to satisfy immediate customer demand very quickly and will be of particular interest to customers operating in the more remote areas of Australia. It will be available in 1986.

Other ISS products currently under consideration include medium and high speed data services to business customers. These services are expected to be attractive to customers needing links or networks under their own control for reliability or security. The range of ISS products will be specifically tailored to suit customer needs and will exploit more fully the flexibility that a satellite system has to offer.

Telecom expects to make use of satellite facilities to meet some of its internal needs. Leased satellite transmission capacity is being considered as a convenient and cost effective method of overcoming short term congestion in some parts of the Telecom long distance network. When less expensive terrestrial alternatives become available, they could replace the satellite facility.

Research Department Satellite Studies

While Telecom has been planning commercially available satellite services for only a short time, it has been active in the study of satellite communication systems for over twenty years. These studies have been conducted by its Research Department, which is responsible for advising Telecom on technologies that may be economically incorporated in the Australian communications network.

In preparing Telecom for its use of satellite communication systems, the Research Department has been involved with a number of innovative activities that assisted in the specification of Australia's national satellite system. Between 1967 and 1971 the Research Department carried out several experiments using the NASA/ATS-1 satellite, a NASA transportable earth station located in Queensland and a smaller earth station developed by the Research Department in Melbourne. These studies greatly enhanced Telecom's understanding of satellite communications to remote areas. From 1972 to 1977, Research Department officers participated in a Telecom Satellite Task Group. Its final report, 'National Satellite Systems Studies', was a significant input to planning of the national satellite system. Another input to these plans was the co-ordination of trials of small satellite earth stations conducted in 1979 using the Canadian 'Hermes' satellite. The trials successfully demonstrated Telecom's ability to provide automatic telephone services to its remote customers. Another significant input to the development of the Australian national satellite system was the Research Department's modelling of impairments that satellites introduce onto signals they relay.

The ability to predict these impairments accurately using both hardware and computer modelling techniques was a critical input to the planning of the Homestead and Community Broadcasting Satellite Service (HACBSS) to be provided by the Australian Broadcasting Corporation. Studies had shown that design limitations for this service were severe and the proposed systems would require experimental verification. This was subsequently done under contract to the Overseas Telecommunications Commission (OTC) in 1981 through tests conducted in Italy using the European Space Agency (ESA) Orbital Test Satellite (OTS).

A continuing Research Department activity that has further contributed to the implementation of the Australian national satellite system and has attracted international recognition is the measurement of the effect of rain on satellite radio signals. Satellite systems make use of microwave radio signals and these signals are attenuated by any rain that intercepts the transmission path. Measurements of these effects have been conducted since 1971 using radiometers and results have been incorporated in internationally accepted procedures for designing satellite systems. When a satellite transmission is not available, earth-space rain attenuation effects are measured with radiometers, which measure sky radiation. Past results in this area are soon to be enhanced with results from two new experimental programs. A new radiometer operating in the 30 GHz microwave radio band is being designed and constructed in the Research Department and, when complete, will be located at Perth to assess the effect of rain on satellite systems operating in this new frequency band — a band that could be used in future Australian satellite systems. At the same time another series of measurements in the 12 GHz radio band will be conducted in conjunction with Aussat Pty. Ltd. using signals emanating from either the INTELSAT V satellite or the Aussat satellite. A special beacon receiver terminal will continuously monitor signals from the satellite on both orthogonal polarizations and will provide Australian propagation data from an operating satellite for the first time. These results will be compared with existing results from radiometer measurements and are expected to confirm existing design procedures.

The Research Department has in the past successfully modelled the imperfections suffered by radio signals as they are relayed by communications satellites and this work remains an important continuing activity. A new travelling wave tube amplifier has been purchased to provide hardware that accurately models the operation of Aussat satellites and that will be used to assess the feasibility of services Telecom proposes to implement via the national satellite system.

Hardware satellite models are complemented by computer models and existing models are being expanded to encompass digital techniques, which are expected to be a major aspect of future satellite systems. The combination of these models provides accurate predictions of the performance of proposed satellite systems and allows Telecom to develop services that minimize customer costs while meeting agreed performance standards.

Besides the systems studies mentioned above, Telecom considers that it is essential to participate in technological studies if it is to be able to offer services based on the use of satellites. An important aspect of this work is the study of antennas for satellite earth stations. Antenna performance is critical in the design of satellite communication systems as antennas control the strength of signals received from satellites and the amount of interference received from satellites in nearby portions of the sky. The Research Department has a continuing program of antenna studies and is presently concerned with the control of antenna side-lobe and polarization discrimination performance and methods of designing and fabricating microstrip planar array antennas for low cost satellite earth stations. Another technological study now under way is the investigation of methods of implementing and applying small low cost portable and mobile earth stations. It is expected that these studies will lead to an experimental system to demonstrate Telecom's capability in this aspect of satellite utilization.

International Affiliations

Telecom's involvement with satellite-based services obliges it to participate in international activities aimed at standardizing communications systems and minimizing the possibility of interference between them. Towards this end, the Research Department participates in the activities of the International Telecommunications Union (ITU) and its subsidiaries such as the International Radio Consultative Committee (CCIR). Many of Telecom's recommendations on satellite systems have been accepted internationally. Among these are recommendations to co-ordinate access to the geostationary orbit, control side-lobe performance of satellite antennas, limit possible interference between satellite systems by appropriate design and change the way in which the acceptable transmission performance of digital satellite systems is specified. The outcomes of this continuing work are an international recognition of Australia's requirement for satellite systems, a recognition of its ability to engineer satellite systems effectively, a recognition of its status as an informed purchaser of equipment and a reduction in the actual cost of satellite systems developed for Australia.

TELEMATIQUE SERVICES

Range of Services

The field of telematique services has blossomed in the past decade from the established world of telex and low-quality facsimile to a seemingly boundless set of opportunities embracing electronic messaging, electronic documentation, information data banks and funds transfer and management systems.

Apart from voice telephony, the main thrusts in the development of end-user telecommunication services in recent decades have been associated with document and data transfer. Such services have generally been motivated by the needs of business for inter-office communication. As technology is now providing extraordinarily powerful terminals or workstations for processing of data and documents and is also opening up the concept of information bank access, the range of business customer telecommunication needs has broadened considerably. The field of telematique services can now be considered to embrace those end-user services that employ both computing and telecommunication technologies to provide a versatile range of facilities to the customer involving access to, and the transfer and storage of, information in text, image, voice (encoded) or data form.

Text Services

Telex has been the mainstay of Telecom Australia's telematique services in recent times, providing a widespread customer service with local and international capability and proving to be a substantial revenue earner for Telecom. Despite improvements in the technology of telex terminals, the emerging generation of text services will eventually place telex in the background. The character-by-character transmission of telex is being superseded by the more efficient document-based methods of Teletex, a new internationally standardized service for the transfer of properly formatted business documents. When this service is introduced by Telecom Australia in 1985, it will allow direct communication from suitable terminals or word processor systems to distant end users, whether they be other word processors or standard Teletex terminals, thus enabling reliable document transfer across national and international networks. The introduction of this service has taken into consideration the capability for interworking between Teletex and the Telex network. This facility will also soon be available in Australia.

Message Handling

The scope of text services has been expanded by the introduction of a Computer Based Messaging Service, offered by Telecom Australia as Telememo. This provides users having limited capability ASCII terminals access to a host 'electronic mailbox' sited within Telecom's network. Public subscribers may deposit mail in text form in a personal mailbox, which is always accessible to its subscriber. More advanced forms of electronic messaging systems in which 'mail' in the form of compound documents may be transferred on a store-and-forward delayed delivery basis, potentially across international boundaries, are currently under study in the Research Department. The so-called compound document may comprise any combination of text, images, computer data and encoded voice. Such systems are known as Message Handling systems and much investigation is current throughout the world in this field. Message Handling systems will not only facilitate access to store-and-forward services by other telematique terminals, e.g. videotex, teletex and facsimile, but will ultimately provide conversion facilities to enable interworking between these service types, e.g. videotex characters and standard text in a Teletex document.

Research Department Contributions

The Research Department has made a major contribution to the new telematique service developments within Australia in various ways. The skills generated in the Department are being applied in the planning and implementation aspects of Telecom's new service offerings, in the fields of Teletex, interworking between Teletex and Telex, Telememo and electronic funds transfer. Initiatives taken in the electronic messaging field have stimulated service developments in Australia that the customer is only beginning to see. With accelerated effort in world standardization bodies in the fields of electronic messaging and electronic directories, internationally compatible products can be expected on the world market by 1986-87. Telecom's Research Department staff have contributed to the standardization efforts concerned, both through the Standards Association of Australia (affiliated to the International Standards Organization) and the CCITT (International Telegraph and Telephone Consultative Committee). The importance of international standards in the fields of electronic document transfer, financial transaction services and business data communication is paramount. Telecom is dedicated to the implementation of systems that achieve maximum, internationally-standardized connectivity.

Future Developments

The future holds an enormous range of possibilities for the customer in the telematique services area. Developments in office automation products and personal computing that make the facilities for information access, processing and transfer more accessible and friendly to the user are being witnessed. New technology is giving people the capability to mix various information modes (voice, text and images) into one electronic document. Such documents are generally communicated on a delayed-delivery basis or they may be accessed from within databases in an interactive (query-response) manner. Within these operations, a number of generic categories of communication process and of information content can be identified as follows:

(a) basic information representations for voice, text, images, business graphics and computer data,

(b) document architecture (agreed structured representation of information when several information types are involved),

(c) Store-and-Forward messaging of information, which may have a mixed-mode information content, with a wide range of facilities associated with multiple delivery (to distribution lists), time stamping of messages, non-delivery notification, priority delivery, conversion of content types, etc., and

(d) interactive access to databases (containing the full range of information types) and to business and financial transaction services.

Value Added Services

The four categories above embrace the future of telematique services, in which the users' requirements take highest priority. These categories provide the framework for the development of a range of future Value Added Services. These Value Added Services are end user services that meet special customer needs and involve information processing, information access and a range of additional information technology features. These services will facilitate the convergence of increasingly diversified user services and the increasing proliferation of user terminal types. Such Value Added Services will be based within telecommunications networks and will provide facilities that maximize the customers' communication options. Value Added Services are provided when network infrastructures are not only developed for information carriage but also for increased functionality within those networks. Particularly useful Value Added Services include:

(a) versatile international messaging systems,

(b) service interworking facilities providing conversion capabilities for dissimilar users,

(c) Electronic Directories, providing, in a distributed manner, access to other international directories, support functions for the management of multiple service communications and an extensive database of user facilities and names and

(d) interactive transaction services including financial and business transactions, access to information banks, telesoftware access and security and authentication services.

All of these developments are particularly useful in the business environment and all are telematique services.

Summary

The Research Department is investigating many of the fundamental aspects of these new telematique services, with a view to contributing to interim strategies for their implementation and to longer term planning for their deployment within Australia's telecommunication networks. The results of this work will be seen through Telecom's Commercial Services product developments over the next decade, resulting in substantial benefits for the customer in all fields. Particularly in the business field, Telecom will be able to facilitate wider public access to information sources, compatible communications between complex office systems and more efficient access to rapidly changing directory information. For the general telecommunications' user, these developments will lead to ease of information access and to more efficient use of our highly developed network infrastructure, giving the prospect of more favourable tariff structures in the future.

LIST OF EXHIBITS

Each exhibit is the work of one of the six Branches of the Research Department. The Branch involved is indicated, in the list *right*, by the relevant Exhibit Code Prefix and, on the buildings and at the exhibit, also by the Branch Colour.

For details of the Location Code, see page 5, 'Guide for Visitors'.

Exhibit Code Prefix	Branch Title	Branch Colour
CS	Customer Services & Systems	Pink
SS	Switching & Signalling	Red
TS	Transmission Systems	Orange
TT	Telecommunications Technology	Yellow
AS	Applied Science	Green
SE	Standards & Laboratories Engineering	Blue

CUSTOMER SERVICES AND SYSTEMS BRANCH

Code	*Room*	*Title*	*Description*
CS01	6134	MESSAGE HANDLING — ELECTRONIC MAIL SERVICE	Standards, architecture and user perceptions of Electronic Mail Systems are covered in general terms. Two terminals are available for use by visitors.
CS02	6131	ELECTRONIC DIRECTORY SERVICE	Some basic concepts of Electronic Directory Service (EDS) ar introduced.
CS03	6131	TELECOMMUNICATION SERVICE INTERWORKING	The Message Handling System and Directory Service are combined to allow communication between previously incompatible terminal types. Incoming messages are referenced to the Directory Service to ascertain target terminal requirements for forwarding.
CS04	6205	ISDN TERMINALS & INTEGRATED SERVICES DELIVERY	The basic functions and capabilities of an Integrated Services Digital Network are described. ISDN's capacity to deliver multiple services (voice, data, text and graphics) is emphasized. Details of an experimental ISDN terminal are given.
CS05	2143	FROM TELECONFERENCING TO COMPUTER-BASED TELECOMMUNICATIONS	An historical perspective of the Department's Human Communications work with a view towards future research. The exhibit provides an overview and introduction to CS07 and CS08.
CS06	2141	HUMAN FACTORS RESEARCH: MAKING NEW SERVICES EASY TO USE	Human Factors Research studies the characteristics of people as they interact with complex machines. Computer simulations allow people to interact with proposed new telecommunications services while they are still in the concept stage.
CS07	2145	RESEARCH AND DEVELOPMENT IN TELECONFERENCING	Teleconferencing allows remotely located groups of people to communicate both between and among themselves. The Department's significant social and engineering research contributions in terms Audio and Video teleconferencing are highlighted.
CS08	6235	SUBJECTIVE TESTING OF SPEECH QUALITY	The subjective performance testing of a speech coder using the Voice-Ear Team is demonstrated.
CS09	6235	VOICE ACTIVATED TELEPHONE SYSTEMS	A demonstration of hands-free dialling using speaker recognition.
CS10	6231	VOICE STORE & FORWARD SERVICES	A description of Voice Store and Forward Services.

CS11	6229	THE PRODUCTION OF SYNTHETIC SPEECH FROM TEXT	Production of synthesized speech from printed text.
CS12	6L01	ACOUSTIC CHAMBERS	1. Anechoic Chamber — measurement of polar sensitivity of a directional microphone. 2. Reverberant Chamber — measurement of acoustic spectra for telephone calling devices.

SWITCHING AND SIGNALLING BRANCH

Code	*Room*	*Title*	*Description*
SS01	6G16	THE USE OF COMPUTER-BASED LEARNING IN TELETRAFFIC ENGINEERING	A microprocessor generates dynamic displays illustrating basic principles of Teletraffic Theory. Visitors may interactively modify the display.
SS02	6G16	NETWORK DESIGN & OPTIMIZATION	A demonstration of the latest computer-based methods for designing a telephone network, using the Melbourne network of 1990 as a database.
SS03	6G10	PERFORMANCE TESTING OF PACKET SWITCHED DATA NETWORKS	The principles of packet switching are described and parameters quantifying the performance and methods of measuring them are presented. The working exhibit provides a colored display of the protocol transactions occurring on a link.
SS04	6G10	PROTOCOL VERIFICATION 'PROTEAN'	PROTEAN is a computer tool for analyzing the various communication protocols used by different computers. An active exhibit demonstrates the relevance of analyzing protocols.
SS05	6G10	'MELBA'	A graphics workstation demonstrates the interactive manipulation of graphical symbols.
SS06	6G16	FIELD TRIAL OF AUSTRALIA–JAPAN COMMON CHANNEL SIGNALLING	Demonstration of the configuration and activities of the field trial using active equipment in mostly local connections
SS07	6G16	PROGRAMMABLE ARRAY LOGIC DEVICES	Circuit design using PAL family devices involves a sequence of design steps. Many of these steps can be automated. An 'expert' system is being developed to assist designers in minimizing the designing and testing times.
SS08	6G16	EXPERIMENTAL ISDN EXCHANGE NETWORK	Describes a Department-wide experimental ISDN exchange to be set up in 1985 and introduces the work to be done.

TRANSMISSION SYSTEMS BRANCH

Code	*Room*	*Title*	*Description*
TS01	2G07	AUSTRALIAN DEVELOPMENT OF DIGITAL TRANSMISSION TEST EQUIPMENT	Outlines the involvement of the Research Department in Telecom's Innovation, Research, and Development Program with respect to Digital Transmission Test Equipment. Laboratory prototypes together with contractor developed equipment are displayed.
TS02	2G07	COMPUTER MODELLING OF CUSTOMER ACCESS NETWORKS	A computer simulation package that computes and outputs, in graphical form, Frequency and Time Response from subscriber to exchange and Eye Patterns. Visitors can input data and obtain a hard copy printout.
TS03	2G07	INTERFERENCE FROM DECADIC DIALLING	The impact of adjacent dialling interference on the error performance of a digital transmission system is demonstrated.
TS04	2G07	THEORETICAL STUDIES IN DIGITAL TRANSMISSION SYSTEMS	Publications arising from research work are on display.
TS05	2G11	HIGH CAPACITY SINGLE MODE OPTICAL FIBRE	Displays the high information carrying capacity of single mode cable by demonstrating the effect of placing an object in the optical path of a high bit rate signal.

TS06	2G11	INTRODUCTION TO OPTICAL FIBRE SYSTEMS	Introduction of the basic concepts of transmission by optical fibres with an outline of system configuration.
TS07	2G11	OPTICAL FIBRE ELONGATION AT CABLE PLOUGH-IN	The operating life of optical fibre cable is adversely affected by improper cable-laying techniques. A technique for measuring cable elongation at plough-in has been devised.
TS08	2G11	JOINTING OF OPTICAL FIBRE	Depicts fusion splicing of optical fibres and associated measurement techniques for evaluating joint loss and fibre loss.
TS09	2G11	SINGLE-MODE OPTICAL FIBRE MEASUREMENTS	Depicts the measurement of the geometrical parameters of a single-mode optical fibre cable using a television image of the fibre end face and software processing of the image.
TS10	2G11	HETERODYNE OPTICAL SYSTEMS	Display demonstrates a working heterodyne optical system.
TS11	2G06	DIGITAL MICROWAVE RADIO	A microwave fading simulator is used to show the effects of fading on a microwave radio system. Relates to a system design technique developed by the Department.
TS12	2G06	POINT-TO-POINT ATMOSPHERIC INFRARED COMMUNICATIONS	An optical system transmits a beam that is reflected through a window. A receiver unit monitors the impact on the beam.
TS13	2G06	CELLULAR MOBILE RADIO SYSTEMS	Background to Digital Cellular Mobile Network Concept showing advantages of the network and the use of digital techniques to overcome the effects of multipath propagation.
TS14	2G08	WIDEBAND INTEGRATED SERVICES EXPERIMENT	Two computer terminals and packet communication units display the digital communication aspect of a broadband local area network while a television receiver and modulator show the analogue capability of the system.
TS15	2G08	SPREAD SPECTRUM COMMUNICATION	Introduction to spread spectrum (direct sequence) Code Division Multiple Access.
TS16	2G08	POINT-TO-MULTIPOINT ATMOSPHERIC INFRARED COMMUNICATIONS	Illustrates the applications of Freespace Infrared Communications.
TS17	2G08	FIXED MULTIPOINT RADIO	Time Division Multiplexed Radio enables fast provision of medium rate digital services, independently of the cable distribution network.
TS18	2G07	ECHO CANCELLATION	Digital transmission over the existing cable network requires dynamic echo cancellation. The Department has been involved in the development of international standards, evaluation of commercial equipment and theoretical studies.
TS19	2G24	ELECTROMAGNETIC INTERFERENCE FROM INFORMATION TECHNOLOGY EQUIPMENT	Equipment such as personal computers, terminals and microprocessor controlled telex machines can be a disruptive source of interference to radiocommunication services. The effects of typical interference forms on television reception are shown.
TS20	2142	ADVANCED ANTENNA TEST RANGE	The procedures and considerations inherent in the measurement of antenna characteristics are detailed. Computer controlled antenna positioning equipment is demonstrated.
TS21	*C	EXPERIMENTAL SATELLITE EARTH STATIONS	Earth terminals used in various satellite comunications research projects are displayed. Specifically television receive-only terminal displaying picture via INTELSAT satellite: a beacon receiver with dish and a 12 GHz radiometer.
TS22	2142	RESEARCH ACTIVITIES IN SATELLITE COMMUNICATIONS	The general principles of communication by satellite together with typical service applications are described. Also Research involvement with satellite transponder simulation, earth space propagation and small terminal services.

**C Caravan next to dish antenna*

TELECOM TECHNOLOGY BRANCH

Code	*Room*	*Title*	*Description*
TT01	1G07	COMPUTER AIDED DESIGN OF INTEGRATED CIRCUITS	The use of computer based design tools can greatly simplify and speed up the development phase for Integrated Circuits.
TT02	1G07	MULTI-PROJECT CHIP IMPLEMENTATION	By implementing several integrated circuit designs per chip and several chips per wafer, designers have access to integrated circuit technology at low cost, enabling them to gain design experience and produce experimental designs.
TT03	1G07	GATE ARRAY AND CUSTOM INTEGRATED CIRCUITS	The designers of integrated circuits may employ either of the partly implemented technologies, Gate Array and Standard Cell or opt for full customization. The exhibit provides insight into the advantages and disadvantages of each approach.
TT04	6L06	PHOTOELECTROCHEMICAL ENERGY CONVERSION & STORAGE	A description of the development and operating principles of photoelectrochemical cells for the conversion and storage of solar energy.
TT05	6L06	REMOTE POWER SYSTEM CONCEPTS	Demonstration of fault-tolerant design methodologies yielding minimum cost photovoltaic and hybrid stand-alone power systems for varying Australian climactic conditions.
TT06	2243	OPTOELECTRONIC SEMICONDUCTORS	Indium Gallium Arsenide is the fastest semiconductor known and will be a vital component of the 1990s supercomputers. The exhibit shows the properties of the material, a possible technique for growing it and some applications.
TT07	2237	FIXED POLARIZATION OPTICAL FIBRES	The stress-optic effect in materials may be used to fabricate polarization sensitive optical fibres. Such fibres are proposed for future heterodyne optical communication systems and tools used in the evaluation of optical communications components.
TT08	2242	INFRARED IMAGING	Practical studies of optical fibres often require the analysis of images formed with infrared light. Conventional imaging systems use a television-type camera but, as illustrated in the exhibit, there can be advantages in a system that combines mechanical scanning of the image with a video frame store.
TT09	2216	FIBRE DRAWING TOWER	The tower will provide the Department with the capacity to manufacture optical fibre cable. The facility will be used in investigations relating to the use of new materials in cable manufacture.
TT10	2203	OPTICAL TECHNOLOGY	An introductory exhibit providing an overview of the use of light in past, present and future communication systems.
TT11	2235	APPLIED HOLOGRAPHY	An introduction to holographic technology, demonstration of approaches to manufacturing and viewing and some insights into telecommunications applications.
TT12	2240	SEMICONDUCTORS FOR MID-INFRARED OPTOELECTRONICS	Optical fibres operating at mid-infra-red wavelengths are being developed for use in the telecommunications network. These fibres require exotic optoelectronic sources and detectors. The Department is investigating the properties of suitable semiconductor materials.
TT13	6L04	TRANSPARENT CONDUCTIVE OXIDE FILMS	Thin cadmium stannate films applied to glass surfaces have useful properties, which can be exploited in the solar energy area. The applications for these films are very broad and production costs are reasonable.
TT14	6LO5	AMORPHOUS SILICON SOLAR CELLS	An exposition of the latest developments in solar cell technology, specifically solar cells made from amorphous semi-conductors. The material has the potential to reduce manufacturing costs by up to one order.

APPLIED SCIENCE BRANCH

Code	*Room*	*Title*	*Description*
AS01	1L03	LIGHTNING LOCATION	The telephone network is susceptible to lightning damage. Sophisticated monitoring equipment is recording the location, nature and intensity of strikes. This information will help identify lightning prone areas.
AS02	3G00	ENVIRONMENTAL TEST CABINETS	The Department tests a wide variety of materials to ensure compatibility with Australia's climactic extremes. An interactive exhibit demonstrates a high performance, microprocessor-based, temperature controller developed within the Department for use with testing chambers.
AS03	3G11	ELECTRICAL SAFETY OF CUSTOMERS STAFF AND EQUIPMENT	Active exhibits detailing the Department's contribution to the protection of staff and equipment.
AS04	3G00	OPTICAL FIBRE ENVIRONMENTAL TESTS	The exhibit depicts the evaluation of the impact of Australian climactic conditions on the service life of various types of optical fibre cable.
AS05	1L07	TEMPERATURE CALIBRATION (NATA)	The Department has established a NATA registered temperature calibration facility to complement the materials testing program. Temperature references exist with uncertainties as low as 0.0005 degrees Celsius.
AS06	*A	PARROT DAMAGE TO MICROWAVE FEEDS	The plastic windows used to protect microwave feed tubes were found to be susceptible to damage by parrots. Various possible replacement materials were tested by exposing them to attack at a local Melbourne sanctuary.
AS07	1241	ANALYSIS OF VAPOURS FROM INDUSTRIAL PROCESSES	The application of new analytical techniques relating to the surveillance of telecommunications plant and practices has resulted in several Research Department contributions aimed at reducing hazardous exposure of worker and plant.
AS08	*B	DURABILITY OF PAINTS ON GALVANIZED STEEL STRUCTURES	Telecom has many galvanized steel L structures sited in a variety of hostile environments throughout the country. The performance of paints, applied for added protection and safety reasons, is of prime importance and interest.
AS09	1223	BATTERY TEST FACILITY	A Department designed and built Automated Battery Testing and Data Analysis Facility tests and analyses batteries for the various duty cycles used in telecommunications.
AS10	1217	EFFECT OF CHEMICAL CONTAMINANTS ON LEAD-ACID BATTERIES	Analytical methods used in the investigation of chemical contamination of lead-acid batteries are based on a microprocessor controlled titration apparatus. A photographic exhibit of battery corrosion and other failure modes is included.
AS11	1G19	METAL SERVICE FAILURES & DEVELOPMENT PROJECTS	Metallurgical work performed by the Research Department incorporates both developmental and failure analysis on a wide range of components and metals. Visitors will use a microscope to view a variety of interesting material specimens.
AS12	1213	TESTING OF MT. WELLINGTON RADOME	The Research Department contributed to this project during the design stage, prototype testing and and quality assurance testing of components used in the manufacture of glass reinforced polyester & polyurethane foam laminate panels.
AS13	1222	FIRE RESISTANT WIRE AND CABLE	Highlights the hazards associated with toxic and corrosive gases produced when PVC sheathed and insulated cable and wires are ignited. The performance of recently developed alternative insulation materials is compared.
AS14	1222	OUTDOOR WEATHERING OF SAFETY HELMETS	A study of the effects of outdoor exposure upon the performance o plastic industrial safety helmets is described. The performance of helmets manufactured from alternative materials is compared.
AS15	1142	I.C. CHARACTERIZATION & FAILURE ANALYSIS	Physico-chemical techniques are used to disassemble Integrated Circuits to facilitate analysis of factors leading to in-service failure. The step-by-step process also reveals much concerning the materials and original fabrication processes used. Current generation ICs have individual structures so small that mechanical probing techniques cannot be used. Consequently electron beam technique are required.

**A Building 1, Gnd. Floor, West Foyer* **B Building 1, Gnd. Floor, South Foyer*

AS16	1119	ELECTRICAL OVERLOAD TESTING OF TRANSISTORS	The fire resistance of plastics compounds used for packaging transistors is determined using electrical overload techniques.
AS17	1119	KEYPAD TECHNOLOGY	Keypads such as those used in calculators and modern telephones have undergone intensive evolutionary change. Relative to their predecessors, keypads are now more reliable in operation and straightforward in design.
AS18	1G28	PULSED SOLAR SIMULATOR	The Pulsed Solar Simulator is an artificial 'sun' used to measure the electrical output of solar photovoltaic cells and modules.
AS19	1G20	LABORATORY TESTING OF SOLAR MODULES	Solar photovoltaic modules are tested for wind and hail resistance using simulated testing.
AS20	1114	SURFACE CHARACTERIZATION STUDIES	Scanning Electron Microscopy, Energy Dispersive X-Ray Analysis and Secondary Ion Mass Spectroscopy are the powerful techniques available for the investigation and evaluation of problems affecting surfaces of the many materials in use with Telecom.
AS21	1119	MECHANICAL LIFE TESTING OF DIP SWITCHES	The exhibit shows the mechanical life tesing of dual-in-line switches and the development of specialized test equipment.
AS22	1218	STABILIZATION OF POLYETHYLENE CABLE INSULANT	The problem and solution relating to the premature embrittlement and cracking of polyethylene in above-ground jointing enclosures are presented.

STANDARDS AND LABORATORIES ENGINEERING BRANCH

Code	*Room*	*Title*	*Description*
SE01	5115	LIBRARY USE OF MICROFORMS	The lack of physical storage space is a problem common to all libraries. The use of microforms such as microfilm and microfiche help minimize storage problems. Typical microform material is displayed.
SE02	5115	ON LINE INTERACTIVE RETRIEVAL SERVICES	The use of computer terminals with link to central mass storage databases has revolutionized the role of libraries. The time required for information searches has been reduced from weeks to minutes.
SE03	5115	MICROCOMPUTERS IN THE LIBRARY	The advent of microcomputers has made computer power widely available without the need for costly facilities or specialist staff. Within the library environment the microcomputer has been applied to a range of hitherto labour intensive activities.
SE04	5G13	CALIBRATION OF THERMISTOR MOUNTS	Involves a set-up for the precision calibration of microwave thermistor power mounts. The set-up employs a desk top computer 'controller' to reduce measurement uncertainties and calibration times.
SE05	5G13	ATTENUATOR CALIBRATION	Precision attenuation measurement system in a screened room for the calibration of 75 ohm reference attenuators.
SE06	5G13	CALIBRATION OF AC THERMAL CONVERTER	Computer controlled precision measurement system for the determination of the AC-DC transfer of thermal converters. The AC-DC transfer procedure is the standard method of providing calibration of absolute AC measurements.
SE07	5G13	STANDARDS & MEASUREMENTS TRACEABILITY	The dissemination of electrical reference standards is depicted within Telecom and within the Reference Measurements Section. The hierarchy of Electrical Standards is traced through to Australian National Standards.
SE08	5227	PRECISION QUARTZ RESONATORS & OSCILLATORS	The Quartz Crystal Facility provides Telecom with high precision or unusual resonators not commercially available locally. Aspects displayed include crystal machining and lapping, chemical cleaning, X-ray measurement and test and evaluation.
SE09	5209	GENERATION OF STANDARD FREQUENCY & TIME INTERVAL	Generation of precise frequency standards using the Research Department's Cesium Beam Frequency Standards is displayed. A dismantled Cesium beam tube is available for inspection.

SE10	5209	TELECOM'S TIME AND FREQUENCY STANDARD	The equipment used to monitor and distribute time and frequency standards throughout the network is displayed.
SE11	6119	MICRO ELECTRODISCHARGE MACHINING	Holes of approximately 0.008 mm diameter, using the Micro E.D.M. fine hole erosion process, are being produced.
SE12	6119	INSPECTION OF SPACES USING ENDOSCOPES	Visitors may inspect inaccessible areas in recesses and bores.
SE13	6119	MACHINE FOR IMPACT TESTING OF TELEPHONE CASES	The Impact Testing Machine, developed within the Department, tests the impact resistance of plastic telephone cases. The test provides some insight into the effect of aging on impact resistance.
SE14	6114	EXTERNAL FACILITIES FOR EQUIPMENT ENGINEERING	A video film describes the role, capabilities and equipment of the Equipment Engineering Section.
SE15	6117	TRANSDUCER MONITOR FOR GAS PRESSURE IN CABLES	The evolution of in-cable monitoring devices is depicted. Several examples of actual units are on exhibit; including the hybrid digital prototype currently under development.
SE16	6117	COMPUTER TERMINAL RESPONSE TIME MEASUREMENT	The ALERT unit monitors the response time of LEOPARD terminals in the Fault Dispatch Centers (FDCs).
SE17	6G06	A COMPUTERIZED INSTRUMENTATION RECORDS SYSTEM	Search and sort techniques are depicted. Visitors may interrogate the Department's Asset Records.
SE18	6114	TECHNIQUES FOR SERVICING ELECTRONIC EQUIPMENT	A video film provides detailed step-by-step instructions on the correct approach to replacing components on printed circuit boards. A second video film outlines the basic operations of a microprocessor and introduces a number of appropriate servicing techniques.
SE19	1131	THICK FILM HYBRID MICROCIRCUITS	Thick Film Hybrid technology offers significant miniaturization potential to the circuit designer. The exhibit summarizes the design process and contrasts the inherent advantages and disadvantages with those of competing technologies.
SE20	1123	PRINTED BOARDS	The Department maintains a comprehensive printed circuit board manufacturing facility for the fabrication of internally developed prototypes. A very large camera and a numerically controlled drilling machine are examples of equipment in use.
SE21	1136	THIN FILM HIGH SPEED HYBRID TECHNOLOGY	Thin film hybrid technology offers advantages in performance, reliability and speed of operation for microelectronic applications. Some typical examples of laboratory produced microcircuits are featured.
SE22	5G13	CALIBRATION OF POWER LEVEL TRANSFER STANDARDS	Depicts hardware and procedures necessary for the precision calibration of Level Transfer Standards used ultimately for the calibration of Telecom's Audio Level Meters. The Level Transfer Standards were designed in the Research Department.
SE23	1G07	CUSTOM DESIGNED INTEGRATED CIRCUITS	A microchip module may be viewed with the aid of a microscope and a large screen display. A thick film version of the same circuit is available for comparison.
SE24	5209	A PHASE LOCKED OSCILLATOR	A high performance phase locked oscillator was designed within the Research Department. The Crystal and Oven assembly of the unit on display was produced within the Department. The remaining hardware being produced under contract.
SE25	5209	A CIVIL TIME CODE RECEIVER	The receiver provides a remote time standard by accessing a time distribution center via a standard telephone circuit. The service is currently used by the ABC and large computer centers. In future, exchange-based Speaking Clocks will use them.
SE26	6119	EQUIPMENT ENGINEERING SERVICES	Explains the role of Equipment Engineering Services and some of their areas of expertise. Photographs of examples of specialised equipment produced are on display.

EXHIBITS BY SUBJECT

Subject	*Code*	*Exhibit Title*	*Room*
ACOUSTICS	CS12	ACOUSTIC CHAMBERS	6L01
ANTENNAS	TS20	ADVANCED ANTENNA TEST RANGE	2142
CELLULAR MOBILE RADIO SYSTEMS	TS13	CELLULAR MOBILE RADIO SYSTEMS	2G06
COMMON CHANNEL SIGNALLING	SS06	FIELD TRIAL OF AUSTRALIA–JAPAN COMMON CHANNEL SIGNALLING	6G16
COMPUTER-BASED DESIGN	SS02	NETWORK DESIGN & OPTIMIZATION	6G16
COMPUTER-BASED DESIGN	SS04	PROTOCOL VERIFICATION USING 'PROTEAN'	6G10
COMPUTER-BASED DESIGN	SS05	'MELBA'	6G10
COMPUTER-BASED INVENTORY RECORDING SYSTEM	SE17	A COMPUTERIZED INSTRUMENTATION RECORDS SYSTEM	6G06
COMPUTERS IN TELECOMMUNICATIONS	SS01	THE USE OF COMPUTER-BASED LEARNING IN TELETRAFFIC ENGINEERING	6G16
COMPUTERS IN TELECOMMUNICATIONS	TS02	COMPUTER MODELLING OF CUSTOMER ACCESS NETWORKS	2G07
COMPUTERS IN TELECOMMUNICATIONS	TS14	WIDEBAND INTEGRATED SERVICES EXPERIMENT	2G08
DIGITAL TRANSMISSION	TS01	AUSTRALIAN DEVELOPMENT OF DIGITAL TRANSMISSION TEST EQUIPMENT	2G07
DIGITAL TRANSMISSION	TS03	INTERFERENCE FROM DECADIC DIALLING	2G07
DIGITAL TRANSMISSION	TS04	THEORETICAL STUDIES IN DIGITAL TRANSMISSION SYSTEMS	2G07
DIGITAL TRANSMISSION	TS11	DIGITAL MICROWAVE RADIO	2G06
DIGITAL TRANSMISSION	TS17	FIXED MULTIPOINT RADIO	2G08
DIGITAL TRANSMISSION	TS18	ECHO CANCELLATION	2G07
ELECTROMAGNETIC INTERFERENCE	TS19	ELECTROMAGNETIC INTERFERENCE FROM INFORMATION TECHNOLOGY EQUIPMENT	2G24
ELECTRONIC EQUIPMENT — SERVICING	SE18	TECHNIQUES FOR SERVICING ELECTRONIC EQUIPMENT	6114
EQUIPMENT ENGINEERING	SE11	MICRO ELECTRODISCHARGE MACHINING	6119
EQUIPMENT ENGINEERING	SE12	INSPECTION OF SPACES USING ENDOSCOPES	6119
EQUIPMENT ENGINEERING	SE14	EXTERNAL FACILITIES FOR EQUIPMENT ENGINEERING	6114
EQUIPMENT ENGINEERING	SE26	EQUIPMENT ENGINEERING SERVICES	6119
HOLOGRAPHY	TT11	APPLIED HOLOGRAPHY	2235
HUMAN FACTORS IN TELECOMMUNICATIONS	CS05	FROM TELECONFERENCING TO COMPUTER-BASED TELECOMMUNICATIONS	2143

HUMAN FACTORS IN TELECOMMUNICATIONS	CS06	HUMAN FACTORS RESEARCH: MAKING NEW SERVICES EASY TO USE	2141
HUMAN FACTORS IN TELECOMMUNICATIONS	CS07	RESEARCH AND DEVELOPMENT IN TELECONFERENCING	2145
INFRARED COMMUNICATIONS	TS12	POINT-TO-POINT ATMOSPHERIC INFRARED COMMUNICATIONS	2G06
INFRARED COMMUNICATIONS	TS16	POINT-TO-MULTIPOINT ATMOSPHERIC INFRARED COMMUNICATIONS	2G08
INSTRUMENTATION & SYSTEMS DEVELOPMENT	SE15	TRANSDUCER MONITOR FOR GAS PRESSURE IN CABLES	6117
INSTRUMENTATION & SYSTEMS DEVELOPMENT	SE16	COMPUTER TERMINAL RESPONSE TIME MEASUREMENT	6117
INTEGRATED CIRCUITS	AS15	I.C. CHARACTERIZATION & FAILURE ANALYSIS	1142
INTEGRATED CIRCUITS	SE23	CUSTOM DESIGNED INTEGRATED CIRCUITS	1G07
INTEGRATED CIRCUITS	SS07	PROGRAMMABLE ARRAY LOGIC DEVICES	6G16
INTEGRATED CIRCUITS	TT01	COMPUTER AIDED DESIGN OF INTEGRATED CIRCUITS	1G07
INTEGRATED CIRCUITS	TT02	MULTI-PROJECT CHIP IMPLEMENTATION	1G07
INTEGRATED CIRCUITS	TT03	GATE ARRAY AND CUSTOM INTEGRATED CIRCUITS	1G07
INTEGRATED SERVICES DIGITAL NETWORKS (ISDN)	CS04	ISDN TERMINALS & INTEGRATED SERVICES DELIVERY	6205
INTEGRATED SERVICES DIGITAL NETWORKS (ISDN)	SS08	EXPERIMENTAL ISDN EXCHANGE NETWORK	6G16
KEYPADS	AS17	KEYPAD TECHNOLOGY	1119
LIBRARY SERVICE	SE01	LIBRARY USE OF MICOFORMS	5115
LIBRARY SERVICE	SE02	ONLINE INTERACTIVE RETRIEVAL SERVICES	5115
LIBRARY SERVICE	SE03	MICROCOMPUTERS IN THE LIBRARY	5115
MICROELECTRONICS	SE19	THICK FILM HYBRID MICROCIRCUITS	1131
MICROELECTRONICS	SE20	PRINTED BOARDS	1123
MICROELECTRONICS	SE21	THIN FILM HIGH SPEED HYBRID TECHNOLOGY	1136
OPTICAL COMMUNICATIONS	TS05	HIGH CAPACITY SINGLE MODE OPTICAL FIBRE	2G11
OPTICAL COMMUNICATIONS	TS06	INTRODUCTION TO OPTICAL FIBRE SYSTEMS	2G11
OPTICAL COMMUNICATIONS	TS07	OPTICAL FIBRE ELONGATION AT CABLE PLOUGH-IN	2G11
OPTICAL COMMUNICATIONS	TS08	JOINTING OF OPTICAL FIBRE	2G11
OPTICAL COMMUNICATIONS	TS09	SINGLE MODE OPTICAL FIBRE MEASUREMENTS	2G11
OPTICAL COMMUNICATIONS	TS10	HETERODYNE OPTICAL SYSTEMS	2G11
OPTICAL TECHNOLOGY	TT06	OPTOELECTRONIC SEMICONDUCTORS	2243
OPTICAL TECHNOLOGY	TT07	FIXED POLARIZATION OPTICAL FIBRES	2237
OPTICAL TECHNOLOGY	TT08	INFARED IMAGING	2236

OPTICAL TECHNOLOGY	TT09	FIBRE DRAWING TOWER	2216
OPTICAL TECHNOLOGY	TT10	OPTICAL TECHNOLOGY	2203
OPTICAL TECHNOLOGY	TT12	SEMICONDUCTORS FOR MID-INFRARED OPTOELECTRONICS	2236
SAFETY	AS03	ELECTRICAL SAFETY OF CUSTOMERS STAFF AND EQUIPMENT	3G11
SAFETY	AS07	ANALYSIS OF VAPOURS FROM INDUSTRIAL PROCESSES	1241
SAFETY	AS13	FIRE RESISTANT WIRE AND CABLE	1222
SATELLITE TECHNOLOGY	TS21	EXPERIMENTAL SATELLITE EARTH STATIONS	*C
SATELLITE TECHNOLOGY	TS22	RESEARCH ACTIVITIES IN SATELLITE COMMUNICATIONS	2142
SOLAR ENERGY TECHNOLOGY	TT04	PHOTOELECTROCHEMICAL ENERGY CONVERSION & STORAGE	6L06
SOLAR ENERGY TECHNOLOGY	TT05	REMOTE POWER SYSTEM CONCEPTS	6L06
SOLAR ENERGY TECHNOLOGY	TT13	TRANSPARENT CONDUCTIVE OXIDE FILMS	6L04
SOLAR ENERGY TECHNOLOGY	TT14	AMORPHOUS SILICON SOLAR CELLS	6L05
SPEECH ANALYSIS AND PROCESSING	CS08	SUBJECTIVE TESTING OF SPEECH QUALITY	6235
SPEECH ANALYSIS AND PROCESSING	CS09	VOICE ACTIVATED TELEPHONE SYSTEMS	6235
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**C Caravan next to dish antenna*

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**A Building 1, Gnd. Floor, West Foyer   *B Building 1, Gnd. Floor, South Foyer*

Sound Design, including all music and tape composition for this exhibition, is by Leslie Gilbert.

Leslie Gilbert is currently Composer-in-Residence with the Australian Telecommunications Employees Association (Victorian Branch), assisted by the Music Board of the Australia Council, the Victorian Ministry for the Arts and Telecom Australia.

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