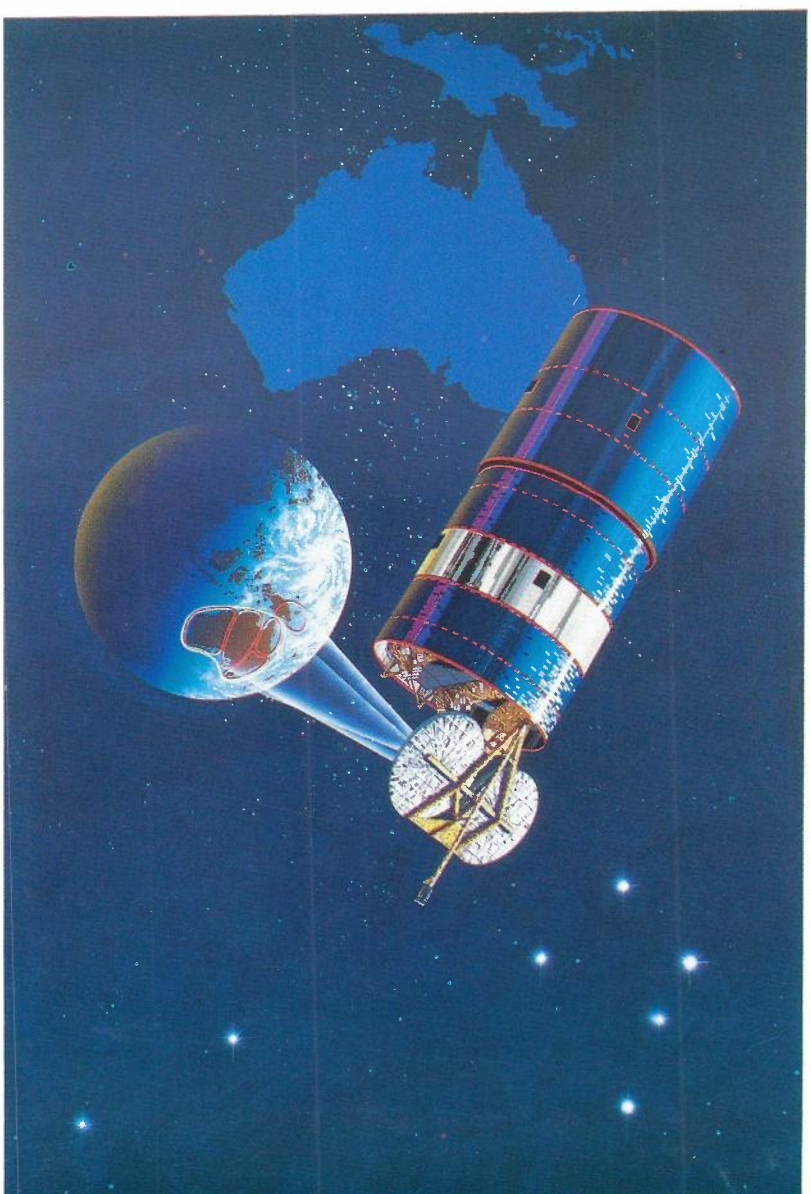
Volume 35 No. 2, 1985

the telecommunication journal of Australia

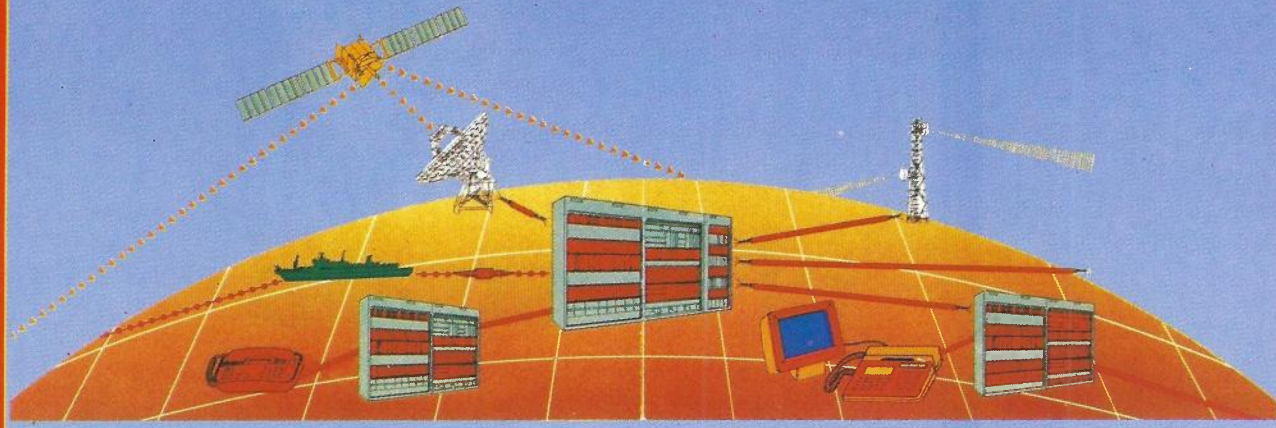
50th Year Golden Jubilee 1935-1985



FEATURED IN THIS ISSUE

35/2

The world of Alcatel Thomson



First in the world for digital switching, Alcatel Thomson have 18 million lines installed or on order. This is 30% of the world total. The company's systems are adopted in over 50 countries.

Alcatel Thomson is also in the forefront of technology for:

- INTEGRATED DIGITAL NETWORKS
- FIBRE OPTICS
- TELEMATICS
- VIDEOTEX
- RADIO COMMUNICATIONS
- MICROWAVE RADIO LINKS
- SUBMARINE CABLE LINKS
- SATELLITE COMMUNICATIONS
- TRANSMISSION SYSTEMS
- AUTOMATED OFFICE TERMINALS

OPTICAL LINE TRANSMISSION SYSTEMS

Alcatel Thomson

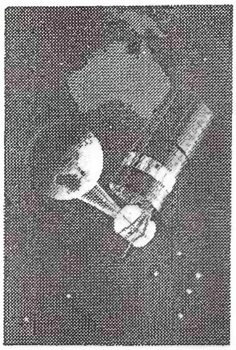
CIT – ALCATEL PTY. LTD.
324 St. Kilda Road, Melbourne. Victoria. 3004.
Telephone 690 8477 Telex AA35566.
(The Australian Company of Alcatel Thomson International, France)

WESTON/C-1

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486 Volume 35 No. 2 1985

50th Year Golden Jubilee 1935-1985



Artist's impression of the AUSSAT satellite over Australia, showing the footprints.

CONTENTS

OTHER ITEMS

Editorial

Telecommunication Society of Australia
Chairman — New South Wales Division
KEITH HARDY

The NSW Division of the Telecommunication Society of Australia was established in Sydney in 1959 by staff of the PMG's Department (now Telecom). Its founding committee formed sub-committees to organise various on-going activities such as lectures and tours and selected district representatives. District and industry Branches were formed subsequently. That organisational arrangement still exists.

The Society's growth has paralleled that of the telecommunications (information transfer) technology. However the rate of growth and importance of information transfer has recently been accelerating sharply with critical affects on business and community progress.

In NSW the Society has been concentrating on coming technological trends and other global pressures. We are assessing the future under a number of scenarios with concern towards members' present and future needs.

Our membership is approximately 1900, Telecom Australia provides 1600 representing 5% of its NSW staff. The remaining 300 are about 1% of the State's information transfer industry and associates. This gives scope for considerable increase in Society numbers but such growth will be possible only if our product is valued.

In the past, Society energy has been directed to recruiting members from Telecom, relying on the undoubted excellence of the Telecommunication Journal of Australia which is closely managed by our National Headquarters. However, the Journal has maintained a low profile as has the Society.

The National body of the Society is addressing this issue, as shown by the recent very successful lectures in Sydney and Melbourne by Sir George Jefferson (Chairman, British Telecom). Additional penetration into Telecom and industry generally requires State action which NSW is addressing as follows:

The NSW lecture programme is carefully chosen to cover topical aspects of interest in the information transfer and associated fields. These lectures will continue at our traditional luncheon lecture time-slot, but the programme is being expanded to include more evening presentations. Some will repeat mid-day ones, whilst others will be slanted towards industry interests.

In addition, short "overview" type, evening lectures will be run later in 1985 designed for members with little formal training in information transfer technology. As with other lectures, transcripts will be published, specially designed to inform members not able to attend. Video tapes will be circulated as circumstances permit.

The AUSSAT Satellite Service — An Overview

Department of Communications and AUSSAT Pty. Ltd.

The establishment of the AUSSAT satellite system has significant implications for remote area communities, the Australian communications industry, broadcasters, a wide spectrum of public and private sector users and generally the whole Australia business and financial community. The system will complement, diversify and add resillience to existing terrestial communications systems, and, in addition, provide a capability for services not currently provided.

The launch of AUSSAT-I took place in August 1985. To mark this historical event, we have compiled this Special Issue of the Journal, focusing on a number of aspects of satellite service in Australia. In compiling this issue we are especially grateful to the assistance offered and material supplied by the Department of Communications, AUSSAT Pty. Ltd., Telecom Australia and other individuals associated with the Information Transfer industry.

We are delighted with the involvement of the industry and we hope you, the readers, will benefit from this association.

In this article we outline the benefits of satellite service to Australia and describe the uses of the satellite by various organisations.

INTRODUCTION

With the launch of AUSSAT'S first two communications satellites in August and November this year a new era in communication will begin in Australia. For the first time all of Australia and its offshore regions will be covered by a single, comprehensive telecommunications capability which will, when combined with the vast terrestrial infrastructure operated by Telecom Australia, provide the capability to extend and strengthen existing telecommunications and broadcasting services and add new services to benefit all Australians no matter where they live.

The Australian National Satellite System, owned and operated by AUSSAT Pty. Ltd., a company established in November 1981 and whose shareholding is held 75% by the Commonwealth and 25% by Telecom, is based upon three operating satellites — the third to be launched by mid 1986 — to be placed in orbit 36,000 km above the equator just to the east of Australia.

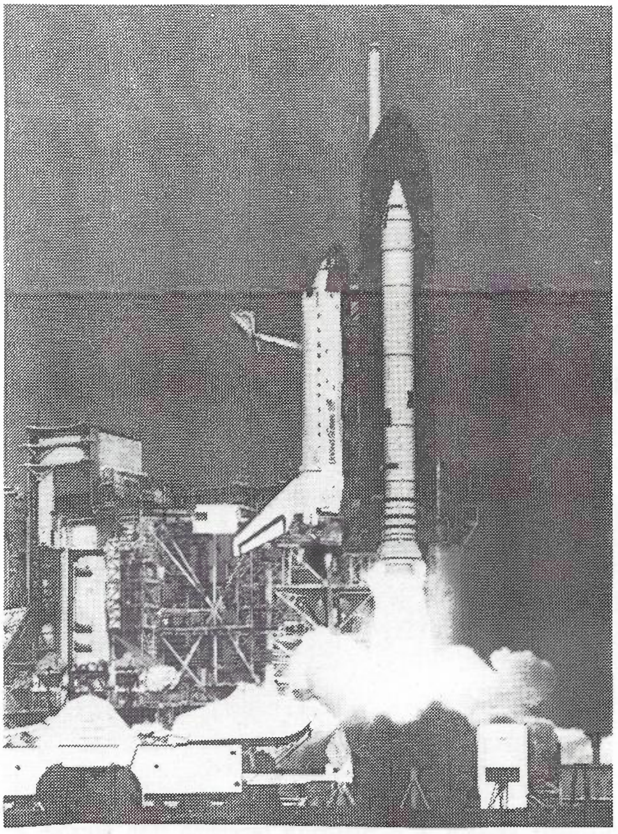
In addition, AUSSAT will also own and operate eight Major City Earth Stations in each of the capital cities including Canberra and Darwin and two Satellite Control Stations located in Sydney and Perth.

Once operational, the satellite system is able to be used for the distribution of television and radio programs by the ABC and commercial operators; the provision of television and radio services to remote areas of Australia; voice and data services for the Department of Aviation; and for organisations such as banks, mining companies, education authorities, police and other public sector organisations.

The first two satellites are scheduled to be launched from Cape Canaveral on board NASA's Space shuttle. Each satellite will be ejected from the Space Shuttle at an altitude some 300 km above the earth. Special rocket motors will then lift each to its specially chosen orbital position. In this position, the satellite will move at the same speed and in the same direction as the earth rotates.

As each orbit will take twenty-four hours to complete, the satellites will always appear to remain 'fixed' or 'stationary' when viewed from the ground; hence the term geostationary orbit.

The satellites are based upon a spinning 'drum' design



NASA Space shuttle lift off

and will be 6.6 m tall, 2.2 m in diameter, and weigh around 1250 kg at launch.

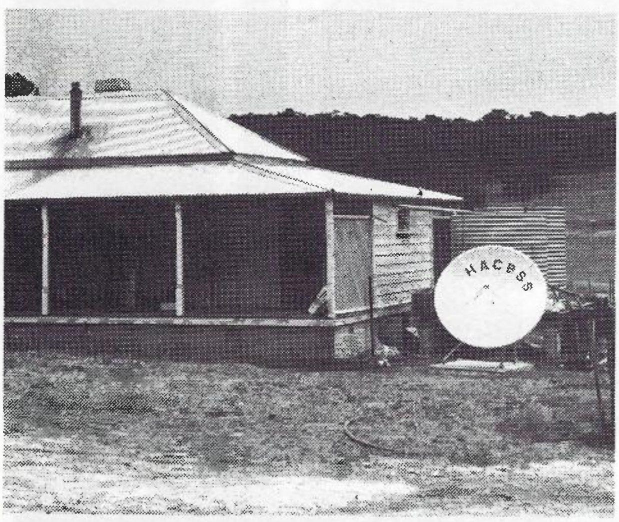
By appropriately designing the satellite's transmitting and receiving antennas, the beam coverage area or 'footprint' can be narrowed and concentrated onto relatively small areas within the satellite's field of view.

The satellite system has been designed so that its coverage area extends over all the six States, the Northern Territory, and surrounding coastal waters.

There is a national beam and four individual 'spot' beams on each satellite with one each covering Western Australia, the Northern Territory plus South Australia, Queensland, and New South Wales, Victoria and Tasmania.

The attractions of a satellite communications system come from three basic features:

- The cost of transmitting information from one point to another is independent of distance. Thus a message, a burst of data or a television picture from Sydney to Perth costs the same as the cost of transmitting the same information from Sydney to Parramatta, or Sydney to Broome, or Sydney to Alice Springs.
- Communication satellites have a multi-destination capability. That is, they can send the same information to any number of destinations within Australia — and all for the cost of one transmission through the satellite. For example, a television picture sent up to the satellite from Sydney can be received at a number of television relay stations anywhere throughout Australia.
- The satellite system can be readily accessed — that is, signals to and from the satellite can be transmitted and received from any location in Australia, whether that location is in the centre of Sydney or in the centre of Australia.
- In addition, users of the AUSSAT satellite system can, if they so elect, establish and operate their own earth stations and interconnect those stations with their own premises by their own interconnecting microwave links.



An early version of a HACBSS receiving dish outside a southern New South Wales homestead.

Major uses of the system will include:

- The Australian Broadcasting Corporation will use it for the relay of programs between studios, distribution of programs to provincial transmitters and provision of the Homestead and Community Broadcasting Satellite Service (HACBSS).
- Commercial television and radio networks can use the system for transmission of news, current affairs and other programs between major studios, and to improve program relay facilities to regional stations.
- Outback communities will receive television and radio services through HACBSS, with high-power transponders on board the satellites being used to provide the service.
- The Department of Aviation is planning a network of more than 200 earth stations to link air traffic control and flight service centres to aircraft through the satellite.
- The Department of Defence can use it for internal administrative communications.
- Telecom is planning to use the satellite system in a variety of ways to extend and add flexibility to its existing network.
- The business community, including banks, who could use the satellite system for electronic funds transfer; mining companies, for voice, video and data transmission from remote mine sites to head offices; manufacturers, for expanded management information systems based upon up to date inventory and manufacturing process data, and major retailers, for expanded merchandise control systems.
- The public sector, in particular distant education authorities who will be able to provide enhanced education services to remote areas through agencies such as the School of the Air.

AUSTRALIAN BROADCASTING CORPORATION

When the first AUSSAT satellite becomes operational, ABC satellite radio and television will become operational with it. Through the all-encompassing power of the satellite to cover the farthest reaches of the country, ABC television and radio will be able to provide services to everyone anywhere in Australia.

The most immediate and tangible impact of the satellite will be through the ABC television and radio Homestead and Community Broadcasting Satellite Service (HACBSS). Through this service people now beyond the reach of ABC radio and television will be able to receive the ABC television service and three radio services relevant to their area by installing a small satellite receiving antenna.

To provide this service the ABC will lease five spot-beam transponders. These will cover south-eastern Australia (New South Wales, Victoria and Tasmania); north-eastern Australia (Queensland); Central Australian High (the Northern Territory); Central Australian Low (South Australia); and Western Australia (Western Australia). Each transponder will be fed from its appropriate capital city, i.e. south-east from Sydney, north-east from Brisbane, Central Australian High from Darwin and Sydney, Central Australian Low from Adelaide, and Western Australia from Perth. Each transponder in turn will then beam down, across its entire footprint area, the relevant ABC television, Radio 2, Radio 3 and Stereo FM Radio service.

For the people not now serviced at all by ABC radio and television it will mean the dawn of a new era of entertainment, an era already enjoyed by their city and some regional counterparts for two decades.

Many advances

For those people living in the remote areas of central and eastern Australia who now view ABC television through the INTELSAT RATV service, the introduction of HACBSS will result in many advances. These audiences will get their State's ABC television program schedule in their State's correct time. No longer will Queensland RATV viewers get New South Wales weather, no longer will New South Wales RATV viewers get programs in eastern time in summer, no longer will South Australian RATV viewers get the wrong program in the wrong time.

To the ABC's regional audiences the impact of the satellite will be just as dramatic, if somewhat more gradual in effect.

Since the relevant ABC television service and three radio services will be available all over each transponder footprint, the ABC will install earth stations alongside all its current television transmitters in all States except Tasmania and Victoria. In this way these transmitters and co-sited ABC Stereo FM radio transmitters will be fed by satellite rather than by terrestrial circuits radiating from the nearest capital city.

Later the ABC will install earth stations at its existing and new regional radio studios and these earth stations will eventually provide the material for a new ABC regional radio network (to replace the current Radio 3) and ABC Radio 2, to be transmitted through all existing regional areas. The viewers of and listeners to these regional services will not have to buy earth station equipment as the programs will be transmitted in the normal way. However, the introduction of the second regional radio network and the extension of ABC FM radio may take several years and people in some regional areas may also choose to install small earth station facilities so as to receive all the available ABC regional radio and television services from an earlier date.

Program interchange

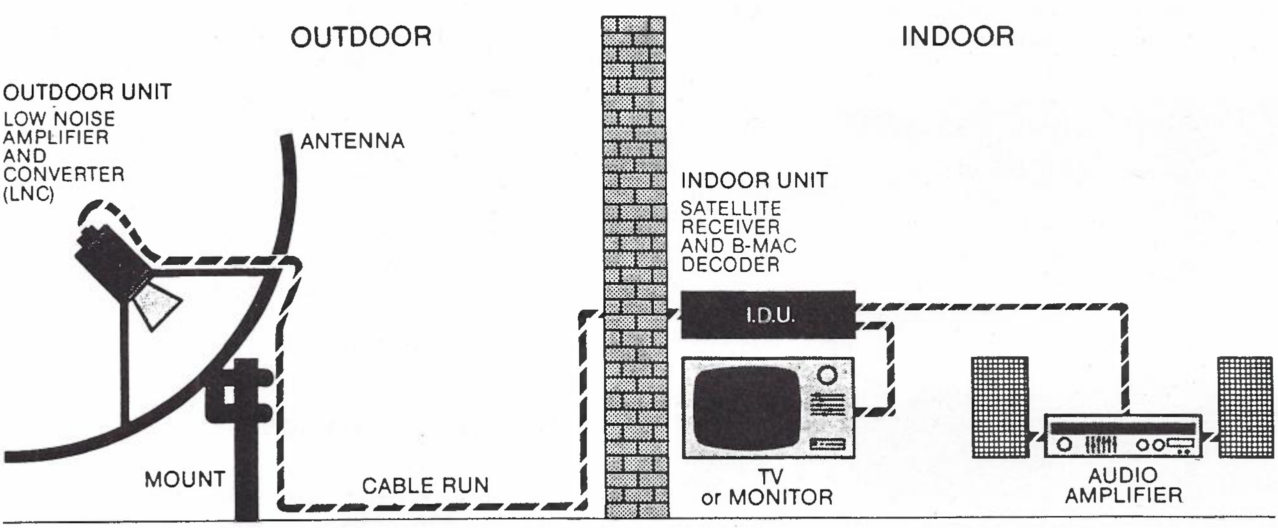
All the above, of course, relates to actual transmission of ABC radio and television programs via satellite. The other area of dramatic change brought by the AUSSAT system will be in program gathering and interchange.

At the moment ABC program makers exchange program material either through the ordinary mail and despatch systems or by using closed circuit Telecom facilities. For example, the Brisbane 'National' gets its daily coverage of important items from interstate by booking a circuit from Sydney and then being fed the items it wants via closed circuit (i.e. not telecast). But this circuit only links Brisbane to Sydney and is available for just short periods of time. It would, for instance, be costly, if not impossible, for Brisbane on a daily basis to audition and exchange news items with, say, Perth and Darwin. With the dawn of the satellite era, however, ABC television in Brisbane, for example, will be able to exchange items with any other ABC television studio almost at will at no marginal cost. The same will apply at the beginning between the capital city production centres for ABC radio, and later on all regional radio studios will have similar interchange abilities.

For this program gathering and program interchange to occur the ABC will lease several 12-watt national beam transponders for television and one 12-watt national beam transponder for radio. These transponders, being national, are able to send material to, and receive material from, all State and territory capital city earth stations. These earth stations are built and owned by AUSSAT with the ABC leasing appropriate up-and-down link facilities at them. Later in the regional areas the ABC will own its own earth stations.

The impact of the program interchange facilites on ABC audiences everywhere will be to make the coverage of important national, State and regional events, no matter where they occur, more immediate and comprehensive. Indeed, the satellite will make certain types of national programs, requiring input from many regionals and States, possible where they were not feasible before.

The impact of this qualitative effect of the satellite on ABC programming will be less immediately obvious than



Recommended HACBSS Equipment Configuration for an Individual Earth Station

the extension of the transmission areas of ABC radio and television services, but in the long term will affect everyone.

In summary, through the provision of five spot-beam transponders the satellite system will:

- provide ABC radio and television for the first time to 300,000 Australians in remote areas; and
- enable the introduction of new, and extensions to existing ABC radio services in regional areas.

Through the provision of several 12-watt national beam transponders the satellite system will improve ABC radio and television's ability to cover important regional, State and national events as, when and where they occur.

All in all, the satellite system will perhaps provide the greatest single mechanical aid to the ABC in its attempt to live up to its ambitious charter.

DEPARTMENT OF EDUCATION

Educational applications of the domestic communications satellite, AUSSAT, can be divided into three main formats:

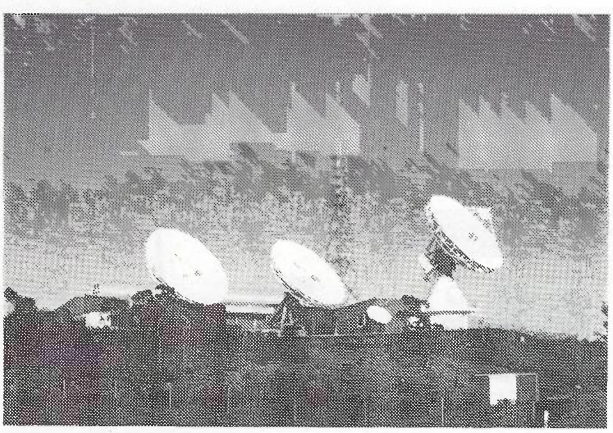
- television
- radio
- data transmission.

Each of these could involve a 'one-way' or broadcasting approach, or a 'two-way' or interactive approach. Furthermore, in devising applications, additional diversity will be possible through combinations of the satellite in a traditional broadcast-like mode, its point-to-point/multipoint mode, and through 'hybrid' use with improved terrestrial facilities.

Educational services are now being developed, especially for remote or communications-deprived areas, with the intention of offering them jointly with non-educational services. For example, in Queensland, the Satellite Pilot Network plans to incorporate telemedicine, water resources monitoring, police communications, railway signalling, and other services with a range of educational services.

Cheaper to receive

Because it is generally much cheaper to receive satellite signals than to receive-and-transmit them, the first educational applications are expected to rely greatly on one-way broadcasting. There is particular interest in this in Western Australia, and a recognition of the potential for reaching educational audiences in high population zones as well as in remote areas by exploiting the higher profile and increasing popularity of television as an educational medium.



AUSSAT'S Major City Earth Centre — the control centre for the satellite system (Belrose, Sydney).

The new technology is not limited to providing alternative means of delivering existing services to new clients, but can be used to develop entirely new services. Exploratory applications of communications technology in remote schools in South Australia during the past few years have led to the concepts of 'hub' city schools (to which isolated children are joined through telecommunications), the 'hub' teacher (whose class can be scattered throughout the State), and networks of schools sharing specialist resource teachers. These concepts could be applicable to educational use of the satellite.

The following list illustrates the range of possible educational applications of satellite or satellite-terrestrial communications, some of which will be implemented on the first generation system:

- improvements in the quality and reliability of teacher-to-student voice communications (for example, School of the Air);
- provision of enhanced services, especially for distance education. For example:
  - — services based on computer resources (including audiographics and videotex-based services);
  - — television downloading (including the beaming of educational films direct to schools, and specially-prepared radio and television programs to meet the specific needs of correspondence students);
  - — electronic mail, including access by individual correspondence students and also by educational administrators with a need to communicate between central office, regional offices and individual schools;
- development of links between schools and data bases of curriculum and administrative material/information and the enhancement of school library/audio-visual services;
- campus-linking for lesson exchanges or sessions allowing regular or **ad hoc** professional contact through interactive television and the use of electronic bulletin boards;
- combined broadcasting and terrestrial applications; for example, the use of FM radio sub-carrier transmissions with student responses via telephone links;
- other services integrating satellite/terrestrial communications with conventional resources (for example, printed materials and residential workshops) for providing a variety of courses open to those outside the scope of post-compulsory education. Such courses might, for example, cater for mature-age students in remote areas, or those disadvantaged within the conventional education system such as the physically handicapped. They could include TAFE and other courses at the trade and non-trade levels.

DEPARTMENT OF AVIATION

A new era in the provision of aeronautical communication systems will follow deployment by AUSSAT, in 1985, of two geostationary satellites. The Department of Aviation is to be a major user, and will install some 100 duplicated satellite ground stations. These will provide a significant portion of the essential aeronautical safety communications, both data and voice, between the existing Air Traffic Control (ATC) and the Flight Service (FS) units located throughout Australia, and from these units to strategically located VHF air-ground communications outlets.

The only means of providing aeronautical communications with aircraft is via the radio frequency spectrum. The aviation industry requires radio communications for:

- safety-of-life;
- regularity of flight.

To satisfy these requirements, the Department has in the past provided aeronautical communication systems associated with air traffic control (ATC) and in-flight information services, namely:

- air-ground-air communications systems, both HF and VHF;
- fixed (point-to-point) networks to support aviation operations, both voice and data.

The existing telecommunication infrastructures place significant limitations on economic and reliable provision of voice and data communications (associated with aircraft operations) between the ATC and Flight Service Units, located throughout Australia.

Long distances

Where economically possible, high quality circuits are provided. Noting the long distances involved, the circuits are often unreliable and of high cost to provide. To meet these requirements, the Department makes use of Telecom-provided facilities where these are available and can provide the required grade of service. In more remote areas, a comprehensive network of HF point-to-point communications is provided via Department of Aviation facilities.

Microwave radio links are also provided by the Department in areas where the density of traffic and the need for high quality communications associated with radar control of aircraft makes such systems economically justified. Overall, a patchwork of networks has evolved that is constrained by inherent technical limitations, difficulties with the terrain, and high costs. Future expansion by these means will be increasingly more expensive and unsatisfactory.

Many years of planning and evaluation have established that the Aviation Satellite Communications System can provide a better and more cost-effective way of meeting the Department's strategy for the provision of aeronautical communications in the future. The Department therefore proposes to implement the system, at a total capital cost of $31 million, to satisfy the requirements best met by satellite to the year 1986, but with built-in potential for expansion in the future.

Two-way communications

As far as aircraft users are concerned, the Aviation Satellite Communications System will provide two-way VHF air-ground communications above 6000 metres within controlled airspace over the Australian mainland, and also some extension of VHF coverage outside controlled airspace, in areas of high traffic density.

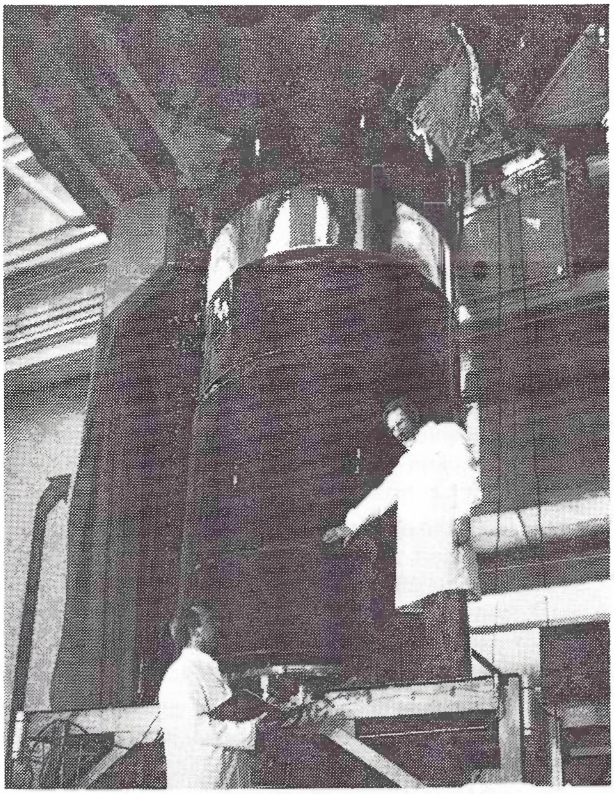
There will be no change to existing VHF equipment in aircraft. It is important to note that direct aircraft-to-satellite communication will not be possible. Aircraft will communicate via one of the remote VHF sites which will be connected to the responsible ATC or Flight Service Units through the satellite.

Extending total VHF air-ground coverage of the Australian airspace below 6000 metres cannot be economically justified at present, or in the foreseeable future. The existing HF networks will remain to provide air-ground communication over some parts of the Australian mainland, particularly at the lower levels of aircraft operations, but further expansion will not be required.

When commissioned, the Aviation Satellite Communications System will carry a significant portion of aeronautical safety communications throughout Australia. At that stage, the full potential advantages of the system, which cannot be achieved by any other means, will be available to meet the challenge of the future. Some of these benefits will be:

- the provision of direct, high quality, aircraft-ground communications to overcome the inherent limitations of the present high frequency system;
- the optimisation of air route structures to allow for direct routing and optimum flight paths for aircraft;
- the optimisation of the location of air traffic service centres to better utilise resources;
- the ability to respond dynamically to the future requirements of the aviation industry.

The Department will consider all of the potential benefits of the Aviation Satellite Communications System, but in all these considerations, the over-riding requirement is that safety is not compromised.



AUSSAT-I undergoing final tests before the Aust. 1985 launch.

TELECOM

Telecom will lease capacity on the Australian domestic satellite to offer customers a wide range of satellite-based products and services. They will be known as the Iterra Service (IS). 'Iterra' is an Aboriginal word meaning 'be quick.' It emphasises the speed with which Telecom will provide customers with the particular services they require, via the satellite.

In addition to the already-announced Iterra Network Service, the IS will include a variety of different data and voice transmission services which take advantage of satellite technology.

Iterra Service customers will have the option of choosing between standard product offerings or else having Telecom design a service tailored to their specific communications needs. These will include such services as consultancy, project management, turnkey services and access to Telecom's technical expertise. The charges for IS services will be determined on a commercial basis.

Iterra Network Service (INS)

The INS will offer a range of switched network services via the satellite, automatic telephone services with STD, ISD and operator assistance will all be available.

The service has been especially designed to provide a comprehensive business telecommunications package to those customers who are currently beyond the range of Telecom's switched terrestrial service. The INS is of greatest benefit to those businesses involved in energy, mining and tourist developments in the more remote parts of Australia and who require service before it could otherwise be provided.

As part of the INS, Telecom will be offering customers the option of service via a Transportable Iterra Network Earth Station (TINES) which will be trailer mounted and be able to provide reliable communications anywhere in Australia. The TINES will offer two telephone circuits per customer and is targeted at mineral exploration and surveying teams operating in the more remote areas of Australia.

Iterra Business Service (IBS)

As well as the INS, a range of services more suited to Telecom's larger business customers is in the final stages of development.

Particular services that will be offered via the satellite will be high speed point-to-point data services for major business customers who require an alternative or back-up service, and video conferencing facilities using the flexibility of the satellite to offer either point-to-point or point-to-multipoint transmission.

Telecom will offer a complete package to business customers and has the ability to integrate both terrestrial and satellite services to provide the most suitable tele-communications system to its customers.

The satellite and Telecom's telephone network

Some confusion has arisen concerning the kind of services and the cost of the services that the satellite will provide. In particular, it should be noted that small satellite dishes designed to receive television and radio will only be able to receive television and radio and will not be suitable for two-way telephone services.

Telephone services will only be provided via the satellite on a commercial basis due to the high cost and scarce capacity available on the satellite. These services will generally be for customers who require telephone services before they can be provided by Telecom through the normal development of its network at the usual subsidised charges to the customer. In order to provide telephone services to the more remote areas of Australia under normal network development at standard rural charges, Telecom will be using an Australian-developed technology called the Digital Radio Concentrator System (DRCS) which is a more economic method of providing service in these areas.

Conclusion

As part of its ongoing commitment to provide the use and understanding of new technology Telecom has produced a range of information which can be obtained by phoning (008) 033 058 for the cost of a local call.

DATA CABLE TO DISTRIBUTE NEC FIBRE OPTICS

NEC Australia Pty. Ltd. has signed a distribution agreement with fibre optic specialist, Data Cable Pty. Ltd., establishing it as the Australian distributor for NEC's complete range of fibre optic components, semiconductor optical devices and gas lasers.

The distribution agreement allows Data Cable to sell and support the product ranges, comprising over 500 items, to all commercial markets, such as the automotive industry, telecom subcontractors, organisations producing computers and communication equipment and defence research.

This is the first time that NEC has appointed a distributor for its range of fibre optic and associated product lines.

The NEC product range from Data Cable includes laser diodes, light emitting diodes, photo diodes, switches, couplers, isolators, multiplexers, line monitors, in-line attenuators, connectors, neolinks, test equipment and both air-cooled Argon-ion and He-Ne gas lasers.

Data Cable has been involved in the design, supply and installation of fibre optic systems for several years, and last year installed the largest fibre optic local area network in Australia at the Melbourne and Metropolitan Board of Works.

Issued by
Data Cables Ltd.,
538 Mountain Highway,
Bayswater 3153,
Victoria.

Satellite Communications

J. WILSON — Telecom Australia

This article outlines some of the history and features of satellites, explains the more commonly used terms of satellite technology and outlines Telecom's approach to the use of the Australian Domestic satellite. This article has been kept as general as possible in order to cater for non-technical as well as technical personnel.

INTRODUCTION

HISTORY

In 1945 Arthur C. Clarke, a British radio communications expert, later to become famous as a science fiction writer ("2001 — A Space Odyssey"), suggested that if suitably equipped artificial satellites were to be placed in an orbit 22,300 miles above the equator they would be stationary, and could be used as radio relay stations for communications between radio transmitters and receivers on earth. A satellite in such an orbit (often called "geostationary") would constantly have the same portion of the earth's surface in view and hence communications between transmitters and receivers in this area would be possible all the year round.

It was not until 12 years later that the first artificial satellite was launched (into a non-stationary orbit) — the Russian Sputnik 1 in October 1957. With Sputnik's faint and repetitive "bip-bip" transmission back to earth the age of satellite communications had dawned.

This was followed by a series of non-geostationary American and Russian satellites culminating in the first satellite transmission of television pictures between the USA and Europe via the American TELSTAR 1 in July 1962.

The first satellite placed in a geostationary orbit, as suggested by Clarke, was the American SYNCOM 1 in February 1963.

The launch into geostationary orbit by NASA in April 1965 of INTELSAT 1 (more popularly known as "Early Bird") meant that regular commercial intercontinental satellite telecommunications links had become a reality. Early Bird handled 240 telephone communications as well as alternatively providing a regular transatlantic TV transmission service.

Although its capacity was small, Early Bird demonstrated the viability of satellites — and the use of geostationary orbit — in the field of communications. It also proved that satellites can be extremely reliable. Built for a nominal lifetime of 18 months, it was finally taken out of service in May 1970, more than 5 years after launch.

Since that time rapid and continuous development has taken place in satellite technology. Satellites now provide a growing proportion of international telecommunications services and facilities. There is also an increasing trend towards the use of satellites to complement and augment domestic communications networks or to develop communications facilities in third world countries where no terrestrial services are currently available.

In the latter half of 1985 Australia will join this trend with the launch in July and October by the U.S. Space Shuttle of the first two satellites in Australia's domestic satellite system.

MAJOR SATELLITE SYSTEMS CURRENTLY IN OPERATION

INTERNATIONAL

The major international satellite telecommunicatios organisation is INTELSAT. It was established on 12 February 1973 after many years of negotiation and provisional agreements amongst various nations. Currently it comprises 109 member countries. Its purpose is to provide the space segment required for high quality and high reliability public international telecommunications services for all regions of the world on a commercial basis and without discrimination. In all, via its satellites, INTELSAT now provides around 60% of all intercontinental links and gives service to some 172 nations and territories. The INTELSAT satellites can also be used for domestic national telecommunications services where this does not impede achievement of the prime objective of the organisation. At present INTELSAT provides domestic telephone, telegraph and television services to some 24 countries.

INMARSAT is the International Maritime Satellite Organisation. It is patterned along the line of INTELSAT and came into existence on 16 July 1979. Its primary purpose is to establish and operate a worldwide satellite communications system to provide improved maritime communications. Its membership to date is 35 countries. Ship to shore services which INMARSAT can offer are telephony, telex, voiceband, dial-up data, and 56 Kbit/s point to point data.

NATIONAL

Domestic satellite systems are in operation in many countries, including the USSR, Canada and the USA, with other countries, including Australia, soon to follow suit.

The Canadian system, for example, is operated by Telesat Canada, a private company with three shareholding groups: the Canadian federal government, approved telecommunications operating companies and the general public; each with one third of the total capital. The system commenced operation in January 1973 and has been expanding rapidly with newer generation satellites being introduced at regular intervals. Over 100 locations spread across Canada's vast and often remote expanses are now linked via satellites to telephone exchanges and TV and radio. There are also over 400 licensed private receive-only earth stations receiving TV transmission via the system. The system offers a wide range of communications facilities from single telephony circuits up to wideband services. In addition, transportable earth stations are available to set up short term telecommunications links.

In the United States there are a number of domestic satellite systems. One of the better known is SBS (Satellite Business Systems), established in November 1980 by a consortium comprising IBM, Comsat General and the Aetna Life and Casualty Insurance Company. The system offers transmission at variable rates between 2.4 Kbit/s and 6.3 Mbit/s, catering for such requirements of customer companies as telephony, telex, facsimile, high speed data, and videoconferencing.

AUSSAT

The Australian domestic satellite system will be owned and operated by AUSSAT, a separate government company.

AUSSAT has responsibility for the management and sale of the Australian domestic satellite's capacity and for the provision of the space segment of various services to its customers.

The Australian Telecommunications Commission (Telecom) has taken up 25% ownership of AUSSAT and will be leasing satellite capacity to offer its customers a wide range of telecommunications services.

WHAT IS A SATELLITE COMMUNICATIONS SYSTEM?

GENERAL

The basic elements of a satellite communications system are:

- a satellite (or satellites) in orbit, which acts as a space relay station, receiving radio signals, translating frequencies, amplifying the signals, and then retransmitting them, and
- earth stations which either
  (a) send signals into space in the form of radio waves directed at the satellite ("transmit-only earth stations"), or
  (b) receive radio frequency signals from the satellite ("receive-only earth stations", or RO stations), or
  (c) both transmit and receive signals to and from the satellite ("two-way earth stations").

The satellite can be envisaged as a "radio repeating station in the sky" which receives radio signals from individual sources on earth — transmitting earth stations — and then retransmits those signals back to earth to be received by the appropriate earth stations within the areas covered by the satellite's transmit antennas, sometimes called the satellite "footprints." The process of repeating the signals requires both amplifying the signal to overcome the loss of signal strength due to the distance it has to travel, and altering its frequency to avoid mutual interference between the signals being sent up to the satellite and those being sent back.

The AUSSAT system will, initially at least, consist of two satellites in orbit, with a third satellite on standby on the ground ready for launch should either one of the other two degrade or be insufficient to meet demand for service.

TRANSMISSION

The radio signals repeated by the satellite are normally in the microwave frequency range, and use much of the technology employed in terrestrial microwave telecommunications systems.

In the case of the AUSSAT system, transmissions from earth stations to the satellites (called "uplinks") are in the frequency band 14.00-14.50 GHz[1] and transmissions from the satellites to earth ("downlinks") are in the 12.25-12.75 GHz band. (As mentioned above, separate bands for uplinks and downlinks are required to avoid interference.) This particular frequency allocation is sometimes referred to as the 12/14 GHz band.

A particular benefit of the 12/14 GHz bands is that they are distinct from the frequencies currently used in

"This article was written under the direction of John Wilson who is currently Manager — Satellite Market Operations in Telcom's Satellite Service Project Team."

terrestrial microwave systems in Australia. Earth stations will therefore be able to be located almost anywhere, including heavily populated centres, without danger of radio interference to other services.

Accompanying this benefit is the drawback that signals in this band are attenuated[2] by heavy rainfall much more than signals at the lower frequencies. This fact must be allowed for in the design of earth stations.

The bandwidth available in satellite systems by the use of microwave frequencies allows for a wide and flexible range of communications links and networks to be provided, varying from wideband services (e.g. high-speed digital data transmission, high definition T.V. and video-conferencing) to individual voice grade circuits.

TRANSMISSION DELAY

All communications satellites are in orbit around the earth. Most of them are placed in what is called the geostationary orbit which is a circular orbit in the same plane as the equator area height of about 36,000 km.

In this orbit, the satellite circles the earth once every 24 hours and thus, if travelling in the same direction as the earth's rotation, appears stationary from the earth — hence "geostationary" orbit.

The geostationary orbit enables the satellite to stay in constant "line of sight" of the earth stations on the ground. Because of the distance between the transmitting earth station and the receiving earth station of at least 72,000 km there is a signal delay of about 0.27 seconds.

On a two-way satellite telephone link for example, there would therefore be a minimum time lag of about 0.54 seconds between the end of one sentence and the reception of the ensuing reply. In practice users do notice this delay but quickly adapt to it.

1. GHz=000 MHz=0^9Hz; where one Hz (Hertz) is one cycle per second.
2. Attenuation is the decrease in signal strength caused by its travelling over a long distance. The loss in signal strength in a radio system is proportional to the square of the distance travelled.

SATELLITES

GENERAL

A communications satellite basically consists of

- a small number of microwave reception and transmission antennas;
- a number of frequency translating amplifiers, usually called transponders;
- control equipment for the antennas and transponders, and ancillary equipment such as solar power arrays, batteries, position and attitude control jets, etc. These power the radio equipment and maintain the satellite in its correct orbit.

ANTENNAS

To be efficient, a microwave antenna must be designed to focus its signal on the distant location to which it transmits. The more directional the antenna the greater the signal gain. High gain in a satellite antenna means either that more information can be transmitted in a given frequency band or that the earth station's antenna can be smaller because of the increased strength of signal and so the cost of the stations is reduced. The situation is similar to a torch beam shining on a distant surface — the narrower the focus of the beam, the brighter and more intense the light reaching the surface, along with a corresponding decrease in the area illuminated. Antenna gain is a function of the area to be covered.

For flexibility and efficiency, therefore, most modern satellites have more than one transmit and receive antenna. These antennas are capable of being aligned to transmit to and/or receive from defined segments of the total area of the earth covered by the satellite's "line of sight." The segment covered by an antenna is called a "footprint," with each antenna alignment being referred to as a "beam."

By selecting suitable footprints a satellite system can be designed to take advantage of the signal gains due to higher directivity of the antennas beams while being able to provide transmission and reception coverage of all areas which the system is to serve.

Further increases in the transmission and reception capacity of the satellite system via the antennas can be achieved by polarisation of the beams. A vertically polarised beam can be transmitted along with a horizontally polarised beam of the same frequency and the two can be detected and received separately. A linearly polarised filter can eliminate one of the beams just as polarised sunglasses can cut out polarised light reflections. This means that two beams can share the same frequency range with little interference, hence doubling the amount of information which can be sent or received in that bandwidth.

The AUSSAT satellites will utilise linear polarisation in their antenna beam configuration. Three separate, linearly polarised reflectors will be used with separate beam-forming apparatus to produce three receive antenna beams and seven transmit antenna beams. The footprints of the beams are shown in **Fig. 1.** As can be seen there are two "national" transmit and receive beams, with the other beams being smaller, "spot" beams covering separate regions of Australia and Papua New Guinea.

TRANSPONDERS

A transponder is the radio equipment on a satellite which amplifies signals received from earth stations in the uplink frequency band and translates those signals into the downlink frequency band with further amplification for retransmission back to earth.

By the time signals reach the satellite from earth they are extremely weak and must be amplified many million times before retransmission. At the same time, however, there are very tight constraints on the design of power amplifiers for transponders. They must be highly reliable, light in weight, and efficient because of the limited capacity of the power supply. The usual solution to the problem is to use Travelling Wave Tube (TWT) amplifiers. The power output of the TWT determines the power of the transponder.

Most satellites have more than one transponder, each receiving signals, via an antenna, in a particular bandwidth of the satellite's total uplink band and then

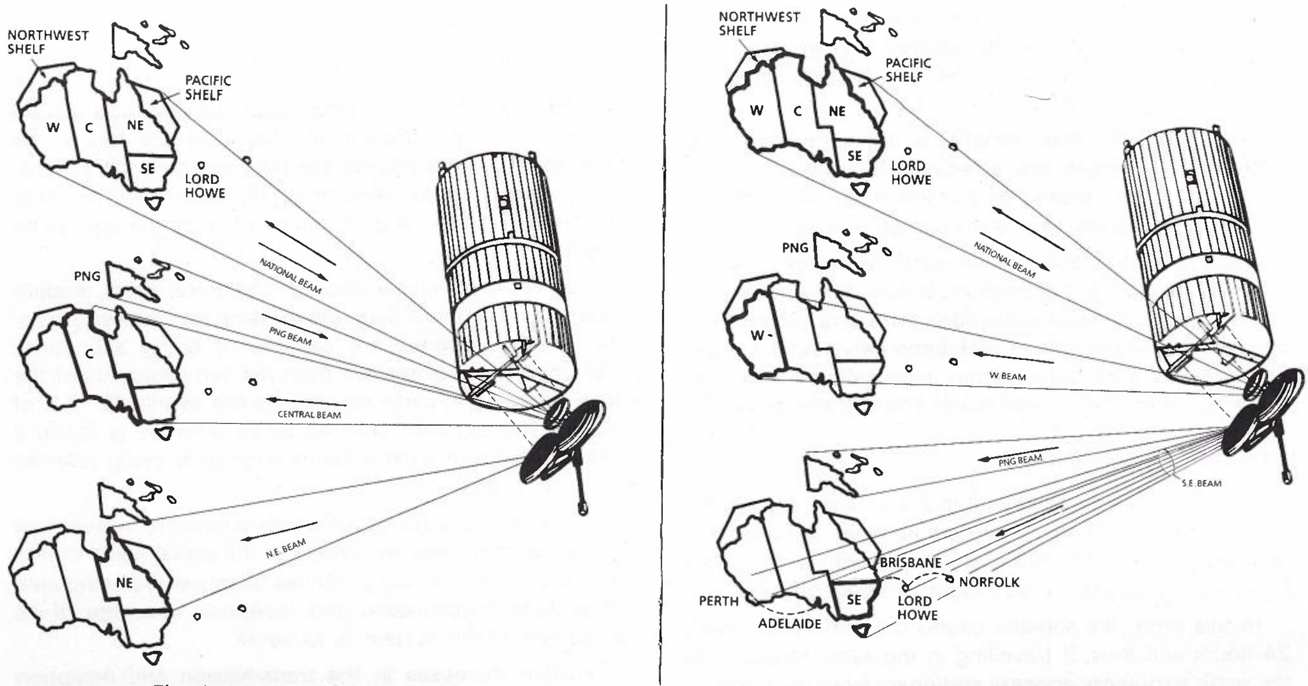


Fig. 1a Horizontal Polarisation

Fig. 1

Fig. 1b Vertical Polarisation

amplifying and translating them into a corresponding bandwidth of the downlink band.

The use of a number of transponders operating in separate bandwidths, rather than one transponder covering the whole frequency range, gives much greater flexibility. Separate transponders can be used for separate communications purposes and requirements; this minimises interference. The transponders can be switched to receive and transmit through antenna beams which give the footprint necessary for that particular communications purpose and thus maximise the signal gain by only concentrating the signals onto the areas where they are required.

As outlined earlier, polarisation of beams enable satellite frequency bandwidth utilisation to be duplicated.* With this technique each transponder operates in one or other of the polarisations. The bandwidth of two transponders can then overlap as long as they operate in different polarisations.

For example, on each of the Australian satellites there will be 15 transponders, each with a nominal bandwidth of 45 MHz, operating a linear polarisation scheme with eight transponders on one polarisation plan and seven on the other.

The centre frequencies of co-polarised transponders (i.e. transponders in the same polarisation) are separated by 64 MHz, while the centre frequencies of cross-polarised transponders (i.e. transponders in different polarisation) are offset by 32 MHz.

Four of the 15 transponders will be nominally 30 watt transponders, with the remaining eleven being 12 watt.

The high power transponders have primarily been designed for the Homestead and Community Broadcasting Satellite Service (HACBSS). This service will provide radio and television broadcasting to remotely located people in the outback. Because the transponders are high powered, feeding a spot-beam, customers will only require a small antenna to receive the transmissions; the price of their receive-only earth stations will therefore be relatively low.

CONTROL EQUIPMENT

Satellites contain much instrumentation and continuously transmit information about their various components to earth where it is monitored at a terrestrial control system.

One important function performed by the control equipment is to switch the transponders between beams as required and as commanded by the control station.

In the AUSSAT system all transponders exclusively for Australian service are permanently connected to one of the two national receive beams. The three transponders capable of serving Papua New Guinea can be switched between a national receive beam and the Papua New Guinea receive beam.

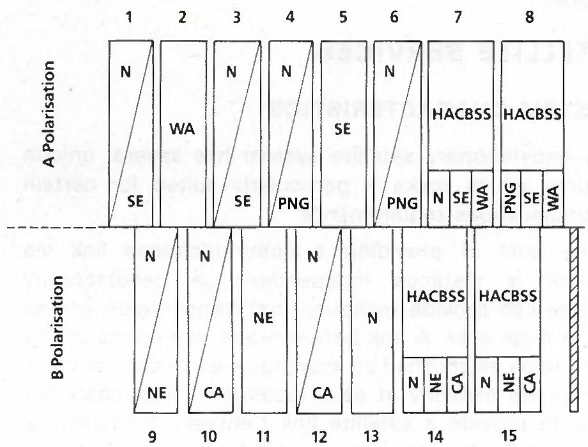
With the transmit beams there is greater operational flexibility. Seven of the eleven low power transponders on each satellite are capable of being switched between beams. The four high power HACBSS transponders are also switchable. The overall transmit switching capacity is depicted in **Fig. 2**, with the various transmit beams corresponding to the areas displayed in **Fig. 1**.

POWER

All commercial satellites currently use solar cells as their main energy source. Groups of photovoltaic cells are used to convert solar radiation into electricity. The solar cells must be protected against cosmic radiation and small meteorites by means of a quartz or glass skin 1 or 2 mm thick. In addition, an energy store is required for the periods during which the satellite is in the earth's

*Note: Orthogonal circular polarisation may also be used.

Australian Satellite Transponder Plan



Satellite Coverage Areas: N – National – All Australia
PNG – Papua New Guinea
NE – North Eastern Spot – Qld.
SE – South Eastern Spot – N.S.W., VIC. & TAS. (Effectively Brisbane to Adelaide)
CA – Central Australia Spot – N.T. & S.A.
WA – West Australian Spot – W.A.

Fig. 2

shadow. Nickelcadmium batteries are used for this purpose.

The generated energy is used to power the satellite's transponders and other sub-systems. However, constraints on the weight of a satellite result in severe restrictions on the amount of solar and back-up power equipment which can be carried. This means that there are stringent limitations on the power available for the transponders. It should be added that technological advances in this area are occurring constantly and in the near future more powerful transponders will be possible.

In the general configuration of a satellite system transponder power limitations can be compensated for by using narrower beams to concentrate radio energy and by increasing the transmission and reception power of earth stations.

EARTH STATIONS

GENERAL

Earth stations usually consist of a dish-shaped antenna and associated microwave receivers and/or transmitters.

One big difference, however, between an earth station and a microwave receiver/transmitter in a terrestrial microwave system is that an earth station has to receive and/or transmit over a much greater distance. The effects of this are compounded by the already limited transmission power of the satellite.

Nevertheless, in the case of receive-only earth stations it is possible to gain good quality reception with a small antenna and modest receiving equipment even though the signal received from the satellite is extremely weak. For example, through the HACBSS it will be possible in many areas to receive television on a receive-only station with a 1 to 1.5 metre antenna.

When an earth station is designed to transmit to the satellite, the size and cost of antenna and radio equipment increases considerably. This, of course, applies to both transmit-only and two-way earth stations. Costs naturally increase with the need for further equipment to interface with various ground telecommunications networks.

The precise size of the antenna required to transmit signals depends on, amongst other things, the transmission capacity required. There are antennas 30 metres in diameter currently in operation; however these are for wideband and thick route trunk capacity (e.g. international trunk telephony circuits). For a single circuit telephony grade transmission, a dish of at least 3.5 metres is usually required if satisfactory cost-efficient performance is to be achieved. In frequency bands above 10GHz the radio equipment, power supplies and antenna requirements also vary according to the intensity of rainfall at the location due to attenuation of the radio signals by rain.

TRACKING, TELEMETRY, COMMAND AND MONITORING STATIONS

Specially equipped earth stations are required to provide ground control for the satellite system. These earth stations are called "Tracking, Telemetry, Command and Monitoring Stations" (TTCM stations). Using a dedicated narrow bandwidth portion of both the uplink and downlink frequency ranges they send commands to and receive information from the satellite. The stations track the satellite's orbit and are able to command the satellite to fire the appropriate thrusters to correct any deviation from the proper orbit. They control the switching of beams between transponders and monitor the overall performance of the satellite system.

In the Australian system there will be two TTCM stations, located at Sydney and Perth. The Perth station will be on standby in case of failure of the Sydney station.

TRANSPONDERS ACCESS AND ASSIGNMENT

GENERAL

If a satellite telecommunications system is to offer the required flexibility and capacity it must be possible for each transponder to be able to provide for a number of distinct communications links between groups of earth stations at the same time. Without this multiple access to transponders, the system would only be able to carry as many simultaneous transmission links as it had transponders.

The two main systems of multiple access are:

- frequency division multiple access (FDMA), and
- time division access (TDMA).

FREQUENCY DIVISION MULTIPLE ACCESS

Historically, this proces is the older of the multiple access systems. It has been in use since the successful INTELSAT II launch in January 1967.

The principle is as follows: A special frequency, specific to station 1 transmits at F1, station 2 at F2 etc. These frequencies are spread over the total bandwidth of the transponder via which the particular stations communicate. Each station occupies only part of the transponder capacity.

For transmission each of the carrier frequencies (F1 etc.) is modulated by all communications which the earth station concerned wishes to transmit to the other stations. After retransmission by the satellite the carrier wave is recieved by all the other earth stations. This is demodulated and each earth station sorts out the communications intended for it.

The signals trasnmitted using an FDMA system are sometimes in analogue form.

TIME DIVISION MULTIPLE ACCESS

In the FDMA mode the earth stations all send different frequencies spread over the bandwidth of the transponder. In time division multiple access, each earth station transmits to the satellite on a common frequency occupying the whole bandwidth of the transponder. However, each station transmits in turn so that blocks of data from different stations reach the satellite in sequence. Transmission by each earth station is therefore repetitive and not continuous. A system of this type uses digital modulation. The signal must first be converted to digital form for adaptation to the sequential transmission technique.

By comparison with FDMA the TDMA mode presents a number of advantages:

- the transponder is used at maximum power since only one signal is amplified at a time; transmitter performance is thus substantially improved,
- the frequency plan is considerably simplified, and
- modification of the capacity of a station is facilitated by the use of digital techniques.

Furthermore, this type of transmission can be further improved by the use of digital conservation and concentration techniques. During the average telephone conversation each party speaks for slightly less than 50% of the time (listening, pauses etc.). Each transmission direction therefore carries no signal for half the time. Digital techniques make it possible to use these dead times to send other communications. The system assigns the transmission channels only during the periods of speech. The capacity of a satellite communications system of this type can thus be doubled.

PERMANENT ASSIGNMENT AND DEMAND ASSIGNMENT

To establish a communications link between two earth stations one can permanently assign, from the set of channels generated by the multiple access system, fixed transmit channels and fixed receive channels between the two. This method ensures that the stations can communicate to each other at any time and is similar to providing dedicated point-to-point links in the terrestrial network. Because it involves multiple access on a permanently assigned basis, this system is reffered to as Permanently Assigned Multiple Access (PAMA).

A system which offers much more flexibility and more efficient utilisation of transponder capacity is Demand Assignment Multiple Access (DAMA). All channels provided by the multiple access system are pooled and may be accessed by any earth station on demand. A link is set up between two earth stations only for the period that they require to communicate with each other. It is available for use by other earth stations as and when required.

SATELLITE SERVICES

SYSTEM CHARACTERISTICS

A geostationary satellite system has several unique features which make it particularly suited for certain communications requirements.

The cost of providing a communcations link via satellite is distance independent. A geostationary satellite can provide reception and transmission access over a huge area. A link between any two points in this area can be established by aligning an earth station of the appropriate capacity at each location. It thus costs the same to provide a satellite link between, for example, Perth and Brisbane as between Melbourne and Geelong. This contrasts with the distance dependent cost of providing equivalent links by terrestrial means. Satellite technology can therefore offer an economically attractive alternative to terrestrial provision for certain long distance point-to-point links. Because of this distance independence and wide coverage, a satellite system can also be used to provide services in sparsely populated remote areas where the distances between customers are large and the costs of providing a service by terrestrial means would be very high.

A satellite system is especially suitable for broadcasting purposes, whether radio or television. Any location within the transmit beam can receive the signal by using a relatively cheap receive-only earth station. The HACBSS is an example of this. Earth stations can be added and removed from the broadcast network at any time without disruption to the service.

Another feature of a satellite system is that it permits almost immediate provision of service. All that is required is to install and align the required capacity earth station and associated equipment: no other terrestrial support is needed. When a particular service is no longer required the earth station can be recovered and is ready for immediate re-use elsewhere.

CONFIGURATIONS

The inherent flexibility of satellite systems mean that a very wide range of communications links, networks and services are possible: one or two-way point-to-point, point-to-multipoint, private networks, links or networks which interconnect to the terrestrial network, etc. The system can carry any information which can be transmitted by using microwaves. The capacity of each of the links in a particular satellite communications configuration can range for example from a single voice grade channel up to a wideband service.

TYPES OF EARTH STATIONS IN AUSTRALIA

In addition to the HACBSS service to be provided by the ABC and certain other services to be supplied by particular Government bodies e.g. the Department of Aviation, the main types of services which will be provided by the AUSSAT satellite system will utilise configurations composed of the following groups of earth stations:

- AUSSAT Earth Stations: AUSSAT will own and operate Major City Earth Stations in each of the state capitals and in Canberra and Darwin (**see Fig. 3**). In Sydney and Perth these stations will be co-located with the TTCM stations.

  The Major City Earth Stations will contain the necessary equipment to receive and transmit radio, television, business data and telephone signals from and to the satellites. Customers will be able, if they wish, to lease capacity on these earth stations in order to establish communications links of the capacity they require. They will require tails (terrestrial links) from the AUSSAT stations to their own premises.

  AUSSAT is also purchasing some smaller earth stations for use in satellite tests and demonstrations.

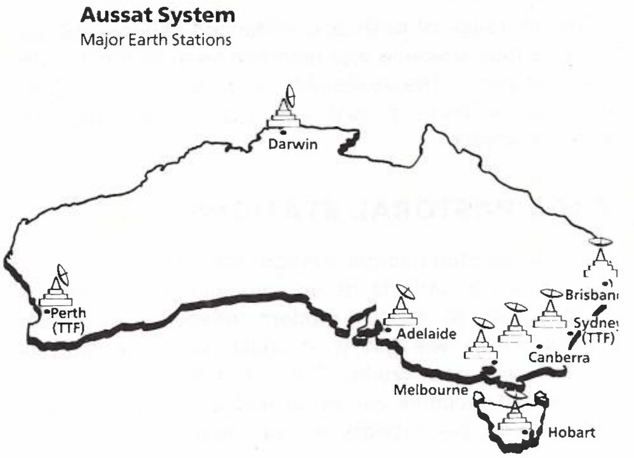


Fig. 3

- Privately Owned Earth Stations: Users of the AUSSAT satellite system will be able to own and operate their own earth stations. The size and type of the earth stations will depend on the user's requirements.
- Telecom Earth Stations: Telecom is purchasing earth stations which will enable it to offer customers a wide range of satellite communications facilities which will be discussed later.

TELECOM SATELLITE SERVICES

ITERRA NETWORK SERVICE

The first service via the domestic communications satellite to be offered by Telecom is the ITERRA NETWORK SERVICE (INS). This service will provide telephony, data (up to 4.8 kbit/s) and text facilities, connected to the national switched telephone network.

The Telecom INS service will be provided via a number of customer earth stations and one Main Earth Station (MES), a Central Control Facility (CCF) and an electronic digital exchange. The MES, CCF and electronic exchange will be located at Bendigo, Victoria, and will provide the interface between the satellite network and the terrestrial network. The service will employ DAMA techniques to assign satellite circuits on a demand basis to link the customer earth stations to the MES, and from these to the national network.

Customer earth stations will be available with from one to fourteen circuit capacity, according to the customer's requirements. The circuits can be used simply as exchange lines for telephones, small business systems, PABXs and other terminal equipment, or as junction circuits for local telephone exchanges provided by Telecom on a commercial basis (**see Figs. 4 to 6**).

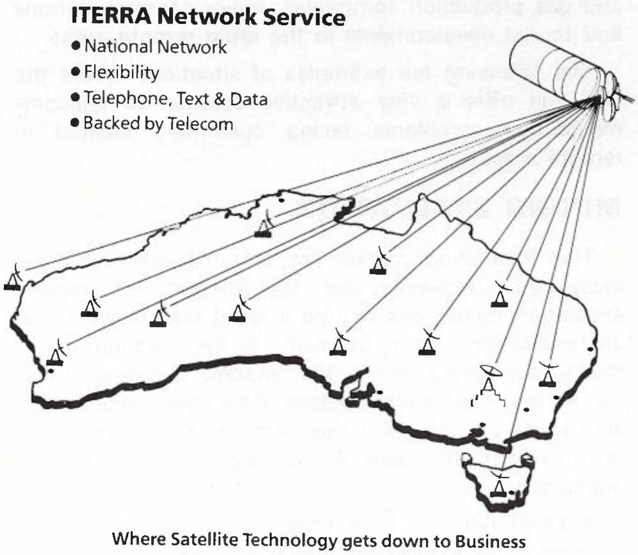


Fig. 4

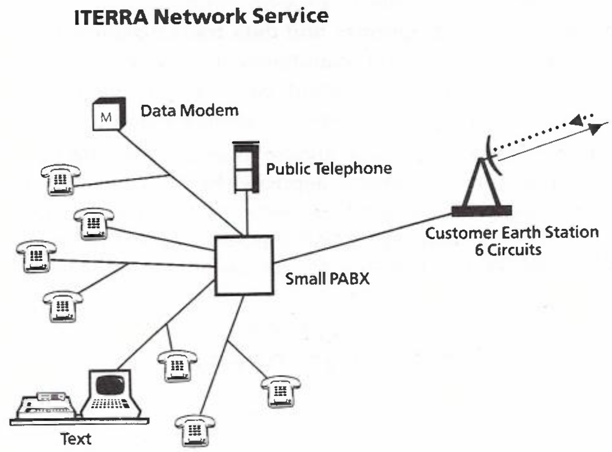


Fig. 5

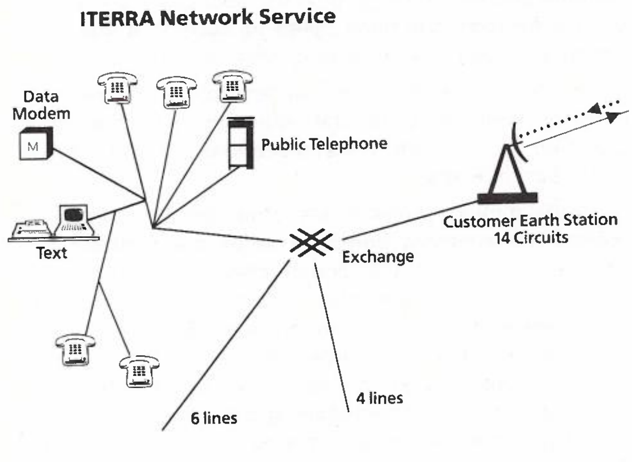


Fig. 6

The ITERRA NETWORK SERVICE will give Telecom the ability to satisfy immediate customer demand very quickly and will be of particular interest to organisations operating in the more remote areas of Australia.

Major industry groups who have expressed interest in the service are: mineral and exploration companies, oil and gas production companies, major pastoral stations and tourist developments in the more remote areas.

The following are examples of situations where the INS will offer a very attractive solution to telecommunications problems facing customers located in remote areas:

MINING EVALUATION

The fluctuating market for raw materials and the increasing complexity and sophistication of mineral evaluation techniques require a rapid transmission and analysis of data from "the field" to the headquarters of mining companies where final analysis and appraisal is carried out. The itinerant nature of the exploration teams also leads to an urgent requirement for modern communications in case of accident or equipment malfunction.

A small team of from three to ten people may be involved in the exploratory mining surveys, which require a high degree of mobility and reliability from their communications equipment.

The INS will be able to provide immediate access to the network for telephones and data transmission which will speed analysis and evaluation of mineral deposits. For this purpose a two-circuit earth station would be capable of providing the level of service needed.

If the exploratory phase should establish the commercial viability of the mineral deposits then the two-circuit station can be expanded as required to cater for the demands of a major extraction/processing plant together with a PABX or exchange for on-site communications.

LARGE MINING PROJECT— CONSTRUCTION AND OPERATION

Following the discovery of major, commercial mineral deposits in remote areas considerable planning and commercial investigation are required prior to committing large sums of money to develop "green field" sites. The commitment to develop major deposits is highly confidential and the ability to provide rapid communications once a decision has been taken to develop a site is of strategic importance to mining organisations.

The development of new mineral/oil resources is of national importance to the economy and the rapid provision of modern communications greatly assists Australian industry.

Major mining projects are often constructed by a project management company whos sub-contract the various aspects of the construction/installation to a variety of other companies. During the construction phase there are various companies working on the site who require their own telecommunications although when the project is completed the day-to-day operations can be monitored from the mining company's head office in a major urban centre far removed from the mining site. These telecommunications requirements are largely for voice with a relatively large number of low calling rate stations; text and data services are also required.

TOURIST DEVELOPMENTS

The growth in the leisure and tourist industry has led to an increasing requirement for tourist developments in "wilderness" locations. The attraction of these very remote tourist locations increases with the growth in the urbanisation of our society.

Whilst it may be acceptable for developers to provide their own water, electricity and sewerage arrangements it has been expected that telecommunications should be provided on demand. It is now possible through the INS to provide network connection whenever and wherever customers request.

The full range of basic and enhanced services will be available thus enabling any resort to keep in touch with their customers. The availability of modern communications in a "wilderness" setting is a major advantage for tourist locations.

LARGE PASTORAL STATIONS

A large isolated pastoral station possibly with only HF radio service to provide its communications at present will be able to obtain modern telecommunications facilities which will put it in touch with the rest of Australia and the world. The full range of network services and facilities will be available via the INS and connection to the network will be rapidly provided.

ITERRA SATELLITE SERVICES (ISS)

Telecom will also offer customers a range of satellite services specifically tailored to suit their needs. These services will be collectively known as ITERRA Satellite Services (ISS), and they will exploit more fully the flexibility which a satellite system has to offer. **(See Figs. 7 and 8** for some of the possible earth station configurations.)

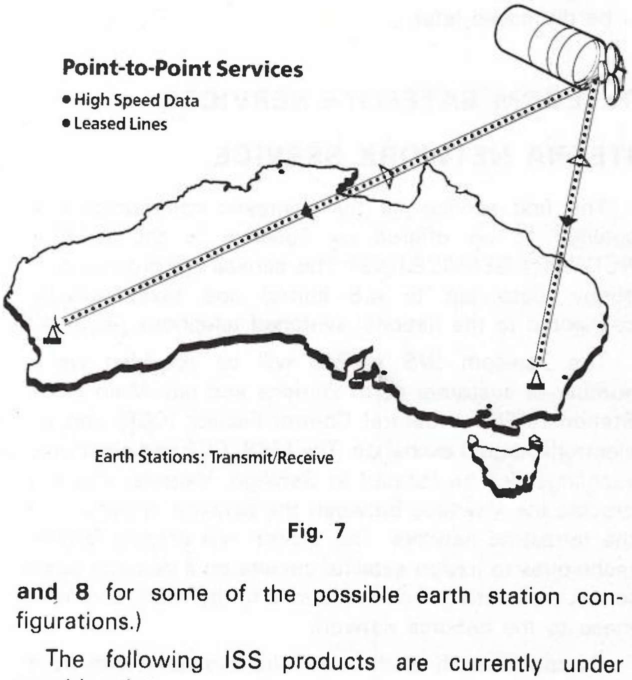


Fig. 7

The following ISS products are currently under consideration.

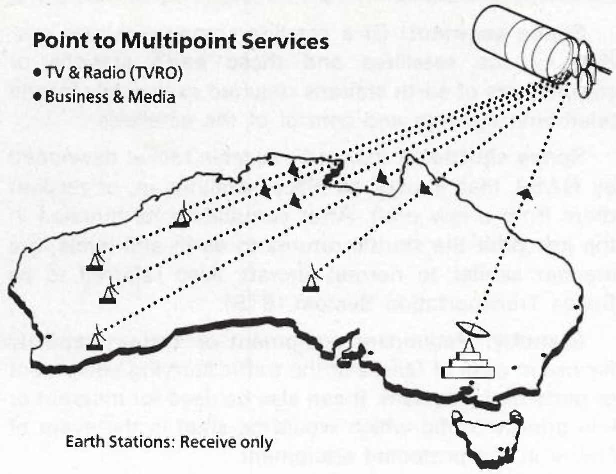


Fig. 8

● **Medium Speed Data Services**

Attractive for customers needing medium capacity links or networks under their own control for reliability reasons, or to reach remote locations. Connection to Telecom data services will be possible using these links.

● **National 48-64 Kbit/s Network Reliability Enhancement**

The reliability of a Telecom multi-location network is enhanced by one 48 Kbit/s link through the satellite being flexibly available to bypass any one terrestrial link which may fail for technical reasons. Alternatively, but at greater cost, a complete standby network can be provided using the satellite.

In these applications the service would be sold to the customer as a complete network featuring enhanced reliability.

● **Premium Point-to-Point 2 Mbit/s Service (SCPC)**

These services can be provided to customers needing such a link under their own control for security reasons.

● **National 2 Mbit/s Complete Backup Network**

This service completely duplicates a large customer's national terrestrial 2 Mbit/s network with satellite 2 Mbit/s links using ground equipment wholly dedicated to the customer.

● **Premium Point-to-Point 2 Mbit/s Service (TDMA)**

These services are most economically provided between capital cities where Telecom will have shared earth stations, but other locations can be included if demand warrants. 8 Mbit/s services could also be provided, and 48 Kbit/s and lower data speeds would be economical between the shared earth stations.

● **National 2 Mbit/s network Reliability Enhancement**

Reliability of a 2 Mbit/s (or higher) terrestrial network can be enhanced as described for 48-64 Kbit/s. The satellite link uses the Telecom system master earth station for clocking and synchronisation.

● **2 Mbit/s Communications Package**

This service is similar to the premium point-to-point service, but includes voice/data/text multiplexing to meet the customer's needs.

GLOSSARY

Amplifier: A device to increase or amplify electrical signals.

Antenna: As used in earth stations, usually a dish-shaped metal reflector used to collect radiowave energy from the appropriate direction of reception and focus it onto the input point of a cable or other suitable device connected to a receiver or conversely, to collect the radiowave from the output of a cable or other suitable device connected to a transmitter and launch this wave in the direction of transmission.

Bandwidth: The width of a transmission channel or circuit, in terms of Hertz.

Broadcasting: A radio communications service in which the transmissions are intended for direct reception by the general public; the service may include sound transmission, television transmissions or other types of transmissions.

Channel: A uni-directional transmission path.

Circuit: A transmission path allowing transmission of signals in two directions — usually made up of two channels in opposite directions.

Communications satellite: A satellite which is designed to be launched into and operated from an orbit around the earth with communications equipment on board for receiving and transmitting radio signals, and also containing other equipment required for this purpose such as power generation (usually batteries and solar cells), position-keeping equipment and control facilities.

DAMA: Demand assignment multiple access — see demand assignment and multiple access.

Demand assignment: A process whereby a given circuit or channel can be assigned and seized on demand by any one of a group of users, between any given points within the communications system. For example, in a telephone satellite service, 65 subscriber earth stations could provide a total of 400 available channels which use a pool of 200 circuits in the transponder. Each channel can provide service to about three customers who are assigned satellite circuits as and when required.

Downlink: The radio path from a satellite to an earth station.

Earth segment: Of a satellite communications system, consists of those earth stations or earth station components required solely for communications purposes through the system.

Earth station: A radio communication station on the surface of the earth used to communicate with satellites.

Geostationary orbit: The orbit in which a satellite should be placed to be a geostationary satellite.

Geostationary satellite: A satellite, whose circular orbit lies in the plane of the earth's equator and which revolves at the same speed and direction as that of the earth's rotation thus causing the satellite to appear stationary when viewed from the earth.

Ground control: Those facilities and components of the space segment located on the earth or ground for the functional control of the orbiting satellites.

HAC BSS: Homestead and Community Broadcasting Satellite Services. The provision of radio and television broadcasts via satellite to outback Australia.

Hertz or Hz: A unit of one full cycle or wave per second; used in the description and measurement of the frequency of electrical or other wave phenomena.

INTELSAT: Business name of the International Telecommunications Satellite Organisation.

Multiple access: The use of a satellite transponder by more than one earth station.

Multiplex: A process of combining two or more signals from separate sources into a single signal format for sending on a transmission system.

Propagation delay: The time taken for a radio signal to travel from its souce to its destination.

Receiver: A device to receive radio signals within a communications system.

Relay: Interchangeable sometimes with the term "repeater" in microwave radio communications systems; in broadcasting, a station which broadcasts a programme which it receives from another station.

Repeater: In telecommunications — a station used for receiving, amplifying, and retransmitting a signal either in a microwave radio communications system or a cable system. In a microwave radio communications system the signal is usually shifted to a different position in the radio spectrum — see transponder. In broadcasting — a station whose programme source consists of recorded material only.

Satellite communications system: A communications system consisting of at least one communications satellite in orbit and at least two earth stations which communicate via the satellite.

Space segment: Of a satellite communications system — the satellites and those earth stations or components of earth stations required exclusively for the telemetry, tracking and control of the satellites.

Space shuttle: A manned, reusable rocket developed by NASA that is used to place satellites in, or recover them from a low orbit. After completing its function in the low orbit the shuttle returns to earth and lands in a manner similar to normal aircraft. Also referred to as Space Transportation System (STS).

Standby: Redundant equipment or system capacity for use in case of failure of the traffic carrying equipment or parts of the system. It can also be used for itinerant or low priority traffic which would be shed in the event of failure in the protected equipment.

Tail: The terrestrial link between a satellite earth station and the customer's premises.

Transmission delay: The time taken by an electrical signal to travel through the transmission system from its source to its destination; see also propagation delay.

Transmitter: A device to transmit radio signals within a communications system.

Transponder: A communications device on board satellites used for receiving an retransmitting radio signals, generally from and to earth stations.

TTCM: Tracking, telemetry, command and monitor — a general description of the facilities required to monitor the functioning and performance of satellites, track their position and control their functioning.

Uplink: The radio path from an earth station to a satellite.

Wideband: A term used to describe the high capacity of the transmission systems used for large blocks of telephone circuits or video channels.

Information Transfer News

GTE's GSTAR I satellite place in geosynchronous orbit

McLEAN, Va., USA — GSTAR I, GTE's third communications satellite, was placed in geosynchronous orbit 22,300 miles above the equator after the successful firing and burn of GSTAR's apogee kick motor (AKM) in May 1985.

The AKM was fired approximately 90 hours after the satellite was launched by Arianespace on board an Ariane 3 launch vehicle on May 7, from Kourou, French Guinana. Since the launch, GSTAR I had been in an elliptical transfer orbit, approximately 120 miles from earth at its closest point and some 22,000 miles away at the most distant point. GSTAR I, now undergoing in-orbit performance test, will be in a controlled drift over the next several days until it reaches its final location at 103° West Longitude.

GSTAR I joins SPACENET I launched in May 1984 and SPACENET II launched in November 1984. The GSTAR I launch was under the responsibility of Arianespace, the private space transport company based in France.

GTE plans to launch SPACENET III in September and GSTAR II in December. Together the SPACENET and GSTAR satellites will offer the widest choice of frequencies (C and Ku-band), bandwidths (36, 54 and 72 megahertz) and power (8.5, 16, 20 and 27 watts) to meet the voice, video and data needs of any customer.

All GTE satellites are monitored and controlled from the GTE Spacenet Satellite Control Centre at Spacenet headquarters in McLean, Va.

Released by GTE Australia
P.O. Box 160
Box Hill, Vic. 3128

Legal Aspects of Australian Domestic Satellite Service

P. BRAVENDER-COYLE

In this day and age, often the legal aspect is more complicating than the technical issues. With the advent of the Domestic Satellite Service, it is essential that we have some appreciation of the legal aspects of the service. This paper deals with the legal side of a new and exciting service — the Domestic Satellite Service.

The Federal Government has recently announced[1] the ground rules governing the operations of Aussat, the Australian domestic satellite service.[2]

The purpose of Australia's satellite system is to provide direct-to-home television and radio broadcasting, some telephone services to remote areas,[3] and new service in urban localities.

Quite apart from the facilities which Aussat could provide, it was essential for the Federal Government to act quickly to secure appropriate frequency bands and orbital positions while they were still available. As the Task Force on National Communications Satellite Systems stated:

> It might be imagined that, with a synchronous satellite orbit lying 35,780 kilometres out in space, there would be ample room for all of the synchronous satellites which might be required, by all countries. Such is not the case (. . .) It is in Australia's interests to establish the orbital positions which it will need (. . .) and to ensure that these positions are not lost to her by allocation to other countries (. . .) it is clear that early action would be needed to secure suitable orbital positions following a decision to introduce an Australian satellite system.[5]

Australia's satellites will be of the geostationary type. A satellite in a geostationary/synchronous orbit (a circular equatorial orbit at a distance of approximately 36,000 kms from the equator) circles the earth at the same speed as the earth revolves and thereby remains stationary/synchronized relative to a particular point on the surface of the earth.[6]

A lot of debate has taken place in the public arena about how Aussat should operate[7] and who should have access to it.[8]

However, this article is concerned solely with the legal implications of the operation of Australian telecommunications satellites.

SATELLITE COMMUNICATIONS ACT

The **Satellite Communications Act** 1984 (Cth.) was enacted by the Australian Parliament in early 1984 and came into operation last April.

Essentially, the legislation sets out the functions and purposes of AUSSAT Pty. Ltd. (called 'Aussat' in the legislation), a company incorporated in Australian Capital Territory in 1981, and governs the operations of its domestic satellite services.

Although Aussat is a private company — indeed the Act states that it cannot be converted to a public company — shares in the company can only be held by the Commonwealth, the Australian Telecommunications Commission, or a person as trustee for the Commonwealth.

However, the legislation restricts the influence of the Australian Telecommunications (commission over Aussat) because it provides that the number of shares in Aussat held by the Commission shall not exceed 25% of its issued shares and that at least three-quarters of its directors must not be 'prescribed persons'. A prescribed person means the Managing Director of the Commission (or another Commissioner holding office under section 22 of the Telecommunications Act 1975) or a person holding an office in the Australian Telecommunications Commission Service which is higher than a State manager or controller.)

The legislation states that it is the intention of Parliament that Aussat have as its primary object the carrying on of business, in accordance with sound commercial principles, of providing: (a) a telecommunications system for Australia by the use of satellites; and (b) space satellite facilities for use in telecommunications systems for neighbouring regions (including Papua New Guinea and other ares in the South West Pacific area). It also states that Parliament's intention is that the Australian Telecommunications Commission's telecommunications system and the telecommunications system provided by Aussat by the use of space satellites will provide the national telecommunications network for Australia.

It will be noted that Aussat is required to carry out its operations "in accordance with sound commercial priniciples". Indeed, the legislation specifically states that nothing in the Act or in any other Act shall be read as requiring Aussat to allow the use by any person of facilities in an Aussat satellite, or to provide any other facilities or any services to any person, without adequate payment to, or other adequate reward for, Aussat.

The directors of Aussat are required to have regard for these objectives and to ensure that, as far as practicable, Aussat is able to meet the requirements for space facilities:

- of the Commonwealth for the purpose of providing and maintaining air navigation facilities and related safety purposes;
- of the Australian Broadcasting Corporation for the purpose of providing television and broadcasting services to remote communities and dwellings; and
- of the Australian Telecommunications Commission for the purpose of providing telephonic services in remote areas and emergency services.

However, Aussat is not to provide certain types of services, viz., public switched telephone services and public switched data services.

No one (except Aussat, the Australian Telecommunications Commission, the Australian Postal Commission, the Overseas Telecommunications Commission, or a person declared by the regulations to be eligible to do so) is allowed to use a facility in an Aussat satellite for the purposes of carrying on the business of providing facilities between other persons.

Penalties of up to $50,000 are provided for anyone who, without reasonable excuse, transmits a signal to an Aussat satellite otherwise than in accordance with the agreement or approval of Aussat.

It is also an offence for a director, officer or employee of Aussat to disclose or record the contents of telecommunications messages, and the Act provides a penalty of two years imprisonment for such an offence. However, the legislation states that this does not prohibit "the doing of anything by a person" in the performance of his duties as a director, officer or employee of Aussat, or as a witness summoned to give evidence or to produce documents in court, or under a Commonwealth or Territory law, or "in other prescribed circumstances, being circumstances in which the doing of the thing was in the public interest".

Regulations can be made under the Act prescribing matters relating to the use of Aussat facilities, prohibiting the sending by a satellite service provided by Aussat of indecent, obscene or offensive communications, or the use of such a service for the purpose of harassing someone. Penalties of up to $1,000 may be prescribed for offences against the regulations.

However, the legislation states that such regulations may be made subject to any agreement (including a treaty or convention) between Australia and any other foreign country.

INTERNATIONAL LAW

The legislation also states that the directors of Aussat must, in the performance of the duties, have regard to, and endeavour to comply with, the obligations of Australia under international law.

It might be useful, therefore, at this stage to examine some of the types of problems which may arise under international law.

However, a word of caution is necessary about the term 'state'.

Australia has a federal system like the USA, Canada, India, Switzerland and the Federal Republic of Germany. The entities in these federal systems are variously called States (Australia, USA, India), Provinces (Canada), Lander (Federal Republic of Germany) or Cantons (Switzerland).

However, generally speaking, these federal entities have no status in international law. Only states (i.e., countries) and international organizations (e.g., United Nations, World Health Organization, International Postal Union, International Telecommunication Union).

In this sense, Australia, New Zealand and the United Kingdom are states in international law, but New South Wales and Victoria are not.

JURISDICTION

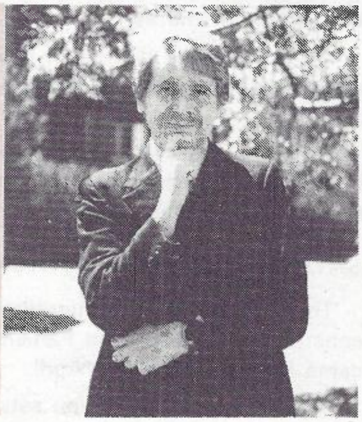
Clearly, Australia would have jurisdiction over an Aussat telecommunications satellite. Article VIII of the **Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies** 1967 **(Outer Space Treaty)** provides that jurisdiction and control over satellites and other objects launched into outer space is vested in the state of registry while the projectile is in outer space.

Australia will probably effect registration in accordance with Article (II(i) of the **Convention on Registration of Objects Launched into Outer Space** 1975.

STATE RESPONSIBILITY

Under Article VI of the **Outer Space Treaty,** Australia bears international responsibility for its national activities

PAUL BRAVENDER-COYLE is a Barrister and Solicitor of the Supreme Court of Victoria and a full-time member of the Faculty of Law, Monash University. He has published numerous articles on legal aspects of new developments in science technology, as well as on space law generally.



in outer space. This applies not only to activities carried out by the Australian Government or its agencies, but also a non-governmental entity such as a private commercial enterprise.

Thus, if the Australian Government were to licence a consortium to operate telecommunications satellite services, Australia would still be responsible in international law for their activities, even though the Australian Government did not exercise any direct or indirect control over their activities. Indeed, failure to undertake this responsibility would constitute a breach of the requirement contained in the same Article that the activities of non-governmental entities in outer space shall require authorization and continuing supervision by the state concerned.[9]

STATE LIABILITY

There have been a number of instances of debris from satellites falling to earth, sometimes causing damage.

In 1962 a part of Sputnik IV, weighing nearly 10 kg, fell on Manitowoc, Wisconsin, USA.[10]

In 1969, some debris from a USSR space object broke a kitchen window in Southern UK.[1]

On 24 January, 1978, debris from the Soviet satellite Cosmos 954 fell in a remote part of the North-West Territories in Canada, causing moderate radiation.[12]

And, of course, debris from Skylab falling over Western Australia.

The question of liability is dealt with in Article VII of the **Outer Space Treaty.** This provides that a state which launches or procures the launching of an object into space is liable for damage to another state or to its natural or judicial persons.

This provision is so general that it has been necessary to supplement it with the **Convention of International Liability for Damage Caused by Space Objects** 1972.

Article II of the Convention establishes **strict liability** for damage caused by a space object on the surface of the earth or to aircraft in flight. Article III, on the other hand, establishes **fault liability** for damage to another space object in flight and to individuals aboard it.

Articles IV, V and VI deal with joint liability.

However, an Australian citizen or legal person could not bring an action against the Australian Government for damage caused to them by an Australian satellite since under Article VII the provisions of the Convention do not apply to them. They could, of course, bring an ordinary civil action in an appropriate Australian court.

Under Article XI, an Australian citizen who suffered loss or damage caused by a foreign satellite, or a person in a foreign state who was injured by an Australian satellite, does not have to exhaust the resources of their own legal system before they can bring a claim under the Convention. But, of course, it would be the state which brings the action on behalf of the individual or legal person.

If the claim could not be settled through the normal diplomatic channels, a mixed claims commission would be established at the request of either party.

There appears to be no upper limit on the amount of compensation which may be awarded.

FREEDOM OF BROADCASTING

The concept of freedom of broadcasting appears to be a well-established principle of telecommunications law,[13] analogous to freedom of flight and freedom of the high seas.

There are, however, three limitations to this principle.

First, there are the provisions contained in the **International Convention Concerning the Use of Broadcasting in the Cause of Peace 1936**[14] prohibiting broadcasts which incite armed revolt, revolution or war or other propaganda endangering internal state security or order.

Thus, if Radio Australia were to use Australian telecommunications satellite facilities to broadcast to other countries, it would have to take account of this limitation. However, it does not preclude it from engaging in propaganda similar to that of the foreign services of the BBC, 'Deutsche Welle', 'Radio Liberty', 'Radio Free Europe' or 'Radio Moscow'.

Secondly, it is clear that pirate radio stations (and, a fortiori, transmissions from pirate radio stations using telecommunications satellite facilities) are excluded from the principle of freedom of broadcasting, and that the Federal Government, which has jurisdiction in this matter, would soon crack down on them.

Finally, the third limitation on the freedom of broadcasting related to the sharing of the frequency spectrum and the need to prevent harmful interference[15] among broadcasting or transmitting stations.

Of course, the direct television broadcasting via satellite raises a number of difficult issues concerning developing countries and freedom of information which need not concern us here.[16]

COPYRIGHT AND PIRACY

Unauthorized re-broacasting of programme-carrying signals transmitted by satellite can easily occur.[17]

Under the **Convention Relating to the Distribution of Programme-carrying Signals Transmitted by Satellite** 1974, **(Brussels Convention)** the state is required to take 'adequate measures' to prevent signal piracy within its territory.

AUSTRALIA INTO THE SPACE AGE

As well as AUSSAT, the domestic communications satellite, Australia is also involved in the following satellite projects:

- INTELSAT, the overseas communications satellite;
- LANDSAT, the US survey satellite;
- the Japanese meteorological satellite;
- a study of STARLAB, the orbiting optical satellite.

The establishment of telecommunications satellites will be followed by another step into the space age : the Starlab project — a joint venture by the USA, Australia, and possibly Japan.

Starlab is an orbiting telescope which will be launched in 1990. It will be stationery 400 km above the earth, free of the atmosphere. Since it will have no dust, clouds or ozone layer to worry about, it will be able to see stars and galaxies 20 times weaker in intensity than the faintest ones visible using Earth-based telescopes. It may even answer the perennial question of whether the universe will keep expanding indefinitely or if it will eventually contract under the pull of gravity.[18]

The Department of Science and Technology has also recommended to the Federal Government the establishment of a working party to study the best way to launch an Australian space programme, including the establishment of a national space agency.[19]

Australia's contribution to Starlab will be the construction of the scientific instrumentation package.

Although Canada, one of the original project parties has withdrawn, it is possible that it will be replaced by Japan or the European Space Agency.

If all goes well, then the project, which is described by the Federal Minister for Science and Technology, Barry Jones, as "potentially the most exciting scientific experiment of the twentieth century", could go up in 1988 or 1989.

INTO THE FUTURE

Plantetary exploration is like an insurance policy for mankind. If a self-sufficient colony were established on another planet, then any ultimate catastrophe, either man-made or nature, which befell mankind on earth would not destroy all.[20]

Indeed, not only interplanetary travel, but also interstellar travel will have to be perfected before our Sun consumes all its hydrogen and develops into a red giant, thereby destroying all life in our solar systems.

But that is an event in the remote future. In the meantime, the special environmental properties of outer space — weightlessness, hard vacuum, limited energy, and high vantage point — could be used to manufacture substances more efficiently, more precisely and more economically than on earth.[21] The mineral resources of nearby planets could be mined.[22]

The nuclear debate could finally be ended because with current technology we could put high solar collectors into orbit. The energy that they would provide would eliminate the need for coal and gas power plants.

With current technology we could send nuclear wastes on a collision course with the sun. The wastes would vaporize immediately.

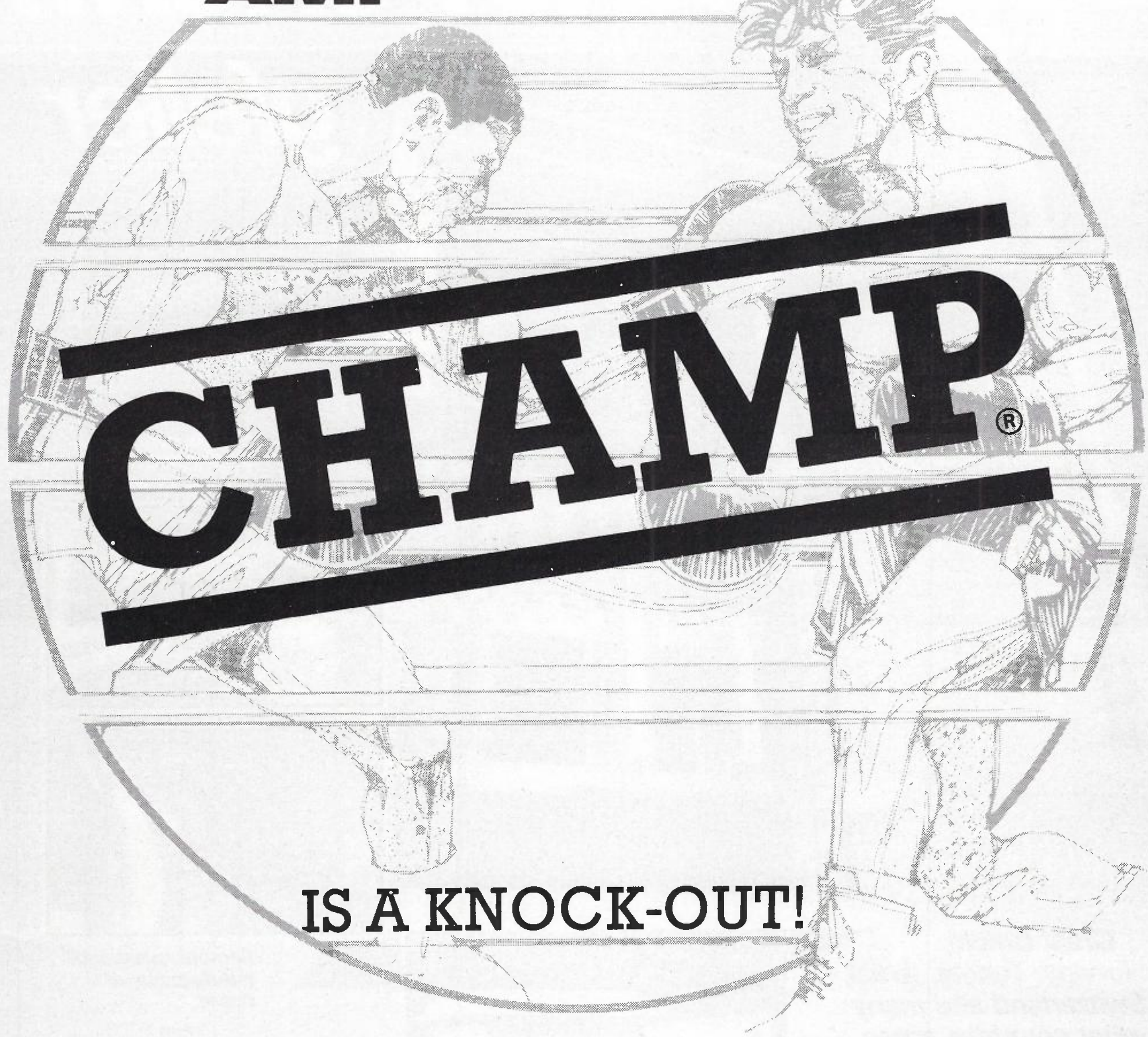
Of course, such projects would undoubtedly be very costly. But outer space is humankind's next logical frontier. It offers us unlimited energy and new supplies of resources.

Space challenges us to explore, just as humans have done for millenia, and it may even hold the answers to those enigmas which have puzzled humankind for centuries.

FOOTNOTES

1. 'Government Says "Yes" to Satellite Project': Press Release by the Federal Communications Minister Michael Duffy, 13 July, 1983 (1983) 54 Australian Foreign Affairs Record 362-364.
2. G. Earl, 'Ground Rules Established for Space Age Transmission' **West Australian**, 21 November, 1983, 9.
3. F. A. Coates, 'Beyond the Black Stump: Satellite Communications in Outback Australia' (1983) 33 **Telecommunications Journal of Australia** 45-48.
4. J. Stackhouse, 'Aussat Opens Up New Age in Technology' **Bulletin**, 22 November, 1983, 26-27; Comment, 'Australia's Satellite Services (AUSSAT)' (1983) 54 **Australian Foreign Affairs Record** 89-93; Comment, 'Our Link in the Sky' **Bulletin**, 22 November, 1983, 107-108, 110.
5. Commonwealth Government Task Force, **Report on National Communications Satellite Systems** (Canberra, Australian Government Publishing Service, 1978) 84. See also Working Group Report, August 1979 (Canberra, Australian Government Publishing Service 1979) 73-83; Comment, 'Domestic Satellites System for Australia' (1981) **Two World Space News Two**.
6. N. M. Matte, **Aerospace Law , Telecommunications Satellites** (Toronto, Butterworths, 1982) 6-7.
7. Commonwealth of Australia, Committee of Inquiry into Telecommunications Services in Australia, Report: National Satellite System, Background paper (1982) vol. 2, 25-28; M. Turnbull, 'How AUSSAT Should Work' **Bulletin**, 26 July, 1983, 22-24; J. Stackhouse, 'Clipping the Wings of Aussat' **Bulletin**, 29 November, 1983, 32, 34.
8. J. A. Gillam, 'Organising for Access to Australia's Domestic Satellites' : Paper delivered to the 52nd ANZAAS Congress, 1982, paper no. 33/82, 1-8; B. Bonney, 'Satellite the Key to Democratic Control' **New Journalists**, no. 40, May, 1983, 20-23; N. Ryan, 'Public Broadcasting in the Twilight Zone' **New Journalist**, no. 42, December, 1983, 35-38.
9. Matte, op. cit. 81-82.
10. UN Committee on the Peaceful Uses of Outer Space, A/AC. 105/PY. 15 33-34 (1962); S. H. Lay and H. J. Taubenfeld, **The Law Relating to the Activities of Man in Space** (Chicago, 1970) 137.
11. Lay and Taubenfeld, loc. cit.
12. **The Times**, 24 January, 1978, and 31 January, 1978.
13. Matte, op. cit. 66-68.
14. 186 L.N.T.S. 303.
15. Matte, op. cit. 69-70.
16. Ibid. 186-187.
17. Ibid. 199.
18. B. Wright, 'Starlab : A Close-up of the Future' **Age**, 24 March, 1984.
19. Note, 'Call for Study of Space Role' **Age**, 24 March, 1984.
20. United Nations, **The World in Space** (Englewood Cliffs, N. J.., Prentice-Hall, 1982) 108.
21. N. M. Matte, **Space Policy and Programmes Today and Tomorrow : The Vanishing Duopole** (Montreal, Institute and Centre of Air and Space Law, 1980) 115-116.
22. W. A. Gale (ed.), **Life in the Universe : The Ultimate Limits to Growth** (Boulder, Colorado, A.A.A.S. — Westview Press, 1979).

AMP

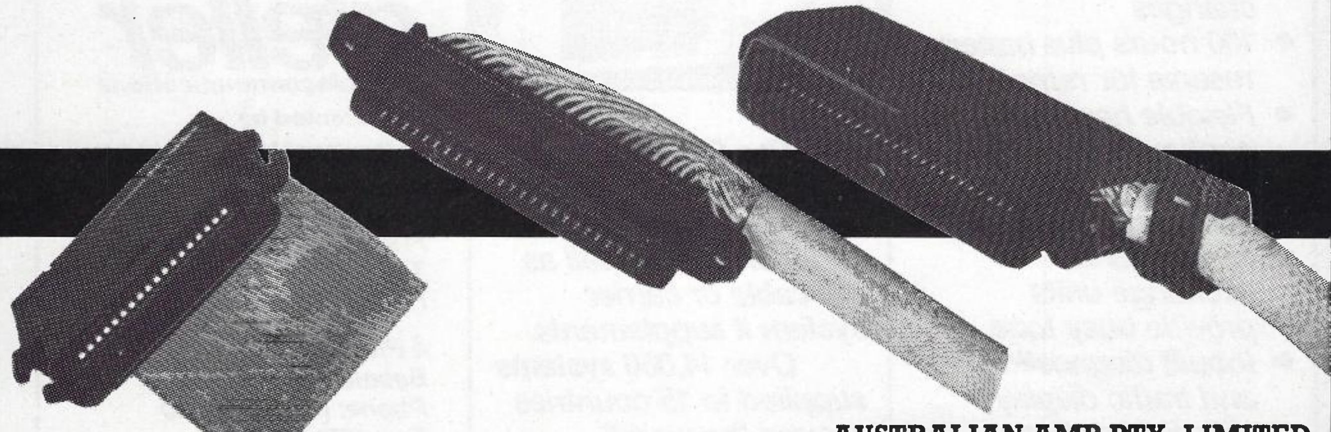


IS A KNOCK-OUT!

FOR COST EFFECTIVE TERMINATION OF PBX's, SBS, OR ANY OTHER
25 PAIR SYSTEM CALL **AUSTRALIAN AMP**

Only **AMP** can offer: • THE RIGHT PRODUCT • THE RIGHT TOOLING • IN FIELD TRAINING • THE FULL TECHNICAL BACKING OF AMP INC. (USA)

AUSTRALIAN AMP - THE CHAMP CHAMPS



AUSTRALIAN AMP PTY. LIMITED
(02) 680-3377
Telex AA22195

The Planning of Operations in Telecom Australia

R. K. McKINNON, BE, DPA, FAIM
General Manager
Network Engineering Dept., Telecom.

Telecom Australia administers the public telecommunications service in Australia. It has developed a sophisticated strategy for planning and operating its network and for controlling its resources. This strategy is continually evolving so as to manage the rapid changes in the interactions between telecommunications technology, social and commercial needs. The special needs in a country with a very uneven population spread have to be particularly addressed.

INTRODUCTION

This paper provides an overview of the environment in which Telecom Australia administers its legislative responsibility to operate the public telecommunications service on the Australian continent. It outlines the processes used to plan the development of the network in its entirety, of the major planning strategies and of systems used to monitor and control operations and the use of resources within the administration.

HISTORY

Australia has a population of 15.5 million which is mainly concentrated on the eastern and south eastern coastal strip as shown in **Fig. 1**. About 70% of the people live in the capital cities of the six States.

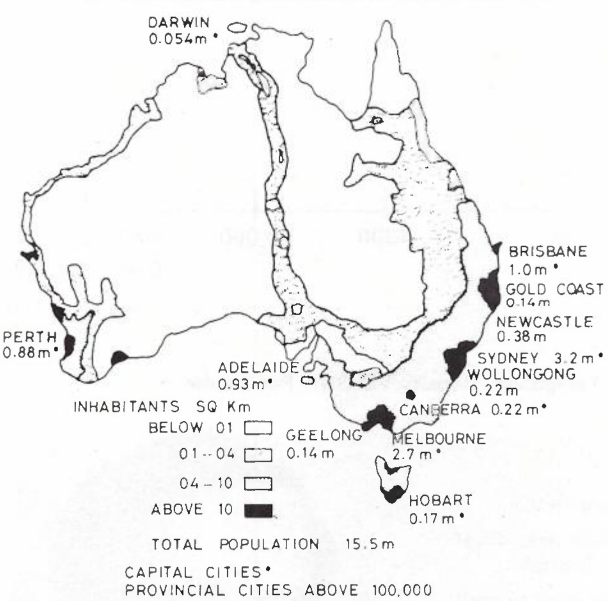


Fig. 1. Population Distribution in Australia.

Australia's first European settlement occurred in 1788. During the 1800s industry was mainly agricultural but in this century the structure of the workforce has moved as shown in **Fig. 2**. A high growth rate in the information section is significant.

In spite of the low surface population density, telephone penetration has always ranked reasonably high

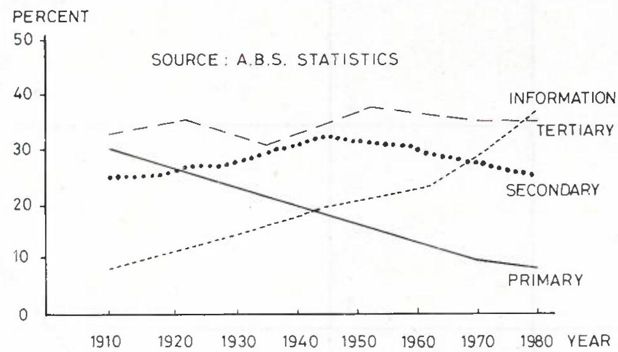


Fig. 2. Structure of the Australian Workforce 1911-1980: Occupation Approach.

by world standards **(Fig. 3)**. There are approximately 6.0 million telephone services with 85% of homes having service.

A corporate objective is to provide 90% of Australian houses with a telephone by 1987. The network is growing at about 270,000 lines per year with over 50 of the growth occurring in the country areas. The existing telecommunications network also provides all of the basic telecommunications services, including telex, data and facsimile.

The special nature of Australia's population dispersion has meant that special regard has always been paid to the needs for telecommunications services of the population outside the cities. One effect from the dispersion is that 90% of the telephone exchanges are each equipped for fewer than 200 services.

NETWORK DEVELOPMENT

Automatic switching has progressed extensively and today only 0.4% of telephone population is without automatic service. The manual services that exist are in the remote outback areas and it is planned to have 100% automation by the year 1989.

There are high penetrations of Subscriber Trunk Dialling (STD) (96%) and International Subscriber Dialling (ISD) (75%) traffic.

The 6.0 million telephone services are accommodated on a mixture of step by step (18%), Ericsson Crossbar (45%), Ericsson ARE with electronic register (36%) and

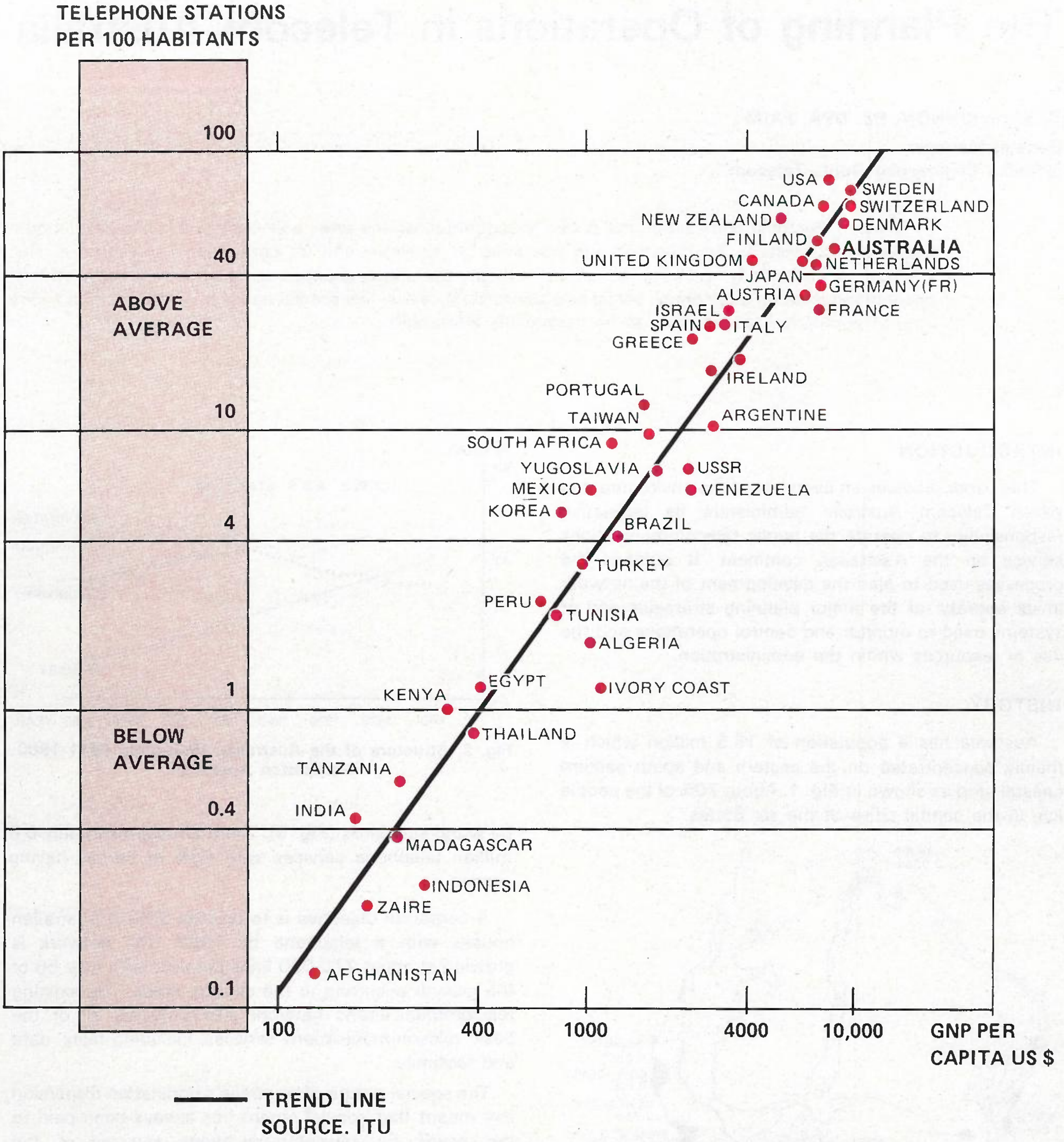


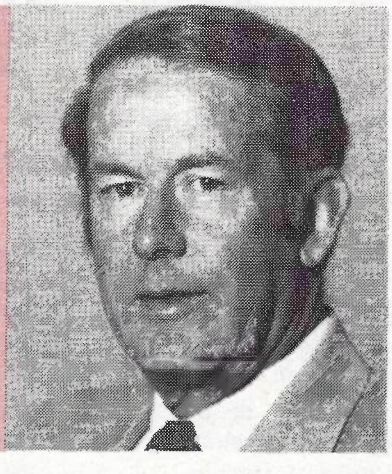
Fig. 3. Telecommunications Development — Telephone Density VS GNP Per Capita.

BOB McKINNON B.E., Dip. Pub. Admin.
General Manager — Network Engineering Department, Headquarters.

Promoted to present position in September 1983, previously was Chief Services Engineer for 3 years and prior to that Chief Planning Engineer.

In earlier appointments, responsibilities have included an Engineering staff position dealing with Technical and Design Policy, management of a Plant Branch (Data and Telegraphs) after earlier engineering experience in SA transmission and telegraph equipment and later at HQ the design and implementation of teleprinter and data switching systems for public and private networks and of voice switching and control equipment of various kinds for application in private networks.

He is the immediate Past Chairman of the Council of Control of the Telecommunications Society of Australia.



Ericsson AXE digital (1%) exchanges. Trunk or toll switching is provided by Ericsson ARM exchanges except for 7 large SPC exchanges — ITT 10C.

This composition will change rapidly between now and the year 2000 as SPC digital systems are phased in and the electro mechanical systems are phased out. (**Fig. 4**).

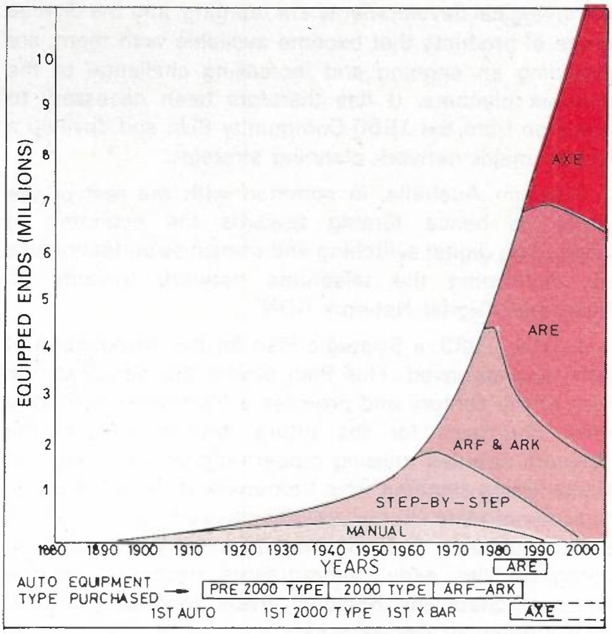


Fig. 4. Growth of Local Telephone in Australia.

Recent important decisions are charting the course of telephony network development towards the growth of a National Integrated Digital Network (IDN). The IDN comprises AXE digital equipment as a standard for local terminal and transit switching integrated with PCM 30 digital transmission equipment into a unified digital technology.

The general network planning strategy is to overlay the IDN over the existing analogue network on a co-ordinated basis as shown in **Fig. 5.** This approach will

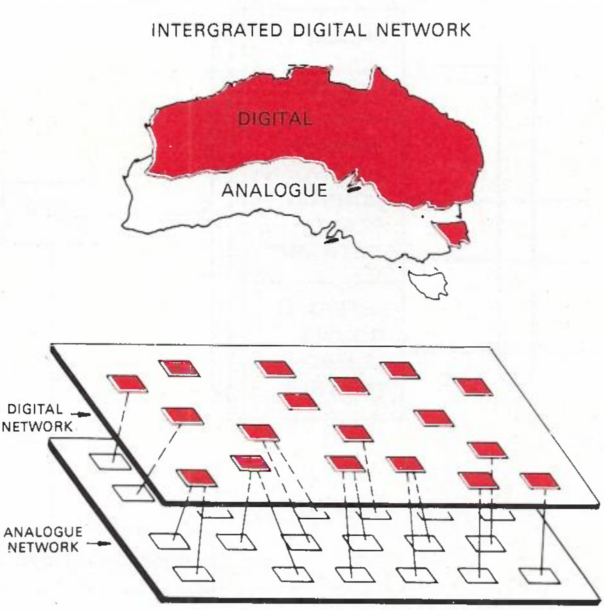


Fig. 5. Digital Overlay Network.

facilitate rapid expansion of the IDN through both urban and country networks. It will also provide an overlay of equipment with modern customer facilities with the potential to meet the special needs of customers in advance of the establishment of a fully national IDN. The digital signals will be transmitted over a combination of metallic conductor cables, optical fibre cables and digital radio systems, the choice depending largely on required capacity.

Rapid developments in teleprocessing since the mid 1960s have created a large and growing demand for data communication services. Until 1982 these services were supported by the Public Switched Telephone Network (PSTN), analogue leased circuits and a telex network. However there are many new teleprocessing applications emerging which require more flexible, efficient and reliable data communications facilities.

Two new national data services are now in operation. The Digital Data Network (DDN) provides the Digital Data Service (DDS). This is a TDM based synchronous hierarchical network for the provision of point-to-point and multipoint data services. Also a Packet Switched Data Service (called AUSTPAC) has been provided. Both the DDN & AUSTPAC are new digital networks overlaying the existing network.

The establishment of the IDN paves the way for the provision of completely digital paths from customer to customer. The provision of an Integrated Services Digital Network (ISDN) is now being planned which would offer shared individual paths to the customers' premises for the incorporation of voice digital services and many of a wide range of data services. All would be compatible with the 64Kbit/s switched digital connections. Implementation of the first stages of an ISDN is planned for 1988.

PLANNING PROCESSES

Telecom Australia needs to be well positioned in the telecommunications market to provide to its customers modern, up to date economic facilities at an appropriate quality and level of service. Its network performance is therefore of tremendous importance and that is very much influenced by the efficiency and effectiveness of the planning processes leading to the optimum network design.

Experience has shown that network planning is very much enhanced by computer application and experience in developing such automated planning processes date back to the early 1960s. The COMET (Cost of Most Economical Tandem) study is such an experience in fact made use of a sophisticated hard wired dimensioning program for the calculation of the most economical tandem for the Sydney telephone network.

Since then the systems have evolved from hard wired programs which were suited only for single applications to more flexible, generalised, transportable network dimensioning programs where the network characteristic is described as data. Systems known as SWITCHNET and TRANSNET are used for designing the Australian switching and transmission networks. They are particularly valuable now because they enable the introduction of the IDN, with attendant complexities of overlaying the analogue network, to be approached in a variety of ways. They assist in the careful analysis of alternatives in terms of economy, network security, simplicity of implementation, administration and practicability.

These network dimensioning systems are supported by automated record keeping systems (planning reference data bases) and automated traffic data acquisition and forecasting systems (planning traffic bases). These systems are linked together (**Fig. 6**) to directly influence the provisioning arrangements for the construction programmes.

MAJOR PLANNING STRATEGIES

Telecom Australia's overall objective is to ensure for Australia the continued development and improvement of national telecommunications services, and to maintain world parity standards in relation to availability, quality, diversity and price of those services. Efficient long term planning has been fundamental towards meeting the objective, and the modern network we have in Australia today is a result of the long term planning of the past.

In 1960 a Community Telephone Plan provided a stable foundation for the development of an automated switched telephone network in Australia and successfully guided the systematic and orderly development of the network during the period to date. The 1960 Plan had as its basic aim a nationwide automated STD network, which has essentially been achieved.

During the 1970s Telecom Australia conducted a major study — "Telecom 2000," into the long term development of telecommunications in Australia. It concluded that long term planning strategies were no longer appropriate in telecommunications and it was far more useful to look at a range of posibilities and all the potential alternatives. There needed to be a shift in planning strategies to acknowledge the close interweaving of the technical, social, economic and commercial aspects of telecommunications.

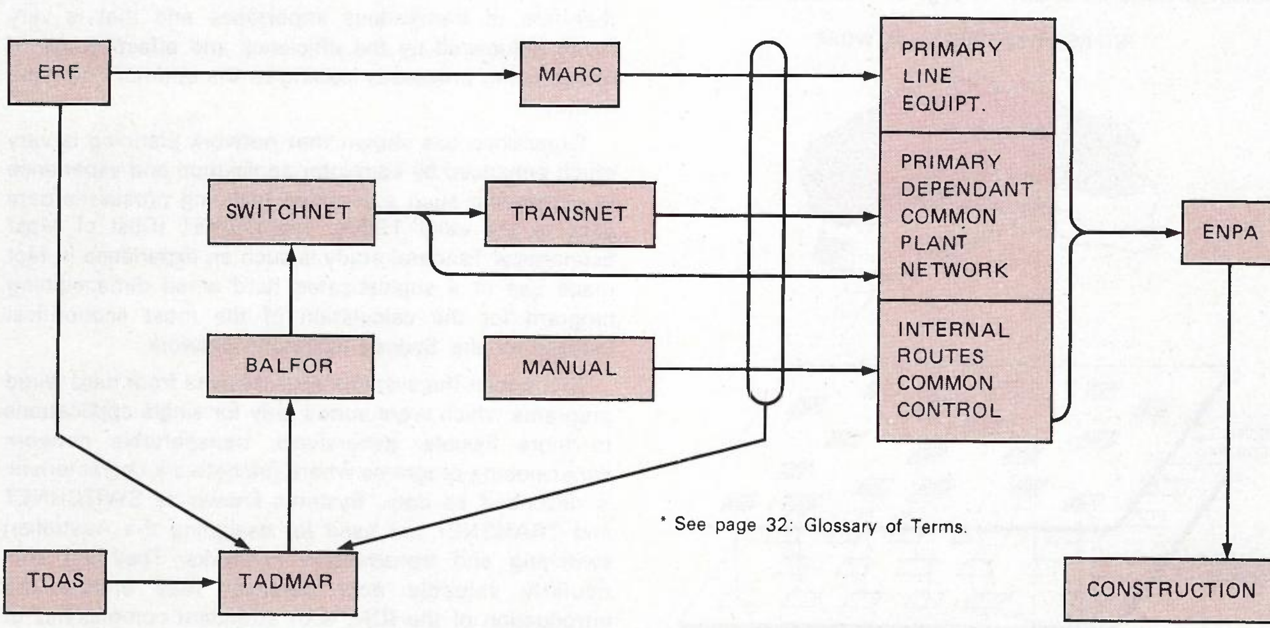
World-wide developments in digital technology for telephony and data, and the general merging of telecommunications and computers, is creating the "Information Revolution." One of the fastest trends is towards unified digital transmission and switching to provide telecommunications systems which generally have increased capacity, greater versatility, reduced unit costs, improved performance, lower power consumption, reduced equipment floor space requirements and lower operational costs. The rapidity with which these technological developments are merging, and the diverse range of products that become available with them, are providing an ongoing and increasing challenge to the network planners. It has therefore been necessary to move on from the 1960 Community Plan and develop a further major network planning strategy.

Telecom Australia, in common with the rest of the world, is hence turning towards the economy of integrating digital switching and transmission techniques for developing the telephone network towards an Integrated Digital Network (IDN).

In May 1983, a Strategic Plan for the Introduction of IDN was approved. This Plan covers the period to the turn of the century and provides a framework with long term objectives for the future development of the Telecom network utilising modern digital switching and transmission systems. This framework is flexible enough to accommodate change, yet definitive enough to provide useful guidance. The Plan provides sufficient detail to recognise the early commitments necessary at the National, State and Regional levels, to ensure optimal development of the network.

Progressive implementation towards the IDN is well in hand.

The establishment of the National IDN represents a fundamental change of direction in network development — a change equal to, if not greater than that experienced in the 1960s with the establishment of the National Automatic Trunk Network — in that even more significant changes in network control, signalling transmission, routing and facilities will occur during the 1980s, with the potential of achieving revolutionary



* See page 32: Glossary of Terms.

Fig. 6. Automated Network Planning Systems.

changes in the use and direction of telecommunication services throughout the community.

The Plan covers all elements of the national network, including urban, regional, rural and remote, and contains the proposed network structure for the long term development of the IDN, including:

- The Switching Plan
- The Charging Plan (including Call Charge Record complementary with Multi Metering)
- The Numbering Plan
- The Transmission Plan
- The Network Product Plan
- Network Interfaces with:
  - — data networks
  - — special services
  - — new terminal products
  - — changing plans
  - — interfaces with specialised networks (e.g. Packet Switching Network)

The IDN Plan does not cover the integration of all telecommunications services, but guides the development of the network in a way which will facilitate the introduction of ISDN at the appropriate time and in the appropriate manner.

An ISDN will evolve from the telephony IDN and will provide end-to-end digital connectivity to support a wide range of voice and non-voice services. Users will have access to the ISDN through a limited set of standard multi-purpose customer/network interfaces.

The transition from present networks to an ISDN will occur over a period of time. It is expected that ISDN capability will be progressively established to serve those market sectors or customers requiring extended digital access to a range of services. The ability for an ISDN to interwork with other specialised networks providing particular services will be crucial for assimilation of existing services and customers into an ultimate ISDN. The degree and rate at which the ISDN and other service networks are integrated, or whether some of them will be integrated at all, will be influenced by the relative demand for those various services as well as by economic, technological, operational and security factors.

A strategy for the forward development of the network consistent with the ISDN concept has now been developed.

PLANNING OF NETWORK OPERATIONS

In looking to the future significantly stronger centralised organisations are proposed to operate and administer the network. This is because:

- Software controlled networks, which will predominate in the future, lend themselves to a more rigid centralised control and discipline than a hard wired electro-mechanical network.
- The features of the equipment and reliability of the technology are improving to the point where sufficient expertise to deal with critical, rare and complex failures can only be obtained with a back-up group serving large networks.
- The community dependence on communications is growing enormously. Business, in particular, cannot tolerate "down times" or poor service. Thus, there is increasing pressure on the telecommunications organisation to have real-time controls to immediately analyse reasons for any poor performance, avoid congestion and also effect traffic control reconfiguration. The network is becoming increasingly complex with myriad paths and services, and traffic control and reconfiguration for large networks can only be effectively managed on a total network basis.
- New services such as Incoming Wide Area Telephone Services (008) are being offered on the network, and, in time, the extensive application of such services could result in focussed overload conditions. Important political or social events and natural disaster situations both within and outside the country can cause overloads. Control techniques can maintain service standards better in such situations.
- The large investment required to equip the network must be used to optimum advantage. Real-time centralised controls for this purpose are required so as to maximise the availability of circuits and plant.

The organisation structure needed to cope with these requirements in a large network must have centralised elements for:

- System support and technical back-up
- Surveillance, measurement and analysis of performance
- Real-time traffic control with facilities for manual and automatic restoration.

The activities to be covered in such an organisation require a high level of management skill and a group of staff who collectively possess extensive software and system design knowledge. Traffic theory and network trunking understanding is also essential. Carefully selected professional and para-professional staff are required for the purpose.

Telecom Australia is examining this question in depth. It has currently a number of Network Operating Centres (NOC) or groups which partly serve the functions discussed, and plans are being developed to integrate and control their activities to better fit the principles outlined. Again, a number of computer based operations support systems associated with the NOCs are being applied to the switching and transmission networks.

In the future, systems, and in particular switching systems, will need to be supplied with inbuilt network management facilities. Suppliers are recognising this need.

The inter-linking of the NOCs and the exchanges requires a well planned and secure data link and message switching strategy.

A proposed strategy addresses the transport of the following categories of data associated with ARE and AXE exchanges:

- Maintenance Data
- Traffic Data
- Network Traffic Management Data
- Charging Data

The strategy is based on a minimum of special development of network facilities specifically for transport of operations data and is based on utilising facilities already in place, committed to be commissioned or proposed to be implemented in the network. Of key consideration in the formulation of the strategy is the criterion of security and vulnerability of traffic carrying capacity to factors outside of Telecom Australia's control. Furthermore, the various categories of data outlined above are not committed to a single network, but spread across various networks depending on application, traffic load, the corporate importance of the traffic and security. In addition, fallback measures are proposed to enable some measure of operation in cases of failure of elements of the network.

New operational factors are bound to emerge with the expanded diversity of services to be carried in the network each of which needs special attention for operational support. They include new message handling services (Teletex, Telememo); new mobile and paging services including cellular radio, and involving new interconnect facilities to the public network; new satellite services (Iterra Network Service); new customer wideband services including PABX.

HUMAN FACTORS

One of the major characteristics of the telecommunications industry is that changes have occurred almost continuously since its inception. Telecom Australia employees and Staff Associations (Trade Unions) have accepted many of these in the past, but there is now serious concern among them and the community in general about the social and economic implications of the introduction of new technology which, over recent years, has been introduced at an accelerated rate.

Apart from the social issues, several job issues have arisen in the case of Telecom Australia's ARE and AXE programmes and have been the subject of industrial action by staff and special examinations by Telecom Australia and independent experts. The issues include: fear of job loss, resistance to redeployment and retraining,job satisfaction and equal opportunity. Agreement has been reached with Staff Associations concerning the basic operating structure for maintenance of the future telephone network.

Telecom Australia has accepted the importance of the impact which the introduction of new technology has on the workforce and the community, and the need for a different approach at least in the Australian environment. Accordingly an agreement has been made that Telecom Australia will notify Staff Associations whenever a significant technological change is contemplated.

CONTROL OF THE USE OF RESOURCES

Commitments & Objectives

The setting of the pattern for the future development of the telecommunications network in Australia must itself be set within the framework of Corporate policies and objectives. Those commitments and objectives of Telecom Australia have been expressed with respect to its legislative charter and on the understanding that it is enabled to manage its organisation efficiently along modern business lines and have access to the capital funds for worthwhile investment.

The commitments and objectives are:

- Services
  The meeting of customer needs for up to date affordable, efficient communications throughout Australia remains Telecom's paramount commitment.
- Prices
  Telecom is committed to pass on to customers wherever possible the savings achievable through the use of new and more efficient technologies and increased operational efficiency in the provision of communications services. A regulatory authority now exists to which Telecom must justify its basic charges.
- Efficiency
  Telecom's objective is continued efficiency improvement, with the goal of becoming by the end of the 1980s, Australia's most efficient large enterprise.
- Industry
  The communications industry is a key growth sector in a modern economy. Telecom, in consultation with Government and industry, is committed to fostering a vigorous communications manufacturing and development capability in Australia.

Telecom Australia has in the past ten years made significant moves towards these objectives. **Fig. 7** illustrates the movement in Telecom prices. It has committed itself to particular quality of service standards and to specific performance standards.

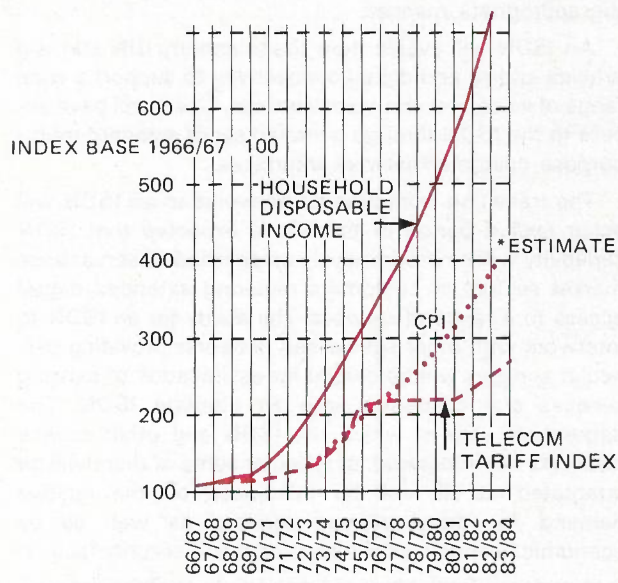


Fig. 7. Comparison of Telecom Tariff, Price and Disposable Income Indices.

The marshalling and controlling of resources is managed through a number of interacting major plans (**Fig. 8**). They are:

- Commercial Product Targets
  The Commercial Product Target Package consolidates, for planning purposes, the levels of activity which must be achieved to effectively satisfy identified market needs. The Target Package presents product targets for commercial activity over a planning period of several years.
  These targets provide a base for strategic planning aimed at the co-ordination and effective management of resources to match availability of products and services with market needs.
- National Telecommunications Development Plan
  The National Telecommunications Development Plan embodies such features as the Community Telephone

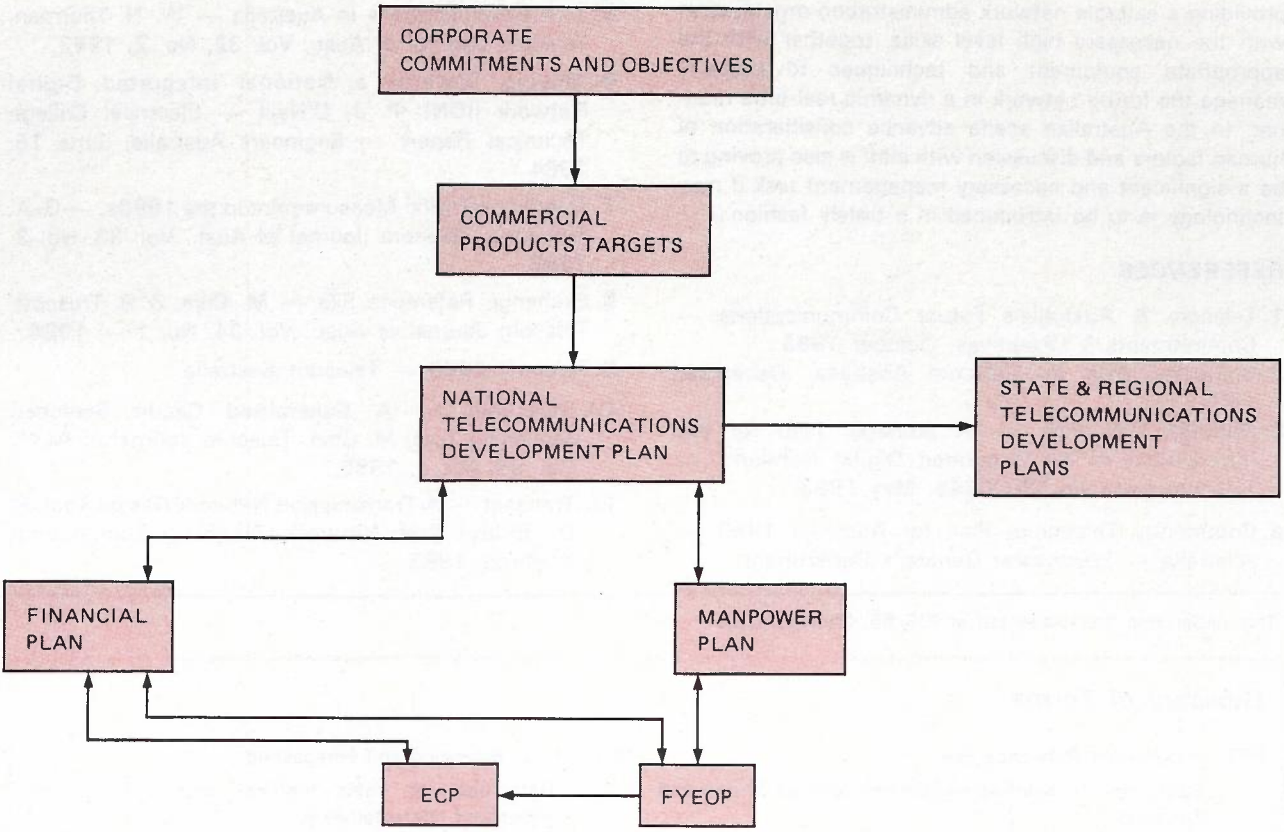


Fig. 8. Telecom Australia — Major Plans.

Plan of 1960 and now the IDN Plan of 1983. It also incorporates features from "Telecom 2000." This National Telecommunications Development Plan is broken down into State and Regional Plans.

- Financial Plan
  The Financial Plan is the overall plan which incorporates capital development, operations, tariff and financing strategies. It projects levels of earnings and receipts and proposed borrowings and determines the total availability of funds to finance the operational plans.
- Manpower Plan
  The Manpower Plan forecasts the staff levels and skill requirements in each designation group. The Plan is endevouring to make forecasts of staffing requirements for longer periods to ensure the availability of skills to meet the demands of new techniology as set out in the Development Plan. The retraining and redeployment of staff is expected to become a more dominant feature of the Manpower Plan.
- Five Year Engineering Operations Programme (FYEOP)
  FYEOP is a forward looking management system for forcasting and programming the resources required for field operations activities. It covers all maintenance activities and day to day construction of the customer access network and installation of customer premises equipment. It take into account the development of maintenance practices, productivity improvements and the achievement of performance targets. The statements made in FYEOP for future years influence the Financial and Manpower Plans.
- Engineering Construction Programme (ECP)
  The vehicle for the implementation of the approved State and Regional Telecommunication Development Plans is the ECP. It is prepared over a three year horizon within the framework of the Asset Provisioning component of the Financial Plan and of the Manpower Plan and the overall strategy plans and targets. From the ECP an Annual Works Programme is scheduled.
- Monitoring
  Each of the Plans and Programmes is audited or monitored. The main influences on the life of plans and the need for their revision are changes in policies, technology, economic factors and data base accuracy. The Planning organisation continually reviews those parameters and modifies plans where necessary. Telecom Australia is a business undertaking and therefore has a system of control over its programming and budgeting systems and of its performance achievements against target. Continuous reviews are conducted throughout the life of each programme and over organisations to gauge effectiveness and towards improving productivity.

CONCLUSION

The Telecommunications scenario for the future in Australia and no doubt other countries indicates a great array of network and customer facilities operating to a rapidly expanding and more complex network. The rate of change of technology is still accelerating and software controlled digital technology is dominating network development.

Community dependence on reliability of telecommunications is very significant and increasing. In such a situation Telecommunication administrations must now place greater emphasis on planning and providing a suitable network administration organisation with the necessary high level skills, together with the appropriate equipment and techniques to properly manage the future network in a dynamic real-time manner. In the Australian scene advance consideration of human factors and discussion with staff is also proving to be a significant and necessary management task if new technology is to be introduced in a timely fashion.

REFERENCES

1. Telecom & Australia's Future Communications — Commitments & Objectives; October 1983.
2. Corporate Plan for Telecom Australia; December 1977.
3. National IDN Plan — A strategic Plan for the Introduction of the Integrated Digital Networks — Telecom Australia TPH 0645; May 1983.
4. Community Telephone Plan for Australia 1960 — Australia — Postmaster General's Department.
5. Telecommunications in Australia — W. H. Thurman, Telecom Journal of Aust., Vol. 32, No. 2, 1982.
6. Moving Towards a National Integrated Digital Network (IDN), P. J. O'Neill — Electrical College Technical Report — Engineers Australia, June 15, 1984.
7. Telephone Traffic Measurement in the 1980s. — G. A. Benjamin, Telecom Journal of Aust., Vol. 33, No. 3, 1983.
8. Exchange Reference File — M. Chin, & R. Truscott. Telecom Journal of Aust., Vol. 34, No. 1 — 1984.
9. Telecom 2000 — Telecom Australia.
10. Switchnet — A Generalised Circuit Switched Modelling Tool, M. Chin, Telecom Journal of Aust., Vol. 35, No. 1, 1985.
11. Transnet — A Transmission Network Design Tool, P. D. Birley, 2nd Network Planning Symposium, Brighton, 1983.

This paper was first presented at ICC 85, Chicago, USA.

Glossary of Terms

ERF — Exchange Reference File

Data base of installed equipment, services in use and forecasts.

TDAS — Traffic Data Acquisition Systems

Data base of occupancy and dispersion, detailed and real time continuous traffic records from terminal and transit switches.

TADMAR — Traffic Data Management Analysis and Reporting.

Large tertiary data base processing traffic and network reference data. Application programs for network dimensioning, congestion monitoring, traffic profiles, network management.

BALFOR — Balancing and Forecasting

Data base of traffic matrices with varying time dependant characteristics.

SWITCHNET — Switched network dimensioning system.

TRANSNET — Transmission network dimensioning system.

MARC — Micro Analysis of Reserve Components

Analysis of capability of network to meet forecast growth. A works programme aid.

ENPA — Exchange Network Provisioning Aid

System for estimating requirements and placing of contracts.

Telecommunication Journal of Australia

Golden Jubilee 1935-1985

Half A Century of Achievement

Cutting the Golden Jubilee Cake by the Chairman of the Telecommunication Society of Australia, Mr Keith Barnes, assisted by the Editor-in-Chief of the Journal, Mr Mun Chin.

ISDN — An Overview

G. P. KIDD B.E. Hons., B.Sc.
P. G. DARLING B.E. Hons., B.Sc.

In Australia, as in many other countries, planning for the evolution of the telecommunications network towards an integrated services digital network (ISDN) has started. This paper provides a broad overview of the ISDN concept, the status of international standardisation, the reasons for moving towards ISDN, and the means by which its introduction will be achieved. Later papers in this series will examine specific aspects of ISDN in more detail.

INTRODUCTION

The idea of an integrated services digital network or ISDN as it is more commonly called has been under discussion in international circles for at least the past ten years. Just now there is considerable interest in ISDN arising out of agreement within the CCITT in late 1984 of a first set of recommendations on services, access arrangements and network support functions which will see initial ISDN features being progressively incorporated into the Australian and other national networks during the latter part of this decade.

This paper will present the current international status of ISDN and provide an explanation of what it is and how it will evolve in the Australian network. Subsequent papers over the next few issues of the journal will provide elaboration of specific aspects of ISDN as well as examining in more detail the Australian programme for evaluating and introducing ISDN facilities.

BACKGROUND

Before examing the ISDN, it is useful to place it in historical perspective with respect to other network developments.

Until quite recently the predominant network activity was in developing a nationwide automatic telephony network in accordance with the objectives of the 1960 Community Telephone Plan. Requirements for services other than switched telephony were generally accommodated within the public switched telephone network (PSTN) and, because of the analogue technology, were often constrained in capacity and performance.

It was recognised that in many cases the analogue PSTN was not able to meet the increasing need of these non-telephony services for improved performance, increased flexibility including quick installation, and more reliable service. Marketing studies identified a number of specific areas or "services" where improvement was needed. The means of satisfying these different requirements has been the construction of independent dedicated networks, which have different structures, peformance specifications, and management systems. Thus, by the mid-1980s we have seen the establishment of the:

- Digital Data Network (DDN) for point-to-point data;
- Packet Switched Network (AUSTPAC) for switched data;
- Special Services Network (SSN) for analogue voice-frequency point-to-point special services.

Currently, consideration is being given to another dedicated network for wideband services, initially point-to-point but eventually switched.

While these dedicated networks were being planned, almost independently the telephony network was undergoing considerable upheaval. In the late 1970s it was recognised that, firstly, digital transmission systems (PCM-30) and, secondly, digital switching systems were more economic under some circumstances than traditional analogue systems. Plans were consequently made for the gradual introduction of digital facilities into the network throughout the 1980s. However, technological advances in both transmission media and in switching systems, and associated reductions in cost, have led to an accelerated programme for the introduction of digital techniques.

Moreover, the considerable cost advantages of directly interworking digital transmission and switching components of the network has led to the acceptance that the network infrastructure must be developed in a coherent and integrated manner — hence the development of a national Integrated Digital Network (IDN) for telephony.

The IDN is a network which allows digital paths to be established between terminal exchanges at a transmission rate of 64 kbit/s. Although developed as an economic alternative to the analogue PSTN, it is not necessarily constrained to that role, and could be used to support a range of services based on the 64 kbit/s circuit-switched capability. Such a network could be referred to as a "multi-services" IDN. The proposed support of the teletex service in Australia on the IDN is an example of this multi-services operation.

As the IDN exists today it has one limitation for digital services: the access between a customer and his local exchange is based on analogue technology. This means that only those digital customer services which are capable of being accommodated within the voice frequency band can have access to the circuit switched network. In practice this limits the allowable bit rate to about 4.8 kbit/s. Consequently, the 64 kbit/s capability of the network cannot be fully utilised for data transmission.

International effort has been directed to providing the capability for full digital transmission to the customer's terminals. This effort has resulted in CCITT recommendations which allow potentially several 64 kbit/s services to operate simultaneously and independently over the one existing customer distribution pair.

It is this integrated digital access into the multi-services IDN, making use of a limited set of defined interface, signalling and service standards, which constitutes an integrated services digital network. This concept is illustrated in **Fig. 1**.

THE ISDN CONCEPT:

More formally, the definition of an ISDN as proposed by the CCITT is that . . .

"An ISDN is a network, in general evolving from a telephony IDN, that provides end-to-end connectivity to support a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multi-purpose user-network interfaces".

This definition was agreed during the 1981-84 CCITT Plenary period, and reflects a broadened view of the scope and operation of an ISDN over that originally envisaged, specifically its ability to support for example non-voice, packet and wideband services.

Considerable effort has gone into establishing the standards necessary for implementation of an ISDN. These standards have been consolidated into a set of CCITT recommendations called the I-series Recommendations. Associated Q- and X-series Recommendations have also been prepared. These were approved at the CCITT Plenary Assembly in late 1984 and are being published (along with other CCITT Recommendations) during 1985. A feature of these recommendations is the interest which has been generated in their development and the degree of consensus reached among the large number of participating Administrations and operating companies on their content.

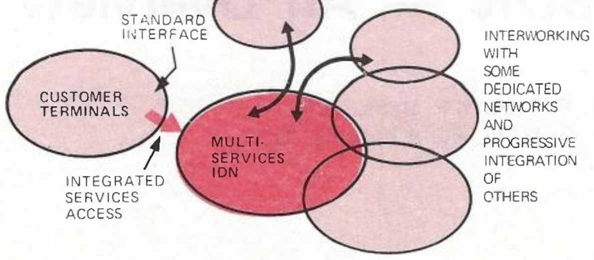


Fig 1: The ISDN Concept.

GRAEME KIDD. After graduating from the University of Queensland, Graeme Kidd joined the Australian Post Office Research Laboratories in 1962. During the 1970s he was involved with evaluation of optical fibres and, in 1980, as a result of that experience transferred to the Transmission Planning Branch of Telecom to assist with the planning for the introduction of optical fibre systems into the Australian network. Most recently he has participated in studies on ISDN and the development of strategies for its introduction.

PETER DARLING was educated at Sydney University (B.Sc., B.Eng). He joined Australian Post Office in Sydney in 1967 where he worked in exchange installation and planning.

He was the GEC Overseas Fellow in Telecommunications from 1971 to 1973, working in Coventry, England.

Since 1974 has been working in Telephone Switching Planning in the Engineering Planning Division at Telecom Headquarters. He has worked on the planning of new systems and network facilities, including development of the IDN and ISDN.

Mr Darling has been the Australian Study Group XI Co-ordinator since 1978, and has attended SGXI meetings as an Australian delegate since then. He has been a Rapporteur in Working Parties XI/4 (Digital Switching) and XI/6 (Digital Subscriber Access).

In broad terms the recommendations agreed at the end of 1984 relate to:

- Evolutionary principles
- User-network interfaces
- Customer signalling schemes
- Parameters relating to user service
- Network signalling

A listing of the specific recommendations is given in the Appendix; their development is outlined in Reference 1. It is generally recognised that these are relatively basic, but nevertheless that they are sufficient for Administrations, equipment and terminal manufacturers to proceed towards establishing initial ISDN services within the next 2-3 years. Telecom Australia is among a number of Administrations proposing ISDN trials over the period 1985-88 based on the 1984 recommendations.

In the current CCITT plenary period (1985-88), it is expected that there will be greater concentration on such areas as

- Network signalling
- Numbering
- Interworking between networks
- Service requirements and performance
- Operations and maintenance
- Support for services at other than 64 kbit/s

Recommendations from these studies will provide a more complete specification of ISDN services and facilities. The more important recommendations in this period are being prepared under an accelerated procedure which should lead to approval in late 1986, so that they could be expected to be incorporated into equipment and networks from about 1988.

NETWORK DEVELOPMENT TOWARDS THE ISDN

The ISDN can only be introduced in an evolutionary way. The process may take one or more decades, and even then it is not clear if there will be just one network which can be identified as "the ISDN". What the ISDN concept is based on, however, is the principle of rationalising and extending the use of existing networks to provide a basic infrastructure capable of supporting a wide range of advanced services in an efficient and timely way. As noted in the definition it is expected that this infrastructure will be based on the telephony IDN.

Telecom in 1983 accepted a network development strategy that recognised the essential inevitability of ISDN and provided for a systematic evolution from the present networks towards that goal. The network development principles outlined in that strategy are:

1. Services will be supported by service-dedicated networks while these continue to provide efficient solutions.
2. Interworking between dedicated networks will be progressively established.
3. The telephony IDN will be enhanced by appropriate switching and signalling intelligence to provide a multi-services inter-exchange capability.
4. Digital transmission to provide integrated services access will be established in the customer distribution network.
5. Wherever appropriate network enhancements will be based on internationally accepted standards for ISDN.

An indication of how the overall network will grow as these principles are applied is given in **Fig. 2.**

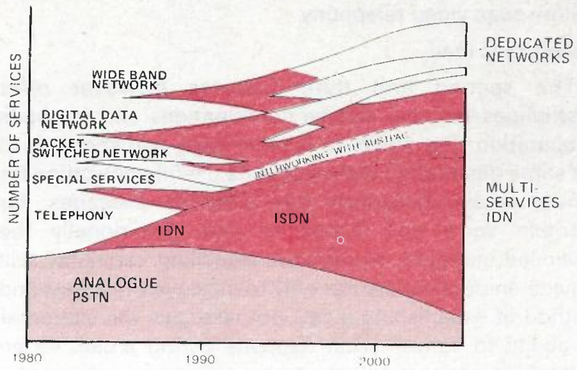


Fig 2: The Growth of the ISDN.

At any time there will be a number of network developments being planned for specific technical, commercial and economic reasons. What the strategy calls for is an assessment that each such implementation proposed, while meeting a defined short-term need, is nevertheless consistent with evolution towards an ISDN network infrastructure, and will facilitate its achievement.

CHARACTERISTICS OF ISDN

The ISDN has some unusual and unique characteristics which open the way for bringing in a range of new and advanced services, as well as more efficiently supporting many existing services. An important aim in developing ISDN standards has been to make them "open-ended", so that they can be readily adapted to accommodate completely new services, including perhaps some not yet envisaged. Effort has also been made to ensure ISDN implementation will, as far as possible, be independent of particular technologies.

From the customers' viewpoint ISDN can be considered as a network supporting a range of services to which access is provided through a small number of internationally standardised user-network "gateways" or interfaces at customers' premises. These access arrangements are designed to allow simultaneous operation of a number of terminals, and hence provide customers with considerable flexibility in the number and type of terminals they wish to connect or use at any time.

In broad terms ISDN access will offer the following features:

— Channels based on 64 kbit/s information rates (and in due course higher rates);
— Simultaneous or multiple use of a number of such channels;
— A customer-to-network signalling scheme allowing an increase in communication capability into and across the network.

The first of these is significant in that it will provide for the first time a 64 kbit/s access to the circuit-switched IDN. Coupled with the necessary support features within the network this opens up the possibility of a range of new high-speed services including:

- Enhanced telephony at 64 kbit/s
- Photo-videotex
- Facsimile
- Teletex including graphics
- Slow-scan video telephony
- Electronic mail

The second and third features however offer possibilities for new service combinations and methods of operation. The ability to have at least two channels to the same destination will have quite useful application for conveying simultaneously two different messages; for example voice and image or text. Additionally the advanced customer to network signalling capability will provide an opportunity not only to improve the speed and method of establishing a call, but also give the customer an ability to control what happens during a call. As an example, a connection set up as a telephony call may be converted to text (say) during the call, and perhaps subsequently returned to telephony.

USER-NETWORK INTERFACES

A key element of service integration for an ISDN is that access is provided through a limited set of standard multipurpose "gateways" or interfaces between the user and the network. In fact, a customer's perception of the ISDN is determined by the service characteristics available through these interfaces, rather than by the network elements themselves. An important consequence of this approach is that user and network equipments will be able to evolve separately.

The standardised access arrangements are defined in terms of "user-network interface structures" which are specified combinations of "channels" of information. Various channel types have already been identified and are discussed in detail in Recommendation 1.412. The designation and bit rates of these are as follows:

B-channel	64 kbit/s
H0-channel	384 kbit/s
H1-channel	1920 kbit/s
D-channel	16 kbit/s or 64 kbit/s

Of these, the B and D channels are at this stage the most important as far as likely usage is concerned.

The B, H0, and H1 channels are intended to carry a wide variety of user-information streams for voice, data, text or facsimile applications for example. These channels may provide access to circuit- or packet-switched network facilities on a demand-assigned or semi-permanent basis. None of these channels is intended to carry signalling information for circuit-switching connections in the ISDN.

This signalling information is conveyed in an associated D-channel. It is this feature of out-band or common-channel signalling in the customer access loop, coupled with common channel signalling in the inter-exchange network, which will allow completely new ways of setting up and handling connections in the ISDN, as well as allowing simultaneous support of a number of services and terminals at the customer's premises.

The user-network interface structures of interest in Australia and so far agreed can be classified as follows:

B-CHANNEL INTERFACE STRUCTURES

i Basic: 2B + D (D=16 kbit/s)
ii Primary Rate B: 30B + D (D=64 kbit/s)

H-CHANNEL INTERFACE STRUCTURES

iii Primary Rate H0: 5H0 + D (D=64 kbit/s)
iv Primary Rate H1: H1 + D (D=64 kbit/s)

A further possibility that has been recognised allows a mixture of B and H0 channels in any combination within the primary rate structure, together with a D-channel at 64 kbit/s.

Each interface structure will exist in the customer's premises as a physical interface which delineates between the customer's terminal equipment and the transmission line to the local exchange. This interface will be seen by the customer as a standardised socket into which can be plugged any of a number of terminals, in much the same way as electrical appliances are connected to the electricity supply.

Some possible examples of how these interfaces might be used are shown in **Fig. 3** and **Fig. 4.**

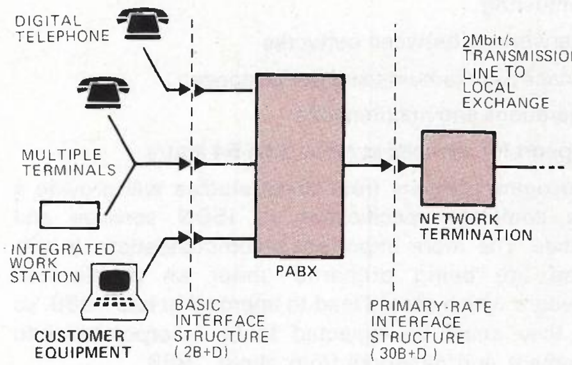


Fig 3: Examples of ISDN interfaces used with a PABX.

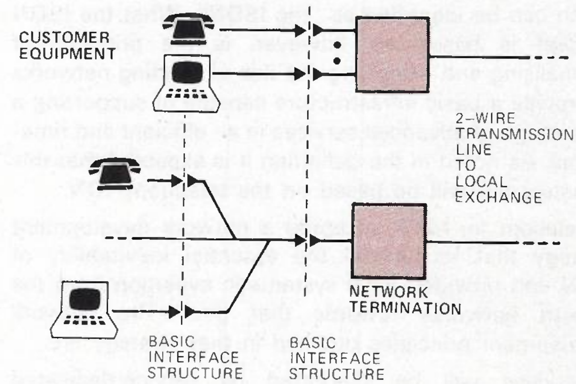


Fig 4: Examples of ISDN interfaces used with a single pair of wires.

CUSTOMER ACCESS NETWORK

The interface structures described above provide the means of bringing a number of streams of information together at customers' premises in a well defined manner. This combined information needs then to be conveyed into the network for distribution to its proper destinations. An underlying principle of ISDN is that the access between the customer and the network will be realised using, in the case of the primary rate channel structures, just one 2048 kbit/s bearer and, for basic access, just one copper pair. Thus, in the early stages of development of ISDN, an access can be provided using as far as possible existing customer distribution plant. Integrated services digital access will consequently allow the potential for a considerable increase in the number of new customer services within the constraints of the existing network.

In the early stages of ISDN, most services will make use of the 64 kbit/s capability of the multi-service IDN, and thus, initially at least, the ISDN accesses have been structured around the B-channel. Later on, as wideband network capabilities expand, access will be provided for the H0 and H1 channels.

Basic Access

ISDN Basic Access provides for the transmission of the 144 kbit/s information stream corresponding to the (2B + D) interface structure between customer and local exchange using just one cable pair. Moreover this access must allow duplex operation; that is, transfer of information in both directions simultaneously over that pair.

In developing suitable systems it will be necessary to examine the influence of the cable loss as a function of distance and frequency, of interferences arising from crosstalk and impulsive noise, and of the constraints of the existing network design. Various transmission techniques have been proposed which balance performance against cost, but it would seem at the moment that one based on adaptive echo cancellation will provide a suitable solution.

This technique will be discussed in depth in a later paper in this series, but very briefly allows for full duplex operation over the one pair of wires by cancelling out echoes caused by impedence mismatches along the line to ensure an adequate signal-to-noise ratio in each direction (see **Fig. 5**).

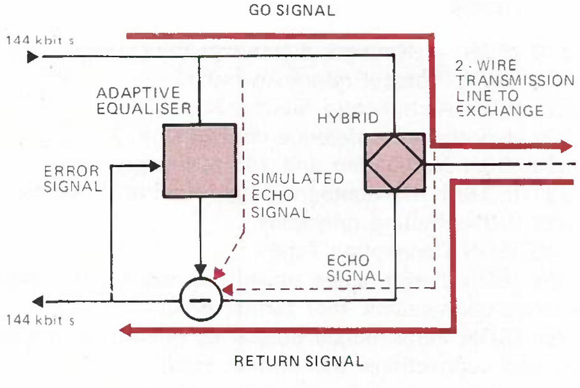


Fig 5: Adaptive Echo Cancellation Principle.

Primary Rate Access

The Primary Rate Access provides for the transmission of the various channel structures described above within the frame structure of a 2048 kbit/s PCM bearer. The transmission equipment used for this application will consequently be similar to that already used in the junction and trunk networks. In much the same way as in those networks, multiplexing of primary rate accesses to higher-order rates will be possible.

The essential distinction, apart from possible accommodation of H0 and H1 channels within the framing structure, is that the signalling information associated with each message channel is conveyed in a "common-channel" rather than "channel associated" format. Thus, within the 64 kbit/s D-channel of the primary rate access, the individual signals are assigned dynamically rather than in a fixed manner, leading to greater speed of operation and greater flexibility. The D-channel protocols themselves are aligned closely with those of the basic access, and therefore provide the same range of advanced capabilities.

The primary rate access is seen to be of importance in providing digital access between PABXs and the digital network, particularly as it is expected that modern PABXs will increasingly make greater use of digital switching as well as integrated services techniques.

Provision of a single primary rate access supporting a range of voice and non-voice services offers the possibility of a cost-effective alternative to individual access for each service.

SWITCHED NETWORK DEVELOPMENT

As described previously, the ISDN is expected to evolve from the telephony IDN. The ISDN will not be a new network, such as the Packet Switched Network developed for AUSTPAC, but will be an addition to the existing network.

The telephony IDN is at present being developed to provide telephony service in the most effective fashion. It is planned that, in the Australian network, future growth will be met by the use of digital transmission (PCM, digital radio, optical fibre) and digital switching (AXE exchanges). The IDN is being developed as an "overlay" network over the current analogue telephone network and will interwork with it.

In common with all major manufacurers of switching equipment, LM Ericsson plan to add ISDN capability progressively to the AXE exchange system. Thus, when this development is complete, ISDN will ultimately be available at all locations with an AXE presence. The use of RSS (Remote Switching Stages) to meet growth and, if necessary, out-of-area lines will allow digital switching equipment to be accessed from all metropolitan locations and the majority of major country centres by the end of the decade.

A later article will describe in detail AXE capabilities for ISDN. In brief, these capabilities are:

- Addition of equipment in the digital subscribers stage (SSS-D or RSS-D) to give CCITT ISDN basic access as described earlier
- Addition of primary rate (2048 kbit/s) access to the exchange for PABXs
- Changes to the central software to support ISDN services and the ISDN network and access signalling
- Development of packet data handling equipment.

Telecom has specified the facilities and services which should be provided for an initial Telecom ISDN, and proposes to conduct an engineering trial to evaluate

ISDN capability in the Australian network. It is expected that ISDN hardware and software will be delivered to Telecom's AXE model exchange in mid-1987, and that dedicated ISDN exchanges will be established in all capital cities during 1988. Initially, emphasis will be placed on providing primary rate access from PABXs to these exchanges.

Further development work will allow both ISDN and analogue telephony services to be offered from all AXE exchanges. As shown in Fig 6, ISDN basic access is achieved by adding a new LSM-D (Line Switch Module) in a digital subscriber stage, which will then be able to support both analogue and ISDN subscribers. A major part of the initial ISDN development is the development of technology to provide data transfer over a single subscribers pair in both directions at 144 kbit/s.

ISDN primary rate access is being developed based on the standard hardware used for primary rate PCM (in Australia, 2048 kbit/s digital transmission) connecting direct to the GSS (see **Fig. 6**).

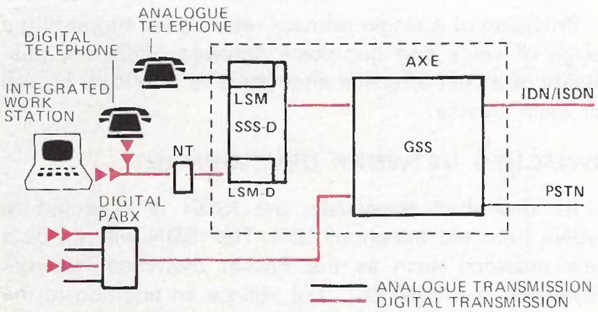


Fig 6: Basic AXE Architecture showing ISDN Access.

Other important work to achieve an ISDN includes the development of an ISDN network architecture with the facilities to support a much greater range of services than at present. Areas which are receiving attention include:

- Charging for the different services to be offered on the ISDN
- Numbering and addressing for all services in the ISDN/IDN
- Interworking between services on the ISDN and existing service-dedicated networks
- Network support and transmission requirements ("bearer capabilities") for different voice and non-voice services
- The provision of network based facilities to give additional services and provide further information, etc. beyond basic data transport ("value added services").

These facilities will require appropriate support at all network elements. In particular, considerable extra software development will be necessary for local and transit AXE exchanges.

FUTURE DEVELOPMENT

The CCITT and individual network operators will in future define many new services to be offered on an ISDN. Customers who want these services will be able to access them via their ISDN "communications gateway" by connecting the appropriate terminal equipment at the standard interface and taking any necessary administrative action. New installation activity (new lines and new network equipment) in general would not be necessary because of the multi-services capability of the ISDN accesses.

This initial ISDN will evolve from the 64 kbit/s circuit switched IDN, but this is not the limit of the ISDN concept. Packet data handing facilities will enable the carriage of packet data, and rate adaption will allow data at rates less than 64 kbit/s to be carried. Data at rates several multiples of 64 kbit/s can be carried by switching multiple 64 kbit/s channels.

Broadband traffic at rates much higher than 64 kbit/s will require new network facilities, but these will be consistent with the ISDN concept and will be integrated with the 64 kbit/s network, using the new customer access interfaces being defined at present by the CCITT.

REFERENCE:

1. DUC, N.Q. and CHEW, E. K., "Evolution towards Integrated Services Digital Networks." Telecom Journal of Australia, Vol. 34, No. 2, 1984.

APPENDIX

GENERAL STRUCTURE OF THE I-SERIES RECOMMENDATIONS

PART I — GENERAL

I. 110 General structure of the I-Series Recommendations

I. 111 Relationship with other Recommendations relevant to ISDNs

I. 112 Vocabulary of terms for ISDNs

I. 120 Integrated Services Digital Networks (ISDNs)

I. 130 Attributes for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN

PART II — SERVICE CAPABILITIES

I. 210 Principles of Telecommunication Services supported by an ISDN

I. 211 Bearer Services supported by an ISDN

I. 212 Tele-Services supported by an ISDN

PART III — OVERALL NETWORK ASPECTS AND FUNCTIONS

I. 310 ISDN — Network Functional Principles

I. 320 ISDN Protocol reference model

I. 32x ISDN Architecture functional model

I. 32y Hypothetical reference connections

I. 330 ISDN Numbering and addressing principles

I. 331 (E.164) The numbering plan for the ISDN era

I. 33x ISDN Routing principles

I. 340 ISDN Connection Types

I. 35x ISDN Performance objectives relating to circuit switched connections. (For further study)

I. 35y ISDN Performance objectives relating to packet switched connections. (For further study)

PART IV — USER-NETWORK INTERFACES

I. 410 General aspects and principles relating to Recommendations on ISDN user network interfaces

I. 411 ISDN user-network interfaces — reference configurations

I. 412 ISDN user-network interfaces — channel structures and access capabilities

I. 420 Basic user-network interface
I. 421 Primary rate user-network interface
I. 430 Basic user-network interface — Layer 1 specification
I. 431 Primary rate user-network interface — Layer 1 specification
I. 43x Higher rate user-network interfaces. (For further study)
I. 440 (Q.920) ISDN user-network interface data link layer — general aspects
I. 441 (Q.921) ISDN user-network interface data link layer specification
I. 450 (Q.930) ISDN user-network interface Layer 3 — general aspects
I. 451 (Q.931) ISDN user-network interface Layer 3 specification
I. 460 Multiplexing, rate adaption and support of existing interfaces
I. 461 (X.30) Support of X.21 and X.21bis based DTEs by an ISDN
I. 462 (X.31) Support of Packet Model Terminal equipment by an ISDN
I. 463 (V.100) Support of DTEs with V-series type interfaces by an ISDN
I. 464 Rate adaption, multiplexing and support of existing interfaces for restricted 64 kbit/s transfer capability

PART V — INTERNETWORK INTERFACES (for further study)

PART VI — MAINTENANCE PRINCIPLES (for further study)

APZ 211 02 — A New Processor for the AXE System

D. N. SYNNOTT ARMIT

Telecom Australia have recently adopted the L. M. Ericsson central processor type APZ 211 as the standard for medium sized exchanges. This decision represents significant cost savings in material, floor area and power requirements.

INTRODUCTION

L. M. Ericsson of Sweden have recently developed a new central processor system type APZ 211 for AXE exchanges.

This new system will supersede the existing APZ 210 as the standard processor and will be used in most new exchanges. It offers considerable advantages in terms of lower cost, less floor space, larger memory capacity and improved operating procedures. The call handling capacity is also slightly higher and apporoximately 150,000 busy hour call attempts can be processed.

The APZ 211 purchases commenced during March 1985 and, by June 1986, 46 field exchanges in Australia will be in service or being installed.

In future, the AXE system in Australia will use three processor types to service the range of new exchanges required by Telecom Australia.

These types are as follows:—

PROCESSOR SYSTEM	APPLICATION
APZ 211	Medium Size Exchanges (Most common)
APZ 212	Large Capacity Exchanges
APZ 213	Small Capacity Exchanges

The development of APZ 211 has been in two stages, APZ 211 01 (stage 1) and APZ 211 02 (stage 2). APZ 211 01 which will not be installed in Australia, was primarily developed for small low calling rate exchanges which required a processor capable of handling approximately 30,000 B.H.C.A. (Busy Hour Call Attempts).

APZ 211 02, was developed for medium sized exchanges having a maximum processor loading of 150,000 B.H.C.A.

This article will mainly concentrate on the differences between APZ 210 06 and APZ 211 02, which will in turn highlight the advantages of the latter.

APZ 211 02 SYSTEM CONFIGURATION

The system configuration is shown in **Fig. 1**.

The subsystems RPS and IOS are identical to the APZ 210 06. Subsystem CPS adopts basically the same operating principles as in APZ 210 06, has basically the same software blocks, but has an entirely different hardware structure to APZ 210 06.

L. M. Ericsson have achieved a dramatic decrease in size for the APZ 211 02 (as compared to APZ 210 06) with the utilisation of modern technology such as multilayer printed board assemblies, standard modern microprocessors, and increased packaging density.

HARDWARE COMPARISONS BETWEEN APZ 210 06 and APZ 211 02

The APZ 210 06 requires 11 magazine types and a total of approximately 1500 printed board assemblies (P.B.As) when fully equipped.

The APZ 211 02 requires 4 magazine types and approximately 50 P.B.A.'S. The reduction in hardware quantities needed for APZ 211 02 leads to an approximate 90% decrease in both power requirements and floor area. **(Fig 2).**

The program data and reference stores in APZ 211 02 are combined into the main store (MS) which in turn is "housed" in the same magazine as the central processor unit (CPU) as well as the regional processor handler (RPH). The in built RPH allows for the connection of up to 128 regional processors (RP). A further magazine is required for an additional 384 RPs (3x128).

In the APZ 210 06, the CPU, program data and reference stores, plus the regional processor interface (RPI) are "housed" in individual magazines.

OPERATING PROCEDURES — A COMPARISON BETWEEN APZ 210 06 AND APZ 211 02

The operating procedures developed by LM Ericsson for the APZ 211 02 have been enhanced to be more "user friendly" and are a considerable improvement on those for APZ 210 06.

The improvements have been based on the experience gained from approximately 50 different countries which have adopted the APZ 210 06 system.

Examples of the "user friendliness" are as follow:—

1. APZ 211 02 requires only one operational instruction when diagnosing central processor faults, whereas APZ 210 06 requires ten such instructions.
2. Built in diagnostic programs will generate printouts and instructions which clearly advise the operator how to handle single APZ 211 02 CPU faults. In the APZ 210 06 case, the printout would usually refer the operator to additional documentation needed to assist in fault clearance.

TECHNICAL SPECIFICATIONS

A COMPARISON BETWEEN APZ 211 02 AND APZ 210 06

ITEM	APZ 211 02	APZ 210 06
Call handling capacity	150,000 BHCA	144,000 BHCA
Environment	Standard AXE	Standard AXE
Cooling	No fans needed	Fan cooled
Power consumption Central processor group	less than 350 W	3500 W (MAX) (Typically 1800W)
Components	● FAST	Shottky T.T.L.
	● C M O S components	
	● Gate arrays	—
	● TTL bit-slice processors	—
	● Commercial micro-processors	LME Designed-processors
Memory	64 k bit DRAM,	16 k bit DRAM
Memory capacity	4 M words (16 bits per word)	12M words (16 bits per word)
★Maximum memory capacity	16M words (16 bits per word)	—
Memory extension	256 K 16 bit words	64K 16 bit words
Maximum number of software blocks	4095	4095
Function block size	16 K	16K
Number of regional processors	512	512
Memory Parity/Check bits	6	1
Single bit fault rectification	Hardware (Automatic)	Software

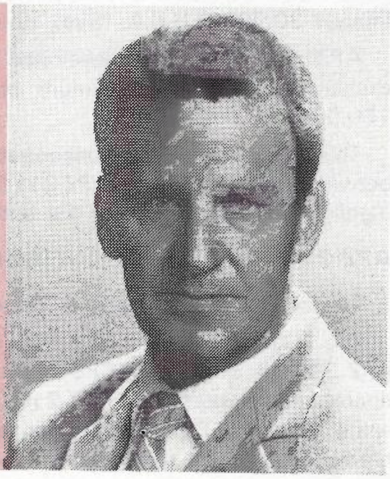
★ A new memory board of 1M 16 bit words is planned to be incorporated into the current APZ 211 02 processor. The new memory board will use 256K bit DRAM. The board can be "housed" in the existing CPU magazine and will extend the memory capacity from 4M to 16M.

DAVID SYNNOTT is a Supervising Engineer in the New Processors Project Group of the AXE Project Team in Headquarters.

He first joined the PMG's Department in 1952 as a technician-in-training and graduated as an engineer in 1967 when he was transferred from the Victorian Exchange Installation Section to Headquarters.

Between 1967 and 1977 he was involved in the equipment engineering aspects of ARF equipment, which included the register modification project (REMO) and the introduction of the ARE-11 switching system.

Since 1977 he has been involved in the following aspects of the AXE switching system — tender evaluation of SPC local systems, equipment engineering, installation engineering, provisioning, implementation, processor capacity studies, and the introduction of new AXE processors.



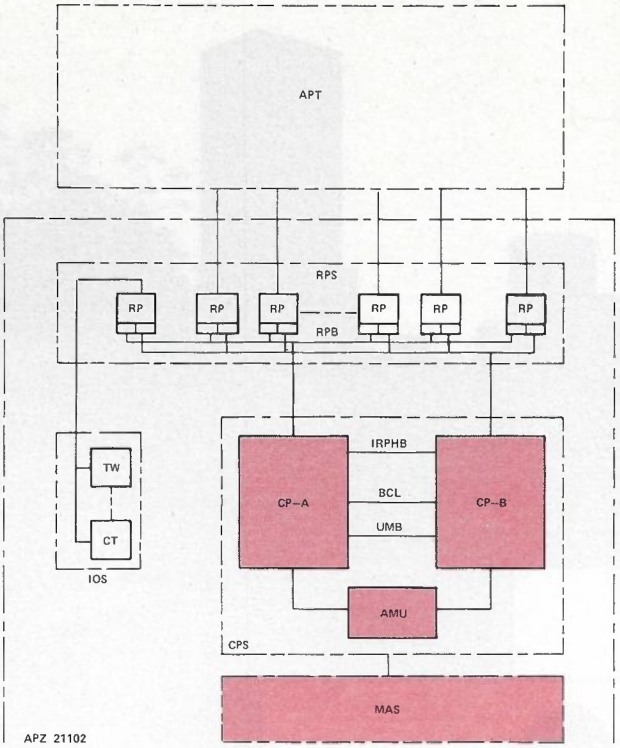


Fig 1 System Configuration

Legend:

AMU= Automatic Maintenance Unit
APT = Switching System
BCL = Bus Access Controller Link
CPA, CPB = Central Processors, 'A' and 'B' Side
CPS = Central Processor Subsystem
CT = Cassette Tape — I/O Device
IOS = Input/Output Subsystem
IRPHB = Inter Regional Processor Handler Bus
MAS= Maintenance Subsystem — handles faults
RP = Regional Processor
RPB = Regional Processor Bus
RPS = Regional Processor Subsystem
TW = Typewriter — I/O Device
UMB= Updating Match Bus

IMPLEMENTATION OF APZ 211 02

The first APZ 211 02 was commissioned in Finland in Nov. '84, and indications are that all countries using AXE will adopt the new processor.

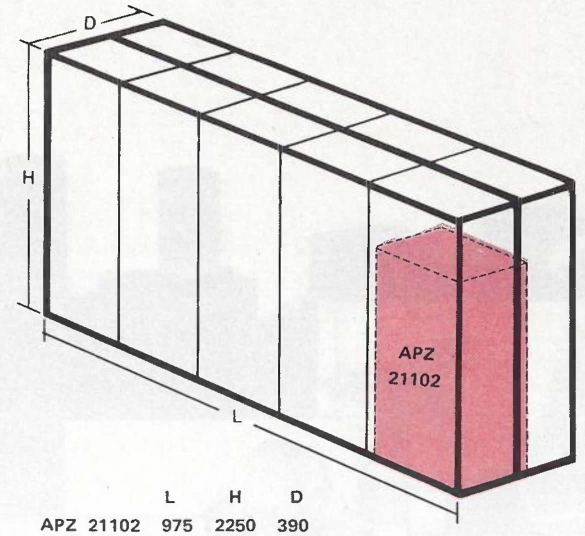
The first APZ 211 02 in Australia was installed at the Headquarters Model in Feb. 1985 and this was followed by the Tooronga Training School in April 1985. Other installations include Parramatta in NSW, Moolap (Geelong) and Mordialloc in Vic. and Salisbury and Mt Gravatt in Qld. A further 41 exchanges using APZ 211 02 will be installed throughout Australia in 1985/1986.

APZ 211 02 SOME OTHER ADVANTAGES OVER APZ 210 06

1. Cost

The purchase cost of APZ 211 02 is significantly less than an equivalent APZ 210 06.

The operating costs will also be less, due to an approximate 90% decrease in the power requirements and a reduction in the number of spares needed to support the system.



	L	H	D
APZ 21102	975	2250	390
APZ 21006	5121	2763	640

Fig 2. Physical Size of APZ 211 02 compared with APZ 210 06

Furthermore, APZ 211 02 requires only 10% of the floor area needed by an equivalent APZ 210 06.

2. "Standard" Factory Testing Techniques.

All APZ 210 06 processors were manufactured and tested in Sweden. Each processor, consisting of a large number of individual parts (typically ten magazines) was extensively tested and then delivered as one unit.

This testing procedure was comparatively costly but ensured that the delivered unit would be fault free.

The design of the APZ 211 02 processor, with its in built central processor test functions (CPT), allows the manufacturer to use much simpler factory testing techniques than were required for APZ 210 06.

CONCLUSION

Telecom Australia will use the new APZ 211 02 Central Processor System in most new AXE exchanges. This new system offers a considerable number of advantages over the APZ 210 06. These advantages include:—

- Reduction in floor space
- Reduction in cost
- Reduction in power requirements
- Utilisation of modern technology
- Improved fault location functions
- Reduction in the number of component parts, with a consequential increase in system reliability
- Reduction in the number of spares
- "Standard" factory testing techniques, pre-delivery

References

1. T.J.A. Vol 28 No. 3 AXE/AOM Some Design Aspects M. K. Ward and W. R. Craig.

2. T.J.A. Vol 28 No. 3 Construction Aspects of the AXE System R. Marshall.

3. T.J.A. Vol 28 No. 3 Operation And Maintenance of AXE In The Australian Telephone Network W. K. Bate.

AXE.
It listens to all the voices.

When a telephone company chooses a network switching system, it must listen to many voices – voices which demand very different, often contradictory, things.

The voices of the town and the country. The voices of business and private subscribers.

The voices of scientists and financiers.

The voices of staff and subscribers.

And, not least, the voices of today and tomorrow.

One system – perhaps *only* one system – listens to all these voices, reconciles all these conflicting demands.

It's the AXE digital switching system, which has successfully solved network problems for more telephone companies than any other digital switch in the world.

One system

Digital switching is at the heart of advanced telephone networks. In less than ten years, it has revolutionized telecommunications planning, installation and operation.

For tiny systems serving remote communities… for vast exchanges handling international traffic… for every size of exchange in between… digital switching offers faster, more economical, more capable service.

But since a single network incorporates exchanges of every type and every size, it's essential that a single, all-embracing system can cover them all. Such a system simplifies training, documentation, deployment of staff, operation, maintenance, spares and parts inventory… all the tasks that occupy a busy telecommunications company.

AXE is just that – a single system structure for all applications. A system proven in more environments, for more applications, for more telephone companies, than any other system in the world.

Listen to AXE

AXE is part of Ericsson's unique total-network capability. Switching, transmission, power, planning – no other telecommunications supplier offers such a comprehensive range of products and services. Telephone companies in nearly 60 countries have ordered or installed AXE exchanges; a total of over 10 million lines.

If you'd like to keep in touch with the spectacular success story of AXE, we invite you to add your name to the circulation list for *Connexion*, Ericsson's English-language magazine which covers technology and applications. Simply complete and post the coupon.

House Sweden E583

ERICSSON

To: L M Ericsson Pty. Ltd.,
P.O. Box 41, Broadmeadows,
Victoria 3047, Australia.
Please send me one issue of *Connexion*.

Name:__________
Title:__________
Organization:__________
Address:__________
City:__________
State/Country:__________
Postcode:__________ Tel:__________

Type of organization
Telephone Administration ☐ Government ☐
Business/Finance/Consultant ☐ Education ☐
Supplier of telecommunications equipment ☐
other (please specify)

Early Automatic Telephony in Australia

J. F. MOYNIHAN APTC (Comm. Eng) MIE Aust.

Although automatic telephone systems become viable in the 1890s, it was 1912 before Australia's first public automatic telephone exchange was commissioned. The reasons for this time lag are examined and the first automatic telephone exchange installation for each capital city is considered, to varying degrees. The first Perth installation is examined in detail, as it caused notable trouble in its early days of service. Emergence of the smaller Rural Automatic Exchange in the 1920s and 1930s is briefly considered.

This paper was originally delivered at Melbourne on 22 May, 1985 to a conference on the Value of Engineering Heritage sponsored by the Institution of Engineers, Australia in association with the National Trust of Victoria and the Museum of Victoria. It is reproduced here with the kind permission of the Institution of Engineers, Australia.

SUMMARY

The paper discusses the initial installation of automatic telephone exchanges in Australian capital city networks in the 1910s and 1920s with particular discussion of problems associated with the Perth installation. Rural Automatic Exchange development in the 1920s and 1930s is briefly outlined.

INTRODUCTION

A fair proportion of engineering heritage matters deal with activity of which some sort of physical evidence remains; eg, bridges. With communication engineering and allied fields such as electronics the working life of plant is relatively brief due to technological changes. Also as the plant is easily disposed of, few artefacts remain. Thus it is necessary to seek out the engineering heritage of communications from written records, photographs and the like. This paper is a case study assembled in that manner.

In this age of automation it is difficult to believe that automatic telephony was not readily received as it emerged. The paper examines the reasons for this, especially as these reasons affected the Australian scene.

Automatic telephone working was first patented in the USA in 1879 but it was some years before a workable system emerged and even this was limited by practical considerations.

After examination and consideration of both automatic and manual systems available world-wide, Australia opted for manual equipment in 1906. It was to take a second overseas trip by the Postmaster-General's Department Chief Electrical Engineer John Hesketh in 1912 before automatic working began to be accepted in Australia. Even then troubles experienced with the Perth installation cast a brief cloud over the system's future. Subsequently World War I slowed up introduction of automatic telephone working to all Australian capital cities.

Rural Automatic Exchanges were introduced to Australia late in the 1920s, but their spread throughout the nation was slowed by the depression.

EARLY AUTOMATIC TELEPHONE SYSTEMS

Bell invented the telephone in 1876 and only three years later Connolly and McTighe were granted a USA patent for an automatic system. This and a number of other early systems, described in references 1-4, were not practical.

The first viable automatic system was patented by Almon B Strowger in 1891 and the first exchange of this type was commissioned at La Porte, Indianna late in 1892[5]. This system used five wires from the exchange to each subscriber. The Strowger company's Alexander Keith together with John and Charles Erickson introduced an improved bi-motional selector in 1895 and the rotary finger-wheel dial in 1896. Other improvements took place and, by 1900, there were only two wires from exchange to subscriber; however a third wire connected to ground at the subscriber's premises was necessary to complete a call from an automatic telephone instrument — this was the so-called three wire working. In some, if not all systems, each instrument required a local transmitter battery.

Presumably there was some interest in Australia in the activity of the 1890s described above, but the writer has not researched that era.

AUSTRALIA: 1901-1910

The first mention of automatic telephony in an Australian publication seen by this writer is in the Melbourne Herald of June 1903. It was stated that the firm of Clarke, Padley and Coy of Melbourne had brought to the notice of the Postmaster-General an automatic telephone system for which they supplied a catalogue. Apparatus was not available for a practical test[6].

At the formation of the federal Postmaster-General's (PMG) Department in 1901 there was initially no Engineering Department at the Melbourne Headquarters.

Late in 1904 John Hesketh, Electrical Engineer for the PMG Department, Queensland, went on an overseas tour to study recent developments in the telephone art, including automatic working. Hesketh, an Englishman, had been brought to Australia by Queensland's Colonial Post Office as their Electrical Engineer in 1896. He was previously an Electrical Engineer with the Corporation of Blackpool.

On his return in 1905 Hesketh reported, inter alia, on automatic telephony; it was, he said, the most difficult problem to solve on his tour; ie, automatic versus manual systems. The greater majority of installations he saw were of the then modern common-battery (CB) manual switchboard. Also the automatic system would not, among other things, work party lines or private branch exchanges. Hesketh's report opted for the CB system but concluded that the PMG Department should not lose interest in automatic working altogether.[7]

John Hesketh was appointed to the PMG Department's Headquarters Administration as the first Chief Electrical Engineer in February 1906. At that time a decision had to be taken as to what type of apparatus would be installed in new exchanges planned for Sydney, Melbourne and Hobart. PMG Austin Chapman decided on CB on Hesketh's advice[8]. Subsequently, Australia's first CB exchange was opened at Hobart in 1907.

Alexander Graham Bell visited Melbourne in 1910 and gave evidence to a Royal Commission investigating the Postal Service. Bell's opinion was that the CB system was "the most perfect system at present existing". He described automatic working as "still in the experimental stage" and seemed to be in favour of it being made "more practical"[9]. Bell was also very critical of the poor quality service being given in Australia by the single wire earth return subscribers' circuits. Only eight percent of lines in the nation were metallic (two wire) at 1901; by 1910 this had risen to fifty percent.

In discussing the state of telephone switching on the world scene as it was in 1910, Chapuis says: "In switching, manual telephony held undisputed sway in 1910, except among a few dissidents who were still regarded as exaggeratedly progressive. Manual telephony had reached a high degree of perfection, especially in the United States ... Indeed automatic exchanges were the exception to the rule and, in the United States, were operated by the independants (non-Bell companies). In Europe a few were put into service ...")

Chapuis then goes on to say that despite the doubts of most telephone authorities, automatic exchanges were proving that they worked properly and that the public was adapting to the new, albeit more complex method of operation.

AUTOMATIC TELEPHONY EMERGES IN AUSTRALIA

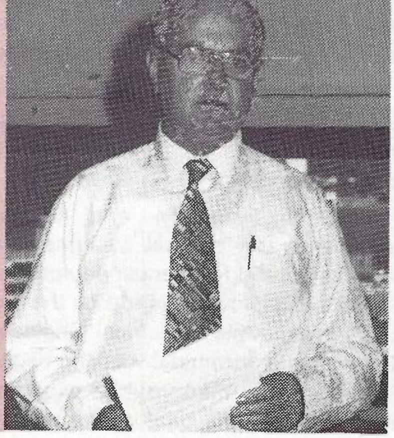
Obviously the PMG Department had been thinking of automatic telephone exchanges in 1910 as, in January 1911, tenders were called for a switchboard at Geelong which allowed for alternative tenders for manual or automatic equipment. The gazettal said that tenders would be accepted for either a branching multiple magneto lamp-signalling switchboard, or an automatic, or semi-automatic switchboard "together with all associated apparatus and subscribers' instruments".

In March 1911, the Sydney Morning Herald announced that a representative of the Automatic Telephone Company would soon arrive from America with an automatic plant capable of dealing with 100 subscribers; PMG Josiah Thomas was hopeful it would be installed in the Sydney GPO to allow automatic working to be given a practical and thorough test. The equipment was installed, at the company's expense, in Sydney's GPO and its operation was demonstrated to Prime Minister Andrew Fisher early in April. The exchange was brought into use on 4 May, 1911, more or less as a PABX, there being at that time 290 GPO extensions and 2 lines each way connected to the City Exchange. The plant was eventually purchased for £500, in 1913[10].

Obviously the Sydney GPO plant had the desired effect as the tender of Automatic Telephones (Australasia) Limited [AT(A)] of Sydney of £14,293 was accepted in October 1911 for "supply and delivery, and installation in working order of an automatic switchboard, together with all associated apparatus at the Post Office, Geelong"[11]. [AT(A) were the Australian agent for the Strowger company, which by 1911 was known as the Automatic Electric Company of Chicago (AEC)].

Unfortunately, no official records or drawings dealing with Geelong have survived in Australia, or with the

JOHN MOYNIHAN joined the Postmaster-General's Department as a trainee technician in 1949. He was later appointed a trainee engineer and graduated in Communication Engineering from Perth Technical College in 1958. He spent most of the 1960s in the Perth Metropolitan Exchange Installation Division and was then on rotation duties as an Engineer Class 2 in the Telephone Exchange Equipment Section at Headquarters 1968-1970. On return to Perth he was an Engineer Class 3 in Metropolitan and Country Field Engineering Sections until promotion to the position of WA State Co-ordinator, Design and Practices (Engineer Class 4) in 1978. He is presently Supervising Engineer, Materials Section, Perth. He was the foundation President of the Post Office Historical Society of Western Australia and he is also a member of the Heritage Sub-Committee of the Western Australia Division of the Institution of Engineers, Australia.



manufacturer in America. The 800 line installation was placed in service on 6 July, 1912[12]. The first automatic exchange in England had been opened at Epsom only two months before, on 14 May, 1912; 500 lines were installed. Both the Epsom and Geelong installations were of the Strowger type, using equipment manufactured by AEC. The Epsom installation's workings are described in detail, including circuit diagrams; at reference 13, it may therefore be assumed that much of this description is applicable to Geelong and other early installations in Australia. A general description of the Strowger system written in Australia at that time is at reference 14.

There had been a number of automatic exchanges opened in Canada prior to 1912[15]. Hence Australia was the third country in the then British Empire to have automatic telephone working.

The Geelong installation seems to have worked reasonably well after commissioning, but late in 1913 there were claims that "the service has deteriorated". Edward Howson, Assistant Engineer Telephone Equipment, Victoria, visited Geelong, examined the exchange and also discussed the matter with twenty-six important subscribers He concluded that the claim did not have any foundation in fact; however Howson reported that a fair number of wrong numbers were called and that the calling device (dial) was capable of improvement[16].

HESKETH'S SECOND OVERSEAS TOUR

A conference of PMG Electrical Engineers from all states met at Melbourne in July 1911. Automatic telephony was on the agenda and they visited Sydney to examine the GPO installation. In a subsequent minute to the Secretary of the Department, a document signed by all the State representatives recommended that a special study be conducted on the system, including an overseas trip by the Chief Electrical Engineer and two others[17]. The Secretary's reaction at that time is not known; however, when tenders were subsequently received for the Perth exchange, as discussed below, Hesketh went overseas to make enquiries about the relative merits of various automatic systems.

Hesketh travelled abroad, alone, from 12 February to 14 July, 1912. On his return he wrote a report favouring automatic telephony. He pointed out that many advances had been made in the Strowger system since his previous trip in 1904; some of these were (a) use of a common battery instead of the local battery system, (b) use of two wire instead of the three wire system (two wire working was introduced in 1909), (c) adoption of party line working, (d) use of the Keith line switch (plunger uni-selector) instead of the costly, individual bi-motional selector for each subscriber's line (the Keith switch had emerged about 1905).[18]

THE PERTH SWITCHBOARD TENDERS

In 1910 Perth's city exchange was an overloaded Western Electric magneto multiple installation, its beginning dating back to 1892. Tenders were called in October 1910 for "the supply and delivery of one Common Battery Switchboard for the Perth Central Exchange".[19] Five tenders were received, four for CB manual equipment and one for automatic equipment[20]. The tenders for CB were in the range £10,500-£12,240 whereas that for automatic [from AT(A)] was for £23,500.

Hesketh considered the tenders and in June 1911 wrote a report saying in effect that automatic equipment should be considered for Perth and that fresh tenders be called for automatic or semi-automatic equipment. His recommendation was accepted and an appropriate notice appeared in the Gazette in July 1911[21].

Tenders were lodged at Perth and sent to Melbourne. It appears that the highest tender for automatic equipment, including supply of telephone instruments, was £35,400 — which included £1020 to install the automatic exchange equipment. No further details of the second lot of tenders have survived as, in February 1912, the Deputy Postmaster-General Perth had all tender papers returned to him with instructions to return deposits to tenderers. The reason given was that, as the Postmaster-General had agreed to the Chief Electrical Engineer visiting Europe and America to enquire into automatic telephony, the matter was to stand over until his return. In making his submission to go abroad, Hesketh had made the point that, while Perth was the only exchange then under consideration, "several exchanges in Sydney and elsewhere require new equipment ... (and that) the Department's officers should be put into possession of all available information on which to decide whether the (automatic) system could be applied ...".

A week before Hesketh's return tenders were again called for Perth switchboards. It appears that the Minister was impatient in this matter, hence his not waiting for Hesketh's advice as to specifications. Tenders were invited for CB manual, or semi-automatic, or fully automatic boards.[22]

The offers received, arranged in order of annual costs, were:

	Annual Cost	Installed Cost
Western Electric Coy — full automatic	5,062	28,355
Western Electric Coy — semi-automatic	5,569	22,955
Siemens Bros — full automatic	5.805	35,109
Automatic Electric Coy — full automatic	5,924	36,193
Western Electric Coy — manual CB	6,250	12,369

Hesketh wrote in favour of accepting a quote for automatic. He went on to point out that the Minister had directed that no order be placed on the Western Electric Coy "until certain questions of an important nature are settled". He also said that acceptance of Siemens' quote would make it "necessary to obtain a satisfactory indemnity as to patents". The offers were referred to the Minister via the Secretary on 30 January, 1913. On 10 February, 1913, PMG Charles Fraser endorsed the file: "Accept tender of Automatic Electric Company". (In fact the tender had been lodged by AT(A) on behalf of AEC).

Hesketh finally had his way in regard to specifications, his recommendation that the tender of AT(A) be accepted subject to various conditions was accepted. These conditions, in fact variations and additions to the tender specification, cover five pages. Extant official papers make no mention of the size of the installation, however, a newspaper article gave this as 4000 lines of equipment. In addition to the exchange equipment, the final contract price of £42,612 10s included extra for the supply of 3350 wall telephones, 750 table telephones and 40 party line telephones, plus 100 public telephone coin collectors[23]. Party line telephone bells were mechanically tuned to respond to one of four frequencies 16, 33, 50 or 66 Hz.

John Hesketh

OTHER EARLY TENDERS

In March 1912, tenders were called for either automatic or CB switchboards at Newtown, Balmain and Glebe in NSW. This was followed by tenders being invited for a CB installation at Brighton, Victoria, two months later. In October 1912, it was announced that alternative tenders or automatic or semi-automatic equipment for Brighton would "receive consideration"[24].

Acceptance of tenders for automatic installations at Newtown, Balmain and Glebe does not appear to have been gazetted. Telecom in Sydney has it noted (without reference to source) that the tender of AT(A) was accepted and contracts signed on 3 February, 1913, prices being Newtown £15,090, Balmain £8,195 and Glebe £12,975. The same firm secured the contract for an automatic installation at Brighton for £15,950 17s 10d[25]. Thus these other four early Australian automatic exchanges were also of the Strowger type.

TROUBLE AT PERTH

The five installations mentioned in the previous two sections were all commissioned within a short space of time. The PMG's Annual Report for 1913/1914 lists the following[26].

Exchange	Commissioned	Subscribers
Newtown	6.6.1914	1060
Brighton	11.6.1914	1160
Balmain	11.7.1914	610
Glebe	22.8.1914	950
Perth	26.9.1914	3200

It appears that all the early installations, except Perth, worked reasonably well — given the fact that the system was entirely new to both subscribers and those in the PMG Department associated with such work, thus requiring a settling down period after commissioning. The Perth installation was by far the largest then in service in Australia; also it was the only one in a central city business area and, from the start, there was trouble. Much of the early problem was due to two causes; firstly, subscribers having no knowledge of how to operate an automatic telephone instrument and, secondly, insufficient exchange equipment had been installed to carry the traffic offered by subscribers (although the contractors had been supplied with information on traffic through the manual switchboards). There were also other matters as discussed below.

There were the inevitable letters to the editor. A week after cutover one correspondent wrote" . . . In common with the rest of the people of this state, we business men have already to contend with three separate and distinct blights — the Scaddan Ministry, the war and a bad season; it is too much to expect that we shall remain silent when this burden is increased by what seems to be a most aggravating and unworkable telephone system'. A month later another correspondent suggested that on Guy Fawkes Day (November 5) Perth's schoolboys be allowed to collect all automatic phones to make a bonfire.[27]

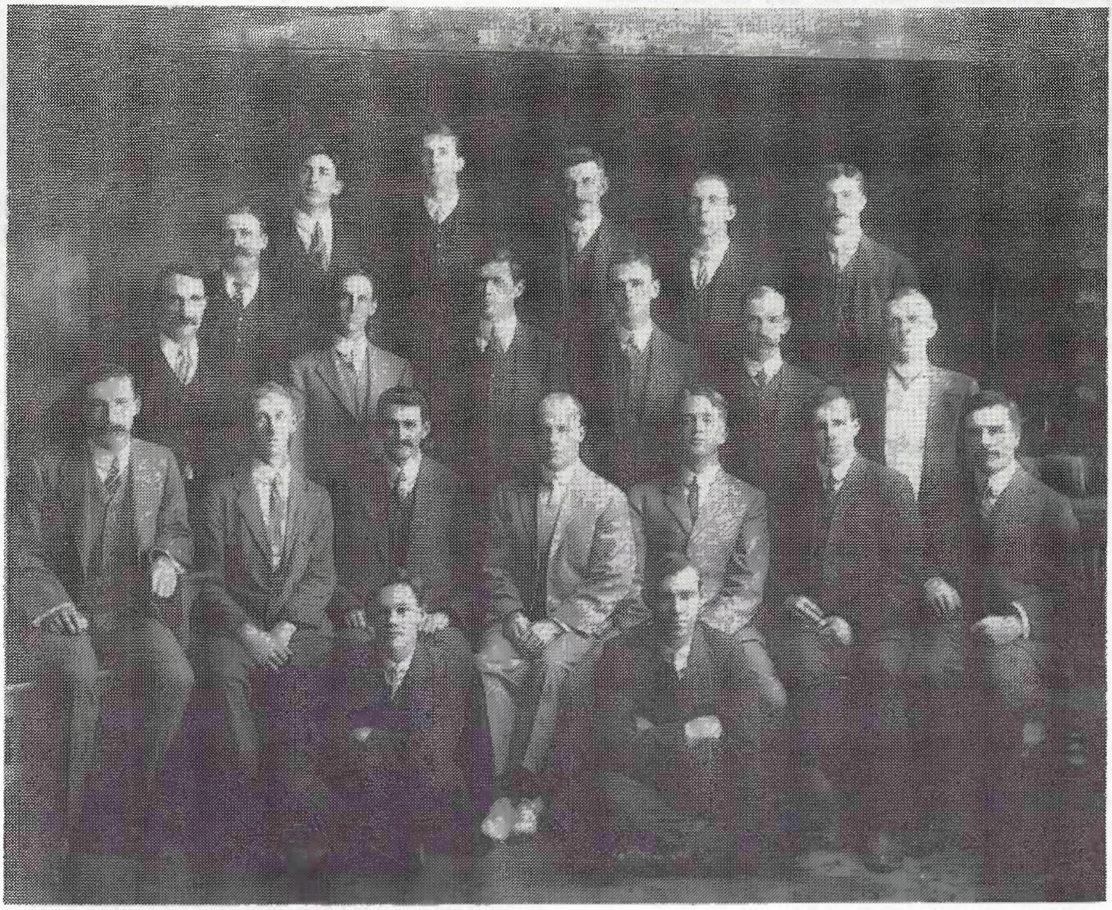
The poor performance of the Central Exchange Perth was aired in Parliament. This resulted in Perth subscribers being rebated one half of their rental charges for the first two week's operation of the new exchange.[28]

Hesketh had been present at the Perth cutover in 1914. He returned in February 1915 for two weeks and subsequently prepared a report on his findings[29]. He was critical of the maintenance and operation of equipment dealing with calls to and from the other (all manual) exchanges in the Perth metropolitan network; PBX operators tied up equipment and caused congestion; insufficient rotary connectors (PBX final selectors) had been supplied; there were insufficient junction lines to Fremantle, furthermore, construction of the open wire junctions to Fremantle was fault prone; it appears that insulation of some other junctions in the network was sub-standard; there was doubt about procedures to ensure proper issue and maintenance of telephone instruments, especially dials which were fault prone; trained switchroom staff were sometimes put on other duties to the detriment of switching equipment; routine tests on equipment were not carried out to schedule; fault analysis was off-handed; although line construction in the city itself was good (having been undergrounded in the years prior to cutover) some outlying areas were not up to standard, this situation was causing various troubles; engineers and traffic officers had not met formally since May 1914; a scheme to observe subscribers' lines was to be provided.

The contractor's engineer, Harry S. Janes, was still being held in Perth, also the Department still held the deposit (lodged with the tender) of £1090 plus £1150 as a portion of the contract payment.

Before he left Perth, Hesketh was interviewed by the press and gave the opinion that the service was as good as any manual system. He also went out of his way to

Installation of Automatic Telephone Exchange, Perth, W.A., 1913-14



BACK ROW: E. Harpham, H. Hokin, J. Boiluea, J. Yates, C. S. Anderson, E. J. Burlton.
SECOND ROW: J. Thompson, S. Cranwell (South Aust.), R. H. G. Gulliver (Queensland), A. U. Lyddall (Queensland), T. Johnston, C. W. Ive (Queensland).
FRONT ROW: C. Greaves (Tasmania), H. B. Barton (Foreman), A. C. G. Rosser (Engineer for Equipment), H. S. Janes (Instal. Engineer, CHICAGO), F. Kessler (Installer, CHICAGO), G. Treacher, N. B. Stone (South Aust.).
SITTING: E. Wilson, M. Foley.

This photograph was donated to Telecom WA, by relatives of the late Mr A. C. G. Rosser early in 1985 and after Mr Moynihan's paper was completed. The fact that the photograph existed was not previously known to Telecom WA. Because of its relevance, the photograph is reproduced here as an adjunct to the above paper.

make it clear that the under-trunking was the contractor's fault — it being written into the contract that sufficient apparatus to carry offered traffic be supplied. The press in its report did not seem entirely convinced in regard to the automatic service vis-a-vis manual[30].

Soon after Hesketh departed, the Deputy Postmaster-General, Perth, proposed to the Secretary that the contractor should be responsible "for the expense to which the Department has been put through their admitted failure to provide sufficient equipment"[31]. Soon after, the contractor tendered an account for £1087 12s 9d for the extra equipment supplied in order to carry offered traffic, the main item being 200 secondary line switches and 130 selectors. Discussion on the whole matter dragged on for some months, with Hesketh arguing that not all the problems and expense had been caused by the contractor. Finally, in August 1915, a legal agreement was drawn up and signed in Perth; the company agreed to withdraw the claim for extra equipment and the PMG Department paid all outstanding monies except £350 which was held to cover some miscellaneous items in need of attention. Harry Janes then left Perth and proceeded to work on the Burwood installation in Sydney.

ACCEPTANCE OF AUTOMATIC WORKING

In September 1915, a Parliamentary Committee on Public Works was formed to hear submissions on the provision of automatic exchanges at City North, Sydney, Malvern and Collingwood. By that time, automatic exchanges were already working in NSW at Mosman, Ashfield, Burwood and Homebush. (It was to be July 1919 before Victoria's second metropolitan automatic exchange was commissioned at Malvern).

In giving evidence Hesketh admitted to "the unfortunate experience at the beginning of the Perth system". He was, however, wholly in favour of automatic working and his evidence and the evidence of others swayed the Committee who in its final report of October 1915 said: "The Committee is satisfied with personal observation, from the evidence of the expert engineers of the Postmaster-General's Department, and from the testimony of commercial men who use the automatic telephones to a considerable extent, that the system is highly efficient and a distinct improvement on the manually operated system. It has, therefore, no hesitation in recommending that the automatic system be adopted in cases where the establishment of a new exchange of a sufficient size is in contemplation, or where manually operated boards of a sufficient size have outlived their period of usefulness and have to be replaced'[32].

From that time, automatic telephony was accepted in Australia although its spread, slowed by two world wars and a depression, was more gradual than would have been envisaged in 1915.

AUTOMATIC IN OTHER STATES

For the sake of completeness, the introduction of automatic working in those Australian states not already mentioned is discussed in this section.

The first automatic equipment in South Australia was, in fact, a semi-automatic installation. Under this system the subscriber lifted off the handset or earpiece and was automatically trunked to a telephonist. If the call was to another subscriber in the same exchange, the telephonist entered the required digits by means of a keysender and withdrew. The method of completing calls to or from other exchanges depended on the type of terminating equipment.

The Port Adelaide semi-auto was cutover in August 1916. The equipment was manufactured by Siemens Bros and, generally speaking, worked on a similar principle to Strowger equipment; ie, using relays, uniselectors and bi-motional switches. Two other semi-auto installations were completed in 1919 — Unley and Norwood. These were both Western Electric (WE) installations, working on a different principle from those already discussed. The WE system used various units that were power driven by a continuously rotating shaft. A brief description of both the Siemens and WE systems and also the Strowger system is at reference 33. A highly detailed description of these three (and other) systems is at reference 34.

The first exchange using full automatic working came to the Adelaide network with the cutover of the new Port Adelaide Strowger (or step-by-step as it had become known) exchange on 3 April, 1926.

In original planning for early automatic exchanges in Australia a number of exchanges in the Brisbane network had been under consideration. However World War I and other matters intervened and it was July 1925 before Queensland's first automatic exchange cutover at South Brisbane. This was the Siemens 16 system, which was step-by-step equipment.

Hobart's Central automatic exchange, also step-by-step, was placed in service in October 1929.

In regard to the Territories, Canberra's automatic exchange was cutover in March 1927 while Darwin's first installation — prefabricated in a portable building at Sydney — was commissioned in January 1958. This supplemented a manual exchange. All Darwin subscribers were cutover to a new automatic exchange in a permanent building during December 1959/January 1960.

INTRODUCTION OF THE ROTARY UNISELECTOR

John Hesketh, who must be considered as the father of automatic telephony in Australia, died aged 49 in 1917. Hesketh's successor was Frederick Golding from NSW. Golding made his mark in the history of Australian automatic telephony, but with unusual results.

In 1922, Golding was charged under the Public Service Act on eight counts. One of these was that he had arranged, without proper authority, for AT(A) to substitute the superior 25 point AEC rotary uniselectors for Keith line switches, as secondary finders, in equipment to be supplied to City North, Sydney in 1920, the extra cost being £1933.

A number of witnesses were examined before it became clear that an AT(A) company engineer in Australia had cabled Chicago to make the change, after some months of unsuccessfully encouraging PMG engineers to place a formal order. Golding's part, it seems, was associated with authorisation of payment of the extra £1933 at a later date. This particular charge was found to be 'not proven'; other charges, strange by today's standards, were found to be 'proven' and Golding was demoted. This is not the place to discuss the case, but the assertion by Golding's advocate, Stanley Lewis KC, that his client had been "treated like a dog", seems apt[35].

RURAL AUTOMATIC EXCHANGES

Previous sections have dealt with metropolitan type, ie, large exchanges, each capable of expansion to nominally 10,000 lines. It is fitting to make brief mention of automatic working in the country.

Rural Automatic Exchanges (renamed Small Country Automatic Exchanges in 1964) are self contained unit type installations serving, in their early days, about 100 subscribers maximum.

Nelder claims that the first RAX in Victoria was built by the PMG Department and installed at Barep in 1925[36]. It is possible that other exchanges in Victoria and perhaps other states were similarly served; ie, by local design and manufacture, but this writer has not pursued that aspect and the remainder of this section deals with units purchased from commercial manufacturers.

The Annual Report of the PMG's Department for 1926/27 says that the first two RAXs were at Sutherland, NSW and Springvale, Victoria, being cutover on 1 December, 1926 and 7 May, 1927 respectively.[37] In 1947, a list of RAXs installed to that time, together with cutover dates was assembled by PMG Headquarters.[38] or the four states not already mentioned the first RAX cutovers listed were — Goodna (Qld) 20 May, 1935; Willunga (SA) 10 January, 1935; Brunswick Junction (WA) 17 July, 1935 and Ross (TAS) 21 September, 1935.

These dates illustrate that while less than ten RAXs had been installed in Victoria and New South Wales in the 1920s, the effect of the depression was to delay initial installations in other states. No technical details of early RAXs have survived but most, if not all, probably would have worked on the step-by-step principle.

CONCLUSION

Australia was fortunate with the introduction of automatic telephony in that John Hesketh was a man of vision and talent. He was instrumental in allaying the concern of both laymen and his fellow engineers, concern also felt in places other than Australia, at the introduction of a then suspect system. Engineers today can look back over the many decades of automatic working to see the solid foundation laid by Hesketh.

ACKNOWLEDGEMENTS

The author is grateful to Messrs M. Gooley and K. Work (Adelaide) for information on early South Australian installations. Mr J. Lightfoot and other members of the Queensland Postal-Telecommunications Historical Society supplied information on John Hesketh's early days in Australia and also on Brisbane automatic installations. Staff of the State Reference Library of Western Australia were most helpful with newspapers and Commonwealth Government publications.

The author is especially grateful to Mr S. R. E. Warner, Manager, Central Registry, Telecom Headquarters, Melbourne, for his help over the years with early files of the PMG's Department.

REFERENCES

1. Chapuis R. J., **100 Years of Telephone Switching (1878-1978), Part 1. Manual and Electromechanical Switching.** North-Holland, New York 1982.
2. Kingsbury J. E., **The Telephone and Telephone Exchanges, Their Invention and Development.** Longmans-Green, London 1915.
3. Lawson R. A., History of Automatic Telephony. **Post Office Electrical Engineer's Journal** (POEEJ) Vol. 5, 1912/13 pp192-207.
4. Hill R.B., Early Work on Dial Telephone Systems, **Bell Laboratories Record.** January 1953 pp22-29 (Contains a list of US Patents for Automatic Telephone Exchange equipment issued during the years 1879-1900).
5. Hill R. B., The Early Years of the Strowger System, **ibid.** March 1953 pp95-103.
6. **Herald** (Melbourne) 16.6.1903 p2, 17.6.1903 p.3.
7. **Reports by Mr John Hesketh . . . on (1) Matters Investigated By Him During His Recent Tour of America and Europe (2) The Message Rate (Measured Service) or Toll System of Charging for Telephone Service (3) Further Report on the Automatic Telephone Exchange System.** Commonwealth Parliamentary Papers, General (CPP), 1905 session, vol 2, pp1461-1485.
8. **Argus** (Melbourne) 20.2.1906 p7: See also **Commonwealth Parliamentary Debates** (CPD) 22.8.1906, vol 33, p3240.
9. **Royal Commission on Postal Services.** CPP, 1910 session, vols 4 and 5; see Bell's evidence vol 5, particularly pp2417, 2418.
10. **History of the Telephone Service in New South Wales,** Section 13, Telecom Public Relations Section, Sydney, n d.
11. Geelong switchboard: Tenders called, **Commonwealth Gazette** (CG) 28.1.1911 p89; contract let **CG** 7.10.1911 p2020.
12. Articles on the Geelong installation appear in the Melbourne **Argus** as follows: 15.8.1911 p4; 2.11.1911 p6; 1.4.1912 p6; 25.4.1912 p9; 8.7.1912 p11; 9.7.1912 p6; 22.7.1912 p15; 1.8.1912 p10.
13. Bailey W. J., The Strowger Automatic Exchange at Epsom, **POEEJ** vol 5, 1912/13 pp121-192.
14. Baer F. L., Automatic Telephony, **Proceedings of the Electrical Association of New South Wales,** 1912/13 pp125-139.
15. Collins R., **A Voice From Afar, the History of Telecommunications in Canada.** McGraw Hill-Ryerson, Ontario 1977: Also, correspondence with Bell Canada, 1983.
16. **Report on the Working of the Automatic Telephone Exchange Geelong.** CPP, 1914 session, vol 1, pp337-340.
17. Australian Archives (AA) accession MP341, file 22/1324 'Telegraph Systems — Multiplex — Synchronism' (The papers on automatic telephony were obviously misfiled).
18. Hesketh's report is in PMGs **Annual Report** 1912/13 pp35-38. See also 1911/12 **Annual Report** p23.
19. **CG** 15.10.1910 p1639.
20. Details re all tenders for Perth Switchboards in the period 1910-1913 are from AA acc MP33 file 16/558 'Perth Switchboards'.
21. **CG** 22.7.1911 p1700.
22. **CG** 6.7.1912 p1227.
23. **CG** 8.11.1913 p3024.
24. Newton, Balmain, Glebe **CG** 30.3.1912 p442-444; Brighton **CG** 18.5.1912 p1008, 5.10.1912 p2243.
25. CG 9.5.1914 p840.
26. PMGs **Annual Report** for 1913/1914 p37 (It was common for these reports to list matters outside their nominal date range).
27. 'unworkable telephone system' **West Australian** 5.10.1914 p5; bonfire suggestion **Daily News** (Perth) 5.11.1914 p5.
28. **CPD** 11.11.1914, vol 75 p452; See also **West Australian** 30.11.1914 p6.
29. AA acc MP33 file 15/568 'Perth Automatic Switchboards, Report of CEE'.
30. **West Australian** 10.3.1915 p8
31. AA acc MP33 file 15/1835 'Perth Switchboards'.
32. **Report of Parliamentary Committee on Public Works Relating to Provision of Automatic Exchanges at Sydney, Malvern and Collingwood.** CPP 1914-1917 sessions, vol 4, pp533-587.
33. Becher E., Automatic Telephony, **Proceedings of the Electrical Association of Australia** 1916/17 pp67-115.
34. Aitken W., **Automatic Telephone Systems.** 3 vols, Ernest Benn, London 1921, 1923, 1924.
35. The Golding enquiry, held at Melbourne in the period 9-21 October, 1922, was reported in various newspapers: See also AA ACT series CRS A428, item G22-478, transcript of the Golding enquiry: See also **CG** 9.11.1922 p1969, Golding demotion.
36. Nelder R. R., History of Small Country Automatic Exchanges in Victoria. **Telecommunication Journal of Australia,** vol 20, no 3, 1970 pp274-277.
37. PMGs **Annual Report** for 1926/27 p14, see under "Hours of Attendance at Exchanges".
38. Telecom Headquarters, Melbourne, file 293/7/27: See also AA acc MP341 file 32/8673 "Telephone Matters — Rural Exchanges".


As office automation looks toward integrating Computers and Communication, look who's at the leading edge.
To many companies, the integrated efficiency of Computers and Communication is merely a promise, some vague "tomorrow".
STC can make it happen today.
With abilities beyond those of computer-only specialists, STC is advancing the ways in which computers communicate.
By applying the leading edge capabilities that built electronic systems vital to AUSSAT satellites, STC can now create transparent networks that link your existing hardware with new generation systems and previously incompatible hardware.
These STC transparent networks can be tailor-made to specific needs. At the small business level, we introduce networked Personal Computers with multi-terminal capability.
To major corporations we bring virtually unlimited capability and compatibility.
While at the highest level, STC's association with Christian Rovsing allows the total integration of massive mainframe and terminal installations through transparent networks that span the globe.
Perhaps the most significant factor is that your existing hardware does not become obsolete.
With the fearsome costs of replacement eliminated, the immense efficiencies of integrated Computers and Communication need no longer be considered a far-off wonderland.
Come to the leading edge.
Talk to STC today.
STC
An Australian Company of ITT
THE LEADING EDGE.

New Digital Switch Structures

C. J. SCOTT,
E. TIRTAATMADJA

Integrated circuit technology is playing an increasingly larger role in the development of new switching networks. Advances in VLSI circuit technology have resulted in a reassessmment of the functional partitioning of digital circuit switches. New devices are now possible, merging traditionally seeparate switching functions and introducing the flexibility and economic advantage of modularity in switchblock design.

This paper examines the basic structure and characteristics of digital switchblock elements and the possible partitioning of switch functions to take full advantage of semiconductor IC technology. Known implementations of VLSI based digital switch elements are described and switching system implications identified.

INTRODUCTION

The on-going development of new and improved telecommunications equipment and services is heavily dependent on progress in digital integrated circuit (IC) technology. Much of the current impetus towards full digital telephone switching is derived from the inherent characteristics of IC technology; in particular its small physical size, low power consumption, high reliability, relatively low cost and high degree of functional flexibility.

Traditionally the telecommunications industry has been a conservative user of new technologies. Operational requirements related to equipment lifetime in the network such as reliability, security and maintenance have constrained both the selection and rate of application of new tecchnologies. In such situations the introduction of new technologies presents a considerable challenge to both the equipment manufacturers and their client administrations.

An increased use of integrated circuits in general and very large scale integrated circuits (VLSI), in particular, will influence not only the switching system structure, but also the very nature of the services which can be provided. This paper considers the impact of VLSI technology on digital circuit switch architectures. Significant developments are also occuring in other switching areas such as those concerned with packet and multiservice wideband systems. While not specifically addressed in this paper, VLSI techniques will also exert influence in these areas.

OPERATIONAL BACKGROUND

Digital voice signals are normally encoded according to a Pulse Code Modulation Scheme (PCM) (Ref. 1,2) requiring 64 kbit/sec. for each channel. In primary PCM systems, 32 channels are multiplexed into a single 2 Mbit/s stream. The frame structure used and the manner in which the channel information is represented in 8 bit time slots is shown in Figure 1. The basic function of a digital switch is to provide a transparent 64 kbit/s connection between incoming and outgoing digital bit streams.

This form of connection makes no distinction as to the nature of the information encoded, and so both digitally encoded voice and other digital signals may be switched. Connection between channels is established by reordering the digital streams either in space or time, giving rise to the classical building blocks of digital switching; viz. space and time switches.

Space switching involves the reordering of the digital bit streams in space; i.e. information is switched from one physical line to another. In this paper 'space switching' refers to time division space switching; i.e. the switch elements are time shared among a number of customers. Fig. 2 shows the general structure of a space switch. The connections of the crosspoints are reconfigured at every timeslot. The control memory provides storage of interconnection records of the crosspoints. Simple logic gates can be used to realise the crosspoints of a space switching array and this is the approach used to achieve integrated circuit space switches.

The term 'time switch' describes a situation in which the interconnection function is performed solely in the time domain. Functionally a time switch performs 'time slot interchange'; i.e. message contents are transferred from an incoming to an outgoing timeslot. Figure 3 gives the general structure of a time switch, and shows that two blocks of memory are required. One memory stores the contents of incoming timeslots in sequence and the other controls the order in which the messages are placed on the outgoing bus.

Time switches delay the passage of information through the switch by the period of time which elapses between storing the message and reading it onto the outgoing bus. No such inherent delay occurs in a space switch, where a dedicated physical path ensures immediate transfer of information through the switch. Time switches are described as 'nonblocking' when the number of outgoing timeslots equals, or exceeds, the number of incoming timeslots. Hence any incoming timeslot can be connected to any free, or unoccupied, outgoing timeslot.

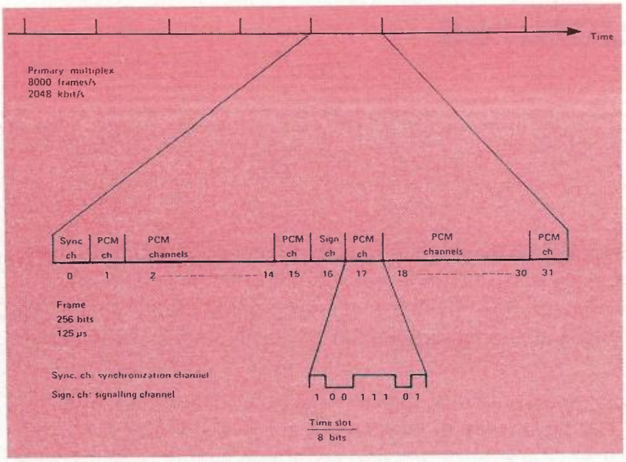


Fig. 1 PCM Frame Structure

VLSI CONSTRAINTS AND INFLUENCES ON SWITCH DESIGN

The present economic structure of a digital switching system is such that the exchange interface equipment absorbs about 80% of the total hardware cost of the exchange. The switch and control equipment accounts for the remaining 20% (Ref. 3). While VLSI device development costs are considerable, the technology if appropriately applied can offer significant switch hardware cost benefits. In contrast, software for switching systems, because of its increasing complexity and its labour intensive nature assumes an increasing share of switching system establishment and maintenance costs. One of the major reasons for the use of VLSI technology in switching networks is to produce modular, flexible hardware structures which in turn promote easier software production and so support a lower overall system cost.

While the application of VLSI confers a large measure of switch design freedom, it also imposes a number of technical and economic constraints on the user. It is within the boundaries imposed by these that the next generation of digital circuit switches will be developed and applied. Traditional switch structures may not be suitable for VLSI implementation. Thus, new switch

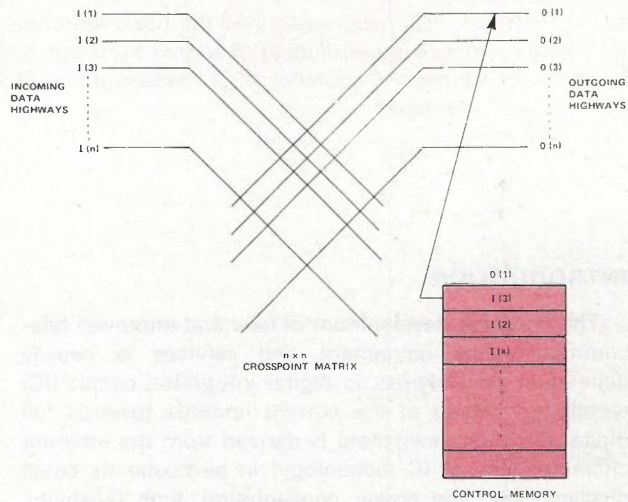
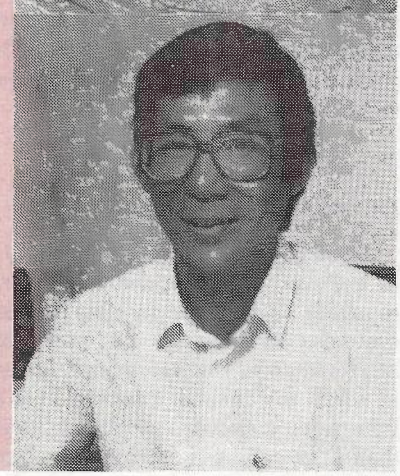


Fig. 2 A General Space Switch Structure

CAROL J. SCOTT is a member of the Switching Technology Section of Telecom Australia's Research Laboratories at Clayton, Victoria. Since joining the Laboratories she has been involved in a number of investigations into the assessment and application on new techniques for use in switching equipment. Current activities include the study of device technologies and application techniques appropriate to the switching of possible wideband services.

EDDY TIRTAATMADJA graduated with a B.E. from Melbourne University in 1976. He then joined the Switching and Signalling Branch of the Telecom Research Laboratories. Since then he has received a M.Eng.Sc. degree from Monash University. He has participated in a variety of projects within the Switching and Signalling Branch and Customer System and Services Branch of the Laboratories. His areas of study have included the assessments of the impact of new device technologies and the application of novel and complex design techniques in the design of telecommunications equipment. His current activities includes the study of the architectures of future switching systems and the design of a test bed for investigations into the implementation of various ISDN ideas and concepts.



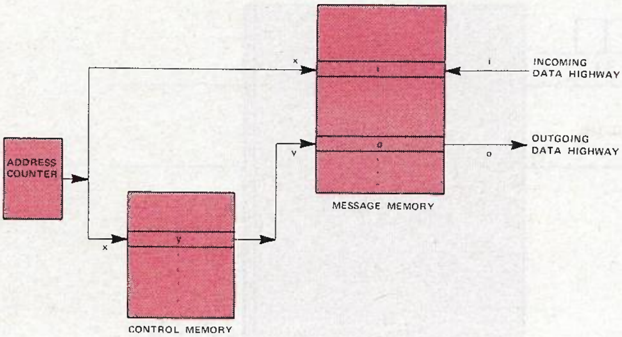


Fig. 3 A General Time Switch Structure

structures which fully exploit VLSI characteristics must be developed.

The volume production and consumption of integrated circuit devices allows sharing of device design and development costs and hence a low unit cost per device. In specialized application areas, such as telecommunications switching equipment, it is more difficult to ensure that this aim is met. It becomes necessary to reconsider the traditional design of the equipment and investigate the functional and physical partitioning of the switching task to suit it to VLSI implementation. In the case of digital switchblock devices, this has resulted in the development of modular, highly structured switch architectures which allow the repeated use of identical VLSI switch elements. The partitioning of switchblock functions in such a manner as to allow the entire switch to be realized as an array of identical devices is therefore one of the chief characteristics of VLSI based switch design.

VLSI SWITCH STRUCTURES

Integrated circuit technology can be applied to produce both traditional and new innovative switch architectures. It is possible, for example, to realise both the classic space and time elements in VLSI form, but limitations arise which restrict the general usefulness of this approach.

As mentioned earlier, the crosspoints of a space switch may be realised using integrated circuit gates. However, the upper size limit of the resulting matrix is constrained by the pinout limitation of a single integrated circuit package. Thus n^2 crosspoints require 2n input/output (I/O) lines plus those lines required for device power and control functions. Conventional IC packaging offers a maximum of 64 pins/device and while newer VLSI package provides the potential for several hundred pins per device they remain generally untried and prohibitively expensive in most system applications.

In practice, efficient crosspoint utilization and the reduction of physical I/O lines has resulted in time sharing of the switch resources and the development of 'time-divided' space switches. The result, however, has been relatively small and inflexible devices which have not found widespread application or industry acceptance.

The upper limit to the size of time switches is generally imposed by the speed of the memory technology in which they are implemented. The speed requirements of the control memory are not such a constraint, since its contents are read once per frame and written to only occasionally. However, during switch operation, the entire message memory must be written to and read from once per PCM frame. This translates to a requirement for a relatively high speed semiconductor memory technology, such as Emitter Coupled Logic (ECL), and historically such technologies have not proved to be entirely suited to VLSI techniques. Current VLSI technologies are not very fast; consequently the single stage time switch is used mainly for small switch applications where the number of time slots required is typically less than 1000.

Expansion of time switch capacity requires the use of multistage switches which provide intermediate space switch stages. This is the form of a switchblock most commonly encountered in existing digital switchblock designs. The combination of time and space switching in either Space-Time-Space or Time-Space-Time switch elements provide the basic form of larger capacity switches. Such structures are not readily realisable in VLSI technology, since the building blocks are not identical units.

Large capacity VLSI based digital switches can be achieved however by the merging of the previously separate time and space switching functions into one physical element and one technology. The resulting Time-Space (TS) switch device is both a switch in its own right and also can be used to construct large switching systems from arrays of identical integrated circuit devices. This approach allows economic production of a wide range of switch capacities. Furthermore, the regular structure of the switch allows fault tolerant techniques to be used to minimise the effects of an element failure.

Several alternatives exist for partitioning a digital switchblock for realization as an array of TS switch elements. Two options have emerged within the telecommunications industry and both have been successfully implemented. The major difference between the two is whether the information is presented to the switch in a single or multi link arrangement, thus:

ALTERNATIVE 1. Switches supporting multiple parallel primary PCM links.

ALTERNATIVE 2. Switches supporting a single primary PCM link.

In practice, the devices result in distinctly different switching networks, the physical and operation characteristics of which will be outlined below.

MULTIPLE I/O TS DEVICES

The multiple input/output TS switch device is capable of switching in both time and space between a number of primary PCM links. The general structure of the device is as shown in Figure 4, and while the majority of the devices offer symmetrical I/O, configurations are available which allow for expansion or concentration functions.

Switch devices with a multiple I/O structure have been developed by many switching systems manufacturers, and vary in the degree to which they are available on the open market. It is apparent that the general structure developed is seen to be of value over a wide range of both capacity and applications.

The device performs the physical switching task only. Auxiliary activities such as frame alignment, diagnostics etc., must be performed external to the switch device matrix. In addition, the control arrangements are also ex-

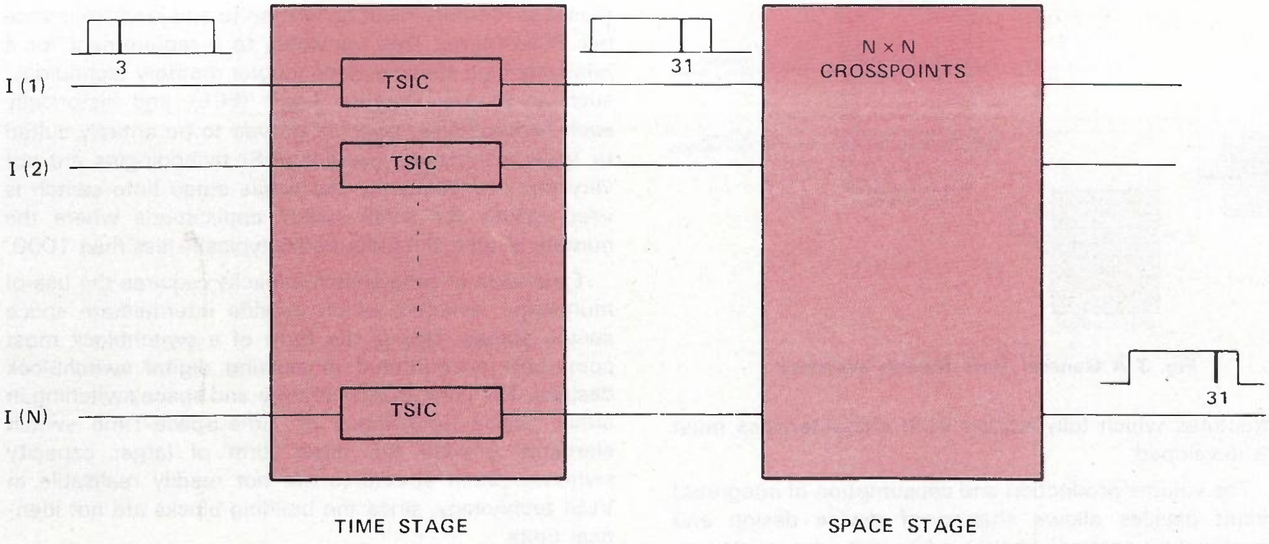


Fig. 4 A Multiple 1/0 Time-Space Switch

ternal to the device and require a microprocessor to translate the route analysis information into switch control information. In practical terms, this corresponds to a requirement for a quantity of specialised circuitry outside the boundary of the switch matrix. While the switch matrix may be expanded in a regular, modular fashion, the extent to which the support circuits are capable of matching this growth is a factor generally requiring further study. To date only a few VLSI based switch support devices have been announced (Ref. 4,5) and these have been custom designed to meet the needs of specific systems.

The most popular device switch dimension is the configuration providing a switch capacity of 8x8 primary PCM links. A device of this capacity, and complexity, can be comfortably accommodated within a conventional Dual-in-Line package (DIP). Compared with other general purpose VLSI devices, such switches represent a moderate level of both device integration and design complexity.

Figure 5 gives the general functional structure of a TS device capable of handling 8x8 PCM links, or 256x256 channels. Eight bit samples for each of the 32 channels per link are written into a message (data) memory organised as 256 words of eight bits each. The control (connection) memory is used to read the message memory and place the appropriate message on a PCM link. The selection of an outgoing link is controlled by a counter which cycles through the available outgoing links. Table 1 is a summary description of an actual device and is representative of what is being achieved on a single chip device of this kind.

- 8 line x 32 channel inputs
- 8 line x 32 channel outputs
- 256 ports non-blocking switch
- single power supply (+5 V)
- power consumption 125 mW Typical
- microprocessor control interface
- 3 state serial outputs
- 40 Pins Dual-in-Line package

TABLE 1. DESCRIPTION OF A TS SWITCH

Application of such devices to produce larger networks have been described, (Ref. 3, 5, 6) and multistage switches can be constructed similar to the classic structures of Clos (Ref. 7).

In conventional switching networks, multistage switch expansion is a means of minimising the number of crosspoints required. In switches based on parallel I/O TS switch devices, there is a close relationship between the switch capacity and the number of switch devices used. Optimization under these circumstances is less important due to the low cost of the switch elements; it becomes a matter of maximizing the capacity and performance, i.e. blocking or non-blocking, at a given cost.

Considering a complete switching network however, other factors may also act to limit the flexibility for switch expansion. Most notable among these is the control structure offered at the chip level and the device interconnect options available. For example, in the development of larger non-blocking networks it may be of value to depart from symmetrical devices and use components offering either expansion or concentration. Interconnect options other than primary PCM could also add to flexibility in application at the cost of some loss of generality.

In summary, the parallel I/O TS switch device is a flexible, general purpose tool for use in the design and development of digital switching networks. The networks arising from its application will however have features not encountered in existing switch designs.

SINGLE LINK TS SWITCH DEVICES

Only one single link TS device has been announced. It reflects a specific system design employing distributed control architecture (Ref. 6, 8). This device is an example of a different combination of trade-offs in partitioning switchblock functions to suit VLSI implementation.

In this design approach, each device provides timeslot interchange and input/output control for a single 30 channel PCM link. The devices are then grouped around a common time-divided bus to provide a basic switch element dimensioned 16x16. Figure 6 shows the general

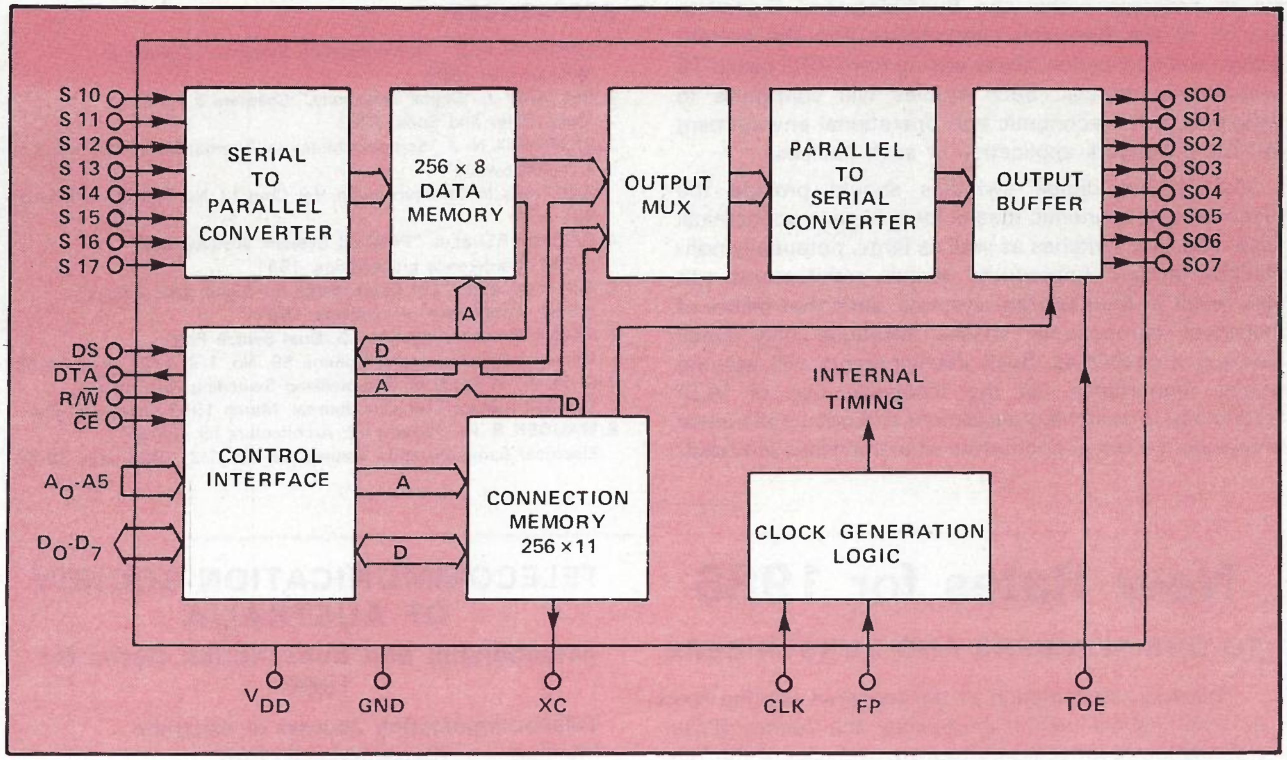


Fig. 5 Functional Block Diagram of a TS switch I.C.

structure of both the device and the resultant switch element. The 16x16 switch element then forms the building block used to implement larger switching networks.

In this example, each device has within it the processing and control capabilities necessary to direct its operation in a fully distributed control environment. All device communication is over the multicycle, time divided bus and all switching network control information flows through the switch to its destination, rather than using a separate control path. Thus individual switch devices are capable of receiving and responding to system level commands concerned with tasks such as connection establishment, call cleardown etc. As a result self routing of calls is possible with such a switch if given source and destination addresses and an appropriate network numbering structure. Frame alignment of incoming and outgoing PCM links is also performed within the switch device.

Reviewing the resultant switch structure, it is apparent that much of the switching network design complexity has been absorbed by the device and its immediate operating environment; i.e. the inter-device bus. Within the environment for which it was designed and developed it represents a powerful, yet flexible, medium for switch development.

CONCLUSION

This paper has reviewed key issues in the development and application of VLSI digital switchblock elements for narrowband circuit switching. Similar developments can be expected in other digital switching areas.

In order to take advantage of the economic and performance benefits of VLSI technology, the designer must partition the switchblock into structures which use arrays of identical integrated circuit devices. This in turn has resulted in the development of new switch structures which merge the time and space switching functions into a single integrated circuit device. Such switching elements can be the basic building block of a fully digital switching network with the possibility of decentralisation of the switch elements and their control. Investigations

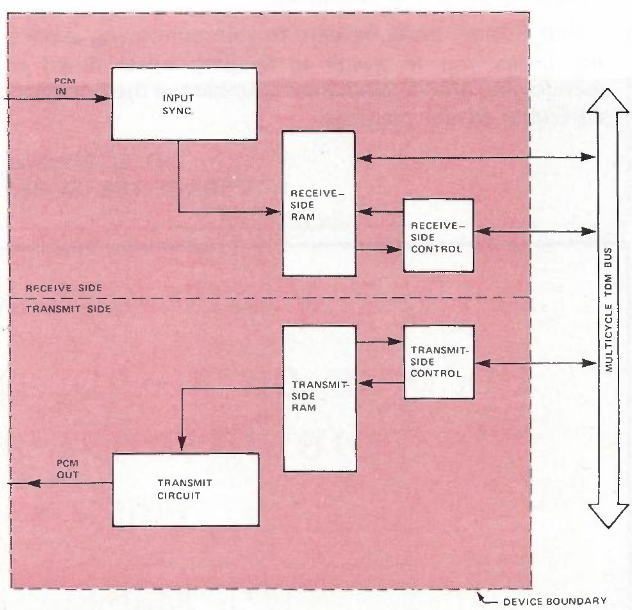


Fig. 6 General Structure of a Single Link TS device

are in progress within the Switching and Signalling Branch of the Research Laboratories into the system design and application issues arising from VSLI based TS switchblock devices. Such studies will contribute to definition of the economic and operational environment for future network application of such devices.

VLSI based digital switches should provide the technical and economic means for achieving economical small capacity switches as well as large, potentially non-blocking arrays. Appropriate switch architectures can also result in fault tolerant systems, such that failure of individual components should introduce only small blocking probabilities. Such developments will assume greater importance, as the increased use of VLSI technology in switching equipment extends its influence to include the range and nature of the services provided.

REFERENCES

1. CARLSON A. B. "Communication Systems," Chapter 8 McGraw-Hill, 1969
2. BELLAMY J. "Digital Telephony," Chapters 3.1-3.2 John Wiley and Sons, 1982
3. SKAPERDA N. J. "Some Architectural Alternatives in the Design of a Digital Switch" IEEE Trans. in Communication, Vol. Com 27, No. 7, July 1979, page 961-972.
4. GALIMBERTI et.al. "PROTEO System: An Overview" ISS'81, Conference proceedings, 1981
5. MELINDO et.al. "LSI Components for Digital Line Stages" ISS'81, Conference proceedings, 1981
6. FRANK W. et.al. "System 12, Dual Switch Port" Electrical Communication Volume 59, No. 1/2, 1985 page 54-49
7. CLOS C. "A Study of Non-blocking Switching Networks" The Bell System Technical Journal, March 1953 page 406-424
8. MAUGER R. H. "System 12, Architecture for change" Electrical Communication Volume 59, No. 1/2, 1985 page 35-42

New Rates for 1986

TO OUR MEMBERS AND SUBSCRIBERS:

Following examination of the tendered printing costs and the financial plan of the Society, the Council of Control has found it necessary to increase costs of the Telecommunication Journal of Australia and the Australian Telecommunication Research in accordance with the adjoining table.

The Council of Control is concerned about the increased costs of both the TJA and ATR and continues to be mindful of its objective of providing up-to-date information about advances in telecommunications technology to its members at prices they can afford. The Society has been assisted generously by Telecom Australia which in 1984 provided financial assistance in the form of subsidy amounting to $11,500. This subsidy, together with prudent management of costs and increased revenues from higher rates, has consolidated the financial position of the Society to a degree where increased confidence about the future of the Society is shared by all of the Executive.

The Society looks forward to your continuing support and urges you to assist in keeping costs down by encouraging others to become members of the Society or subscriber to the Journals.

D. D. Mattiske
HONORARY TREASURER

TELECOMMUNICATION SOCIETY OF AUSTRALIA

Membership and Subscription Rates for 1986

Telecommunication Journal of Australia

Member (Australia)	Subscription $11.00 Payroll Deduction (per fortnight) 43c Back Copies or Single Current Copies $7.00 each
Non-Member (Australia)	Subscription $20.00 Back Copies or Single Current Copies $9.00 each
Non-Member	Subscription $25.00
Back Copies or Single Current Copies	$12.00 each

Australian Telecommunication Research

Member (Australia)	Subscription $13.00 Payroll Deduction (per fortnight) 50c Back Copies or Single Current Copies $10.00 each
Non-Member (Australia)	Subscription $24.00 Back Copies or Single Current Copies $14.00 each
Non-Member (Overseas)	Subscription $28.00 Back Copies and Single Current Copies $16.50 each
Monograph	Member $6.00 Non-Member (Australia) $8.00 Non-Member (Overseas) $13.50

Share your knowledge.

Become an author of this Journal. For more information, drop a note to the

Editor-in-Chief
Box 4050, GPO
Melbourne, Vic. 3001.

Development of an Insect Resistant Telecommunication Cable for the Australian Environment

H. J. RUDDELL
Telecom Australia Research Laboratories

Damage to telephone cables caused by insects has been known to occur in the Australian network for over 70 years, and has always represented a small yet significant percentage of total cable faults. All underground cable was lead sheathed prior to the introduction of polyethylene in 1956 which resulted in an increase in the incidence of insect attack. Many poisons, insecticides and repellants were investigated but none provided the degree of protection against insects required in high risk areas such as tropical Australia. Materials were therefore sought which by their toughness and other related factors would resist penetration of the insect's mandibles. Nylons 11 and 12 were found to satisfy these requirements when applied as a thin, unblemished jacket over normal cable sheaths, and 16 years of practical experience in the Australian telecommunication network has proven these materials to be outstandingly successful in preventing insect damage to cable.

Introduction

Initially all external cables used by Telecom contained three basic constituents, copper conductors, paper insulation and lead or lead alloys sheaths.

The traditional lead sheath suffered from a number of disadvantages, but for many decades retained its role due to lack of a suitable alternative material. For many years lead was the only metal which could be economically formed into a cable sheath and being soft, lead sheathed cables could be coiled on drums and made to follow contours with reasonable ease. The material was resistant to chemical corrosion, readily solderable, and impervious to moisture, all requirements for satisfactory protection of the cable pairs from the external environment. However, it was heavy, expensive and could be damaged by anodic electrolysis. It also suffered intercrystalline fracture when subjected to prolonged vibration [5]. In addition, lead was prone to attack by termites, and required protection by steel tapes embedded in bituminised jute wrappings, which was not always successful if the tapes were imperfectly wound. These disadvantages influenced the development of plastics materials as alternative sheaths, and in 1956 the first polyethylene sheathed cable was introduced into the Australian network.

The polyethylene sheathing proved to be a satisfactory answer to the cost, weight and corrosion problems associated with lead. It was also free from vibration fatigue, and although polyethylene was itself subject to a new mechanical failure problem, environmental stress cracking, the Telecom specification for the material was able to impose an acceptably high standard of resistance to this form of failure.[5]

There were, however, three degradation or failure hazards associated with the use of polyethylene sheathing. These were:

i. joint sealing
ii. moisture permeation
iii. termite and ant attack

Only the subject of the latter problem will continue to be covered in this paper.

Attack by termites or ants resulted in the cable sheath and often the conductor insulation being penetrated, and subsequently water entered the cable and caused electrical faults. The pattern of damage varied with the species; individual holes ranged from larger than 600 mm^2 diameter down to 0.5 mm^2 spread over a distance of a few centimetres to hundreds of metres.

Classification of Termites & Ants

Termites and ants share the class of Insecta in the animal world with 27 other groups. Termites alone occupy the order of Isoptera which means equal-winged, ie. two pairs of wings of similar shape and size (Fig. 1). Termites are soft-bodied and in the evolutionary classification they are placed very close to the Blattodea. Although commonly called "white ants", termites are not related to Hymenoptera, the order containing ants, bees, and wasps, even though their social organisation in many ways parallels that of the true ants, the most highly specialised species in Hymenoptera.[6]

The Colony & Habitat of Termites & Ants

A. Termites

Of the 2000 species of termites known in the world, near 300 occur in Australia. Termites are pre-eminently social and live in complex colonies or termitaries. The self-replenishing colony, as a unit, can exist indefinitely. The work of providing food, maintaining and increasing the population, building, repairing, and protecting the

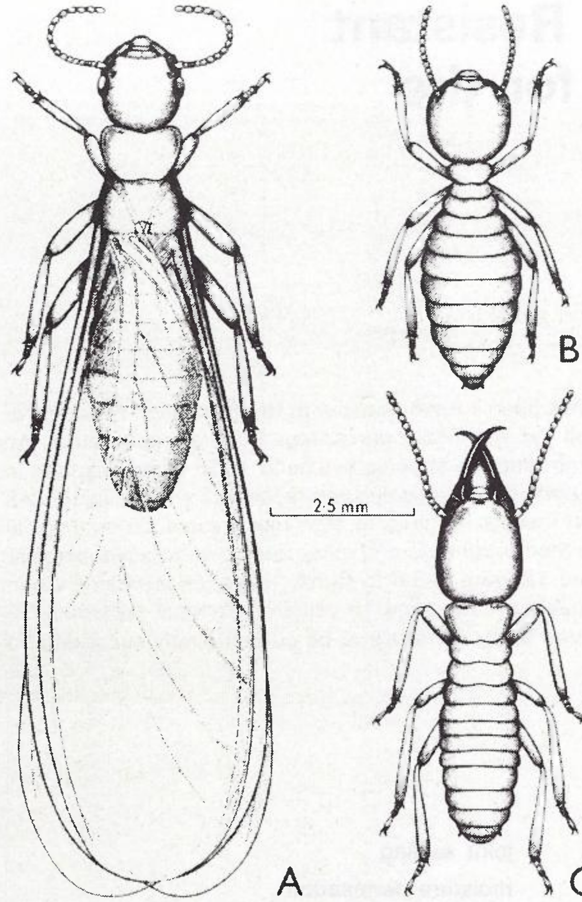


Fig. 1 — Castes of Coptotermes Acinaciformis, Rhinotermitidae : A, Winged Reproductive, or Alate: B, Worker: C, Soldier.[9]

termitary is undertaken by special forms or castes. With most species of termites there are three distinct castes, the reproductive (nymphs), the workers, and the soldier. [7]

The truly reproductive caste is characterised by the possession of wings, and is the founder of new colonies. They swarm out of their parent colony as 'flying ants', pair, and seek out suitable sites for new colonies in soil or wood. Immediately the pair seals itself in under the surface and fertilisation occurs and is repeated at intervals. The king alters little during his lifetime but the queen becomes gradually transfigured as her ovaries enlarge and she becomes a more and more efficient egg-laying machine producing 2000-5000 eggs/day over a period of more than 15 years. In some species she becomes enormous, the head and thorax form an almost insignificant apendage. Such queens are termed physogastric (Fig. 2). A physogastric queen is too large to move or be moved easily through the galleries of the nest and she will generally, but not always, be found in a specially constructed cell, sometimes attended by the king and many soldiers and workers. [7]

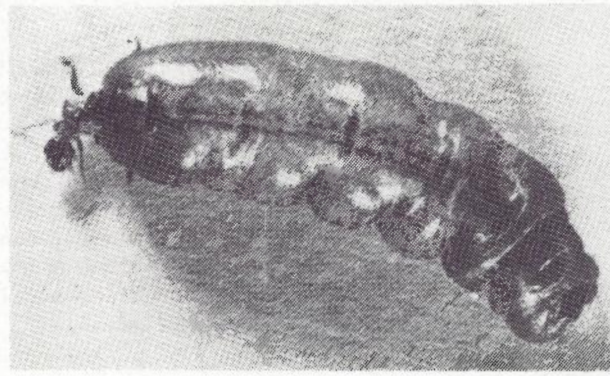


Fig. 2 — Physogastric Queen of Nasutitermes Exitiosus, Termitidae — Length CA 30 mm[9]

The workers are responsible for excavating, building, foraging and the general servicing of the colony including tending the eggs and the young, and feeding those of the other castes which cannot feed themselves. Unlike the true ants, both the male and female sex are represented in the worker caste. They are wingless, sterile and blind. They have round, usually pale-coloured heads, soft unpigmented bodies and saw tooth jaws adapted for cutting. Damage by subterranean termites to cellulosic materials is caused by the workers (and nymphs) only.[7]

The soldier caste is also composed of wingless, sterile and blind termites of both sexes. They are responsible for the defence of the nest, which they do continuously from maturity to death; their most serious enemy being the true ant. As a result termite soldiers are walking weapons. Their head is large and greatly modified and is effective in blocking a breached tunnel, so repelling raiders until the tunnel is sealed by workers. The jaws are large and have various modifications as required for

HEC RUDDELL joined Telecom Australia Research Laboratories in 1955 as a Chemist after 19 years in private industry in the field of oils, general chemistry, rubbers, and plastics. In 1966 he was promoted to set up the Polymer Section which is responsible for the investigation, development and application of all plastics, rubbers, and adhesives in communications equipment. He was actively associated with the early manufacture and installation of plastics cable, including the development and formulation of epoxy resins and the epoxy resin field pack, the design of joints particularly those for multi-pair submarine cables laid off the coast of Queensland, and the recent developments in filled cable, optical fibres, and stabilisation of polyethylene. Mr Ruddell has been an Associate Member of The Plastics Institute of Australia since 1959, and was awarded a Fellowship of that Institute in 1982.

fighting, but are useless for cutting wood. Other defensive mechanisms include the squirting, oozing and daubing of disagreeable chemical secretions on predatory intruders.[26] It is possible that such secretions are also the means by which termites penetrate the steel tape of armoured telecommunication cable. (See later section).

Termites build various types of nests. The simplest is that in which the whole colony lives in a series of galleries and chambers excavated in moist or dry wood and is surrounded by its food. The subterranean forms, the type that attacks cables, construct a more or less complex central nest, either in the soil or in a log or stump, from which subterranean galleries or covered runways extend to food sources below or above ground. The most elaborate nest structures are the termitaria built by about one-fifth of all Australian species. Although termitaria are normally built on the ground, some species construct their clay covered nests on poles, posts or the trunks of trees (Fig. 3A & B).

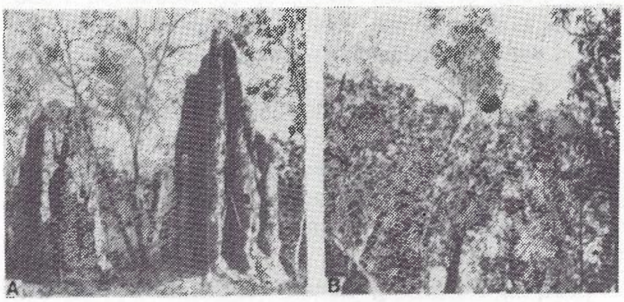


Fig. 3 — Mound and nest of some Termitidae : A, Nasutitermes Triodiae: B, Nasutitermes Walkeri.[9]

Generally, the outer portion of the nest is hard to very hard; built mainly of clay or earthy material, it contains very few galleries or chambers. The inner region is much softer, and is generally composed of woody material fashioned into a complex system of galleries and chambers (Fig. 4). Here are found the eggs and young nymphal stages, as well as the royal pair often in a specialized cell. Mound-building species also reach their food sources by subterranean galleries and covered runways. The gallery system of a single colony may exploit all the food sources over as much as 10,000m^2 (2.47 acres) with individual galleries extending from 75 to 100m in length [9].

Termites shun light and a completely enclosed system of interconnecting galleries and covered ways is maintained at all times. If they are feeding on timber from within, they refrain from eating away the outer layers — if they are feeding on the surface, they build roof-like shelters of "carton" — a semi digested wood/organic matter/soil mixture. They derive two great benefits from their "walled-off" existence: they are protected from many of the dangers to which other insects are subject and they are able to exert a certain amount of control over their environment. Subterranean termites require a substantial moisture supply for the maintenance of the health of the colony and relative humidities greater than 90% have been measured in the so-called nursery. The moisture is derived from the surrounding environment and respiration of the insects themselves. Heat as well as moisture is liberated during respiratory processes in animals and with congregation of large numbers in the nursery region, the nest has an effective central heating system.[8]

Relating specifically to the three most economically important termites in Australia shown in Fig. 7. Mastotermes darwiniensis does not build mounds and lives below ground level in nests composed of a number of tiers of large, thin-walled, horizontally arranged cells, constructed of "carton" material. Coptotermes acinaciformis is a mound builder in the northern parts of its range (Fig. 7C) though not exclusively. South of about latitude 20°C it nests in stumps, poles or trunks of dead and living trees.[8] Nasutitermes exitiosus builds symmetrical dome-shaped mounds, which on an average measure about 1m in diameter at the base and 0.4m high. (Fig. 4).

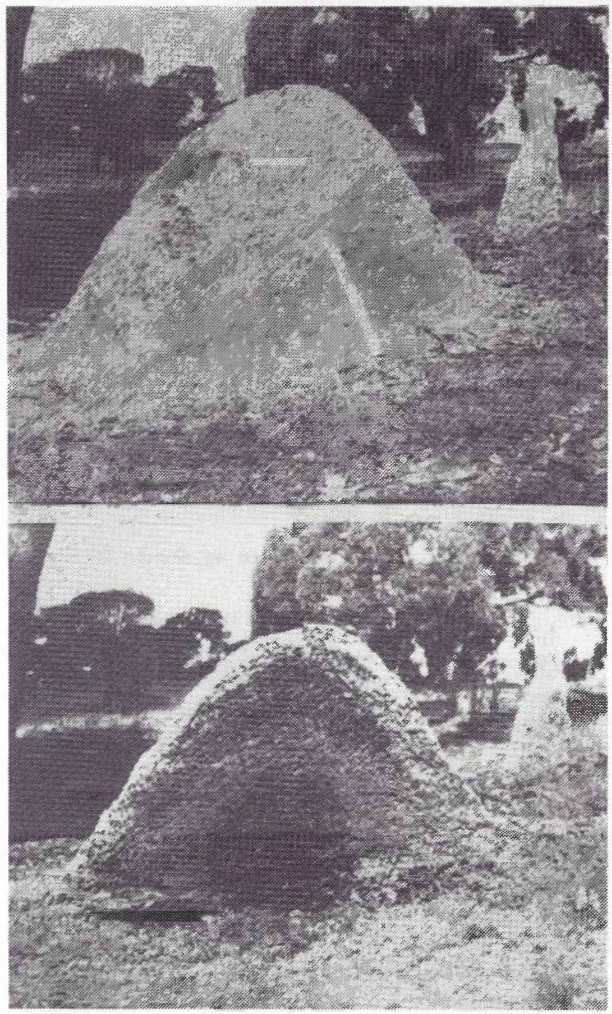


Fig. 4 — Mound of Nasutitermes Exitiosus, Termitidae (above) and cross-section through mound (below) to show internal structure. The Ruler resting against the mound is 305 mm long.[8]

B. Ants

Of the approximate 15,000 species of ants found in the World, around 1,500 of these occur in Australia. Ants usually live in more or less permanent nests, excavated in the soil or in wood or utilizing pre-existing cavities in plants or in rocks. The great majority of Australian ants inhabit the ground layers, in chambers deep in the soil or under rocks or other objects. Many species, particularly those of arid areas, construct mounds or disc nests, often with a large entrance and a surface cover of pebbles, charcoal, etc. (Fig. 5). Forests, rotting logs and small fragments of rotting wood are favoured nesting sites.[9]

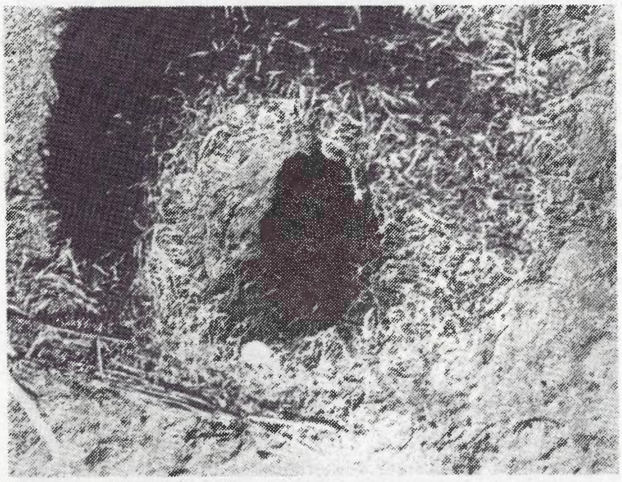


Fig. 5 — "Decorated" nest entrance of Camponotus Nigriceps, Hymenoptera-Formicidae : Leaves of Mulga have been added to the mound around the entrance. Coin is 27 mm in diameter.[9]

Ant colonies may contain as few as ten adults, or up to millions, but colony size in most Australian species is under 2000 workers. Colonies may, however, be extremely numerous in tropical forest, savannah woodland, or semi-desert like that covering so much of Australia, and it is not uncommon to find 20 or 30 nests in a single rotten log, or even two or three colonies of different species under the same stone.[9]

The castes in an ant colony are as shown in Fig. 6.

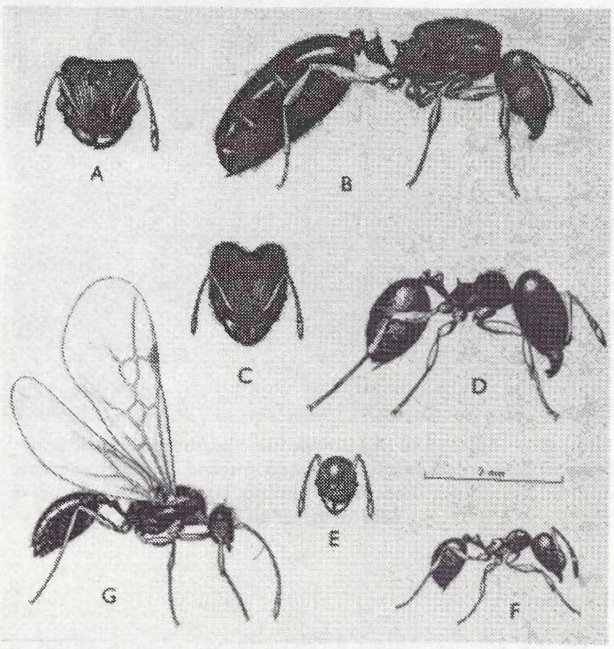


Fig. 6 — Castes of Pheidole, Myrimicinae : A,B, Queen: C,D, Major Worker ("Soldier"): E,F, Minor Worker: G, Male.[9]

- one or more wingless, egg-laying Queens.
- workers which are wingless females of two types — major workers (sometimes called soldiers) have large head and function as defenders of the nest — minor workers, much smaller and the true worker in the nest.
- winged males — produced only as required. After mating with the Queen the male dies, whilst the Queen divests herself of her wings and seeks a place to start a new colony.[9]

(Compare the narrow waist, a characteristic of all true ants, with that of termites in Fig. 1).

The Diet of Termites & Ants

A. Termites

The basis of the termites diet is cellulose, but contrary to popular belief, wood is not the natural food of all termites. A very large proportion of the total number of species found in Australia are grass and debris feeders, and of the wood-eating species, relatively few habitually attack sound seasoned timber, the majority feeding on living trees, on rotten wood, or on weathered wood only.[8] In doing so they play an important and beneficial role in nature, functioning as scavengers; by boring into, breaking up and digesting woody tissue they provide either directly, or indirectly through the activities of other organisms, a contribution towards the nutritional requirements of the succeeding generation of vegetation. In the total bio-system of tropical and sub-tropical areas, the number of termites present, and their activity, are of vital importance.[6]

Generally the feeding habits of most species of termites are fairly stereotyped, but some species, at times, display considerable adaptability and will attack a variety of substances and materials, including some that contain no cellulose. Mastotermes darwiniensis, potentially the most destructive termite in Australia, will, for instance, not only attack timber in buildings, bridges, wharves, poles and fence posts, living trees and crop plants, but in addition damage subterranean electric and telecommunication cables and has been known to attack paper, leather and hides, wool, horn, ivory, vegetable fibres of various kinds, hay, sugar, flour, salt, bitumen, rubber, ebonite and oil-soaked soil and wood. Fortunately Mastotermes darwiniensis is found only in tropical Australia (approximately north of Tropic of Capricorn) see (Fig. 7B) and hence the destruction it causes is limited because it exists in a region of sparse settlement.[8]

The position of Coptotermes, in particular the species acinaciformis, as Australia's most important pest species, is due not only to its extensive range covering all of mainland Australia (Fig. 7C) and the severity of its attack, but also to its extraordinary success in adapting itself to living in close association with man.[8]

Nasutitermes, mainly the species exitiosus, the third genus regarded as of serious economic importance in Australia, is found across Southern Australia from about the Queensland-New South Wales border, see (Fig. 7A). It is a sound wood eater, and does considerable damage to fence posts, poles and bridge timbers. Probably on account of its mound-building habit, the species does not flourish in built-up areas; but farm and station buildings and houses on the outskirts of town suffer infestation.[8]

No satisfactory explanation exists to explain why these highly organised insect communities should

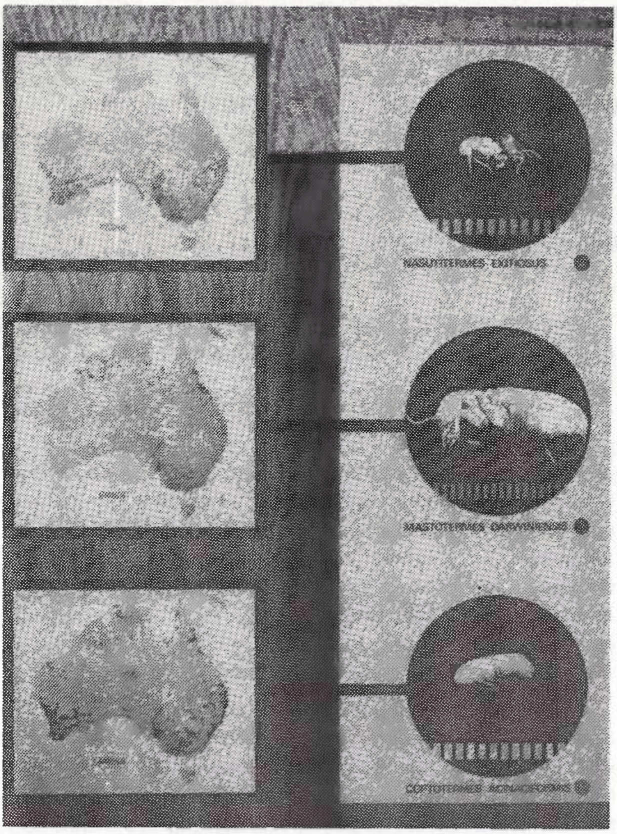


Fig. 7 — Distribution of economically important Termites in Australia : A, Nasutitermes Exitiosus: B, Mastotermes Darwiniensis: C, Coptotermes Acinaciformis.

forsake cellulosic material which is their basic nutrient as well as, in very many cases, their shelter, to break up, gnaw, chew or otherwise destroy other substances. Perhaps the most costly of such attacks, actually quite out of proportion to the amount of physical damage caused, is when underground electric or communication cables are penetrated.[6] One can only assume that the insect chews the cable sheath to find out if palatable material lies underneath, or because the cable is an obstacle in its foraging path.

B. Ants

Most Australian ants feed on a wide range of prey, including other ants, and the carcasses of dead insects and other arthropods. Many species also forage on vegetation, for nectar from flowers, and extra-floral nectaries and honeydew which they obtain from aphids, psyllids (lerp insects) and scale insects. Some ants also feed on seeds and the nest entrance may be surrounded by empty husks. Foragers store liquid food in a crop (pouch-like enlargement of gullet) and regurgitate it on returning to the nest. This behaviour reaches its extreme form in the honeypot ants, some arid zone species of Melophorus and Camponotus, where honeydew and nectar are stored in the enormously distended crops of special large "honey pot" workers that remain in deep chambers of the nest.[10]

The ability of ants to obtain food and moisture from plants, as honeydew and nectar, is important to their survival in summer, especially in arid environments. It also helps to stabilise their populations by making them less dependent on the fluctuating supply of prey, carrion and seeds on the ground. To some extent honeydew producers are farmed according to the needs of the ant colony. Predation by ants on other ants is a stabilising process for the ant community as a whole. If one species has special access to a food source, for example seeds, predation by other species of ants limit its numbers and also make the resource available to the whole community.[10]

The sheer abundance of ants in Australia make them one of the most important animal groups in the environmental system of energy flow. Ants tend to be active through all seasons and many of them are rather general feeders. As predators and scavengers of other arthropods, their operations are broadly beneficial, and the distributions of many other kinds of insects, including especially sawflies, predatory beetles and termites, are strongly influenced, or determined by the presence or absence of ants.[9]

Harvester species of ants may cause occasional damage by attacking crop seed buds or collecting the seeds of forest trees, but the main agricultural damage done by ants is a consequence of their guarding and transporting aphids and coccids, harmful to vegetable crops and orchards. Indeed, several kinds of scale insects are a serious threat only when tended by ants. Australians, as a rule, have problems with ants most directly in the home, where species such as the Argentine ant (Iridomyrmex humilis), black house ant (Technomyrmex albipes) and hospital ant (Monomorium pharaonis) are the main pests in the south, while Pheidole megacephala, the fire ant (Solenopsis geminata), and the ghost ant (Tapinoma melanocephalum) are familiar nuisances in northern or tropical Australia. Bush pests include the sugar ant (Camponotus spp) and the meat ant (Iridomyrmex purpureous). The meat ant can be a serious pest around homes and food-processing plants.[9]

Early Termite and Ant Attack on Cables

The first recorded fault in Australia on a telecommunication cable occurred on a lead-sheathed, paper insulated cable in North Adelaide, South Australia during October 1911. [12] The fault was subsequently traced to subterranean termites, gnawing away at the lead with their mandibles, eventually creating a hole through which water entered causing a service fault. A lead cable sheath damaged by termites is shown in Fig. 8. It is reasonable to believe that other incidences of termite attack must have occured in the following years, but the next recorded incident was in 1934 when damaged cables

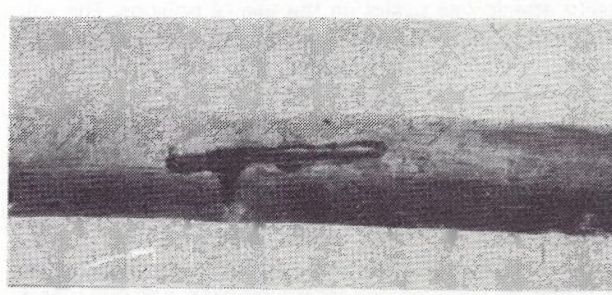


Fig. 8 — Damage to lead cable sheath caused by Termites.

	1947	1948	1949	1950	1951	1952	1953	1954
Faults due to Termites	185	179	145	185	173	154	141	144
Total faults from all causes	6752	5831	6641	9685	10250	11390	11030	11731
Percentage of faults due to Termites	2.74	3.07	2.18	1.91	1.69	1.35	1.28	1.23

Table 1 — Faults in Lead Sheathed Cables during 1947 to 1954 [11]

from Victoria and Western Australia were submitted to the then P.M.G. (now Telecom) Research Laboratories for examination. Between 1934 and 1941 there were 19 laboratory reports dealing with 26 reported termite attacks onlead sheathed cables. For the 8 years between 1947 and 1954, faults attributed to termites accounted for approximately 2% of all known cable faults as shown in Table 1.

The first recorded attack by ants on an underground cable occurred on a lead sheathed, paper insulated cable at Mt. Magnet, Western Australia during May 1941,[13] but it is possible that many of the earlier faults attributed to termites could well have been caused by ants. The ants responsible for this damage were identified as Monomorium destructor (Singapore ant). Other species that have been definitely connected with attacks on cables in Australia are Pheidole megacephela and Iridomyrmex humilis.

A notable distinction, pointed out by investigators at that time, between termite attack and ant attack on lead sheathed cable, was that ants left the attacked area clean, in distinct contrast to the brownish nest building material deposited by termites. It was also observed that the grooves produced by the mandibles of ants were much finer than those produced by any of the termite species.[13] See Fig. 9 for comparison.

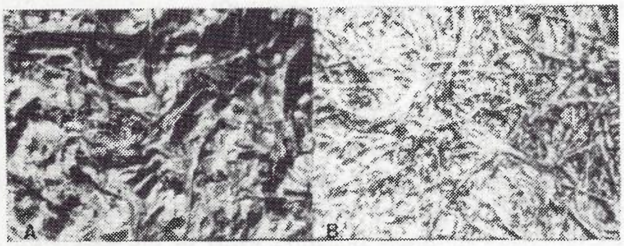


Fig. 9 — Micrographs of damage to lead cable sheaths : A, by Termites: B, By Ants.[12]

Attempts to Prevent Termite & Ant Attack of Lead Sheathed Cables

The earliest protection of lead sheathed cable against insect attack was based on the use of poisons. The soil surrounding the cable was impregnated with a solution of arsenic or mercury compounds, and although lethal to termites and ants, this was found to be unsatisfactory. Whilst many of the attackers were killed, the numbers involved were so great (up to several million in a colony) that serious cable damage occurred before any great inroads were made on the population of the colony. In addition, the use of such poisons was expensive, hazardous to staff and stock, and loss from the area to be protected by leaching due to groundwater and rain was a matter of concern.

Around the middle 1930s incorporation of chlorinated naphthalene (Seekay wax) in petroleum jelly "hauling-in" compound, and soil treatment with creosote, were tried with only limited success. Other chemicals like paradichlorobenzene (1939), pyrethanol (1939), DDT ["Rucide"] (1949), pentachorphenol (1950) and dieldrin (1954) were investigated, as they became commercially available, with little or no success. The usual method was to spray a dilute, emulsified form of the chemical onto the cable and surrounding soil, as the cable was being laid. In addition to their apparent lack of protecting from termite attack, materials like creosote and pentachlorphenol were found to be corrosive to lead.[12][14]

At a later date, the coating of conduits with dieldrin and gammexane dusts was carried out in some States with apparent success, but this was usually done as a remedial measure after insect damage had occurred. The success of dusts in conduits, as distinct from solution application to soil, may be attributed to the habit of termites to groom one another and thus consume the poisonous dust carried on the bodies of other termites into the nest. The dead insects are also eaten so that a very effective extermination occurs. The hazards to humans associated with the use of such dusts, both during installation and future work on the contaminated cables and conduits, led to its discontinuation.

Fault statistics taken out during 1938 indicated that lead sheath, with a high antimony content, was more resistant to termite attack than soft lead (referred to as pig-lead). This was considered to be due to the variation in surface hardness. Termite mandibles could readily scratch pig-lead which has a Hardness Vickers (HV) of 4.8 whereas lead containing 0.8% antimony or 1.0% antimony and 0.06% copper (HV values of 11 and 14 respectively), were both found to be more resistant. Further improvement by the use of Copper (HV40) or Brass (HV70) tapes were tried, but lapping the lead sheath with a double layer of soft, mild steel tape (HV100-140), bedded between layers of bitumised jute, was found to be the most economically effective protection. Such cable was almost exclusively used in Northern Australia, where Mastotermes darwiniensis was prevalent, and the extra cable expense could thus be justified.

In spite of the steel tape and bituminised coverings, many cases of cable failure occurred, because the termite entered the armouring through gaps resulting from displacement of the helically-wound steel tapes during laying, or by the apparent penetration of the steel tape itself. It was thought unlikely that the termite could actually pierce the steel with their mandibles, but there was some evidence to suggest that the termites damaged the steel through an acidic secretion[14] or gained entry through holes made by lightning or mechanical damage during cable laying operations. Fig. 10 shows a typically damaged cable.

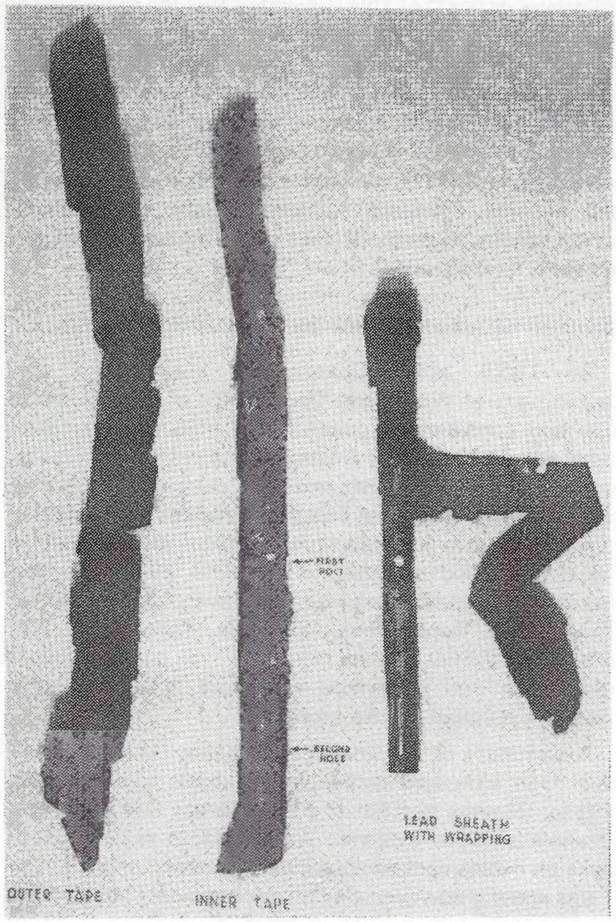


Fig. 10 — Termite damage to double steel tape armoured cable installed at Darwin.[14]

Introduction of Plastics Cables

In the early 1940's, knowledge of whether the new and light weight, plastic insulated and sheathed cables could be used in tropical regions was required by the British Government for military purposes.[15] A joint committee of cable makers in the UK was therefore formed under the name of Cablemakers' (War Emergency) Technical Committee to examine anti-termite properties of cable coverings. Subsequently, a number of poly vinyl chloride (PVC) compounds flexibilised with different types of plasticisers, and one PVC compound containing copper naphthenate, were placed under test in field plots in various parts of India. The sites were chosen where termites were known to be abundant. The conclusions drawn from the tests were that "the PVC samples had proved to be highly resistant to damage by insect attack"[16] and "that polymerised vinyl chloride plastics can be declared termite-proof!"[15]

This was later proved incorrect, but at the time it gave British investigators encouragement to continue developments on plastics sheathed cables. In 1950, the Australian Post Office (APO) received a request from the Telegraphs Construction and Maintenance Co. of Great Britain to evaluate nine cable sheaths of various PVC and polyethylene compositions (see next section) for resistance to attack from the termites prevalent in Australia. Because of the possibility of such compositions being used in future underground services by the APO, the APO proceeded to conduct field tests in areas of known termite activity and co-opted the services of the Division of Entomology CSIRO, to carry out controlled laboratory exposure tests with various species of termites.

Testing of Plastics for Resistance to Termites

The CSIRO laboratory tests on the following plastics, extruded as insulation on wire, commenced during February 1951, using standardised test conditions developed by them. [17]

Sample No.	Description
1	Polyethylene, MFI 20, containing lead naphthenate.
2	Non-migratory PVC.
3	Arctic PVC.
4	General purpose PVC insulant.
5	Polyethylene MFI 7.
6	General purpose PVC.
7	Polyethylene MFI 20.
8	Telcothene (polyethylene MFI 20 with 12.5% polyisobutylene).
9	Polyethylene, containing 1% pentachlorophenol.

Three series of laboratory tests were conducted using 90 mm long specimens exposed to Coptotermes acinaciformis, Coptotermes lacteus and Nasutitermes exitiosus as the test insects. The cut ends of the test specimens were in all cases covered with sealing wax to restrict attack to the wall of the cable sheaths.

Field tests were commenced in late 1951 at the following four sites: Darwin, Northern Territory; Salisbury, South Australia; Winton, Nth. Queensland; Miles, Sth. Queensland. The method of test adopted consisted of laying down test plots containing sufficient samples to permit withdrawal of each type under test after 1, 2 and 3 years exposure, recovery of each lot being made in such a manner as not to disturb the remainder. Each individual sample, approximately 380 mm long, was sheathed in, or attached to, a 305 mm long termite susceptible timber (radiata pine) peg (Fig. 11).

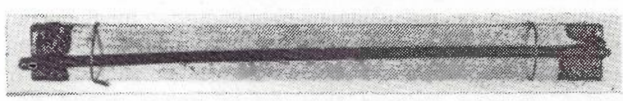


Fig. 11 — Plastic cable sample mounted on wooden peg for test exposure.

The pegs were buried in a square matrix similar to that shown in Fig. 12, to a depth of 330 mm, with a separation of 230 mm between neighbours, in rows and columns. Timber connecting laths were buried 25 mm below the surface, contacting each peg in a row, and the outside two columns. Plain wooden control pegs were also included at various points of the matrix, as a means for checking termite penetration during the course of the test, without having to disturb the samples. In laying down a test plot, it was essential to create the minimum

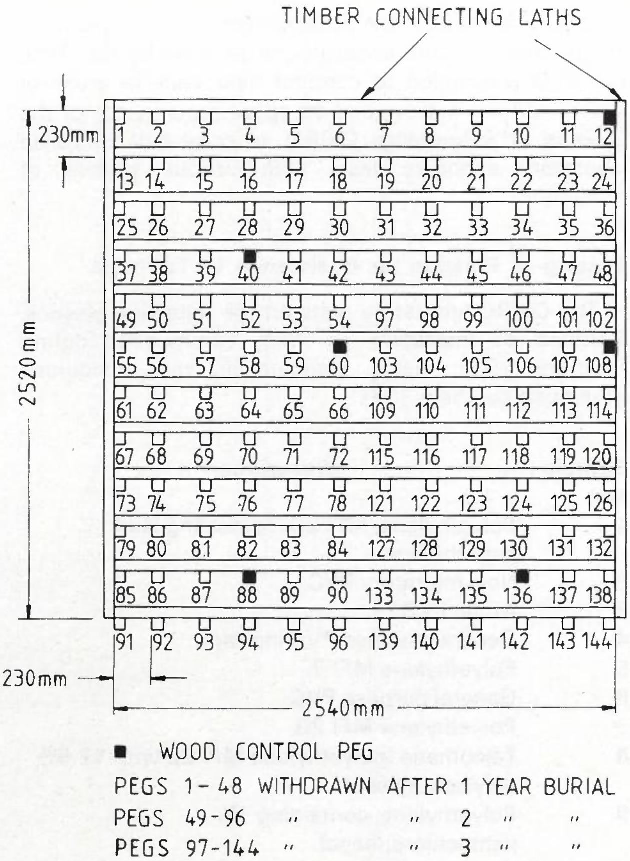


Fig. 12 — Plan of Conventional Test Plot Design : Type-1 Plot.[20]

disturbance of the surrounding soil, so as not to drive the insects away.[18]

The results of both field and laboratory tests failed to reveal any particular type of plastic under test to be completely immune to termite attack. Polyethylene was somewhat superior to PVC in its resistance to attack, the harder grades (higher molecular weight) showing fair resistance. The inclusion of insecticides, lead naphthenate or pentachlorophenol, in the polyethylene did not prevent attack.[11]

In spite of the above discouraging results, the APO installed approximately 330 km of small diameter polyethylene insulated and sheathed cable in extended field trials during 1956. The cable had no protective covering over the polyethylene sheath, and in most cases was laid directly in the ground without treatment of the surrounding earth to discourage termite or other insect attack. It was claimed that future policy would be governed by the experience gained with, and the fault incidence of, these cables.

Testing of Plastics for Resistance to Ants

Early installations of plastic cables had indicated that the biggest hazard in such cities as Sydney or Brisbane came from ant, not termite, attacks. As there were no facilities available for the laboratory evaluation of the resistance of plastics to ant attack, all tests had to be conducted in the field. A series of such tests were carried out in Queensland during 1956/57 when a number of one and two pair polyethylene insulated and sheathed cables were buried in ground infested by the ant Pheidole megacephela, at four separate locations. All cables were damaged within 12 months of installation, whether the cable trench had been treated with the repellant spray chlordane or not.[14] This suggested that the widespread use of plastics sheathed cable could result in an increasing incidence of faults due to insect damage and be of such magnitude that it would be uneconomic to take general remedial measures to prevent attack. On the other hand, it was evident that the development and testing of remedial measures would take several years, and it was therefore judged prudent to continue investigations of methods that could be adopted, if the necessity should arise.

Concern of Insect Attack by Other Departments

By 1958, other Government bodies like the Department of Works and Department of Civil Aviation also had considerable quantities of underground cable installations throughout Australia, and with the increase in the use of cable in tropical and semi-tropical areas, considerable trouble was being experienced with insects. Various methods had been tried to deter the insects but these had failed similarly to the APO efforts. It was therefore suggested that representatives from the three Government Departments and the Division of Entomology, CSIRO, confer, in order to pool available information and determine the most likely approach toward a solution to the problem.

A summary of the knowledge at that time was that steel tape armoured cables were subject to attack but only by termites peculiar to tropical areas (Mastotermes darwiniensis). No evidence was available regarding attacks on cables containing copper, bronze or brass tapes. It was known, however, that aluminium was not attacked by termites, but it was subject to electrolytic and mechanical problems which limited its use in practice. PVC and polyethylene cables had been attacked by Mastotermes although it appeared possible to protect such cables against termite attack by incorporation of aldrin or dieldrin. Lindane (gammexane), which acts as a repellant, could have been incorporated but its effectiveness or lasting qualities were unknown. Other plastics such as nylon and SAN (styrene acrylonitrile) appeared to offer some promise, but their resistance to Mastotermes had not been established.[19]

With regards to future action, it was considered that because of the difficulty in relating laboratory test results with those from short term exposure in termite colonies or long term exposure in actual installations, that adequate and carefully conducted experiments to be carried out jointly by the APO and CSIRO were necessary on various cable types. The insect problem was considered to be of sufficient importance to warrant a coordinated approach by users and manufacturers, so that a satisfactory solution be reached as quickly as possible, and further, to avoid duplication.

Consequently in August 1958, the Plastics Institute of Australia (PIA) called a conference of all interested parties which resulted in the formation of two committees — a Materials Committee whose function was to design and prepare formulations for laboratory evaluations by CSIRO, and a Testing Committee which was to examine cable's from a users point of view and arrange field tests.

The APO's main contribution to the PIA work was the coordination of its own continuing field testing programme with those of other concerned bodies. This in no way prevented freedom of action on the part of the APO to carry out any experimental work which they desired to conduct outside of the activities of the PIA group.

Sixteen PIA conferences were held between 1958 and 1971 to report on the "Performance of Plastics materials with Termites and Ants", but as the major field and laboratory investigations were being conducted by the APO and CSIRO working in close harmony, it is not surprising that the conclusion reached by the PIA in 1971 [24] was identical with the practical step taken by the APO in 1968. (See details in later section headed Test Results).

It is only the APO's independent investigations that will continue to be discussed in this paper.

Further Field Trials Against Termite & Ant Attack

In field trials run between 1959-1964, the following plastics submitted by local and overseas manufacturers were exposed to termites and ants at field plots in Australia and New Guinea for up to four years.

a. Polyethylene MFI 2.0 or 0.3, some with 10% polyisobutylene
b. PVC
c. Nylon 6
d. Epoxy resin
e. Acrylonitrile butadiene styrene (ABS)

In the case of polyethylene and PVC the following chemical poisons and repellants were incorporated at various concentration levels:

i. Dieldrin
ii. Gammexane
iii. Aldrin
iv. Lead pentachlorophenol (LPCP)
v. Chlorinated aryl sulphonamide (CAS)
vi. Arsenical compound
vii. Finely divided silica

In addition some copper, brass and steel taped cables, as well as steel wire armoured and copper clad cables, were included in the field trial. A total of 46 separate samples manufactured at three cable companies were exposed at all test sites.

For the evaluation against termites, test plots were established by the APO at Darwin, Northern Territory; Charters Towers, Queensland; Wagga Wagga, New South Wales and Bomona, New Guinea; and by CSIRO at Rollingstone, Queensland.

The APO samples were buried in the test plots, using the layout shown in Fig. 12, in areas known to be infested by termites. The construction of the test plot was undertaken with as little disturbance of the soil as possible. Periodic inspections of the plots were made by the local field staff, and reports on soil conditions, climate, degree of infestation furnished.

In all the termite tests, the indications were that infestation of the plots had taken place, as shown by the severe damage to, or complete destruction of, the wooden pegs and connecting laths. However, there was some uncertainty about the continuing activity at the Charters Towers plot after the first year. This may have been due to unseasonal drought conditions which prevailed in this area over part of the test period causing the termites to become less active.[20] Results of the Darwin and CSIRO tests plots only are given in Appendix 1.

The following sites were used in the tests against ants.

Sydney	Dulwich Hill
	Vaucluse
	Concord (2)
Brisbane	Sandgate
	Salisbury
	Rochedale
	Nundah
	Daybro
	Clayfield (2)

These sites were selected as a consequence of the large number of attacks on plastic cable reported in the Sydney and Brisbane areas, attributed to the ant Pheidole megacephela. A number of test sites in both cities were selected as offering a high probability of encountering this species of ant. Samples were cut to 27-36m lengths and buried 300-450 mm deep at the test sites with only the ends protruding. Insulation resistance measurements between conductor and soil were made at regular intervals, the occurrence of very low insulation resistance being indicative of a penetration of the sheath, likely to have been occasioned by ant attack. The samples were left in the soil for 2-2.5 years, and then recovered and examined for positive signs of ant attack.

The attack by ants is so characteristic, as to make a false attribution of the causes of damage most unlikely.[20] (Fig. 13).

In the tests with ants (typical results given in Apendix 2), all test plots were infested by the ant Pheidole megacephela, and samples were attacked by this species in all the seven Brisbane test plots and in two out of four sites in Sydney. The degree of attack was variable, ranging over a few centimetres to many metres, with the damage in all cases being in the form of numerous small holes about 1-2 mm in diameter, which is characteristic of Pheidole attack. [20] (Fig. 13a).

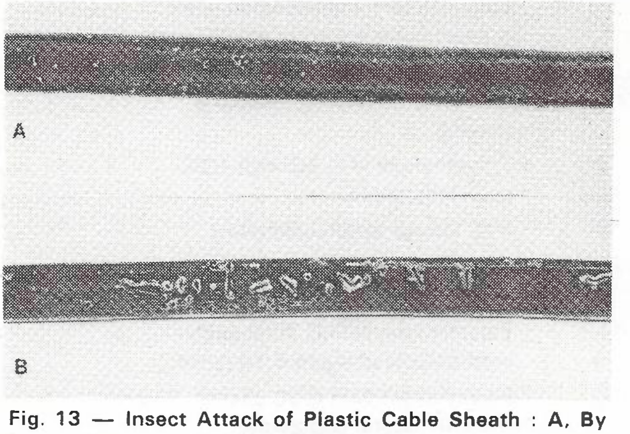


Fig. 13 — Insect Attack of Plastic Cable Sheath : A, By Ants: B, By Termites.

The conclusions reached were that polyethylene and PVC cable sheathing incorporating various insecticides and repellants, are not immune to attack from termites or ants. Nylon 6 or 6.6 jacketed cable, whilst showing early promise, was in fact attacked by ants and further investigation of these materials was required.[20]

The findings of the above field trials on termites were in general confirmed by results obtained by the CSIRO in their work with laboratory colonies of termites and at their field test sites, (Appendix 1). The only exception was the performance of nylon 6 or 6.6, which was found in CSIRO's laboratory tests to be totally resistant.

The nylon 6 and 6.6 used in the field trials exhibited blisters and delamination after exposure, which was attributed to the high water absorption of this type of nylon. Whilst some of the ant attacks seemed to have been through the blistered areas, there was also evidence of attack on undamaged sections of the samples. As a consequence, it was decided that the lower water absorbent grade of nylon (nylon 11) should be used in all future evaluations.

The study proved that no insecticide or repellant incorporated into a cable sheath could provide the high degree of protection required to ensure cable reliability in high risk areas such as tropical Australia. A decision was therefore reached that any future developments should be directed toward materials which, by their toughness and other related factors, offered resistance to penetration by the insect's mandibles. Subsequently, the following 14 cable sheath compositions were exposed in 1964 at two sites in the vicinity of Darwin. CSIRO ran concurrent laboratory evaluations.

Sample No.	Description
1	High density (960 kg/m^3) polyethylene.
2	Polypropylene.
3	Polyethylene MFI 0.3C incorporating 1% finely divided silica.
4	As above, but with 5% silica.
5	Polyethylene MFI 0.3C sheath, single lapping of 0.10 mm brass tape with 20% overlap, jacket of 1.02 mm polyethylene.
6	Polyethylene MFI 0.3C sheath, wrapped with jute yarn impregnated with grease, outer covering of PVC tape.
7	Polyethylene MFI 0.3C sheath, wrapped with tanalith impregnated jute serving.
8	Polyethylene MFI 2C with 10% polyisobutylene.
9	PVC (composition unknown).
10	Polyethylene MFI 0.3C sheath, nylon 11, 0.76 mm thickness, jacket.
11	Polyethylene MFI 0.3C sheath, light-stabilised nylon 6.10 jacket.
12	Polyethylene MFI 0.3C sheath, Alkon M25-01 acetal copolymer.
13	Celcon M90-02 acetal copolymer.
14	Polyurethane (Estane 58016) containing 10% carbon black, 1% barium stearate.

One site was in Darwin and the other 16 miles south of Darwin at Howard Springs. The conventional test plot layout in which samples are buried in a rectangular matrix, Fig. 12, was used at both sites. This was called Type-I plot. In addition, a second test plot construction was employed and designated Type-II plot. In the latter the samples are placed in a circle around a termite mound, with buried connecting strips of susceptible timber making a closed circle around the mound as shown in Fig. 14. The aim in this type of construction is to ensure that termites leaving the mound encounter the timber strips and thus find their way to the test samples.[21]

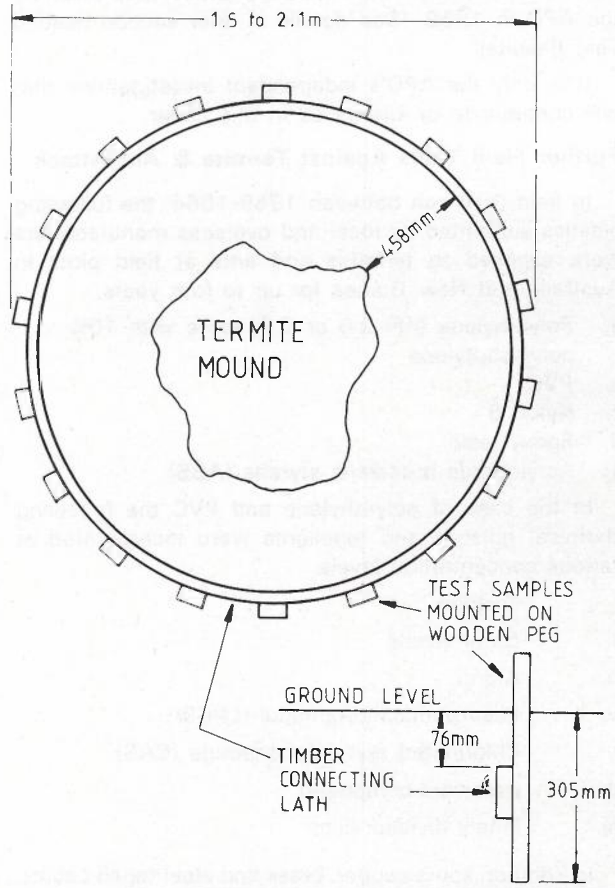


Fig. 14 — Plan of Specially Designed Test Plot : Type-11 Plot.[21]

Test Results

The field test program terminated in 1968, and the results given in Appendix 4, together with CSIRO laboratory tests, make it evident that nylon 11 provided excellent protection from termite attack. The results with acetal copolymer, though only limited in scale, were also impressive as were those with nylon 6.10, although in the latter case, possibly due to the surface roughness of the experimental samples, there had been some minor, shallow attack. It is interesting to note that the laboratory exposure tests demonstrated that all these materials were liable to damage at the cut ends, where the termites were able to use their mandibles in scissor fashion, but samples where the ends were capped with a metal ferrule did generally escape all attack. This confirmed the belief that smoothly extruded sheathing, free of scratches and creases will always be more difficult for the insects to grip with their mandibles. In addition, if the material is of reasonable hardness and good resilience, attack is most unlikely. The tests clearly stressed the importance of proper extrusion conditions and installation practices if the advantages gained by the choice of a highly resistant material, are not to be partly sacrificed. Results obtained with high density polyethylene, polypropylene, rigid PVC and polyurethane, whilst not as good as those for nylon, were far superior to those for low density polyethylene, plasticised PVC, natural and synthetic rubbers.[24]

Another field trial was conducted from 1965-1970 on various experimental cable constructions at more than 20 test sites around Australia. In these trials, lengths of approximately 50m of cable were buried at depths of 250 to 500 mm, with one end sealed and the other connected to above ground terminals. Periodic measurements of insulation resistance between conductor and earth were carried out to give an indication of damage, and at the end of approximately five years the cables were recovered for detailed examination. It was shown that whilst none of the nylon 11 jacketed samples had been attacked, there had been several instances of penetration of nylon 6 jackets. Various other types of plastic materials, with and without additives such as silica, gave poor to average results. In the case of brass barriered cables, there was considerable evidence of penetration of the outer plastic jacket leading to metal corrosion, but the insects had not damaged the inner plastic sheath. Some cable types performed reasonably well, such as those covered with greasy barriers or "Tanalith" treated wrappings, but because of their poor physical properties, large size, and the difficulties in handling, they cannot be considered as practical solutions for cable.[23] They could, however, be used to good advantage in the protection of cable joints. CSIRO also found similar grease impregnated materials, like "Densotape" and "Densopol", to be completely effective in excluding termites. In their tests the termites quickly plastered over the wrapped samples, and although they moved over the surface of the plastered samples quite freely throughout the entire exposure period, no evidence of any attempt to penetrate either tape wrappings could be detected.

On the basis of this trial it was decided to introduce nylon 11 jacketed cable into the network, and regular

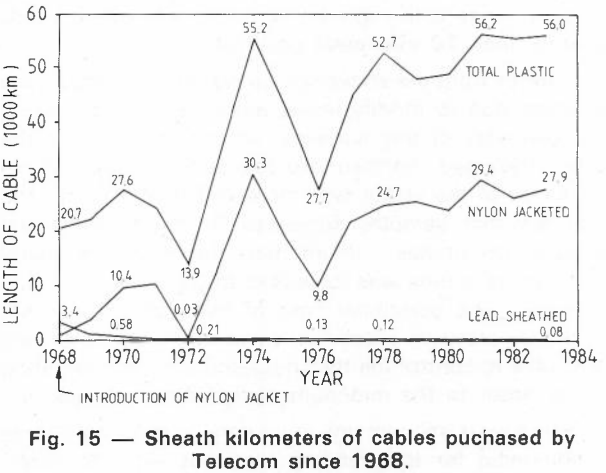


Fig. 15 — Sheath kilometers of cables puchased by Telecom since 1968.

production commenced in 1968. In 1982/83, nearly 28,000 sheath km of cable was nylon jacketed out of a total cable production of 56,000 km (Fig. 15). To the best of our knowledge, no other solution of comparable cost effectiveness has been found anywhere else in the world.

Nylon 12 as an Alternative

Nylon 11 (polyundecaneamide) is available from only one manufacturer, and in 1969, a worldwide shortage of castor oil, the basic raw material, created a difficult supply situation for our ever increasing demand for nylon jacketed, insect proof cable. It therefore became necessary to search for an alternative material.

Nylon 12 (polylauryllactam) made from a readily available petro-chemical, butadiene, was an obvious choice and offered a price advantage. Its chemical and physical properties were similar, and with regards to water absorption slightly superior, to nylon 11. Field and laboratory tests confirmed that nylon 12 conferred insect resistance equal to nylon 11, and as a result of several years of testing, four manufacturers' materials have been type approved.

The Effects of Formic Acid

Many families of ants are known to possess venom and/or scent producing glands. In the group of Formicides, the active ingredient of the venom has been identified as 50% concentrated formic acid and it has been calculated that an individual ant can contain up to 2 mg, that is, 20% of its total body weight of formic acid. As formic acid is known to cause degradation of some nylons, experiments were conducted to study the effects of 5% and 50% formic acid solutions on various grades of nylons. It was shown that nylons 11 and 12, whilst suffering some decrease in surface hardness, after immersion for up to 28 days at temperatures between 20 and 50°C, were still satisfactory.[22] However, various other grades such as nylon 6, 6.6, and 6.10 and also acetal copolymer were found to suffer severe degradation, and whilst the danger from prolonged exposure to formic acid in service may not be very great, our preference for nylons 11 or 12 over other nylon materials has been reinforced by these findings.

Nylon Specification

Concurrent tests by the APO (renamed Telecom Australia after 1975) Research Laboratories, cable manufacturers and nylon suppliers confirmed that nylon could be adequately heat and light stabilised, and that up to 2% carbon black could be used without unduly degrading the physical properties. Furthermore, no special processing conditions were necessary within certain temperature/time profiles. Consequently, the Telecom specification for nylon 11 and nylon 12 for cable jacketing requires the use of heat and light stabilised grades containing 2% by mass of a specified grade of carbon black. The temperature of the molten resin during extrusion is not permitted to exceed 260°C for more than 15 minutes. However the time is permitted to double for every 10°C reduction in extrusion temperature. Type approval tests and periodic check tests include tensile stress at yield (median of five tests, to exceed 30 MPa) elongation at break (median of five tests, to exceed 280 per cent). Recently, the specification has been modified to require that the median results for tensile stress and elongation do not vary by more than 10% after being thermally aged in an approved air circulating oven at 100 + 2°C for a minimum of 120 hours.

Surface Finish of Manufactured Cable

The laboratory evaluation and field tests included samples that had a surface finish in which small bubble-like imperfections, lumpiness and absence of surface gloss were evident. These samples showed the greatest propensity to insect attack.

It was later found that the reason for the poor surface finish was due to moisture content of the granules entering the extruder. A high moisture content lowers the melt viscosity and increases the rate of nylon deterioration (by hydrolysis) at high extruder temperatures.

From the user point of view the problem can be controlled by the inclusion of a specification requirement demanding that the jacket have a smooth glossy surface, free of imperfections.

This surface finish requirement should provide adequate assurance to the user that jacket defects existing at manufacture will not result in points of weakness which can be attacked by insects. However, the Telecom Australia specification also limits the moisture content of granules entering the extruder to a maximum of 0.1% by mass, and limits the time/temperature of the material within the extruder. These requirements are set primarily to guard against other forms of jacket degradation, but they give added security against manufacture of cable with defective jacket.

The aim must be to provide a cable with a "smooth gloss surface" ex factory, but for maximum protection against surface damage, attention should also be paid to the surface finish and cleanliness of the cable chutes of cable ploughing equipment during installation (Fig. 16). This is desirable but not always achievable. Fig. 17 shows damage to a nylon jacketed cable that initiated from deep score marks in the jacket presumably introduced during cable laying.[25]

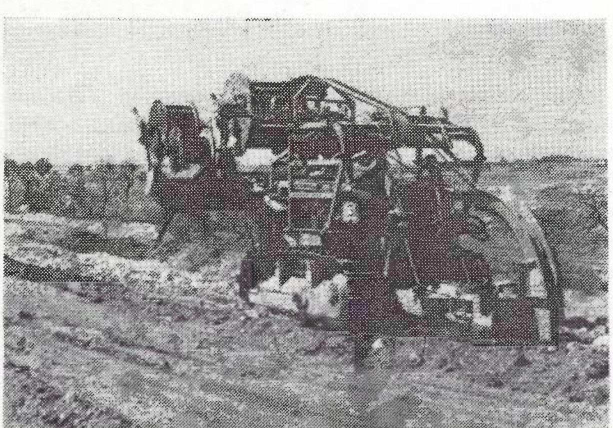


Fig. 16 — A Typical Mole Plough Cable Laying Machine.

Creasing of Jacket

Nylon jacketed cable must withstand the bending associated with factory processes, culminating in winding onto a despatch drum, and then after a variable period of storage, sometimes in a hot dry climate, it has to withstand unwinding from the drum and passage into and through cable laying equipment. Finally the cable ends are coiled up in the small pits used for housing joints. The cable jacket must undergo these operations without significant deterioration of its "smooth gloss surface" which has been shown to be important in maximising protection against insect attack. Also, if the jacket becomes creased, it may serve as an initiation point for insect attack (Fig. 18) or it could catch in the cable laying plant, and be severely torn.[23]

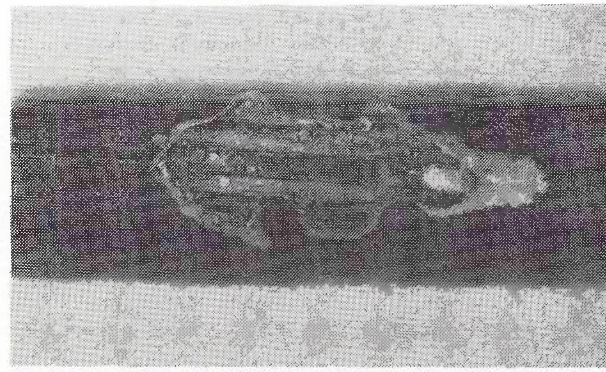


Fig. 17 — Termite damage to Nylon Jacket initiating from a surface defect (score marks) introduced during cable laying.

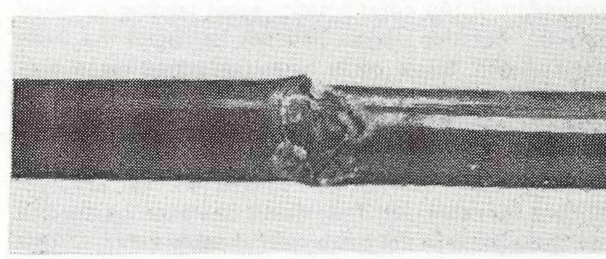


Fig. 18 — Termite damage to Nylon Jacket initiating from a surface defect (crease) introduced during cable laying.

Early specifications required the nylon to be at least 0.25 mm thick and to withstand a bending test on a mandrel with a diameter twenty times the cable diameter. After two forward and reverse 360° cycles of bending, the jacket had to "remain continuous and undamaged".

Some problems occurred in the field while this specification was operative. The worst of these were found to arise with cable laying machinery where bends sharper than 20 diameters occurred.

Creases from the above source were observed and the solution was to modify laying equipment by increasing the diameter of any surfaces, wheels, etc., which the cable traversed. Furthermore the minimum acceptable thickness of the jacket was increased to 0.30 mm, and required that samples subjected to the bending test exhibit "no ripples". In addition the minimum barrel diameter of drums was increased to 30 times the cable diameter. The additional cost of increasing the jacket thickness was not excessive, since manufacturers were now able to control the thickness and set their operating limits closer to the minimum acceptable thickness.

Some work still remains to be done in defining sample conditioning for the bending test that will adequately simulate adverse field conditions. For example, immediately after extrusion the nylon has an extremely low moisture content (well below 0.1%) and performs badly in this test, but after being conditioned in a standard 65% RH test environment for a reasonable time the cable is able to pass the bending test.

Perhaps the solution to the problem of creasing under severe bending lies in providing a high strength bond between the underlying polyethylene and the nylon jacket, or alternatively in lightly plasticising the nylon.

Jointing of Nylon Jacketed Cable

An attractive feature of nylon jacketing has been its complete compatibility with our standard methods of jointing plastic cable. These methods were developed with insect protection in mind and are based on the use of two rigid PVC mouldings, with on-site poured epoxide resins providing a mechanical bond between the cable sheath/jacket and the mouldings. Rigid PVC is termite resistant and the epoxide resin, whilst not immune from attack, is in the form of a thick casting so that total penetration is most improbable. The joints are placed underground in small pits made from fibre reinforced cement.

In rural areas joints are made in above-ground steel posts and whilst not constructed from recognised insect proof materials, attack within the posts has not occurred, probably because the insects tend to prefer cooler, i.e. underground locations.

General Costs

Approximately 50% of all cable currently purchased by Telecom Australia is jacketed with nylon (Fig. 15). This consumes some 600 tonne of nylon per year at a raw material cost of around $3.7 million. The manufacturing cost of jacketing individual cables ranges from 10-50% of the total cable cost. This large expenditure must be set against the derived benefits and compared with the costs for alternative solutions.

Benefits of Nylon Jacketed Cables

A record of all faults occurring in the entire Australian network has been maintained for many years, with the procedure for collection and fault designation periodically upgraded. Fig. 19 shows that the number of faults attributed to insect damage per 1000 km of cable has more than halved over the last 17 years.

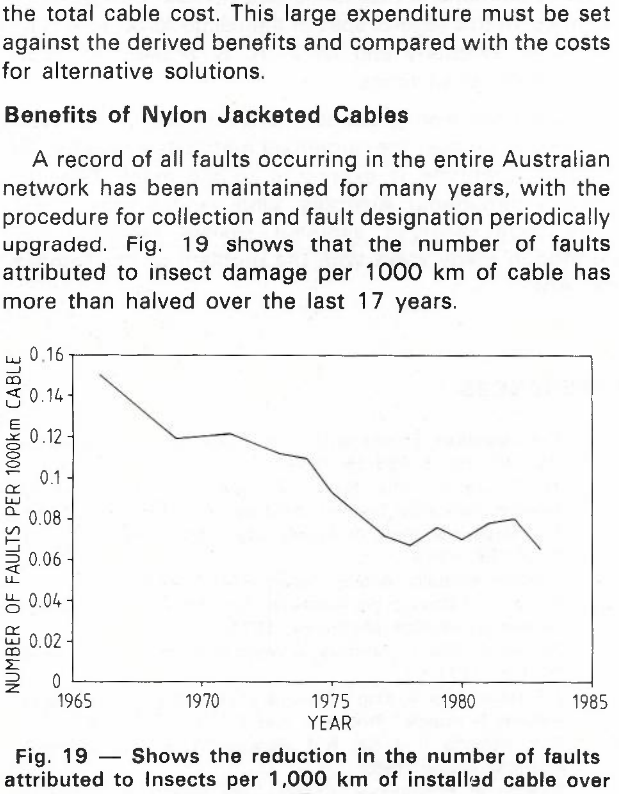


Fig. 19 — Shows the reduction in the number of faults attributed to Insects per 1,000 km of installed cable over past 17 years.

However, the major benefit achieved by the use of nylon jacketing is not in the savings achieved by the elimination of faults.

Before the adoption of nylon jacketing, the fault incidence in plastic cables in some rural areas was so high that required service standards could not be met. Therefore operating districts had to adopt other forms of cable, typically lead sheathed with plastic jacket or steel tape armour. Hence to achieve a real benefit it is necessary that nylon jacketed cables cost less than lead sheathed cables and yet give comparable, or better, service performance.[23] In point of fact, purchase of equivalent quantities of lead sheathed cable would cost at least twice that of nylon jacketed cables and in addition there are substantial installation cost disadvantages with lead sheathed cables.

This analysis could still lead to an incorrect assessment of the benefit if nylon jacketed cables were to be used in areas where the performance of standard plastic cable is adequate. However, this would only become a significant factor if over half the nylon jacketed cable were used incorrectly.[23]

Alternative Solutions

To spend over $3.7 million per year on nylon for protection of cables could still not be justified if cheaper solutions were available. One other possible solution subjected to extensive field trial in Australia was brass tape protection. This cable had brass tapes helically applied over the polyethylene sheath, and held in place by a thin extrusion of polyethylene. The corrosion liability of such a cable, as demonstrated by our field trials, has been already mentioned in an earlier section of this paper. Its cost was much greater than nylon. Even when allowance is made for some advantages conferred by the metal tape such as protection against of lightning strikes, the nylon is a preferable solution.

The use of steel tapes over plastic cables is another possible solution as also would be the Western Electric "Stalpeth" sheath but, in Australia, this would not be cheaper than nylon and has therefore not been investigated.[23]

Many materials not covered in the major trials described in this paper were evaluated on an ad hoc basis. The incorporation of insectides in the plastic sheath as part of the extrusion process, advocated by various manufacturers and designers, created many such samples. In our experience, which covers a substantial number of compounds in both polyethylene and PVC, none of the insecticides available have given the required degree of protection. The difficulty appears to be that if the insecticide "blooms" rapidly to the sheath surface, it will effectively repel the insects but its life will be too short, whilst if the blooming rate is slow enough to allow for a 20-40 year life, there is insufficient material available at the outer periphery to give adequate protection. In addition, the presence of insecticides is an undesirable health hazard to cable manufacturers, installation and repair staff.[23]

Whilst we are therefore in the happy situation of having reached a solution to our problem, we are continuing to search for cheaper alternative jacketing materials with at least equal insect resistance. This work has not advanced to a stage where it is possible to reach any firm conclusions, even though there are a number of promising materials in the course of investigation.

In view of the high proportion of faults being attributed to ants (and borers), as compared to termites, and the apparent upturn in faults caused by ants (and borers) in recent years (Fig. 20), possibly due to an increase in non-jacketed cable installed in the more populated areas, close attention will have to be given to this aspect in any new development.

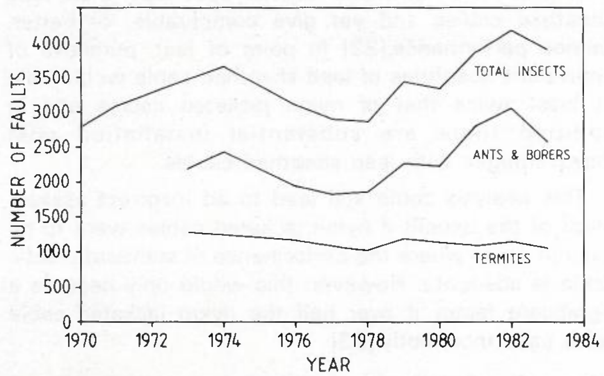


Fig. 20 — Compares the slight decline in the number of faults attributed to Termites over the past 10 years with an increase of faults for Ants and Borers over the same period.

Other Pests

Damage to telecommunication cable by other pests such as rats, mice, rabbits, bandicoots, birds, etc., occurs over most parts of Australia, but does not follow any predictable geographical or seasonal pattern. The number of faults attributed to all pests (including insects) has doubled (near 18,000 in 1983) in the past 12 years, in contrast to that for insects which has been contained to an average of around 3,400 faults per year over the same period. At this stage no economically feasible solution for preventing attacks from "other pests" has been developed.

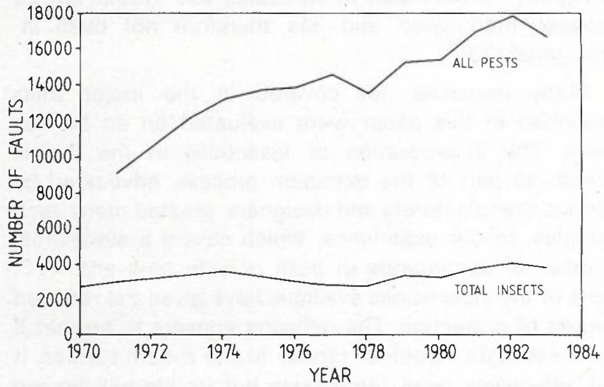


Fig. 21 — Shows a doubling in the number of faults attributed to all Pests over the past 12 years, compared to relatively steady level of faults per year for Insects over the same period.

Conclusion

Termite and ant attack of underground cables has been known to occur since 1911 and attempts to combat the insects with poisons, repellants and insecticides failed to provide the long term protection required. Nylon jacketed cable on-the-other-hand has been outstandingly successful since its introduction into the network in 1968. In fact, there have been very few failures due to penetration by an insect of cable jacketed with nylons 11 or 12. All samples submitted for examination have clearly shown the fault as being the result of installation damage, manufacturing defects or incorrect choice of the grade of nylon. Having also surmounted the original limitations with regard to cable size and ease of handling, Telecom Australia has now reached the stage where the probability of insect attack on newly installed jacketed cable has been reduced to a very low order of magnitude. Some faults, however, must still be expected in unjacketed cable and cable installed prior to 1968.

Acknowledgements

Many dedicated people within the organisation have endeavoured to solve the termite and ant problem for over 70 years and it is only through a combination of their efforts that we have been able to reach the solution we have today. I do, however, wish to name a few who have been responsible for the continuation of work on this unique problem in the Telecom (formerly APO) Research Laboratories since 1934. In particular, I acknowledge the early work of fault identification by the late Mr D. O'Donnell, the introduction of field plot testing by Mr P. R. Brett and the persistence of Mr G. Flatau, who, over many years designed programs, arranged field tests and coordinated results of field tests with laboratory evaluations conducted by CSIRO.

The close working relationship maintained with officers of the Division of Entomology, CSIRO Canberra for more than 30 years is also gratefully acknowledged. Their help has been vital, not only for insect identification but also in conducting test programs, in particular the running of laboratory tests on cable specimens to obtain rapid evaluations of resistance to a number of species of termites. In this regard, special thanks go to Mr F. J. Gay, Mr A. H. Wetherly and Dr J. A. L. Watson for their cooperation at all times.

Thanks are also given to the many companies who supplied at no cost the numerous materials evaluated. In addition, gratitude is expressed to the many Telecom workers throughout Australia, who, over a span of 50 years, have observed, sampled, trialled, recorded and assisted in many ways with the problem of the Termite and Ant.

REFERENCES

[1] The Australian Encyclopedia, The Grolier Society of Australia Pty. Ltd., Vol. 5, P95-96, 1979.

[2] H. T. Davis "The Place of Cable in the Australian Telecommunication System", APO Seminar, Melbourne, 1972.

[3] The Macquarie Book of Events, Macquarie Library Pty. Ltd. P126-128, 1983.

[4] Telecom Australia, Annual Report, P78, 1982-83.

[5] R. Clark, "Plastics in the Australian Post Office", 7th Australian Plastics Convention, Melbourne, 1973.

[6] Norman E. Hickin, "Termites: A World Problem", Hutchinson & Co. Ltd., 1971.

[7] J. F. Giblin & W. T. King, "Damage to Lead Sheathed Cables by Rodents & Insects" Proc. IEE, Part 1, Vol. 101, 1954.

[8] F. N. Ratcliffe, F. J. Gay & T. Greaves "Australian Termites," Morris & Walker, 1952.

[9] Division of Entomology, CSIRO. "The Insects of Australia" Melbourne University Press, P275-293; 951-959, 1973.

[10] P. J. M. Greenslade "Ants of South Australia" the South Australian Museum, 1979.
[11] G. Flatau, P. R. Brett "Resistance of Plastic Sheathed Cable to Attack by Termites" APO Research Laboratory Report, No. 4036, 1955.
[12] APO Internal Correspondence File No. 65/9/13 Part 2.
[13] D. O'Donnell & O. Gable "Cable Damage by Singapore Ants — Mt. Magnet, W.A.", APO Research Laboratory Report, No. 1420, 1941.
[14] APO Internal Correspondence File No. 65/9/13 Part 2.
[15] Imperial Chemical Industries Ltd. UK "Control of Termites" Report No. HL/M/3464, 1943.
[16] Ordnance Laboratories Cawnpore, India "The Susceptibility of PVC Materials to Biological Damage" Report No. B10/45/7, 1947.
[17] Laboratory Testing with Termites, CSIRO Bulletin No. 277, 1955.
[18] G. Flatau "Protection of Telephone Cables from Attrack by Insects" 36th International Wire & Cable Symp., USA., 1966.
[19] Minutes of "Conference on Termite Attack on Underground Cable", Melbourne, 1958.
[20] G. Flatau "Resistance of Plastic Sheathed Cables to Attack by Termites & Ants — Field Trials 1959-1964". APO Research Laboratory Report, No. 5974, 1966.
[21] G. Flatau "Resistance of Experimental Plastic Cable Sheath to Attack by Termites — Field Trials in the Northern Territory 1964-1968", APO Research Laboratory Report No. 6350, 1968.
[22] H. J. Ruddell "Effect of Formic Acid on Polymers Approved for Insect Resistant Cable" APO Research Laboratory Report No. 6582, 1971.
[23] R. A. Clark & G. Flatau "Development of Nylon Jacketed Telephone Cable Resistant to Insect Attack" 21st International Wire & Cable Symposium, USA, 1972.
[24] The Plastics Institute of Australia Inc. "Termite Protection of Cables" Press Release, 1971.
[25] B. A. Chisholm "Investigation of Insect Damage to Nylon Jacketed Cables" Telecom Research Laboratory Report No. 6928, 1974.
[26] G. D. Prestwick "The Chemical Defences of Termites" Scientific America, 1983.

The Telecommunication Society of Australia

Corporate Review

Introduction

Formed over 100 years ago, the Telecommunication Society of Australia now boasts a strong membership all over Australia and many overseas subscribers. The object of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia (TJA) and Australian Telecommunication Research (ATR) and by any other means.

The affairs of the Society is administered by a Council of Control and six State Committees. The Council of Control is responsible for:

- the policy of the Society
- publications of the Society for national and international distribution and sale by the Society

The Council of Control is made up of twelve Headquarters officers of the Australian Telecommunications Commission who are also members of the Society and six Councillors representing respectively the six States.

There are six State Committees, one in each of the following cities: Sydney, Melbourne, Brisbane, Adelaide, Perth and Hobart. Each Committee is responsible for the execution of the Society's policy as laid down by the Council of Control, and for the achievement of the objects of the Society in its own State. Each State Committee comprises twelve members of the Society resident in that State.

The Society is a non-profit organisation and financially it depends on membership subscriptions, sale of publications, advertising revenue and most important of all, support from the telecommunications industry. Historically, Telecom Australia has been the Society's most generous benefactor. Undoubtedly, without Telecom Australia's support, the Society would not have been able to serve the community in general so well.

The Society in the Information Age

For over a century, the Society has served its members well, keeping its members informed of the advancements in telecommunications, broadcasting and television services. The world is moving into the Information Age and it is appropriate that the Society reviews its position in the changing environment. It was with this in mind that under the then Chairman of the Council of Control Mr Bob McKinnon a major Coprorate Strategy Review took place. The Corporate Strategy Review culminate to an historic Extra Ordinary Meeting of the Council of Control with Chairman/Representatives of State Divisions in July, 1983.

As a result of the 1983 meeting, a further special meeting of the Council of Control, chaired by Mr Keith Barnes was held, again in Melbourne on August, 1985. At this meeting the matters discussed included:

- The constitution of the Society
- The Marketing Thrust of the Society
- The provision of service and facilities to members
- Society Management issues.

Also, at the meeting, the following aspects were noted:

- The improved performance of the Society over the last few years, both financially and in terms of activities and services
- The dependence of the Society on recruiting membership for its financial health
- The importance of overall planning for marketing and membership
- The need for market research using the TJA as the vehicle, to identify membership needs.

The meeting decided broad priorities of various target groups on which increased membership initiatives could focus and established a target for membership numbers. While the Journal is recognised as the centre piece of the Society's activities and presence, especially in Country areas, every effort must be made to take a broader view of the Society, its activities and its potential for the future in terms of products and services, and also of membership.

APPENDIX I

Tests with Termites — 1959/64 Trials [20]

Sheath Material	Additive	Darwin Test Plot						CSIRO Field Test		
		Test period, 13 months			Test period, 40 months			Test period, 12 months		
		No. exposed	No. attacked	Degree of attack	No. exposed	No. attacked	Degree of attack	No. exposed	No. attacked	Degree of attack
Polyethylene MFI 2	1% Dieldrin	4	0	—	4	1	v. slight	9	1	slight
Polyethylene MFI 2	0.5% Dieldrin	2	0	—	2	1	mod.	9	2	severe
Polyethylene MFI 2	0.25% Dieldrin	1	0	—	1	0	—	9	6	severe
Polyethylene MFI 2	0.10% Dieldrin	1	0	—	1	0	—	9	4	severe
Polyethylene MFI 2	0.05% Dieldrin	1	1	mod.	1	0	—	9	4	severe
Polyethylene MFI 2	0.025% Dieldrin	1	1	mod.	1	0	—	9	3	severe
Polyethylene MFI 2	0.01% Dieldrin	1	1	mod.	1	1	slight	9	6	severe
Polyethylene MFI 2	1.0% Aldrin	1	0	—	1	1	slight			
Polyethylene MFI 2	0.5% Aldrin	1	1	slight	1	1	slight	9	6	severe
Polyethylene MFI 2	0.25% Aldrin	1	1	slight	1	1	slight	9	6	severe
Polyethylene MFI 2	0.10% Aldrin	1	0	—	1	1	slight	9	3	severe
Polyethylene MFI 2	0.05% Aldrin	1	1	v. slight	1	1	slight	9	3	severe
Polyethylene MFI 2	0.25% Aldrin	1	1	slight	1	1	slight	9	6	severe
Polyethylene MFI 2	0.01% Aldrin	1	1	slight	1	1	mod.	9	5	severe
Polyethylene MFI 2	0.5% Gammexane	3	0	—	3	0	—	9	1	slight
Polyethylene MFI 2	0.2% Gammexane	3	1	mod.	3	1	slight	9	2	slight
Polyethylene MFI 2	5% LPCP	1	1	slight	1	0	—	9	5	severe
Polyethylene MFI 2	1% Silica	2	1	slight						
Polyethylene MFI 2	0.1% Silica	2	2	slight						
Polyethylene MFI 2	Nylon 6 jacket	1	0	—	1	0	—			
Polyethylene MFI 2	0.5% Gammexane/ Nylon 6 Jacket	1	0	—	1	0	—			
Polyethylene MFI 2	Untreated	10	5	mod.	10	6	severe	9	0	—
Polyethylene MFI 0.3	1% Silica	2	2	mod.						
Polyethylene MFI 0.3	0.1% Silica	2	1	v. slight						
Polyethylene MFI 0.3	Untreated	2	1	slight						
PVC	1% Dieldrin	4	1	v. slight	4	1	slight	9	6	severe
PVC	0.25% Dieldrin	2	1	mod.	2	0	—	9	5	severe
PVC	0.5% Gammexane	3	0	—	3	1	mod.	9	6	severe
PVC	0.2% Gammexane	3	2	mod.	3	1	slight	9	6	severe
PVC	1% CAS	1	1	v. slight	1	0	—	9	2	severe
PVC	Nylon 6 jacket	1	0	—	1	0	—			
PVC	Untreated	12	5	slight	12	5	mod.			
Epoxy resin	—	2	0	—	2	0	—			
ABS pipe	—	1	0	—	1	0	—			

APPENDIX 2

Tests with Ants — 1959/64 Trials [20]

Sheath Material	Additive	Brisbane				Sydney	
		32 months exposure		64 months exposure		24 months exposure	
		No. exposed	No. attacked	No. exposed	No. attacked	No. exposed	No. attacked
Polyethylene MFI 2	1% Dieldrin	4	1	2	0	6	0
Polyethylene MFI 2	0.5% Dieldrin	1	1				
Polyethylene MFI 2	0.25% Dieldrin	1	1				
Polyethylene MFI 2	0.10% Dieldrin	1	1				
Polyethylene MFI 2	0.05% Dieldrin	1	1				
Polyethylene MFI 2	0.01% Dieldrin	1	1				
Polyethylene MFI 2	0.5% Gammexane	4	0	2	0	6	1
Polyethylene MFI 2	0.2% Gammexane	4	1	2	0	6	0
Polyethylene MFI 2	Nylon 6 jacket			2	1	2	0
Polyethylene MFI 2	0.5% Gammexane/ Nylon 6 jacket	4	0	2	1		
Polyethylene MFI 2	Untreated control	4	3	2	2	10	3
PVC	1% Dieldrin	4	1	2	1	12	0
PVC	0.5% Gammexane	5	0	1	0	6	1
PVC	0.2% Gammexane	8	3	4	0	6	0
PVC	1% CAS	4	1	2	1		
PVC	Untreated control	6	4	2	1	12	2

APPENDIX 3

Summary of Termite and Ant Resistance of Cable Sheathing Incorporating Additives (minimum of 10 samples exposed) — 1959/64 Trials [20]

Sheath Material	Additive	% of Samples Attacked
Polyethylene MFI 2	1% Dieldrin	5.4
Polyethylene MFI 2	0.5% Dieldrin	9.1
Polyethylene MFI 2	0.25% Dieldrin	25.0
Polyethylene MFI 2	1% Aldrin	18.2
Polyethylene MFI 2	0.5% Aldrin	36.4
Polyethylene MFI 2	0.5% Gammexane	13.3
Polyethylene MFI 2	0.2% Gammexane	13.3
Polyethylene MFI 2	5% LPCP	27.2
Polyethylene MFI 2	Untreated control	30.2
Polyethylene MFI 0.3	1% Silica	25
Polyethylene MFI 0.3	0.1% Silica	21
Polyethylene MFI 0.3	Untreated control	18.7
PVC	1% Dieldrin	15.7
PVC	0.25% Dieldrin	18.2
PVC	0.5% Gammexane	11.1
PVC	0.2% Gammexane	17.7
PVC	1% CAS	23.6
PVC	Untreated control	38.2

APPENDIX 4

Tests with Termites — 1964/68 Trials [21]

Sheath Material	Additive	Field Tests Darwin Area Type-I Plot			Field Tests Howard Springs Area Type-I Plot			Field Tests Howard Springs Area Type-II Plot			CSIRO Laboratory Tests CL★	CSIRO Laboratory Tests NE★	CSIRO Laboratory Tests CA★
HD Polyethylene	Untreated	0	0	v.slight	0	0	0	v.slight	v.slight	v.slight	0	0	mod.
Polypropylene	Untreated	v.slight	0	0	0	slight	slight	0	0	0	v.slight	v.slight	mod.
Polyethylene MFI 0.3C	1% Silica	0	0	0	0	v.slight	v.slight	0	0	0	0	0	slight
Polyethylene MFI 0.3C	5% Silica	0	0	0	0	0	0	0	0	slight	0	0	slight
Polyethylene MFI 0.3C	Brass tape/PE jacket	slight	0	0	0	v.slight	slight	v.slight	v.slight	v.slight	v.slight	slight	slight
Polyethylene MFI 0.3C	Greased tape/PVC jacket	v.slight	0	v.slight	0	v.slight	v.slight	v.slight	0	0	slight	mod.	—
Polyethylene MFI 0.3C	Tanalith jute wrap	0	0	0	0	0	0	0	v.slight	0	0	0	mod.
Polyethylene MFI 2C	10% PIB	slight	0	v.slight	v.slight	v.slight	slight	v.slight	mod.	0	—	—	—
PVC	Untreated	0	0	mod.	mod.	mod.	mod.	mod.	mod.	0	—	—	—
Polyethylene MFI 0.3C	Nylon 11 jacket	0	0	0	0	v.slight	0	0	0	0	0	0	0
Polyethylene MFI 0.3C	Nylon 6.10 jacket	0	—	—	0	0	—	0	0	0	—	0	slight
Polyethylene MFI 0.3C	Acetal copolymer jacket	0	—	—	0	0	—	0	0	0	—	0	0
Acetal copolymer	Untreated	—	—	—	0	0	—	—	—	0	—	—	—
Polyurethene	10% Carbon black	—	—	—	—	—	—	—	—	—	v.slight	0	slight
Exposure Time,	**Months**	**12**	**24**	**36**	**12**	**24**	**36**	**12**	**12**	**24**	—	—	—

★ Refers to test species of termite:
CL = Coptotermes lacteus
NE = Nasutitermes exitiosus
CA = Coptotermes acinaciformis.

HISTORY OF THE ITU 120 YEARS

Flanking the United Nations, in its battle of 40 years for the future, are its specialized agencies. Each of them an international organization in its own right, they deal, as their collective name implies, with specialized branches of human need and endeavour. Most of them came into being in their present form following the creation of the United Nations itself. Others however, go back to earlier generations. Oldest of all, and the first to reach 120 years, is the International Telecommunication Union (ITU).[1]

This might seem strange. Nothing, surely, could be more modern than telecommunications, which are wiping out distance and gradually shrinking our planet Earth.

For what after all is telecommunications?

The need to communicate

Human societies, as they developed and began to master the concept of distance, worked out a number of ingenious ways for communicating over the vast areas which separated them. Mostly, messengers of one kind or another were used. But there were also methods involving direct sight and sound — drums in the jungle, beacons along the coast, smoke signals on the horizon. These methods, picturesque today, were strictly practical solutions devised by man's imagination for overcoming the obstacles that distance placed in the way of his basic need to communicate. They were the first real telecommunications.

From the early dawn of civilization until a little over 100 years ago man did not get much further than the written message, the drum, the beacon and the smoke signal in his efforts to communicate at long distance. One of the last of these devices was an "optical telegraph" or semaphore invented by Claude Chappe, a Frenchman, at the end of the 18th century. Signal towers with moveable arms were set on hill-tops a few kilometres apart. Messages spelt out by different positions of the arms were read by telescope from one tower to another and passed on. The system worked quite fast on clear days but was useless at night or in fog.

With the development of electricity in the first half of the 19th century, man's capacity for practical achievement was suddenly enlarged a hundred-fold. Nowhere has this been seen more dramatically than in the invention of the electric telegraph.

The pioneers of the electric telegraph

Amongst the pioneers of the electric telegraph was Samuel Finley Breese Morse who exhibited a model of his apparatus at the University of New York in 1835 and took out a patent in 1837. On 6 January 1838, by using electric current, he managed to transmit the signs of the alphabet he had invented, and which bears his name, along a wire 5 km long. On 24 May, 1844, the first public link using Morse apparatus was inaugurated between Washington and Baltimore.

The electric telegraph was made available to the general public in Europe about 1848. At first the lines stopped short at national frontiers and the telegrams were taken by hand from one locality to another across the border for further transmission. But the popularity of this useful and marvellous means of communication was such that States soon felt the need to regulate, by intergovernmental agreements, the use of particular types of conductors and apparatus, the application of uniform operating instructions, the collection of charges and the mutual settlement of accounts.

The regional unions

The governments had to face difficulties that would be overcome in a trice today. To give only one example, when Prussia, in 1848, decided to link its capital with places on the borders of the kingdom it had to conclude no less than 15 conventions with the German States to obtain the rights of passage necessary for the construction of its lines, and these conventions were only effective within Germany itself. The convention on "The establishment and use of electro-magnetic telegraphs for the exchange of State despatches," signed in 1849 by Prussia and Austria, was the first agreement on the subject with any claim to be international.

A number of German States concluded with each other and with other European countries agreements which formed the foundation of all subsequent agreements — the Austro-German Telegraph Union, the Berlin Convention, the West European Telegraph Union — leading up, in 1858, to the Berne Convention.

Founding of the Union

In 1864, there were several regional conventions in existence. The progress of science, the extension of lines and the complexity of telegraph relations made it more and more obvious that the provisions of these conventions were no longer in tune with the requirements and conditions of the time.

Accordingly France, desiring to profit from experience and realizing the advantages of complete telegraphic uniformity for international relations, proposed that not only the signatory States to the previous conventions but all the powers of Europe meet at a conference to negotiate in general treaty. Great Britain was not invited because its telegraph service was at that time in the hands of private companies.

[1] The International Telecommunications Union is the specialized agency of the United Nations for telecommunications. It was set up in 1865 and has 160 Member countries. Its headquarters are in Geneva.

The Conference met in Paris on 1 March and lasted until 17 May 1865, on which day the first International Telegraph Convention was signed; it was to be the foundation of the International Telegraph Union. This memorable document was signed by the French Emperor, the Swiss Minister, and representatives from Austria (Hungary), the Grand Duchy of Baden, Bavaria, Belgium, Denmark, Greece, Hamburg, Hanover, Italy, Netherlands, Portugal, Prussia, Russia, Saxony, Spain, Sweden and Norway, Turkey, and Wurttemberg. These 20 States were the founders of the union. Mecklenburg acceded to the convention before the end of the year.

The first International Telegraph Convention

Although drawn up on a distinctly federal basis, the first International Telegraph Convention was already imbued with a spirit of universality which, in course of time, was to develop into a resolute disposition towards common action. In no other statute of an international organization of comparable scope was this intention so positively expressed.

The common provisions of the two preceding Telegraph Unions were incorporated in the new treaty which grouped into a single unit almost all of the European States. The Paris Conference recognized the Morse instrument as the international telegraph apparatus; all languages used in the contracting States were admitted for telegraphic correspondence; the acceptance of coded messages was left to the discretion of administrations but such messages had in any case to be registered; special service telegrams were also accepted, such as reply-paid and multiple address telegrams, telegrams to be delivered by express and by courier, to be handed to the addressee in person, or to be forwarded within the country, and finally semaphore telegrams. The Convention stipulated that administrations should as far as possible interconnect economic centres with heavy traffic by direct lines set up according to given standards; it placed all lines under the protection of the contracting States and regulated the fixing of terminal and transit charges. The Paris Conference decided that the provisions of the Convention should be reviewed and supplemented at periodical meetings.

The history of the Union's first 100 years, a mirror of the history of telecommunications

This historic Conference was followed in 1868 by one in Vienna which took a decision of almost equal importance for the history of international organizations. It set up a headquarters with a Secretariat. The headquarters, established in Berne as the Bureau of the Union, was under the control of the Swiss Government until 1947 and started off with a staff of three, two Swiss and a Belgian. Modest though this beginning may have been, it established the principle for the future that intergovernmental organizations need a home and servants.

• The telephone

Throughout the rest of the 19th century the Union pushed purposefully ahead, holding a succession of larger and larger conferences in the romantic setting of capitals of a Europe that has long ceased to be. It revised and redrafted the international Telegraph Regulations, sternly forbade telegrams contrary to public order or decency, tirelessly wrestled with legal and financial problems, wondered whether the widespread use of private codes might not be imposing too great a strain on ordinary telegraphists. In 1885 it also began legislating internationally for the telephone which had been launched by Alexander Graham Bell in 1876.

• Wireless telegraph

A few years later, in 1895 and 1896, the first successful wireless transmissions, crowning decades of research and experiment, brought about what is still the greatest revolution in the history of telecommunications. The invention of radio, one of the proudest conquests that science can point to, will always be associated with such names as James Maxwell, Heinrich Hertz, Oliver Lodge, Alexander Popov, Guglielmo Marconi, Lee de Forest and Edouard Branly.

At first regarded purely as a radically advanced form of telegraphy, radio spread across the international scene even more rapidly than the parent invention, for the first time bringing ships at sea within the reach of telecommunications. It became clear with equal rapidity that international regulations were needed. One major problem was highlighted as early as 1902, when Prince Henry of Prussia, returning across the Atlantic from a visit to the United States, attempted to send a courtesy message to President Theodore Roosevelt, only to have it refused because the radio equipment on the ship was of a different type and nationality from that at the shore station.

Partly as a result of this incident, the German Government called a Preliminary Radio Conference in Berlin in 1903 which prepared the way for the Berlin Radio Conference of 1906. The 1906 Conference drew up an international radiotelegraph convention and the first international Radio Regulations, incorporating the principle that ship and coastal radio stations must accept messages from each other, and adopting the SOS distress signal.

The problems of ensuring effective radio communications at sea were far from solved, as was shown dramatically in 1912 when the desperate radiotelegraph operator of the sinking "Titanic," which claimed 1,513 victims, was unable to communicate with a ship within rescue distance simply because its operator had gone off duty for the night! This led to the convening of a radiotelegraph conference in London that same year to revise the Regulations.

• Radiotelephony and broadcasting

The First World War greatly stimulated the development of radio and then in the early 1920s a new kind of radio service began — broadcasting. All this gave rise to a new problem — how to share out the radio frequencies over which transmissions travel so as to avoid the otherwise inevitable interference between stations. Since the use of radio constantly grows, it is a problem which has to go on being solved all the time, and now today, nearly 60 years and many conferences later, the international responsibility for radio frequencies remains one of the Union's heaviest and most vital jobs. The first move was made at the Washington Radio

Conference of 1927 which allocated bands of frequencies to all of the different radio services, including maritime and broadcasting.

• The International Consultative Committees

Development of modern techniques and their complicated nature was to lead during this same period to the successive creation of three International Consultative Committees to carry out technical studies and prepare international standards:

— the International Telephone Consultative Committee (CCIF, 1924);
— the International Telegraph Consultative Committee (CCIT, 1925);
— the International Radio Consultative Committee (C-CIR, 1927).

• The International Telecommunication Convention

At Madrid in 1932 the Union decided to combine both the Telegraph Convention and the Radiotelegraph Convention in a single international telecommunication convention. It also decided to change its name to the International Telecommunication Union, to cover all its new responsibilities. In fact with the advent of radio a new era of telecommunications was dawning. Television and radiodetection (radar) both made their appearance in 1930. The Second World War speeded up technical progress still more. During the war broadcasting brought the fact home to everyone that radio waves were no respecters of frontiers. It was not difficult therefore to see that much wider international agreements would have to be drawn up for radio.

Thus two ITU Conferences met in Atlantic City in 1947 with the aims of developing and modernizing the Union. Under the agreement with the United Nations, the ITU became a specialized agency and its headquarters were transferred from Berne to the traditionally international atmosphere of Geneva. Futhermore, the "International Frequency Registration Board (IFRB)" was created to manage the radio frequency spectrum.

Five years later another ITU Plenipotentiary Conference, held in Buenos Aires, completed the reorganization of the Union, and laid down the groundwork for the ultimate amalgamation of the CCIT and CCIF, telegraphy and telephony, but the International Telegraph and Telephone Consultative Committee (CCITT), had to wait until 1956 to come into being in its present form.

Back in Europe, in Geneva, the ITU Plenipotentiary Conference met in 1959 to revise the Buenos Aires Convention, and to finalize the process of integrating the ITU into the United Nations family by assimilating the Union into the Common System of service conditions, salaries, pensions, etc.

The ITU enters its second century

The Plenipotentiary Conference which was held in Montreux (Switzerland) in 1965 marked the Centenary of the Union and another milestone in its history. It took special measures with regard to technical cooperation and introduced important changes in the structure of the Union.

The advent of the space age presented the ITU with a new challenge, since man's exploration of outer space depends on telecommunications. The Member countries of the Union decided to take the necessary steps to meet these new demands. Thus as early as 1963 the first Conference on Space Communications was convened in Geneva. This was followed by the 2nd Space Conference in 1971, and in 1977 by the World Broadcasting-Satellite Radio Conference, both held also in Geneva.

Finally, the Plenipotentiaries of the Member countries of the Union met from 14 September to 26 October 1973 in Malaga-Torremolinos (Spain) to review the Convention established at Montreux in 1965. The purpose of the decisions taken was to adapt the Union's action to the spectacular developments in telecommunications that had occurred during the eight preceding years and to modify its structure and activities to meet contemporary needs: further action to develop international and national telecommunications, through preinvestment surveys and specific projects for setting up regional networks and training centres, organization of the TELECOM world telecommunication exhibitions and convening of world or regional conferences for planning the use of the radio frequency spectrum.

This led to the World Maritime Mobile Conference, Geneva, 1974; the LF/MF Broadcasting Conference for Regions 1 and 3, Geneva, 1974 (First Session) and 1975 (Second Session); the world Radio Conference on the Aeronautical Mobile (R) Service, Geneva, 1978; the World Administrative Radio Conference, Geneva, 1979, which revised the entire Radio Regulations.

• The Plenipotentiary Conference of 1982: a decisive turning point

Given the manifold responsibilities of the Union and the trend of world telecommunications network design towards service integration and digital transmission, not to mention the shocking imbalance in the availability of communication infrastructures throughout the world, the Plenipotentiary Conference of Nairobi, Kenya, convened in 1982 to revise the International Telecommunication Convention of 1973, adopted exceptional measures.

Besides preparing an impressive schedule of conferences on radiocommunication services (space, broadcasting, maritime and aeronautical mobile services) and in the field of transmission (telephony, telegraphy, data transmission), the Plenipotentiary Conference endeavoured to give the ITU Member countries — now numbering 160 — the means to redress the inequality of telecommunication development in the world.

• World Communications Year: 1983

World Communications Year marked an important new move towards the realization of the idea of universality which inspired the founders of the Union. The very fact that in December 1981 the United Nations General Assembly proclaimed 1983 "World Communications Year: development of communications infrastructures" and designated the ITU as lead agency to coordinate the Year's activities gave the Union a unique opportunity for promoting, from 1983 onwards, at world level, large-scale action not only to encourage the accelerated development of communication infrastructures but to enable Member countries to make an in-depth analysis of their communication development policies.

- **"The Missing Link," report of the Independent Commission**

As a further sign of a firmly innovative approach to telecommunications, development based on the Union's traditional activities in the regulation, standardization, coordination and planning of international telecommunications, the Nairobi Plenipotentiary Conference, besides encouraging the organization of world and regional telecommunication exhibitions under the aegis or with the assistance of the Union, decided to set up an Independent International Commission, one of whose tasks was "to recommend a range of methods including novel ones for stimulating telecommunication development in the developing world."

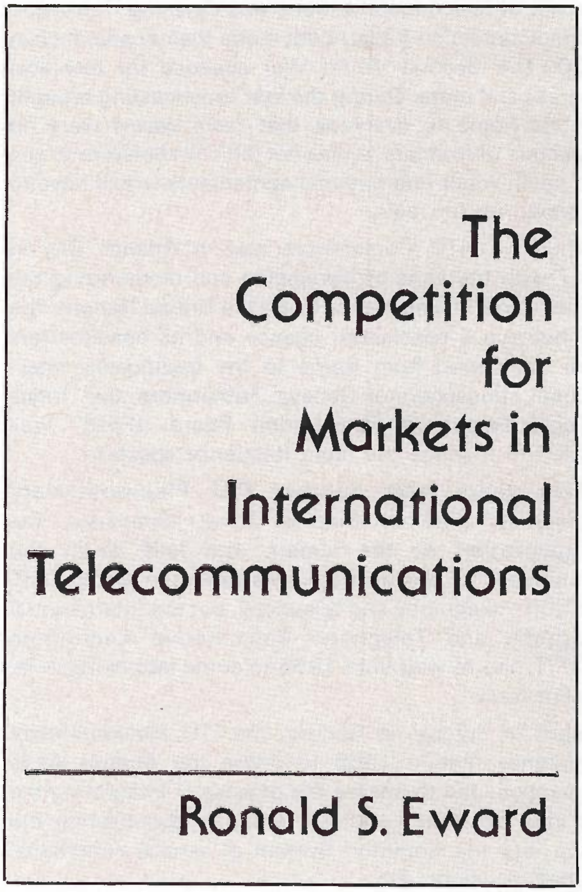
This multidisciplinary Commission of 17 representatives from every continent, all eminent men, delivered its report to the ITU Secretary-General on 22 January 1985. Entitled "The Missing Link," it offered a set of recommendations in seven fields:

— international cooperation
— choice of technology
— internal organization and management of telecommunications
— training
— research, development and local manufacture
— creation of a centre for telecommunications development
— financing of the development of telecommunications.

As soon as the report was received, a start was made to implement the Commission's recommendations to Governments, industry and the ITU. The task will certainly prove a lengthy one since, in view of the rapid development of communication techniques, it is intended to extend their benefits to mankind as a whole and reduce the present inequalities, a long and difficult task. However, as the Commission's report concludes, "if the effort is sustained, the situation worldwide could be transformed in 20 years and our objective achieved."

BOOK REVIEW

"THE COMPETITION FOR MARKETS IN INTERNATIONAL TELECOMMUNICATIONS" BY RONALD S. EWARD (PUBLISHER ARTECH HOUSE INC., 610 WASHINGTON ST., DEDHAM M.A.)



This book reports the outcome of a project funded, in part, by the U.S. Department of Commerce with the National Telecommunications and Information Administration. In short the findings of the project are concerned with the likely penetration of United States suppliers into international markets.

Seventeen (17) sovereign nations (which included Australia) are explored with the overall aim of identifying the degree of competitive access allowed to U.S. companies in the provision of telecommunications and information products and services. The book contains a comprehensive profile of each country studied, with special attention paid to organizational structures and telecommunications policies. The countries were selected on the basis of size of international traffic volume, geographic location and prominence in information activities.

The book is not a comparative analysis per se. The information contained in the Australian profile is factual with a market structure classified as a Government monopoly. It quotes the Telecommunications Act of 1975 and describes the domestic Services Structure and policies of Telecom Australia including material procurement procedures. The conclusion is drawn that the overall effect of current policies is to generally exclude US manufacturers and service provides from the Australian marketplace. However, there will be isolated pockets of market opportunity for certain firms. Any competition which does take place will be in terminal equipment and satellite digital communications.

The book could be of use to students and readers interested in studying organizational structures and overall market patterns existing for Telecommunications Services in the major countries of the World.

E. A. GEORGE
Telecommunication Society of Australia

Facts about INMARSAT

The International Maritime Satellite Organization (INMARSAT) operates a system of satellites to provide telephone, telex, data and facsimile, as well as distress and safety communications services, to the shipping and offshore industries. Headquartered in London, INMARSAT began operations on 1 February, 1982. Users of its system include oil tankers, liquid natural gas carriers, offshore drilling rigs, seismic survey ships, fishing boats, cargo and container vessels, passenger liners, ice-breakers, tugs and cable laying ships, among others. As of April, 1985, more than 3300 users were equipped with ship earth stations to access the INMARSAT system.

In order to operate its system, INMARSAT leases the MARECS A and B2 satellites from the European Space Agency, maritime communications subsystems (MCS) on several INTELSAT V satellites from the International Telecommunications Satellite Organization and capacity on a MARISAT satellite from COMSAT General of the United States. The system is currently configured as follows:

Ocean region:	Atlantic	Indian	Pacific
Operational: Location:	MARECS A 26 W	INTELSAT MCS 63 E	MARECS B2 177.5 E
Spare: Location:	INTELSAT MCS 18.5 W	INTELSAT MCS 60 E	MARISAT F3 176.5 E

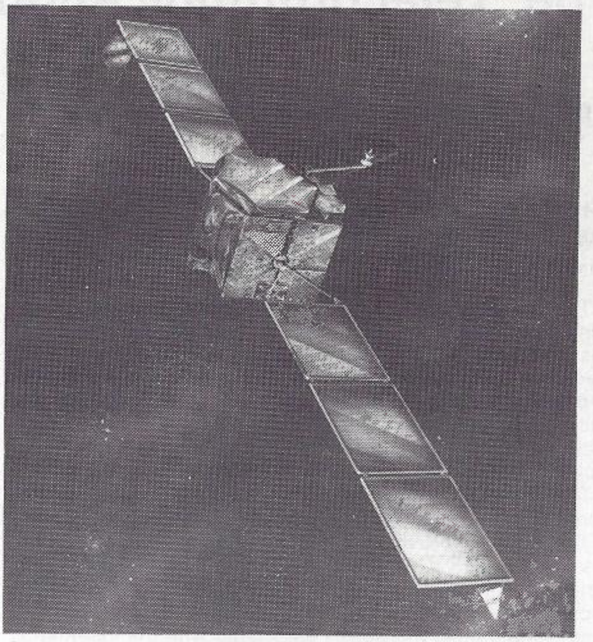
INMARSAT is now in the process of procuring a second generation of satellites (INMARSAT—2). These spacecraft, the first of which is expected to become operational in mid-1988, will have a capacity about triple that of the most powerful satellite in the present INMARSAT system.

The first INMARSAT-2 is expected to be completed by mid-April, 1988, for launch during June into its geostationary orbit over the Alantic Ocean, about 36,000 km above the equator. It should then go into operation later that year. Production of the second and third satellites will follow at four-month intervals.

The INMARSAT-2 series will be three-axis stabilised satellites, with a height of 2,557 metres, length 1.586 metres, width 1.480 metres, span of solar arrays 15.23 metres, launch mass 1160 — 1269.3 kg (depending on launch vehicle), and an in-orbit lifetime of 10 years. The communications payload, consisting of four transponders operating in C and L-band, will provide power sufficient for a minimum of 250 voice channels in the ship/shore direction and 125 channels shore/ship. However it is expected that the actual number derived will be equivalent to up to 400 two-way voice circuits.

The satellites have been designed for launch aboard either an Ariane vehicle or the Shuttle. However, INMARSAT will consider other alternatives, including Atlas Centaur, Proton, Titan and Thor-Delta, before reaching a decision.

Another component of the INMARSAT system is the coast earth stations, which provide the link between the satellites and the international telecommunications networks. Coast earth stations are generally owned and operated by the Signatories — organizations nominated by their countries to



An artist's impression of the satellite proposed for the second generation of communications satellites for the global maritime communications system operated by the Immarsat organisation.

invest in, and work with, INMARSAT — of the countries in which they are located. There are now 13 coast earth stations.

INMARSAT comprises three bodies: The Assembly is composed of representatives of all member countries, each of which has one vote. It meets once every two years to review the activities and objectives of INMARSAT and to make recommendations to the Council. The Council functions in a similiar fashion to the Board of a company. It consists of representatives of the 18 Signatories with the largest investment shares and four others elected by the Assembly on the principle of a just geographical representation and with due regard for the interests of developing countries. It meets at least three times a year and each member has a voting power equal to its investment share. It oversees the activities of the Directorate, the permanent staff of INMARSAT. Comprising about 140 people of 28 different nationalities and working under the Director General, the Directorate carries out the day-to-day tasks of INMARSAT.

The organization is financed by the Signatories of the member countries, each of which has an investment share based on its expected usage of the system. There are 43 member countries, and some of their current investment shares are as follows:

USA	30.7	France	1.6
United Kingdom	14.5	Greece	1.6
Norway	11.5	Kuwait	1.1
Japan	6.9	Spain	1.1
USSR *	6.9	Sweden	1.1
Canada	3.8	Australia	1.0
Denmark	2.4	Brazil	0.9
Singapore	2.3	India	0.9
Netherlands	2.2	Poland	0.9
Italy	1.9	Saudi Arabia	0.9
Germany, F.R.	1.6	China, P.R.	0.7

The Telecommunication Journal of Australia

ABSTRACTS: Vol. 35 No. 2

THE AUSSAT SATELLITE SERVICE — AN OVERVIEW: DOC and AUSSAT Pty. Ltd., Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 3.

The establishment of the AUSSAT satellite system has significant implications for remote area communities, the Australian communications industry, broadcasters, a wide spectrum of public and private sector users and generally the whole Australia business and financial community. The system will complement, diversify and add resillience to existing terrestial communications systems, and, in addition, provide a capability for services not currently provide.

The launch of AUSSAT-1 took place in August 1985. To mark this historical event, we have compiled this Special issue of the Journal, focusing on a number of aspects of satellite service in Australia. In compiling this issue we are especially grateful to the assistance offered and material supplied by the Department of Communications, AUSSAT Pty. Ltd., Telecom Australia and other individuals associated with the Information Transfer industry.

SATELLITE COMMUNICATIONS: J. Wilson, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 9.

This article outlines some of the history and features of satellites, explains the more commonly used terms of satellite technology and outlines Telecom's approach to the use of the Australian Domestic satellite. This article has been kept as general as possible in order to cater for non-technical as well as technical personnel.

LEGAL ASPECTS OF AUSTRALIAN DOMESTIC SATELLITE SERVICE: P. Bravender-Coyle, Telecom Journal of Aust., Vol. 35, No. 2 1985, Page 19.

In this day and age, often the legal aspect is more complicating than the technical issues. With the advent of the Domestic Satellite Service, it is essential that we have some appreciation of the legal aspects of the service. This paper deals with the legal side of a new and exciting service — the Domestic Satellite.

THE PLANNING OF OPERATIONS IN TELECOM AUSTRALIA: R. K. McKinnon, Telecom Journal of Aust., Vol. 35, No. 2 1985, Page 25.

Telecom Australia administers the public telecommunications service in Australia. It has developed a sophisticated strategy for planning and operating its network and for controlling its resources. This strategy is continually evolving so as to manage the rapid changes in the interactions between telecommunications technology, social and commercial needs. The special needs in a country with a very uneven population spread have to be particularly addressed.

ISDN — AN OVERVIEW: G. P. Kidd and P. G. Darling, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 33.

In Australia, as in many other countries, planning for the evolution of the telecommunications network towards an integrated services digital network (ISDN) has started. This paper provides a broad overview of the ISDN concept, the status of international standardisation, the reasons for moving towards ISDN, and the means by which its introduction will be achieved. Later papers in this series will examine specific aspects of ISDN in more detail.

APZ 211 02 — A NEW PROCESSOR FOR THE AXE SYSTEM: D. N. Synnott, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 41.

Telecom Australia have recently adopted the L. M. Ericsson central processor type APZ 211 as the standard for medium sized exchanges. This decision represents significant cost savings in material, floor area and power requirements.

EARLY AUTOMATIC TELEPHONY ON AUSTRALIA: J. F. Moynihan, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 45.

Although automatic telephone systems became viable in the 1890s, it was 1912 before Australia's first public automatic telephone exchange was commissioned. The reasons for this time lag are examined and the first automatic telephone exchange installation for each capital city is considered, to varying degrees. The first Perth installation is examined in detail, as it caused notable trouble in its early days of service. Emergence of the smaller Rural Automatic Exchange in the 1920s and 1930s is briefly considered.

NEW DIGITAL SWITCH STRUCTURES: C. J. Scott and E. Tirtaatmadja, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 53.

This paper examines the basic structure and characteristics of digital switchblock elements and the possible partitioning of switch functions to take full advantage of semiconductor IC technology. Known implementations of VLSI based digital switch elements are described and switching system implications identified.

DEVELOPMENT OF AN INSECT RESISTANT TELECOMMUNICATION CABLE FOR THE AUSTRALIAN ENVIRONMENT: H. J. Ruddell, Telecom Journal of Aust., Vol. 35, No. 2, 1985, Page 59.

Damage to telephone cables caused by insects has been known to occur in the Australian network for over 70 years, and has always represented a small yet significant percentage of total cable faults. All underground cable was lead sheathed prior to the introduction of polyethylene in 1956 which resulted in an increase in the incidence of insect attack. Many poisons, insecticides and repellants were investigated but none provided the degree of protection against insects required in high risk areas such as tropical Australia. Materials were therefore sought which by their toughness and other related factors would resist penetration of the insect's mandibles. Nylons 11 and 12 were found to satisfy these requirements when applied as a thin, unblemished jacket over normal cable sheaths and 16 years of practical experience in the Australian telecommunication network has proven these materials to be outstandingly successful in preventing insect damage to cable.

TELECOMMUNICATION SOCIETY OF AUSTRALIA
ADDRESS CHANGE AND APPLICATION FORM

TO STATE SECRETARY *(For local subscribers) (Mark the appropriate box)*

☐ Box 6026 GPO Sydney, NSW 2001
☐ Box 1802Q GPO Melbourne, Vic. 3001
☐ Box 1489 GPO Brisbane, Qld. 4001
☐ Box 1183 GPO Adelaide, SA 5001
☐ Box T1804, GPO Perth, WA 6001
☐ C/- Telecom Australia, Engineering Branch, Hobart Tas. 7000

OR GENERAL SECRETARY *(For Overseas Subscribers)*

Telecommunication Society of Australia,
Box 4050, GPO Melbourne, Vic. 3001. Australia.

I WISH TO ADVISE:

☐ CHANGE OF ADDRESS ☐ MEMBERSHIP APPLICATION ☐ SUBSCRIPTION APPLICATION

[ ] Telecommunications Journal of Australia ☐ Australian Telecommunication Research.

PLEASE SEND JOURNALS TO:
(Work address for Telecom employees)

NAME ....
(BLOCK LETTERS)

ADDRESS ....

....

.... POST CODE ......

Previous Journals were sent to:

ADDRESS ....

....

.... POST CODE ....

REMITTANCE $........ENCLOSED PHONE .....
(Rates are as shown on back of this page)

Signature ....Date........

TELECOMMUNICATION SOCIETY OF AUSTRALIA
Authority — Deduction From Salary
(TO BE FORWARDED THROUGH SOCIETY STATE SECRETARY)

TELECOM AUSTRALIA

I hereby authorise the Australian Telecommunication Commission, its duly authorised servants and agents to deduct .... each fortnight from my salary/way, to be paid to the Telecommunication Society of Australia.
The amount to be deducted may be varied from time to time by the Society in accordance with revised rates of contribution.
All payments made on my behalf in accordance with this Authority shall be deemed to be payments by me personally.
This Authority shall remain in force until revoked by the Telecommunication Society of Australia or cancelled by myself in writing.
In consideration of this deduction being made, I indemnify the abovementioned employer and employees thereof against any failure to make deductions and remittances as authorised herein. Dated this .... day of .... 19 ......

☐ Temporary Signature .... Designation .... Branch ......

☐ Permanent Commission Address ....

Pay sheet Number or Staff Clerk Code .... Work Telephone ....

PLEASE USE BLOCK LETTERS

A.G.S. No.	Surname	Given Name	Commission Code
			TSOA 685

This Portion Must be Completed By The Society	Old Basic Rate	New Basic Rate	Certified by Society
	$	$	

DETAILS BELOW FOR INSERTION BY TELECOM AUSTRALIA

Permanent Variation		Remarks	Team No.	Paysheet No.
Increase	Decrease			

Computed by .... Processed for

Checked by .... period ending ..../......./.......

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

POLICY. The Journal is issued three times a year (March, July and November) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, information transfer, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal reports on the latest developments, both technical and commercial, in telephony, radio and TV and is distributed to professional engineers, executives and technical staff engaged in the planning, marketing, installation and operation of telecommunication services in Australia and overseas, also to manufacturers in this field, government departments, universities and consultants.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

Editors of other publications are welcome to use not more than one-third of any article, providing credit is given at the beginning or end, thus, "Reprinted from the Telecommunication Journal of Australia". Permission to reprint larger extracts or complete articles will normally be granted on application to the General Secretary.

Contribution of papers are encouraged. Information on how to prepare contributions for the Journal is available from members of the Board of Editors. Communication to the Editors should be addressed to Editor-in-Chief, TJA, Box 4050 GPO Melbourne, Victoria, Australia 3001. (Phone (03) 606 7644 or (03) 67 5622).

SUBSCRIPTION AND MEMBERSHIP RATES 1985.

Enquiries

Any enquiries, changes or applications may be directed to the State or General Secretaries on the Address Change and Application form overleaf.

Membership Rates — $9.00 p.a.

Residents of Australia may join as members using the Application Form directed to their State Secretary. Others should apply to the General Secretary. Cheques should be made payable to the "Telecommunication Society of Australia". A member is entitled to copies of the Journal.

Subscription Rates — $15.00 p.a. Australia, $22.00 Overseas

These rates apply to organisation and overseas applications. A subscriber is a non-member who is entitled to secure copies of the Journal. Cheques should be made payable to the "Telecommunication Society of Australia".

Postal Charges

Journals are sent post free by surface mail to members and subscribers in Australia.

Additional Copies

These may be purchased by members for $6.00 per copy, non-members for $8.00 per copy and overseas applicants for $12.00 per copy.

Addresses of The General Secretary or Editor-in-Chief,
Telecommunication Society of Australia,
Box 4050, G.P.O., Melbourne, Victoria, Australia 3001.

ADVERTISING: The total net advertising revenue is paid to the Telecommunication Society of Australia, whose policy is to use such funds in the dispersion of knowledge within the telecommunication industry.

Advertising Manager: Mr M. Chin, Box 4050 GPO, Melbourne, Victoria 3001, Australia.

Advertising Contractor: ADTEL — Contact B.H. Worrell. Tel. (03) 772 9398. Address: 81 Lochiel Avenue, Edithvale, Victoria 3196.
Rate Cards giving full details of specifications and charges are available from ADTEL.

CIRCULATION. Average circulation during year ending December 1982:

Within Australia:	6462
To Overseas Countries:	461 (60 Countries)
Total Readership (estimated by survey)	10,548

Printed by Standard Commercial Printers, 2 Railway Rd., Cheltenham, 3192.

Sleep easy
with GEC remote control and monitoring.

Remote monitoring and control is made easy and cheap with the SRC 4 Narrowband Telemetry System.

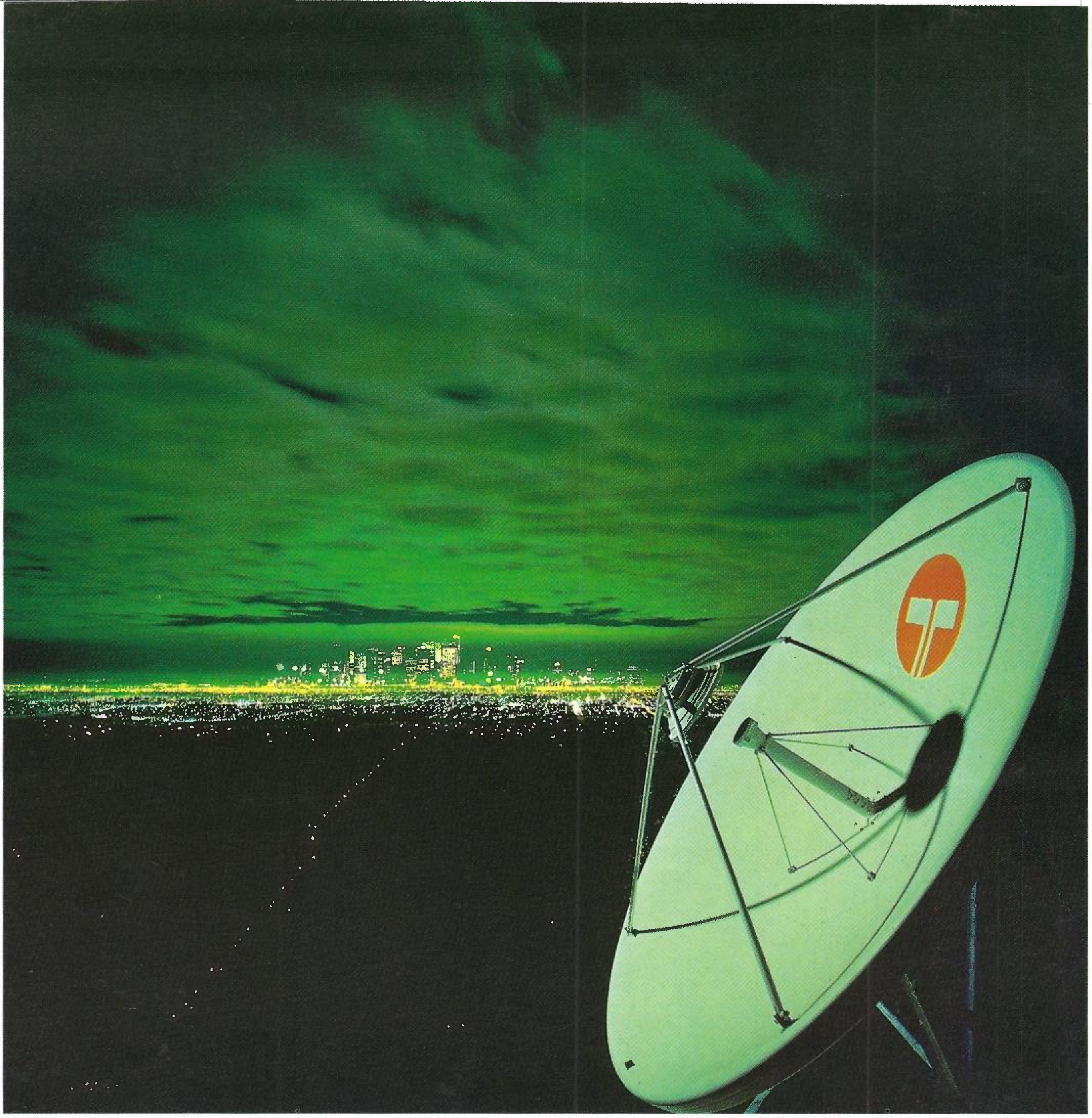
- Up to 25 independent systems on two wires.
- Expandable, flexible, easily changed.
- Many options and facilities.
- Small number of cards.
- Quick installation.

Digital and analogue signal transmission facilities;
Approved for connection to Telecom Australia lines;
Various types of transmission plan;
Computer interface and software.

GEC Marconi
Telecommunications Division
5 Slough Avenue
Silverwater, NSW 2141

A Division of GEC Australia Limited

Telephone: (02) 647 2455 Telex: AA20973



Customised communications: anywhere in Australia, from Telecom Iterra.

For remote area operations or for a metropolitan business application, Iterra satellite services are backed by Telecom's nationwide expertise and resources.

Telecom Iterra provides a range of communication and ancillary services; from consultation and analysis of your needs, to installation, network integration and maintenance.

Iterra services include telephone, text and data transmission – and Telecom's ability to integrate satellite and a wide range of terrestrial services is unique.

Phone 008 033 058 (for the cost of a local call) for details on how Telecom Iterra can provide your business with customised communications.

You'll soon see why Iterra means more than just satellite technology.

Telecom
ITERRA
Services

Telecom Australia
Better for Business

TAT 1098