Volume 33, No. 3, 1983

the telecommunication journal of Australia

WORLD
COMMUNICATIONS
YEAR 1983

33/3

FEATURED IN THIS ISSUE:

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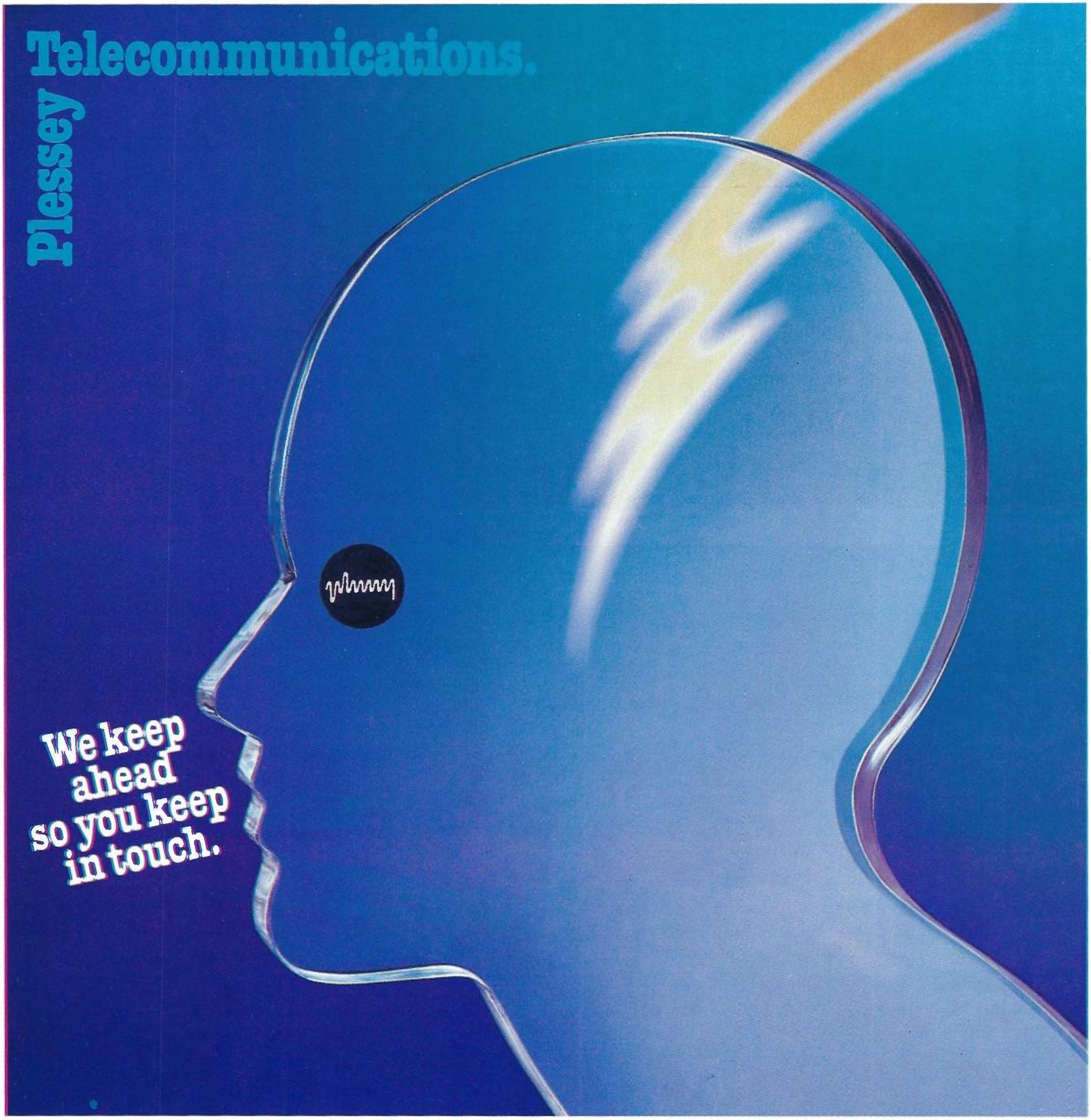
- OPTICAL FIBRE PLANNING
- PCM LOOP SIGNALLING EQUIPMENT
- TRAFFIC MEASUREMENT
- TRANSMISSION PATH IDENTIFICATION



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THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486

Volume 33 No. 3 1983

Cover:
The F-18A introduced into RAAF service will carry a range of CE technologies.

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OTHER ITEMS

Editorial

Guest Editor
Keith J. Simpson
General Manager Engineering
Telecom Australia

On the eve of my retirement from a career in telecommunications spanning 45 years, 33 of them as an engineer, it seems to be a time to reflect on the technology and the people, past and future.

The continually changing world of telecommunications has created its own excitement, challenges and opportunities. Let us recognise that much of what we now take for granted, represented major change and technological development for the people of the day. The change from manual to automatic telephony, and the construction of the Sydney/Melbourne coaxial cable, for example, were just as great a change and just as exciting as the change to computerisation of today.

The job in the past has been well done. The network has been well built. When I began in 1938, many metropolitan services were still manual; automatic service in the country was virtually unknown; the telegraph system used a then modern technology called the Murray multiplex system; and the first 2000 type step-by-step exchanges were installed.

The Community Telephone Plan of 1960 provided a major change of direction. During the 1960s, the crossbar switching system was introduced, and the automatic trunk network using broadband radio and coaxial bearers, spread across Australia. Closed numbering areas, national numbers and zone and district charging were developed and the STD service expanded rapidly throughout the automatic network. As well, automatic telex came into being and the data transmission became an important new element in telecommunications.

Today we have begun changing the network to digital working. We have SPC switching systems for telephony, telex and data, digital data services on the analogue transmission network, digital transmission over existing cables, digital radio systems, optical fibres and many new and sophisticated forms of equipment for the customers, as well as many computerised support systems.

The next decade will see the completion of the national digital network, the convergence of telecommunications and computer technology and services and the Integrated Services Digital Network. There will be long distance optical fibre links, service to the most remote areas, video and graphics services and the marriage of terrestrial and satellite techniques.

The advances in technology have created many opportunities, but let us not forget that it could not have happened, nor would it continue to happen without the people of various skills and qualifications and dedication that is needed. These people are in the development, manufacturing and servicing industries as well as the operating authorities. More attention is now needed to advance the technology in balance with the people skills. We must not force the technology at any price or delay it because it represents change, or in self interest.

The objective is to service the community and we must recognise that the technological infrastructure, whilst so very important, only provides the means by which the Australian community can communicate within itself and with other communities of the world.

I do not need to remind you of the value of the communications between people, but therein lies the secret of finding a balanced approach to the expansion of new technology and to achieving a unified approach by all to the advancement of Telecommunications. I have every confidence that the balance will be found.

I wish the Telecommunication Society of Australia and its Journal every success in the future and recognise the part it plays in providing communication amongst the people of telecommunications.

Communications-Electronics in the RAAF

R.J. NOBLE WGCDR

The use of telecommunications and the broader field of communications-electronics for operations, command and control in the Royal Australian Air Force, is described.

INTRODUCTION

The historical term 'Telecommunications' in RAAF and general military usage has come to mean much more than the use of electronic means of communication. In recent years the term 'Communications-Electronics' has been coined to describe the broader field, involving computing, sensors, and control systems in addition to communications.

Modern Air Forces rely on an extensive communications-electronics (CE) base for responsive communications, navigation, weapons support and command and control of air operations. The RAAF is no exception. From fledgeling beginnings in the 1930s and through the maturing experiences of the Second World War, Korea and Vietnam, the present RAAF CE infrastructure has emerged as a capable, responsive and flexible operational support arm — an infrastructure vital to the effective and efficient employment of military air-power, and for providing assistance to distressed communities.

RAAF CE activities and capabilities are broad in scope, ranging from airborne communications, navigation and weapon control systems, through air traffic control, air defence, strategic and tactical CE systems to computer systems and an embryonic automated command and control network. This article presents, in a necessarily brief manner, an overview of RAAF CE capabilities in these areas.

AIRBORNE SYSTEMS

RAAF aircraft, **(Fig. 1, 2 and 3)** depending on their role, can be required to carry a plethora of electronic systems. These are used for communications, navigation, identification, computation, weapons control and surveillance.

Fig. 1 — Introduction of the F-18A into RAAF service will bring with it a wide range of new CE technolgies, including Fly-by-wire controls and computerised radar, navigation and weapons delivery systems.

A fundamental requirement in all aircraft is for communications, both air-to-ground and air-to-air. The Air Force operates in the following frequency bands:

- HF — used for long distance communications to both civil and military authorities;
- VHF — used for air traffic control when operating with civil authorities and for tactical communications with the Army on the ground;
- UHF — used for military airspace control and air-to-air communications.

Technological developments in airborne communications has prompted the introduction of

Fig. 2 — The F111C has sophisticated avionics, radar and weapons delivery systems enabling low level penetration to target areas.

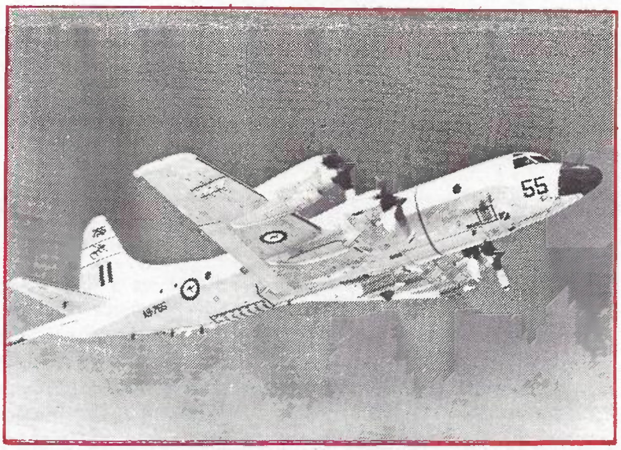

Fig. 3 — The P3C Orion is one of the most advanced maritime patrol aircraft in the world. Centrallized and automated data processing, coupled with advanced technology communications, sensor and avionics systems enable this aircraft to carry out effectively the most demanding of anti-submarine warfare (ASW) and surveillance missions.

multiband and multimode equipments capable of operating in both the VHF and UHF bands and in the AM and FM modes appropriate to these bands.

Equipments used for navigation fall into two groups, those relying on ground stations for navigational information and those able to provide navigational information independent of any ground station signals. Of the first group, the RAAF has:

- automatic direction finders (ADFs), using ground based non-directional beacons (NDBs) to provide bearing information;
- VHF omni-range (VOR) equipments and distance measuring equipment (DME) to provide bearing and range respectively;
- TACAN — a military version of the above systems which provides both bearing and range information; and
- Loran-Omega equipments which provide positional information using the signals transmitted from a number of ground stations.

Of the self-contained systems, there are only two equipment types used by the RAAF. These are the Doppler radar systems which provide groundspeed and drift information along the aircraft track, deriving this information from the echoes of (usually) four beams transmitted from the aircraft, and the inertial navigation systems which provide latitude and longitude data using accelerometers mounted on a stable gyro platform. Future developments include the introduction later this decade of the NAVSTAR global positioning system (GPS). The GPS provides very accurate and stable three dimensional positioning information using a constellation of NAVSTAR satellites.

Most fixed wing aircraft use some form of radar. The RAAF uses airborne radars for:

- search, and ground mapping;
- terrain avoidance;
- weather display;
- weapons control;
- altitude measurement; and
- navigation.

The advent of improved radar antennae and embedded micro-computers will see an increasing amount of radar-derived data available to the aircrew. From the radar display, aircrews will be assisted in deciding the highest threat from a number of targets and they will be advised via the head up display on the most appropriate action to take.

One form of radar not previously mentioned is used for 'identification friend or foe' (IFF). Originally developed for military use in World War II, this has evolved into a secondary radar system and is carried on some civil and most Service aircraft to positively identify aircraft to ground-based interrogators. The airborne system responds with a coded reply when interrogated by a secondary surveillance radar, the radiated beam of which is co-axial with the beam of a parent air defence or air traffic control surveillance radar.

As a means of increasing an aircraft's survivability in a hostile electronic environment, many Service aircraft carry equipment used to jam, deceive or to 'warn of' an enemy's electronic emissions. These systems are included in the increasingly important category of electronic warfare (EW) equipment.

There is a trend with newer generation aircraft to digitise and computerise the telecommunication equipment and provide the aircrew with the absolute minimum of information which is required. The cockpit of the F-18A is an example of the simplification that has taken place with the use of TV displays to show data appropriate to the various missions. (See also **Fig. 4**) To cope with the increasing amount of data required as input to, or provided as output from, the different aircraft systems, fibre optics and new multiplexing techniques will be introduced.

AIR TRAFFIC CONTROL

Safe and efficient air traffic control (ATC) is totally dependent on reliable communications. These communications include:

- air/ground/air (A/G/A) between controllers and aircrew where the controller can be acting in an advisory role for enroute or overflying aircraft, or in a control situation when an aircraft is arriving or departing;
- on-base call/answer and hotline intercom systems for direct liaison between local authorities, for example between an approach radar controller and a tower (local controller) or between the operations and ATC personnel;
- off-base selective call (SELCAL) call/answer and hotline intercom systems for liaison between base ATC personnel and off-base authorities, for example — the D of A control centres;
- and the telephone system.

RONALD NOBLE enlisted in the RAAF as a Radio Apprentice in 1955. He graduated from the Royal Melbourne Technical College in 1959 with a Fellowship Diploma in Communications Engineering. Since then he has held a broad range of squadron and staff appointments associated mostly with aircraft and avionic engineering. He attended the RAAF Staff College in 1974. Presently he holds an appointment in the Directorate of Communications and Electronics within the Air Force Office of the Department of Defence, Canberra. Here, he is responsible for determining and staffing RAAF operational requirements for communications and electronics systems in respect of avionics, electronic warfare, air traffic control and air defence. WGCDR Noble is a Senior Member of the Institute of Radio and Electronics Engineers Australia.

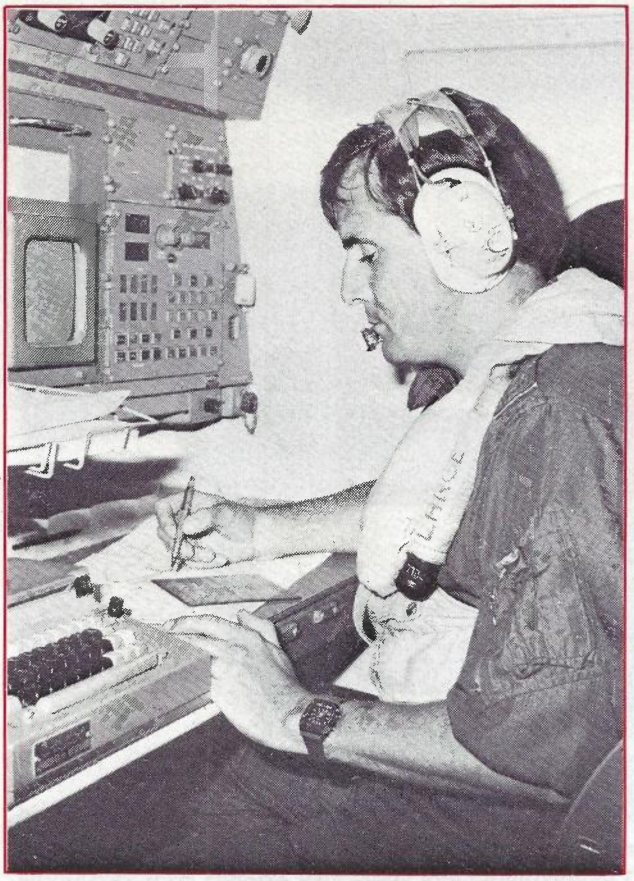

Fig. 4 — Partial view of the Navigator/radio operator position in a P3C maritime patrol aircraft. The operator is able to perform off-line electronic message preparation and editing before transmission.

Hotline intercom systems provide direct controller to controller voice communications for the transfer of high priority flight information. The call/answer systems provide controller-to-controller voice communications for the transfer of lower priority flight data, the call/answer circuits usually have multiple terminations whereas the hotline circuit is usually a single termination system.

A/G/A communications are conducted in the military UHF and civil VHF bands. Separate UHF and VHF transmitters and receivers are installed at each airfield for ATC use. Each UHF or VHF channel is supported by main and standby equipment and each band is covered by an emergency transceiver which is battery powered in the event of a total mains or generator power failure.

RAAF ATC is supported by terminal radar and precision approach radar (PAR) facilities. The RAAF currently has five terminal radar facilities with a sixth to be installed in 1984. At some locations, terminal radar support is provided by D of A. PAR facilities are provided at eight RAAF bases, five of which are new equipments which enable multiple aircraft (simultaneous) approaches; the three older equipments still in service will only support single aircraft approaches. The radar controller positions are all provided with duplicated A/G/A communications facilities.

Navigation aids (NAVAIDS) also play an important part in ATC. The RAAF's main airfield NAVAIDS are TACAN and NDBs.

Information on local airfield conditions, for example, wind speed and direction, general weather picture and runway(s) in use, is broadcast on an automatic terminal information service (ATIS). This information is regularly updated and is broadcast on a discreet UHF frequency.

Future developments in RAAF ATC will probably include the following:

- Automation of terminal radar data processing and display systems. Automation will increase the reliance on secondary surveillance radar (S-SR).
- Digital target data extraction equipment to be fitted to the terminal radars.
- New generation automated remote control and monitoring systems.
- The replacement of existing UHF and VHF A/G/A communication facilities is planned. It is hoped that the installation of an automated control system with each facility, coupled with high mean time between failure (MTBF) figures, will eliminate the expensive requirement for 100% duplication of each communications channel.

AIR DEFENCE

The monitoring, control and defence of national airspace today require the complex interaction of information (visual, aural and radar observations) and weapons systems (fighter aircraft and missiles) under expert control. The effective operational management of such a system is heavily dependent on speedy, reliable communications. A typical air defence system comprises a number of remotely located sensors (including ATC radars **(Fig 5)** as well as dedicated air defence radars) feeding information into a sector air defence operations centre (SADOC) which in turn controls available weapons systems.

Voice communications are still extensively used between elements of the air defence organisation — between ground controllers and pilots (in a similar manner to air traffic control), and between the SADOC and other weapons controllers. The SADOC is equipped with inter-communications and a number of remotely controlled VHF and UHF radios. Unlike air traffic control installations where fixed frequency radios are used, air defence controllers are able to select any available frequency. Air defence radio installations do not feature the same degree of duplication as air traffic control systems. Rather, their reliability is inherent in the availability of a number of controllers, each with separate radio facilities.

Until recently, radar target information was transmitted either by voice telling or by direct analogue transmission of the video by microwave link. However, modern air defence radars employ digital plot extraction techniques to enhance the quality of targets, eliminate unwanted return signals, and simultaneously display information concerning target height, speed and classification. This information is generated, stored and distributed under computer control throughout the SADOC, and may also be distributed to other air defence agencies.

Apart from improving the quality of displayed radar data, digital plot extraction means that radar data can now be transmitted over long distances using standard narrow band bearers using appropriate MODEMs.

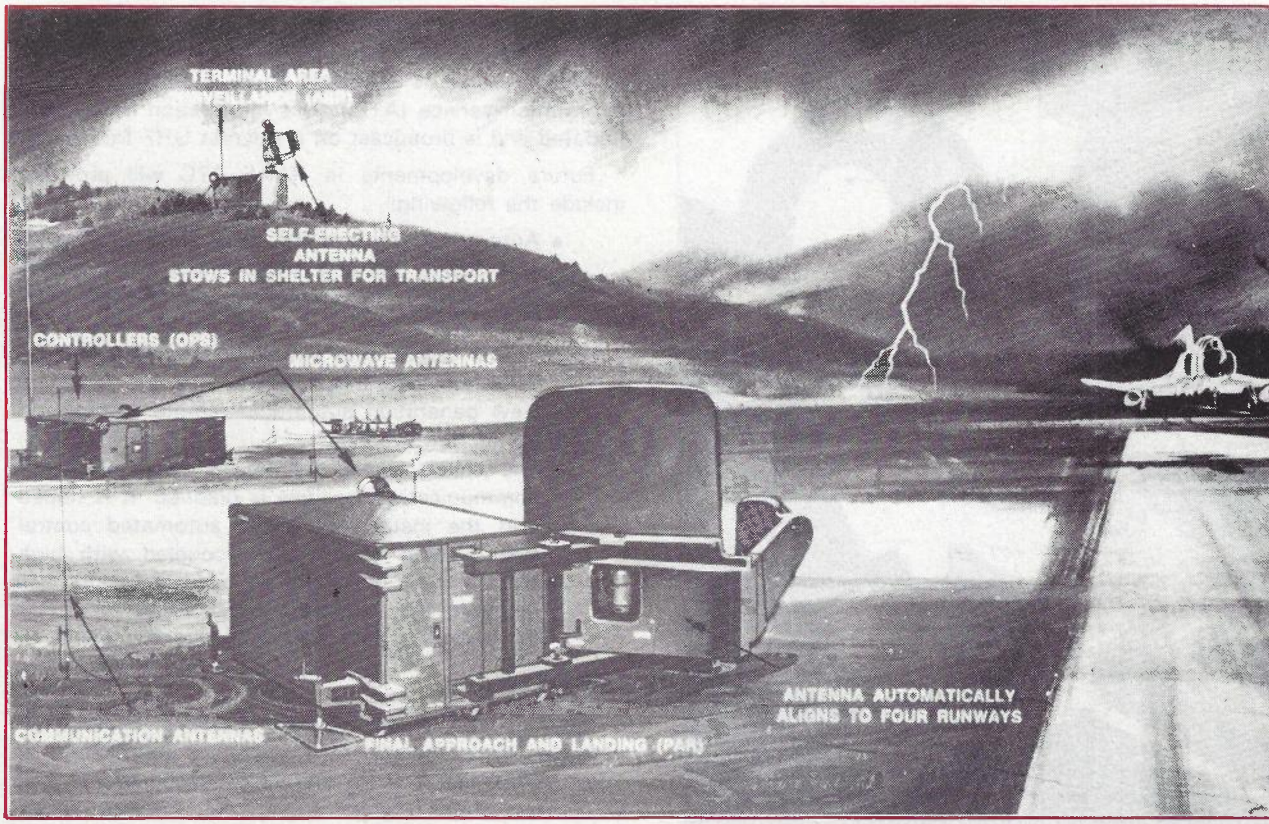

Fig. 5 — Artist's impression of a mobile ATC radar and communications system. The RAAF recently purchased a radar system of this type. It will be used to support aircraft deployments and could also support ATC operations during civil emergencies. The system is transportable by Hercules (C130) aircraft.

Combinations of landlines, HF, VHF, UHF and tropospheric scatter radio systems are generally used to transmit radar and associated command and control data. The transition to digital data transfer is also occurring on circuits to other agencies such as air traffic control, meteorology and logistic support depots. As fighter aircraft and other weapons systems develop, making even more use of on-board computers, communications between the SADOC and aircraft may also change. Direct computer-to-computer data links will become feasible, reducing the work-load on pilots, and allowing them to concentrate on other higher priority tasks.
tasks.

Proposed future developments in the air defence scene promise to considerably enhance Australia's ability to monitor and control her sovereign airspace. Proposed acquisition of additional sensors, such as the JINDALEE over the horizon radar (OTHR) airborne early warning radar aircraft and possibly aerostat (balloon) borne radars are cases in point. Such new sensor systems will necessitate expansion and upgrading of communications systems to carry the increased volume of air defence radar and associated command and control data.
data.

MOBILE COMMUNICATIONS

The RAAF maintains a rapid deployment capability whereby tactical communications, navigation aids and other electronic systems can be deployed within Australia and nearby regions to meet a variety of military and civil continencies. (See **Fig. 6**).

Land Mobile Communications

Most RAAF Bases have been provided with a low power HF/SSB base station, complemented by mobile transceivers to provide HF communications coverage within 330kms around each base.

These facilities are intended primarily for use in land search and rescue operations, and also in providing assistance during contingencies such as floods, bush fires and the like. Furthermore, these facilities interface with other agencies such as the police and the State Emergency Services in respective States.

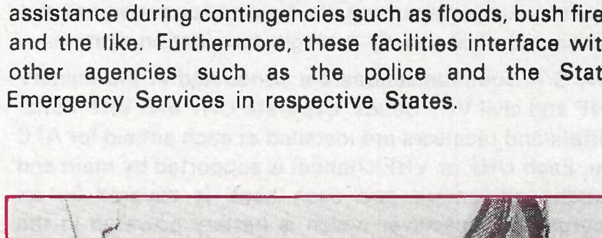

Fig. 6 — View of RAAF's new tactical air defence radar in operation during exercise Kangaroo '81. A tactical communications facility is in the background.

Air Mobile Communications

Long range air mobile communications with military aircraft and RAAF marine craft are provided by the RAAF's air operations communication system (AOCS) which is a high frequency voice and teletype radio network covering the Australian continental and maritime regions.

The AOCS consists of four air operations communication centres (AOCCs) located at Sydney, Darwin, Perth and Townsville. The AOCS provides:

- a general purpose net (GPN) on which all AOCCs monitor the same three frequencies. The GPN is also used for emergency contact by military agencies;
- special nets as required by any or all AOCCs following initial GPN contact;
- a telephone patch facility between aircraft and ground based personnel;
- continuous monitoring of the military HF distress frequency.

Command and control of the AOCS is achieved by dedicated inter-AOCC communications links from the master station at Sydney.

The Royal New Zealand Air Force (RNZAF) operates a similar communication system for their aircraft. With the imminent installation of an HF inter-AOCS communications link between Australia and New Zealand, mutually supporting operations will be achieved. This will lead to improved reliability and effectiveness of both HF ground-to-air communication systems.

BASE COMMUNICATION SERVICES

A number of UHF-AM communication networks have been provided at each RAAF base. Separate networks provide the communication needs for base security, maintenance operations, vehicle control and administrative co-ordination purposes, including fire fighting activities.

Complementing these networks, a pocket pager system operates, wherever this TELECOM service is available, to enable key personnel to be readily accessible.

TACTICAL COMMUNICATIONS

All of the ground based communications services just described play a part in the command and control of RAAF resources. However, virtually all are fixed installations at permanent bases or sites. In contrast, single-service and joint-service operations often require deployment of aircraft and support logistics to temporary or bare bases. In these cases, appropriate communications services must also be provided. As well as the usual air traffic control and base communications, many command and control links between deployed single-Service and Joint Force Headquarters, outlying landing zones and airfields, and various operations centres are required. In addition, rear links to the permanent headquarters must be installed. Whereas mobile air defence elements are largely self-contained regarding communications capabilities, the other RAAF deployable communications requirements are satisfied from a common pool. For this purpose, the RAAF has established its Air Transportable Telecommunications Unit (ATTU), with an extensive communications inventory. (See **Fig. 7**).

Fig. 7 — RAAF technical and operative personnel of ATTU checking out the communications equipment in a mobile air support facility which has been installed in a converted armoured personnel carrier.

Low, medium and high powered radios, antennae of various sizes aircraft navigational aids, teleprinters and switchboards, intercoms, vehicles, generators and air conditioners are operated and maintained by the Unit. Many of the items are mounted in specialised cabin-like shelters, and all are capable of air transport. Combinations of landline systems, HF/SSB, VHF (AM and FM) and UHF radios are required, in considerable numbers, to satisfy the various applications and radio path lengths with the necessary reliability. Similarly, various voice, teleprinter and facsimile terminal equipments are required to interface with the other Service tactical networks, the Defence fixed networks and the Australian telephone system. ATTU therefore has a wide variety of equipment with a quick reaction, and self-supporting, capability. The unit can deploy detachments swiftly to support military operations, provide interim facilities during airfield installations or in the event of major failures of fixed facilities, or in emergencies or natural disasters such as cyclones, floods or bushfires.

FIXED COMMUNICATIONS

The RAAF, in conjunction with Army and Navy, operates a considerable part of the Australia-wide integrated Defence Communications Network. (Ref. 1). Computer controlled switching centres, operating in the store and forward mode, automatically route low speed telegraph message traffic between the communications centres on Bases. (**Fig. 8**).

The RAAF's investments in fixed communications is very considerable both in terms of money and people. Some 700 personnel, both operator and technical, are required to keep the RAAF elements of the network operational around the clock.

To ensure survivability, the network is inter-connected by a combination of HF radios, microwave line-of-sight and landline bearers. For economic reasons, the HF radio equipment used for both point-to-point services and the AOCS are co-located at the same sites.

The facilities used in the fixed network will be upgraded by the DISCON project (Ref. 2) in the latter half of this decade.

Fig. 8 — View of section of RAAF first generation automated message switching centre.

TACTICAL ELECTRONIC SERVICES

A small but very important section of ATTU is responsible for communications security (COMSEC) monitoring. The role of this COMSEC sub-unit is to selectively monitor, analyse and report on the general state of discipline and security of friendly communications. The sub-unit therefore acts as a watchdog and provides a form of quality control on friendly transmissions. Any breach of security which is detected is reported immediately to the Force Commander for his action.

To meet the COMSEC monitoring task, ATTU is equipped with a transportable cabin fitted with appropriate receivers and recorders. Improvement of this capability is an ongoing matter.

A modern tactical air traffic control radar system has recently been added to the RAAF's tactical deployment capability. This now enables the RAAF to operate effectively from bare airfields as well as providing an interim capability at permanent airfields should their existing facilities be damaged.

COMPUTER SYSTEMS

The RAAF's administrative computing system is large and is supported by UNIVAC mainframe computers in Defence Central. Minicomputers are being installed at the larger bases to automate maintenance management and the distribution and control of stores and equipment.

A personnel management computer is presently in use and tenders will soon be let for the purchase of a computing system to automate the investigation of aircraft and personnel accidents. Furthermore, a pilot project that will automate many of the mundane repetitive tasks at RAAF bases is presently being developed. Operational requirements for an automated system to co-ordinate the management, deployment and operation of our aircraft resources will soon be raised.

The RAAF will soon have many computing assets, including some tactical systems (these are presently maintenance management oriented), which may be deployed to forward bases.

Computing assets will need to be closely managed to ensure continued RAAF operations if and when the computers fail. Part of this management is to ensure that a parallel manual expertise is maintained, while another part concerns configuration management — the RAAF has thus implemented software configuration management procedures to enforce the integrity of software.

AUTOMATED COMMAND AND CONTROL

All the foregoing systems form part of an overall air defence **Command** and **Control** (C^2) structure providing masses of data for a force commander in operational control to assimilate and co-ordinate. The force commander will vary from situation to situation. He could be an RAAF member controlling only Air Force elements, he could be a member from any Service having joint operational control of elements from two or more Services, or he could be the Chief of Defence Force Staff (CDFS) directing, in the strategic sense, operation of all Australia's defence assets.

All this requires an efficient and effective automated C^2 system which is 'interoperable' between single Services and Defence Central and we must also anticipate the need for interoperability with our allies. The C^2 system must be configured so that operational commanders are presented 'filtered' information which is pertinent to their level of command. Such a system is presently in its infancy and is being developed in parallel with, firstly, the new sophisticated, largely digitized, weapons systems which are now entering service, secondly, DISCON and, thirdly, our large administrative computing assets.

Australia has been tardy in introducing such a C^2 system. However, this tardiness has allowed Australian observation of the successes and pit-falls of other C^2 systems. To coin a phrase, Australia's and consequently the RAAF's automated C^2 system will result from a 'top down' design approach with interoperability being the key parameter.

SUMMARY

The RAAF has long been involved in broad, 'State of the Art' communications-electronic systems for operational and national purposes. Integration and interoperability with Australian and Allied forces has led to the common use of procedures and equipment, some of which have later found use in a civil environment. The impact of computing on the RAAF began in 1960 (one of the first users in Australia) and has spread into every facet of operational and administrative functions. There is every prospect that the spreading use of C-E systems involving 'State of the Art' technology to meet Defence and RAAF requirements for communications-electronic systems will continue into the foreseeable future.

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This ends the series on Communications — Electronics in the Australian Defence Forces — Editor.

Planning the use of Optical Fibre in the Australian Telecommunication Network

John Burton
Alan Dubberley

In the past few years, important changes have occured in the application of fibre optics in transmission systems. This paper reviews the progress which has been made by Telecom in the use of optical fibres.

INTRODUCTION

In the past five years, important changes have occurred in the application of fibre optics to the provision of telecommunication transmission systems. Great improvements have been made in this technology in areas including fibre transmission losses, optical sources, and in detector sensitivities.

The point has now been reached where the cost effectiveness of optical fibres is growing in a number of telecommunication applications compared to traditional transmission techniques such as copper pair cable and coaxial cable.

One of the most remarkable features of this technology is the rapidity of its penetration into the transmission marketplace. In 1977 the first prototype optical fibre links were installed by the Bell System of the USA to carry live telephone traffic. Today fibres are in the mass production stage and telephone administrations around the world including Telecom are using or are planning to use optical fibres as a standard transmission network element. A primary factor which has influenced the use of optical fibre is the declining prices of fibre and cable compared to other traditional transmission techniques.

This paper outlines the progress which has been made by Telecom in the use of optical fibres in the urban transmission network and some future plans for the cost effective application of this technology in other parts of the network.

BACKGROUND

The current telecommunication network is based upon analogue switching coupled with analogue transmission systems and it is relatively modern by international standards.

However, the cost effectiveness of digital systems and the convergence of digital switching and transmission technologies in the world telecommunication marketplace is leading towards the evolution of a purely digital network.

A major step in this evolution in Australia is the decision by Telecom to establish an Integrated Digital Network (IDN) on a national basis. This step will build upon earlier decisions to use digital transmission and switching. One of the important features of the planning towards the implementation of a National IDN is to provide the digital network as a separate overlay on the existing analogue network. The objective is to use digital equipment to cater for normal telephone traffic growth and for the replacement of obsolete equipment. Digital transmission equipment will be provided to fully interconnect digital terminal exchanges where possible. Therefore, there will be a rapid growth of digital equipment as a percentage of telephony network equipment. Before the year 2000, the IDN will tend to dominate the telephony network and will provide the basis for the possible evolvement towards an Integrated Services Digital Network (ISDN).

Fig. 1 shows a possible development plan for the establishment of digital exchanges to 1990 which would enable this approach to be realised. In general, introduction will commence this year with the provision of terminal exchanges and local transit digital networking in capital cities.

By 1987 most major cities will be connected to this national IDN and by 1990 IDN facilities will have been progressively introduced into smaller cities and country areas. As far as possible, digital transmission facilities will be co-ordinated with the provision of digital switching; a rapid growth in the amount of digital transmission in the network is therefore expected.

DIGITAL TRANSMISSION NETWORK ELEMENTS

There are a number of techniques available to provide digital transmission in the junction network. The major techniques used in urban areas are illustrated in **Fig. 2**.

Some features emerging from **Fig. 2** are:

- Low capacity 2 Mbit/s digital line systems make use of Telecom's large investment in junction cables; especially for the shorter, small to medium capacity routes. Repeaters are required every 1 to 2 km.
- On medium growth routes where spare tubes in coaxial cables are available, 140 Mbit/s digital line systems will be used. Repeaters are spaced each 4.5 km.
- On high growth routes, optical fibre may be competitive with 2 Mbit/s digital line systems. Multimode fibre systems, generally operating at 140 Mbit/s, are being installed in urban centres and they are particularly attractive on routes which already carry a large number of 2 Mbit/s systems or where duct space is scarce. Power feeding is not necessary as the repeaters are rack mounted in exchanges.
- For longer junction routes which have a low to medium capacity requirement, digital radio systems (DRS) can be an economic alternative. Although available

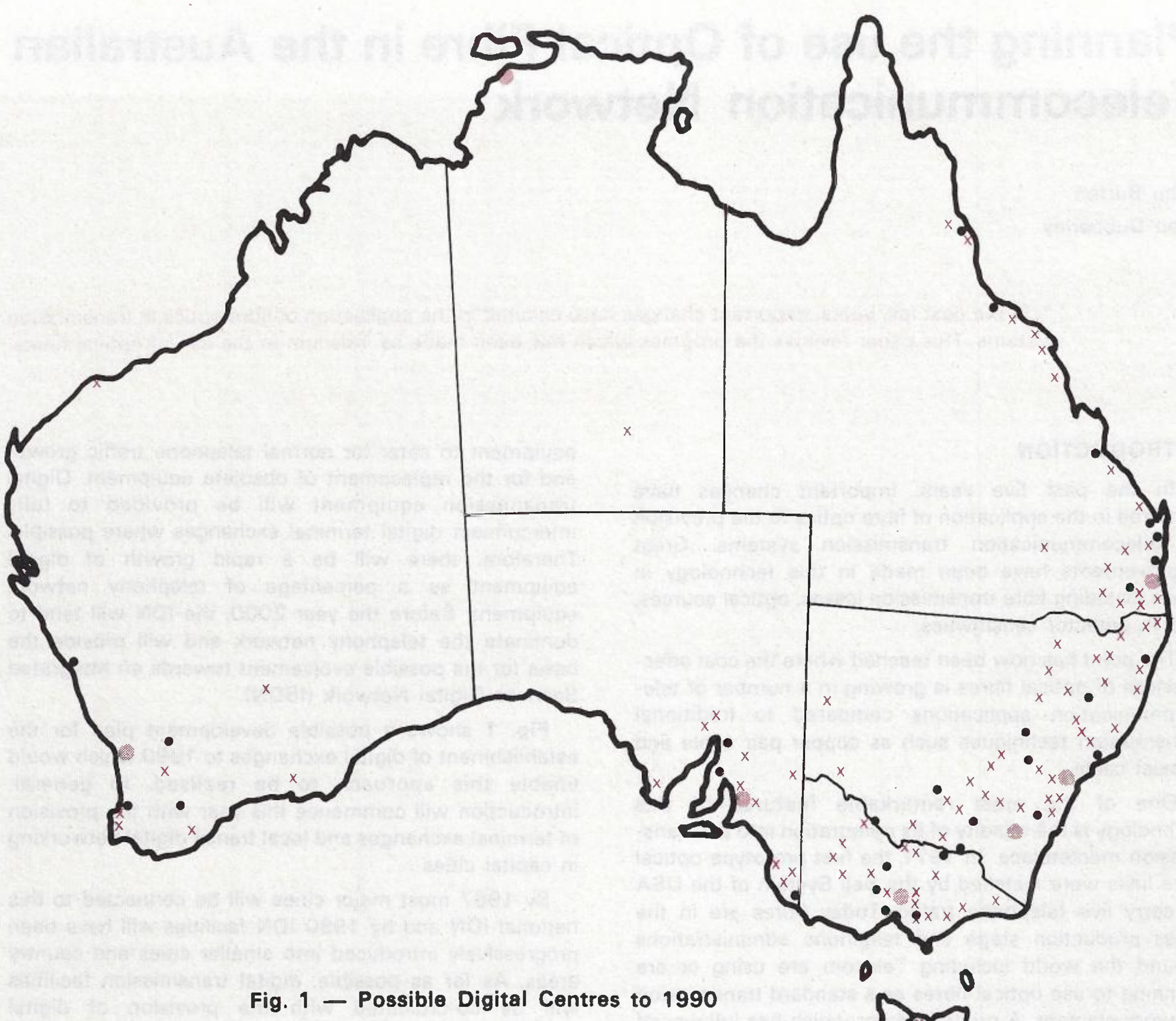
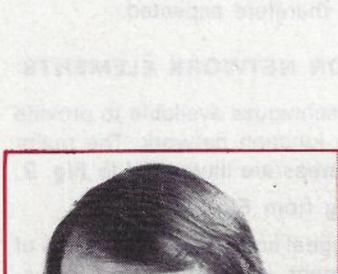


Fig. 1 — Possible Digital Centres to 1990



JOHN BURTON is a Supervising Engineer with Transmission Planning Branch in Telecom Australia Headquarters. After a period as a technician in Queensland and New South Wales, he joined the Telecom Research Laboratories in 1974 as an engineer, working on radio propagation studies. In 1979 he moved to Headquarters Planning Division and has since been involved with planning studies associated with the introduction of new technology into the subscriber and inter-exchange networks.

ALAN DUBBERLEY is presently a Principal Engineer in the Engineering Planning division, Telecom Headquarters.

He joined the Australian Post Office in 1971 as an engineer after working in England for Marconi and the British Post Office. His experience with the APO/Telecom include periods with subscribers' equipment design/maintenance (HQ) and district operation (NSW). He joined Transmission Planning (HQ) in 1976 and has been involved with planning activities in the areas of subscriber networks and inter-exchange networks.

equipment capacities range from 2 to 140 Mbit/s, the first systems used in our network will operate at 34 Mbit/s using radio frequency bands above 10 GHz.

In general, optical fibre cable systems are economically attractive on a route where one or more of the following apply:

- The route has a high growth rate.
- Duct space is scarce or a large number of 2 Mbit/s digital line systems exist.
- Long repeater spacings (about 10 km) are necessary.
- Protection from electro-magnetic interference or lightning strikes is required.

In the long distance network, when use can be made of existing radio route infrastructure, economics currently favour the use of 140 Mbit/s DRS over other digital transmission methods. Although the initial provision of long distance digital circuits will be via DRS up to around 1987, on some routes optical fibre cable technology is expected to become progressively more economic compared to DRS in the late 1980s and 1990s. This will be further discussed in a later section. In addition, optical fibre cable will take over the role of coaxial cable. The decision has been made not to install any more long distance coaxial cable.

One of the advantages of optical fibre cable over coaxial cable for digital transmission is that optical fibre cable repeater spacings are much greater than for coaxial cable spacings. As a result, the need for remote power feeding may be eliminated in many cases (1). Typical digital repeater distances are illustrated in **Table 1**.

CURRENT PLANS

Telecom's current policy is to use optical fibre transmission systems where justified for economic, technical or strategic reasons in the following areas:

- metropolitan/urban inter-exchange routes;
- short-haul inter-urban (intra-state) routes;
- links between digital radio terminals and city centres (radio tails).

With these applications in mind the following trials are being carried out:

Queensland

Springhill Exchange to Strathpine Exchange, 25 Km (34 Mbit/s system).

Victoria

Exhibition Exchange to Dandenong Exchange, 36 Km (34 Mbit/s system).

Exhibition Exchange to Maidstone Radio Terminal 15 Km (140 Mbit/s system).

Melton Exchange to Ballarat Exchange about 90 Km (140 Mbit/s or 565 Mbit/s system).

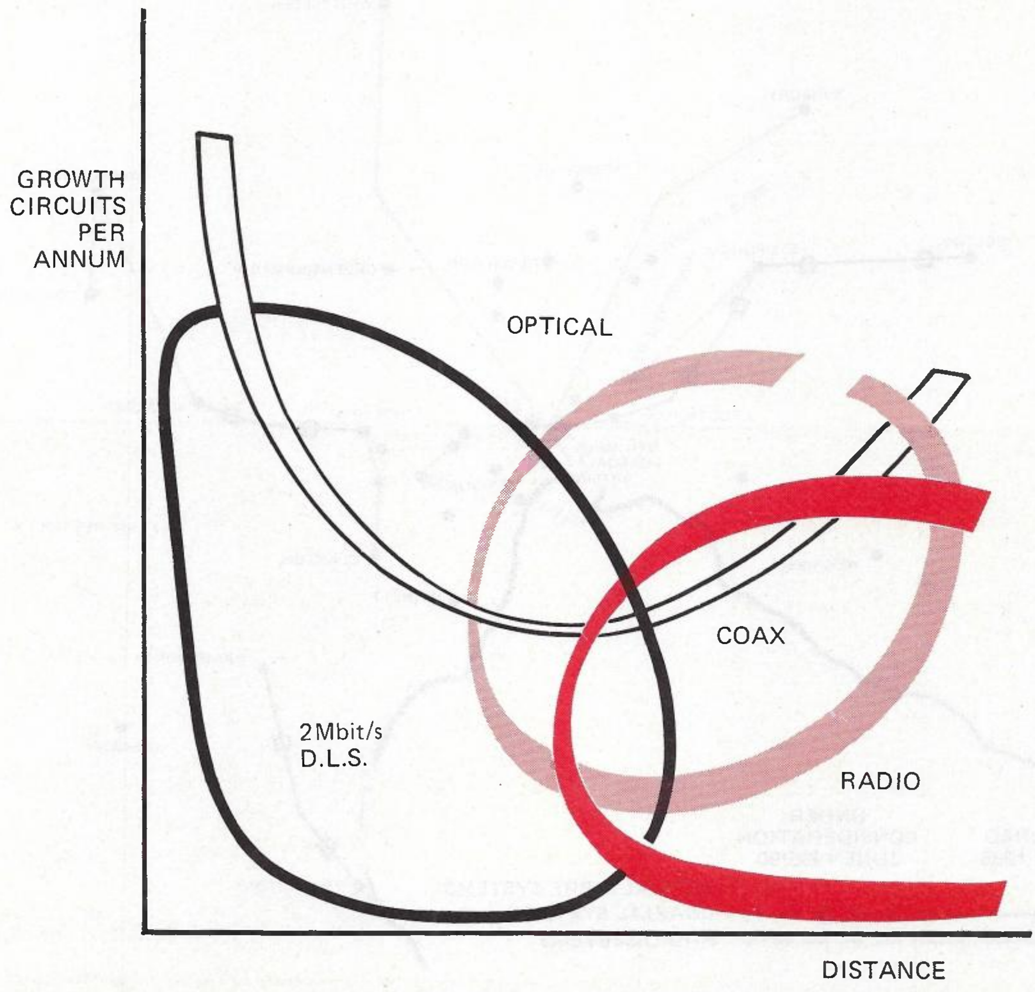


Fig. 2 — Major transmission methods for urban junction circuits

SYSTEM CAPACITY	METALLIC CONDUCTOR CABLE		OPTICAL FIBRE CABLE REPEATER SPACING		
	CABLE TYPE	REPEATER SPACING (Km)	WAVE-LENGTH (nm)	MULTI-MODE	MONO-MODE
2 Mbit/s 30 circuits	Pair Cable	1.5-4.5	850	—	—
			1300	25-30	25-30
8 Mbit/s 120 circuits	Pair Cable	2-4	850	—	—
			1300	25-30	40-50
34 Mbit/s 480 circuits	Coax	9	850	12	—
			1300	25	40
140 Mbit/s 1920 circuits	Coax	4.5	850	8	—
			1300	20	35
565 Mbit/s 7680 circuits	Coax	2	850	—	—
			1300	—	30

TABLE 1 : TYPICAL DIGITAL REPEATER SECTION LENGTHS

(NOTE: 850 nm Optical Systems are used in the 3 trial systems and proposed in one future system. For all other applications, 1300 nm is the preferred wavelength)

OPTICAL FIBRE IN THE LATE 1980s AND 1990s

Telephone administrations over the world are moving towards the use of mono-mode optical fibres because they:

- Offer bandwidths which are orders of magnitude greater than can be obtained using multi-mode fibre techniques, and
- Have significantly lower loss than multi-mode fibres

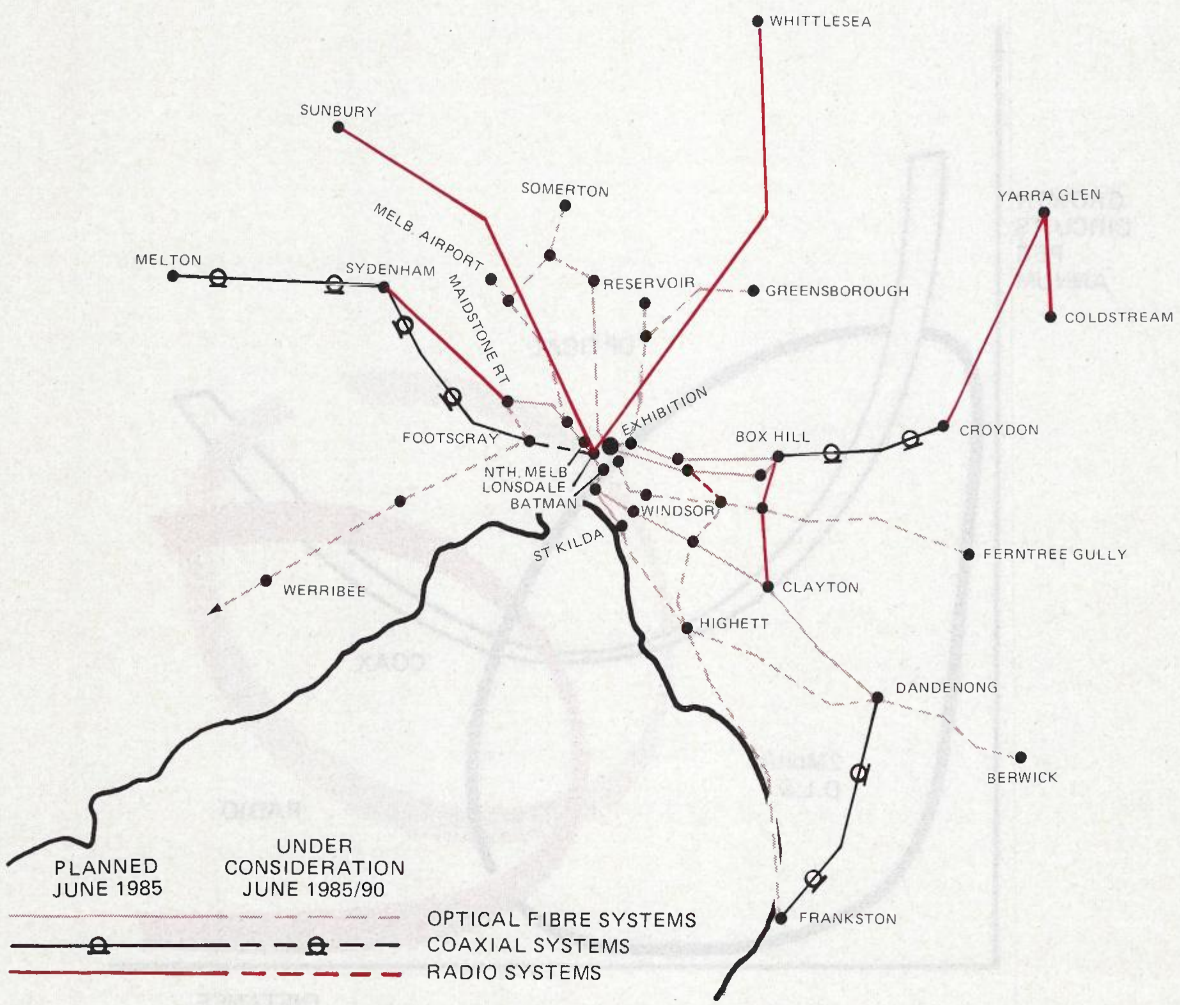


Fig. 3 — Digital Highways in Melbourne

YEAR OF INSTALLATION			
	1983/84	1984/85	1985/86
Route Length (Km)	100	231	425
No. of Routes	9	12	31
Equipment * OLTE	26	92	94
OLR	10	30	29

* OLTE — Optical Line Equipment
OLR — Optical Line Repeater

TABLE 2 — OPTICAL FIBRE INSTALLATION PROGRAMME

(typically less than 0.8 dB/km compared to 2-3 dB/km for 850 nm fibres or 1.5 dB for 1300 nm fibres).

The fact that mono-mode fibres are not limited by bandwidth but only by loss gives these fibres a major advantage in that routes can be easily upgraded by introducing higher capacity equipment. A route can be initially designed for 140 Mbit/s working and when at a later date it becomes necessary to upgrade the route to 280 or 565 Mbit/s working, it is confidently expected that this will be achieved using the same repeater spacing.

Because of these advantages, mono-mode fibre is ideal for general application including routes where high capacity, long distance telecommunication transmission links are required, including undersea routes. Whether for urban, inter-urban or for radio tail routes, mono-mode optical fibre is expected to be the standard fibre technology used by the late 1980s.

Current overseas forward developments are based upon the use of 1300 nm mono-mode technology. British Telecom has achieved a repeater spacing of 102 km at a 140 Mbit/s transmission rate and Bell Laboratories have reached over 100 km at a 274 Mbit/s rate. This latter cable type is intended for an undersea route across the Atlantic Ocean. These experimental test results are unlikely to be reached in general telecommunications applications in the near future but are an indication of the directions of mono-mode development. Telecom confidently expects to be able to use repeater spacings in excess of 30 km as indicated in **Table 1**.

In Australia, Telecom is aware of the potential advantages to be gained from mono-mode technology and is setting up a field trial to commence in 1984. The objectives of the trial will include an investigation of:

- The repeater spacings possible at 140 and 565 Mbit/s transmission rates;
- The techniques required to plough-in mono-mode cable, and
- The general application of mono-mode cable to the long distance network.

A route between Ballarat and Melton has been chosen for the field trial and **Fig. 4** shows the general location. This route was chosen because of its proximity to research and development locations in Melbourne, the

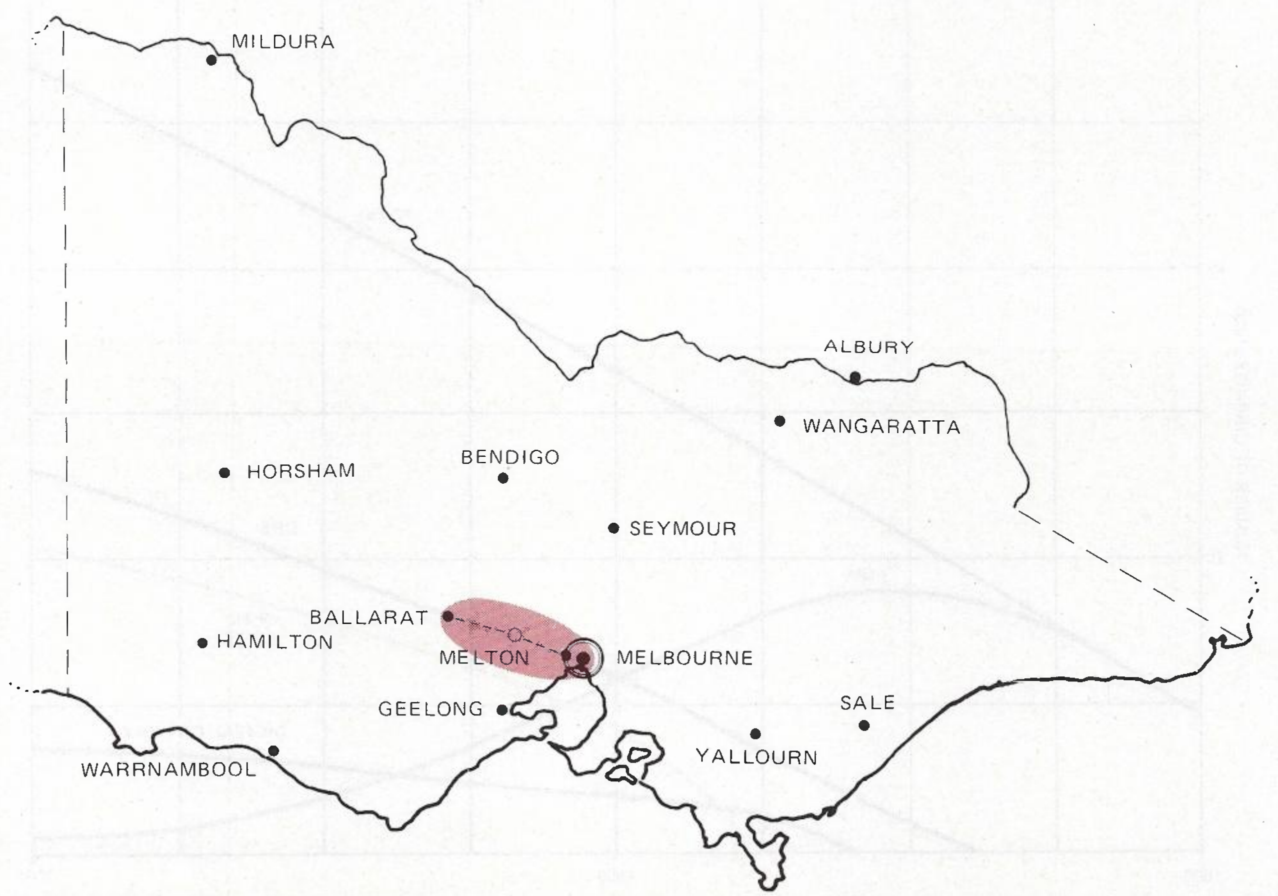


Fig. 4 — Optical Link Field Trial — Melton to Ballarat, Victoria

terrain mix and because at the cessation of the trial the cable can be usefully integrated into the network. The works programme is designed to have the system carrying traffic early in 1986.

A recent study of interstate trunk circuit forward plans has recently been carried out taking into account a number of factors including the potential offered by mono-mode fibre. This study suggests that by the year 2000, interstate trunk circuits are expected to be carried almost entirely on digital bearers. **Fig. 5** illustrates this feature and also estimates the expected number of interstate circuits to be carried on mono-mode fibre.

Some long distance routes where mono-mode fibre could be installed are shown in **Fig. 6**. This figure also illustrates other long distance digital transmission techniques which may be installed by the mid 1990s. The routes indicated are by no means definitive at this stage and planning work is continuing to enable a firm national digital transmission infrastructure to be developed.

In rural areas of Australia an application for the use of optical fibre cable is emerging. It appears on first estimates, that optical fibre cables operating at 1300 nm are a cost effective alternative to copper pair cables in rural areas.

This feature is illustrated in **Fig. 7** where the provision of an 8 Mbit/s link is considered. The comparison shown indicates the relative installed costs of ploughing-in different cable types; namely, 10/0.90 CPFUT, single quad carrier cable and optical fibre cable. For transmission rates of 34 Mbit/s, optical fibre links have the advantage that in most cases inter-exchange repeaters will not be necessary and hence power feeding, repeater housings, supervisory systems and order wires are not required. **Table 1** shows typical repeater spacings for 34 Mbit/s links. Further planning work is being undertaken to define specific application ranges.

A study of forward plans for the metropolitan junction network has also been carried out. **Fig. 8** shows a declining use of physical pairs and analogue carrier (FDM) for metropolitan junction circuits and an increasing use of digital technology. By the year 2000, it is expected that more than two-thirds of metropolitan junction circuits will be digital. The curve marked *Higher Order Digital* estimates circuit numbers provided by optical fibre cables, existing coaxial cables and DRS while the curve marked *2 Mbit/s Digital* estimates circuit numbers provided on metallic copper pairs.

OPTICAL FIBRE DEVELOPMENT

Optical fibre is a technology which is able to replace metal conductors over a range of applications. This is already true in the Telecom network for metropolitan junction routes having high growth rates as seen in previous sections of this paper. With repeater spacings of 9 to 12 km, underground repeaters in metropolitan areas will become a feature of the past.

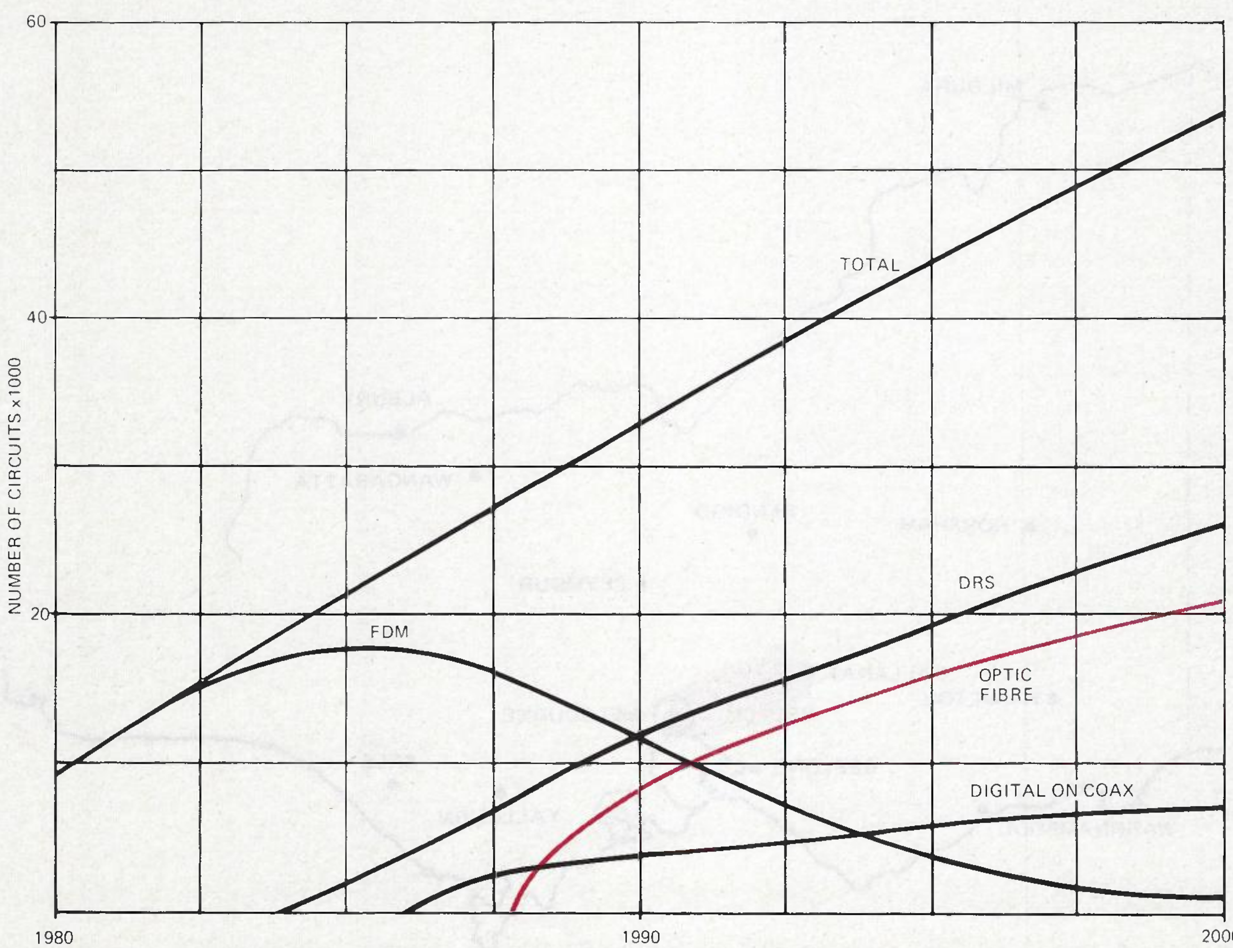


Fig. 5 — Interstate Trunk Telephone Circuits Development Figure showing possible Transmission Media Penetration

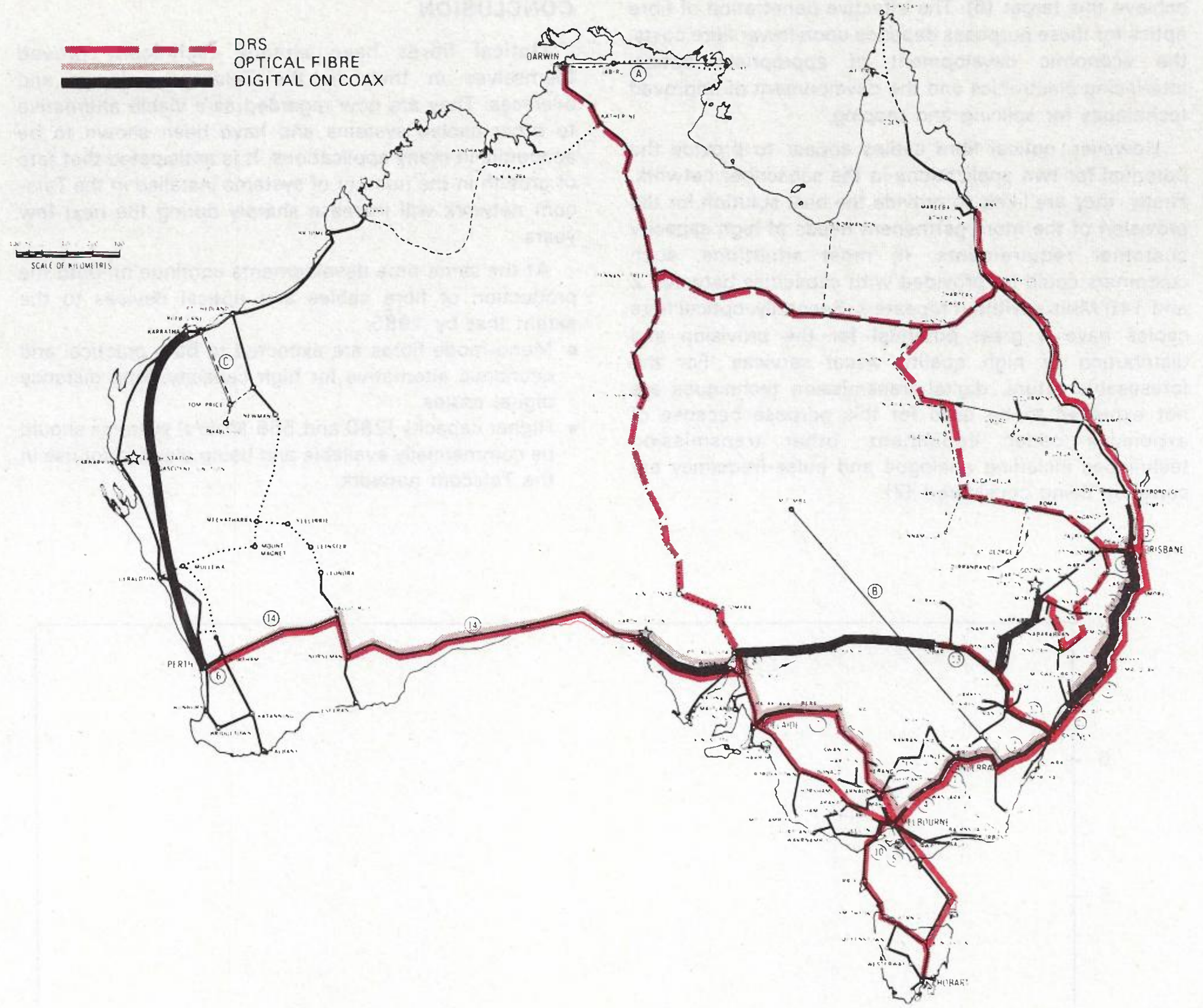


Fig. 6 — Possible Broadband Communication Network 1985-1995

Recently, investigations have begun to centre on the longer wavelengths around 1550 nm where fibre attenuation per km is even lower than at 1300 nm. There are some problems present such as higher dispersions, but researchers have made mono-mode fibre having less than 0.2 dB/km attenuation at this operating wavelength **(2)**.

Many signal processing functions associated with optical fibre technology will become optical in the future. Work in Belgium and other centres has been undertaken to develop optical devices which will operate as direct amplifiers at the operating wavelength. The implications of such work are significant as the availability of direct optical amplification could have an impact on the economics of optical systems **(3)**.

Currently, optical intensity modulation is used in fibre transmission. If optical phase or frequency shift keying were employed for modulation, and an homodyne or heterodyne detection system used for demodulation, repeater gain could be improved by more than 10 dB **(4)**. Coherent optical transmission would improve single-mode optical transmission providing that a low noise optical frequency local oscillator is developed.

Another possibility receiving attention is that of optical multiplexing. One form of multiplexing, called wave length division multiplexing, permits several light wavelengths to be placed simultaneously on the same fibre. This would enable the capacity of optical fibre to be increased significantly at a marginal cost or single fibres to be used for two-way conversations. Commercial multiplexers are now beginning to be seen in the market **(5)**. Such a development would imply that an optic fibre pair could carry in excess of 10,000 telephone conversations.

Telecom has no current plans to use optical fibre technology in the subscriber network to provide ordinary telephone services. This is because the existing copper pair cable network still remains to be exploited more cost effectively by such technologies as pair gain systems and line concentrators. Although a Danish manufacturer has predicted that 90% of the subscriber network in that country will be of optical architecture by the 1990s, major technical breakthroughs will be necessary in order to achieve this target (**6**). The effective penetration of fibre optics for these purposes depends upon lower fibre costs, the economic development of appropriate optical interfacing electronics and the development of improved techniques for splicing and tapping.

However, optical fibre cables appear to provide the potential for two applications in the subscriber network. Firstly, they are likely to provide the best solution for the provision of the more permanent needs of high capacity customer requirements. In most situations, such customers could be provided with capacities between 2 and 140 Mbit/s without repeaters. Secondly, optical fibre cables have a great potential for the provision and distribution of high quality visual services. For the foreseeable future, digital transmission techniques are not expected to be used for this purpose because of expensive codec equipment; other transmission techniques including analogue and pulse-frequency are currently being considered (**7**).

CONCLUSION

Optical fibres have already technically proved themselves in trials in the Telecom network and overseas. They are now regarded as a viable alternative to other cabled systems and have been shown to be economic in many applications. It is anticipated that rate of growth in the number of systems installed in the Telecom network will increase sharply during the next few years.

At the same time developments continue on both the production of fibre cables and optical devices to the extent that by 1986:

- Mono-mode fibres are expected to be a practical and economic alternative for high capacity, long distance digital routes.
- Higher capacity (280 and 565 Mbit/s) systems should be commercially available and being planned for use in the Telecom network.

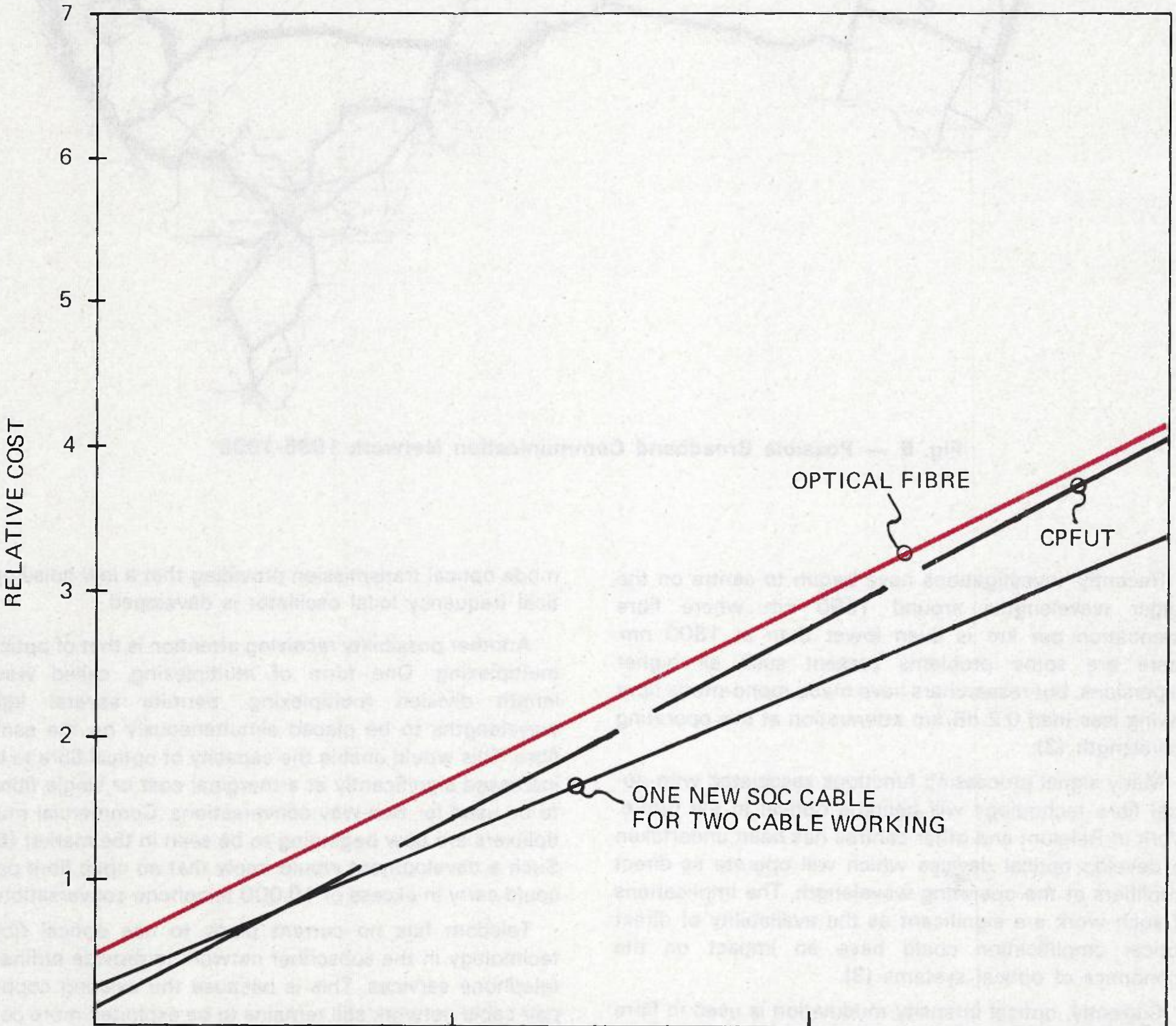


Fig. 7 — Establishing an 8 MBits/s link: Showing Relative Costs

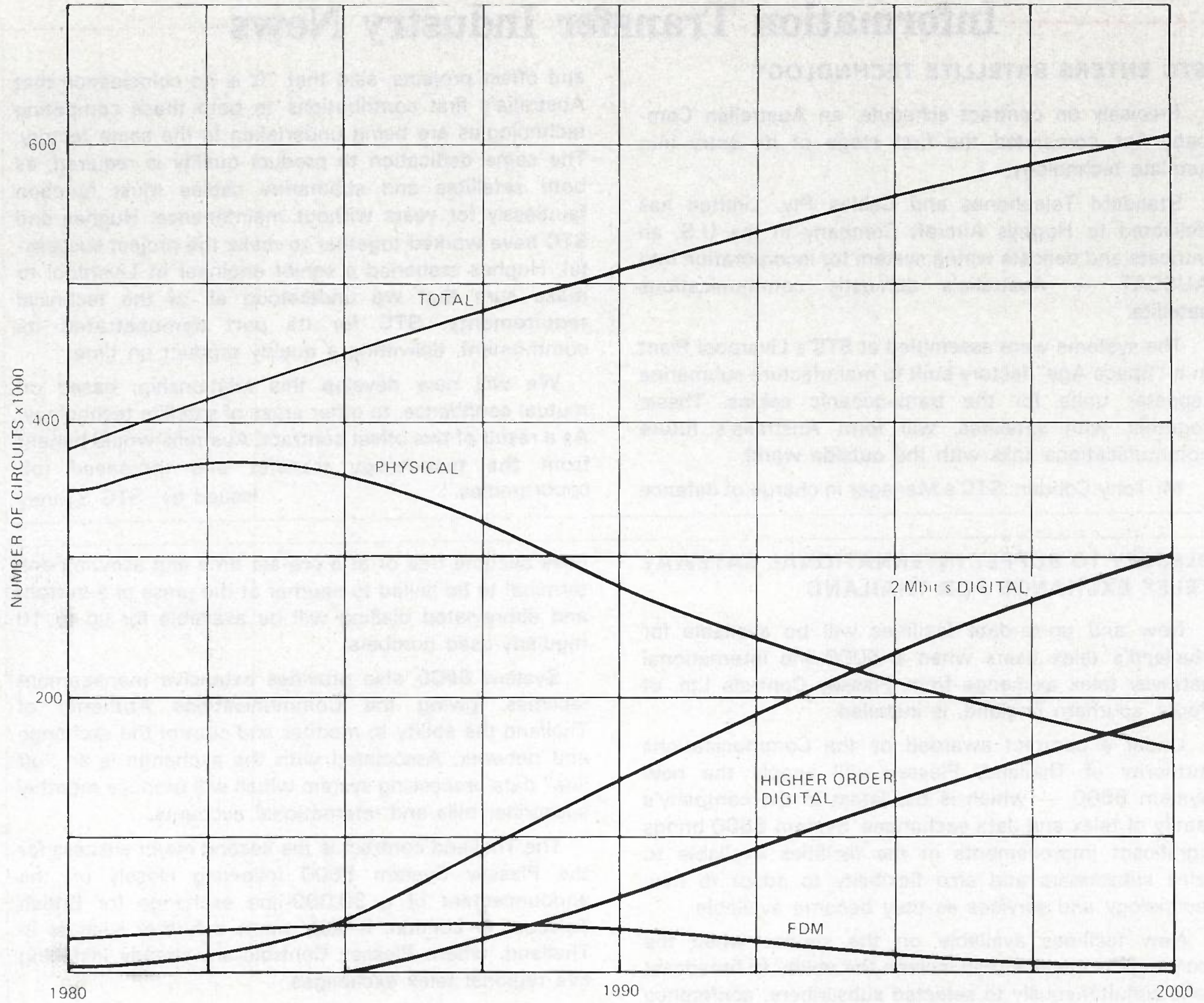


Fig. 8 — Metropolitan Junction Telephone Circuits Development

- Low capacity (8 and 34 Mbit/s) systems using cables with small numbers of fibres will be a viable alternative to existing techniques for providing digital transmission in rural areas.

By the early 1990s, Telecom expects to have optical fibres installed in all parts of the network.

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Information Transfer Industry News

STC ENTERS SATELLITE TECHNOLOGY

Precisely on contract schedule, an Australian Company has completed the first stage of its entry into satellite technology.

Standard Telephones and Cables Pty. Limited has delivered to Hughes Aircraft Company in the U.S. an intricate and delicate wiring system for incorporation into AUSSAT — Australia's domestic communications satellite.

The systems were assembled at STC's Liverpool Plant in a "Space Age" factory built to manufacture submarine repeater units for the trans-oceanic cables. These, together with satellites, will form Australia's future communications links with the outside world.

Mr Tony Cobden, STC's Manager in charge of defence and offset projects, said that "It is no coincidence that Australia's first contributions to both these competing technologies are being undertaken in the same factory. The same dedication to product quality is required, as both satellites and submarine cables must function faultlessly for years without maintenance. Hughes and STC have worked together to make the project successful. Hughes stationed a senior engineer at Liverpool to make sure that we understood all of the technical requirements. STC for its part demonstrated its commitment, delivering a quality product on time.

We will now develop this relationship, based on mutual confidence, to other areas of satellite technology. As a result of this offset contract, Australia would benefit from the technology transfer and increased job opportunities."

Issued by: STC Sydney

PLESSEY TO SUPPLY INTERNATIONAL GATEWAY TELEX EXCHANGE FOR THAILAND

New and up-to-date facilities will be available for Thailand's telex users when a 5000-line international gateway telex exchange from Plessey Controls Ltd. of Poole, southern England, is installed.

Under a contract awarded by the Communications Authority of Thailand, Plessey will supply the new System 8600 — which is the latest in the company's family of telex and data exchanges. System 8600 brings significant improvements in the facilities available to telex subscribers and also flexibility to adapt to new technology and services as they become available.

New facilities available on the service when the exchange is installed will include the ability to broadcast calls simultaneously to selected subscribers; conference calls between three or more terminals; a "store and forward" facility enabling messages to be sent when the lines become free or at a pre-set time and allowing one terminal to be linked to another at the press of a button; and abbreviated dialling will be available for up to 10 regularly-used numbers.

System 8600 also provides extensive management facilities, giving the Communications Authority of Thailand the ability to monitor and control the exchange and network. Associated with the exchange is an "off line" data processing system which will produce monthly subscriber bills and international accounts.

The Thailand contract is the second major success for the Plessey System 8600 following closely on the announcement of a 30,000-line exchange for British Telecom in London. It also marks a further success in Thailand, where Plessey Controls are already installing five regional telex exchanges.

Issued by: London Press Service

IBM announces new high technology initiatives in Australia.

IBM Australia Limited recently announced a series of initiatives in the areas of high technology which will significantly influence the company's future growth in Australia. A major development is the change in role of the IBM plant in Wangaratta to produce the highly successful IBM Personal Computer for Australia, New Zealand and South East Asia. Wangaratta now becomes the third plant in the world to manufacture the IBM Personal Computer. Further initiatives include:

- The establishment of a Software Development Support Centre in Sydney designed specifically to acquire software products from local industry opening up extensive international markets to Australian software companies;
- IBM's plan to produce in Australia software and documentation for the IBM Personal Computer
- Expanded procurement from Australian industry to include assemblies and components for Wangaratta's Personal Computer production and other IBM products.

IBM established a manufacturing operation in Wangaratta in 1976, moved into a new plant in 1979, and is producing IBM Selectric typewriters for the Australian and New Zealand markets. However, typewriter production is to be phased out and in July 1984 IBM will commence shipment of Personal Computer processors, produced at Wangaratta, to Australian customers. In 1985 it is planned to ship Australian-built PCs to the New Zealand and South East Asian markets.

The assembly and test operation at Wangaratta will follow the pattern of operation at the IBM plant at Boca Raton, Florida and Greenock, Scotland.

IBM is also actively working with Australian industry to develop new software products. To accomplish this, the company has established a Software Development Support Centre (SDSC) in Sydney specifically to encourage professional software companies to produce software products to be marketed by IBM internationally.

Issued by: IBM Australia Ltd.

A Standard Identification Scheme for Transmission Paths

A. J. HART, MIE (Aust.)
F. W. HAYES

A standard system of code identification is an important step in providing a uniform approach to identifying all types of transmission paths and services. This paper outlines a standard identification scheme for transmission paths in the Australian network.

INTRODUCTION:

The development of a standard system of code identification is an important step in providing a uniform approach to identifying all types of transmission paths and services. National identification standards are particularly important for links and services which cross State boundaries; the lack of such identification in the past has often contributed to confusion and less than optimum efficiency in various service operations.

Each identification code is designed to:

- be nationally unique;
- be as short and as meaningful as possible;
- use familiar existing identification whenever this is possible.

The identification codes are used by staff involved in the planning, installation and maintenance of the telecommunications network, and also staff involved in the various commercial aspects for provision and maintenance of customer services. Typically, complete codes are used in record systems such as Link Route Detail (LRD), Metropolitan Junction Record (MJR), Records Automation for Special Services (RASS), and Traffic Data Management Analysis and Reporting (TADMAR). In other situations, only significant parts of a code may be used; for example to identify a transmission path on its equipment test points; some parts of the full code are redundant in that situation. Another example occurs when dealing directly with customers; only the directory number portion of a code would be used in such discussions.

Although the identification scheme is intended primarily to identify transmission paths as such, there are some exceptions; noticeably the identification of switching stages in exchanges. Switching stages have been included because of the need to identify the various switching stage options which are available, and also because the type of switching stage is a determinant in the definition of a circuit group, which is one of the categories of transmission paths identified in this scheme.

A transmission path identification code will not be the most suitable code identification for every operational requirement. For example, telephone circuits between exchanges are identified as "T four alpha-four alpha" codes but exchange staff investigating an equipment fault condition associated with the circuit will use a rack and relay set number to identify the particular equipment used on the circuit. As another example, specific computer applications may need to emphasise a particular aspect of transmission paths such as transmission quality or some facility category. Other coding systems more specialised and detailed are required to cater for these specific computer applications.

SCOPE OF THE IDENTIFICATION SCHEME:

Telecom plant and facilities is divided into the following categories for identification purposes:

- Customer Services; i.e. telephone services, telex services etc.
- Telephone circuits and associated voice frequency links and exchange switching stages;
- Transmission bearers; i.e. line transmission systems and radio communication transmission systems and associated cable and radio bearers.

FORMAT OF CODES:

The codes used to identify services, circuits and bearers in this identification scheme consist of alpha and numeric characters combined in various ways to form charactergroups of different lengths and significance depending on the application of the code.

A single alpha listed in **Table 1** is the Identification Code Prefix, and is used to identify the main categories of transmission paths, services, circuits etc. This charactergroup is necessary in computer applications and in other situations where different categories may be referred to and used at the same time. However, in other applications this first character may be assumed and not necessarily used; e.g. when dealing with customers or labelling equipment etc.

The remaining charactergroups make up code elements, which are based on one of the following formats:—

A	AUTOMATIC TELEPHONE SERVICES
B	MANUAL TELEPHONE SERVICES
C	PAIR CABLES
D	DIGITAL CIRCUIT GROUPS
E	TERMINATING EXCHANGE CABLES
F	COAXIAL AND OPTICAL FIBRE CABLES
G	CABLE PAIR GROUPS
K	CABLE AND OPEN WIRE PAIRS ON CABINETS, PILLARS AND TERMINAL BOXES
L	LINE SECTIONS
M	MULTIPLEX LINKS AND DERIVED SECTIONS
N	CUSTOMER SERVICES REGISTER NUMBERS
P	OPEN WIRE FILTER GROUPS
Q	TERMINAL EXCHANGE AREA NETWORKS
R	RADIO BEARERS
S	SWITCHING STAGES AND EXCHANGE EQUIPMENT
T	TELEPHONE CIRCUIT GROUPS
W	COMBINED CIRCUIT GROUPS
Y	PACKET SWITCHING SERVICES
Z	TELEX SERVICES

TABLE 1 — IDENTIFICATION CODE PREFIXES

- Those which use a customer directory number (e.g. telephone directory number) to identify customer services.
- Those which use a 4, 5, 6 or 7 digit number (allocated from a register) to identify customer services which do not have a directory number.
- Those which use four alpha codes to identify the geographical end points of a transmission facility; e.g. a multiplex link between two locations such as between two exchanges.

This format is used mainly for Telecom network transmission paths which are not associated directly with customer services identified by directory and register numbers.

CUSTOMER SERVICES HAVING A DIRECTORY NUMBER

Table 2 gives examples of the identification of typical customer services which have a directory number identification; e.g. a national telephone directory number, a telex directory number and a packet switching service number.

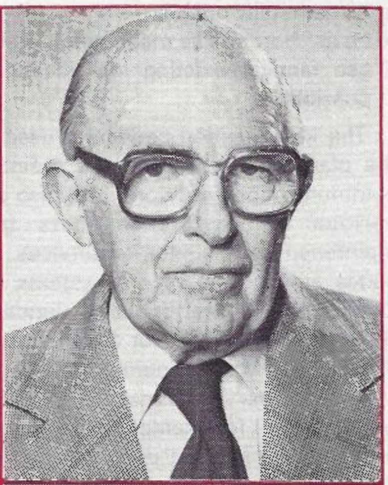
A service type suffix can be allocated to further identify the type of service or facility provided to the customer.

SERVICES WHICH DO NOT HAVE A DIRECTORY NUMBER

Table 3 shows a typical identification code for those customer services which are not identified in any form of public directory — the example shown is a direct datel service between two customers. The service numbers which are used to identify direct special services, Telecom circuits, sound and video programme channels etc. are issued from registers which are held for different areas.

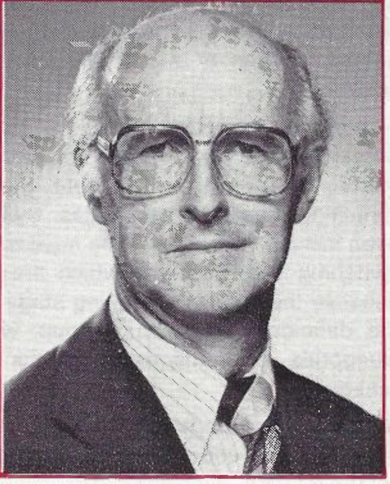
ALLAN HART commenced duty in Telecom in 1945 as an exempt technician at Radio Australia. He served in the Radio and Trunk Service Sections of the Victorian administration up to 1961 when he transferred to Headquarters Long Line Equipment Branch. Subsequently he was promoted to the position of Section Manager, Long Line and Radio Service Section in the Network Operations Branch at Headquarters, until his retirement early this year.

In addition to his work in long line and radio service areas Mr Hart made significant contributions to studies into organisation, training and grading of technical staff.



FRED HAYES, co-author of the article "A Standard Identification Scheme for Transmission Paths" commenced his career in Victoria as a Technician-in-Training in 1945.

After service in the Melbourne Carrier Terminal and with the Victorian Trunk Service Section assisting field staff throughout the State, he joined Network Performance and Operations Branch Headquarters in 1973, as a Senior Technical Officer. Since that time he has been concerned with the early development of Service Restoration and Traffic Control Centres, maintenance of long line equipment and the development and documentation of the standard identification scheme for application to various computer record systems.



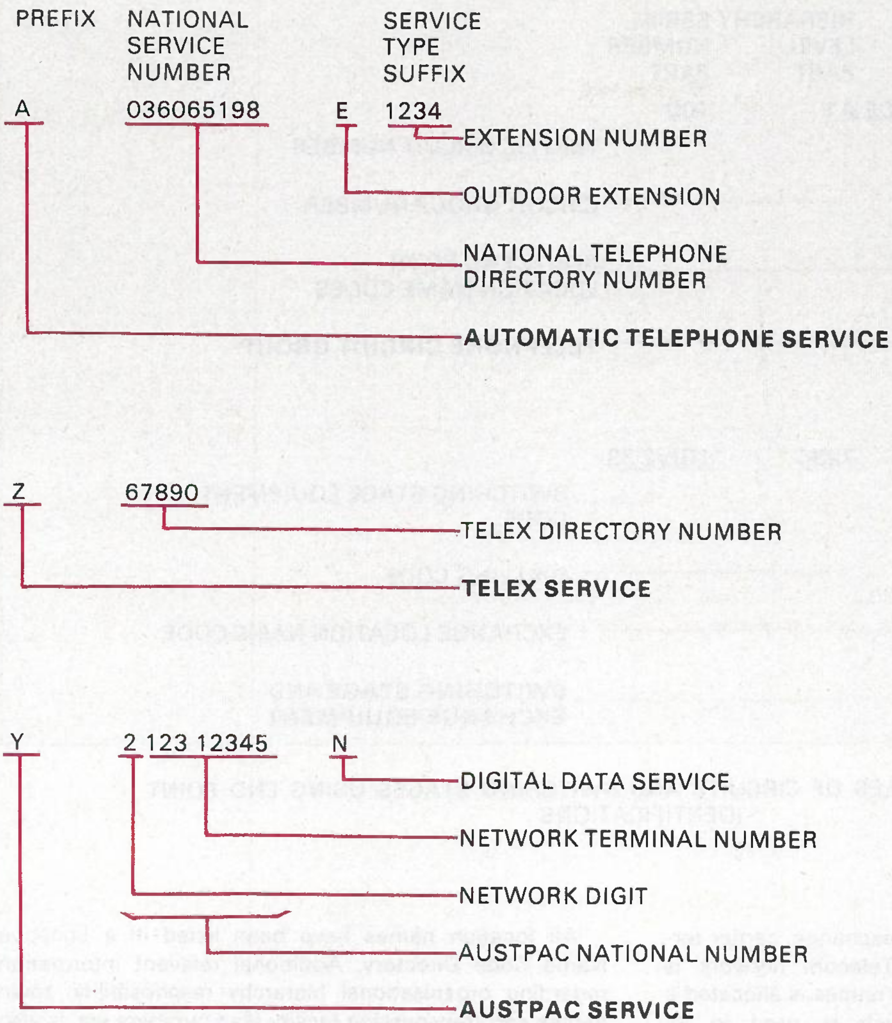


TABLE 2 — EXAMPLES OF CUSTOMER SERVICES USING A DIRECTORY NUMBER TYPE IDENTIFICATION

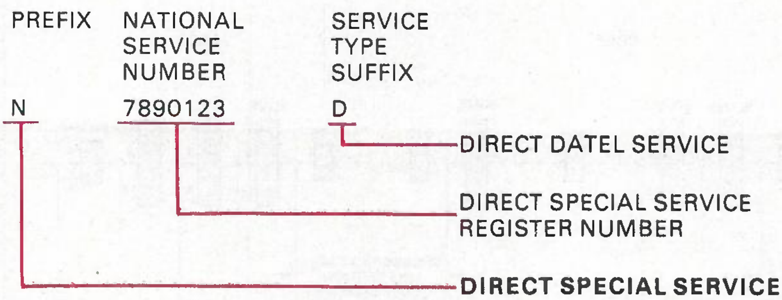


TABLE 3 — EXAMPLE OF CUSTOMER SERVICE USING A REGISTER NUMBER IDENTIFICATION

The prefix 'N' is the only prefix associated with register numbers. Seven digit numbers are used to identify direct special services, six digit numbers identify Telecom circuits, five digit numbers identify sound programme channels and four digit numbers identify video programme channels.

The numbers are made nationally unique by allocating different number blocks for each category to each area register.

TRANSMISSION PATHS REQUIRING GEOGRAPHICAL END POINT IDENTIFICATION

Transmission paths such as bearers and circuits which do not have a directory number or register number are identified using a code format based on the identification of the geographical end point locations of the transmission path and on hierarchical relationships or other distinguishing criteria plus a serial number code element.

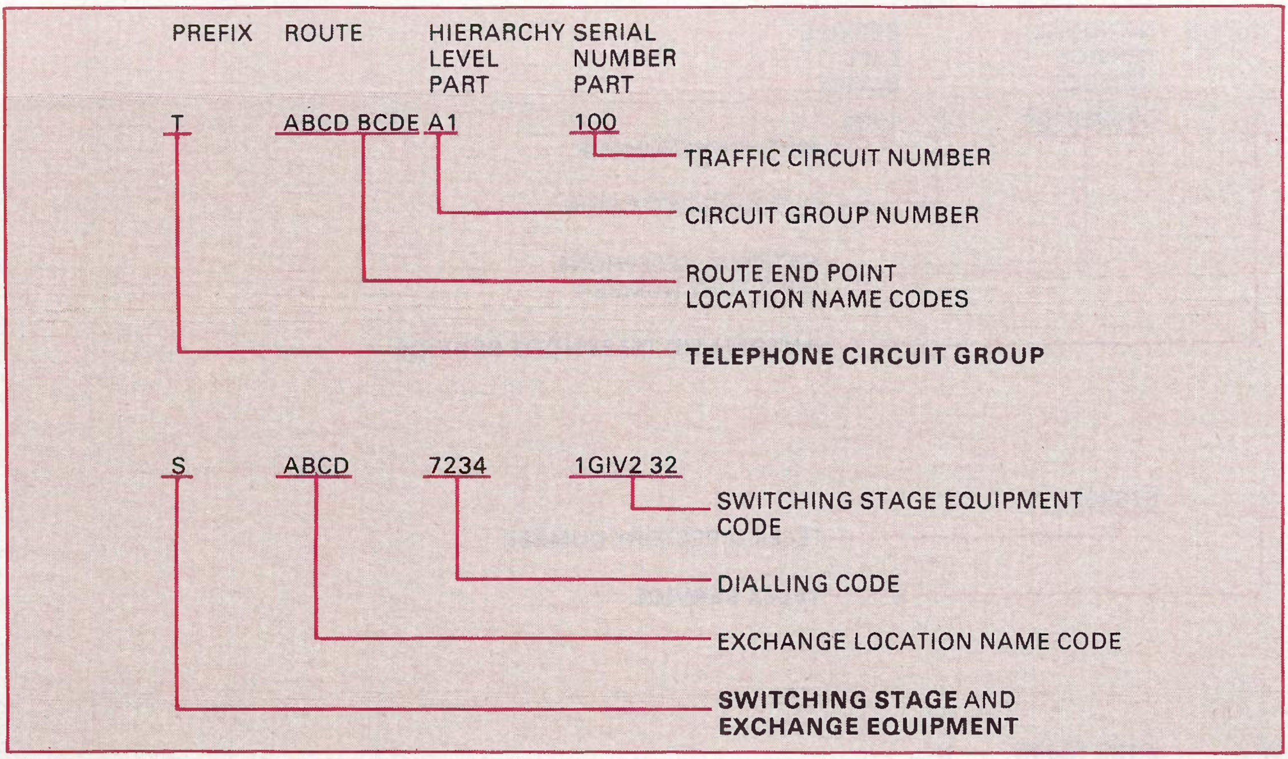


TABLE 4 — EXAMPLES OF CIRCUITS AND SWITCHING STAGES USING END POINT IDENTIFICATIONS

Every location such as terminal exchange, carrier terminal etc. associated with the Telecom network is identified by a name. Each of these names is allocated a unique four character code which is used in all identification codes associated with the location.

All location names have been listed in a Location Name Code Directory. Additional relevant information regarding organisational hierarchy responsibility, town names and transmission facility plan numbers etc. is also included in the directory.

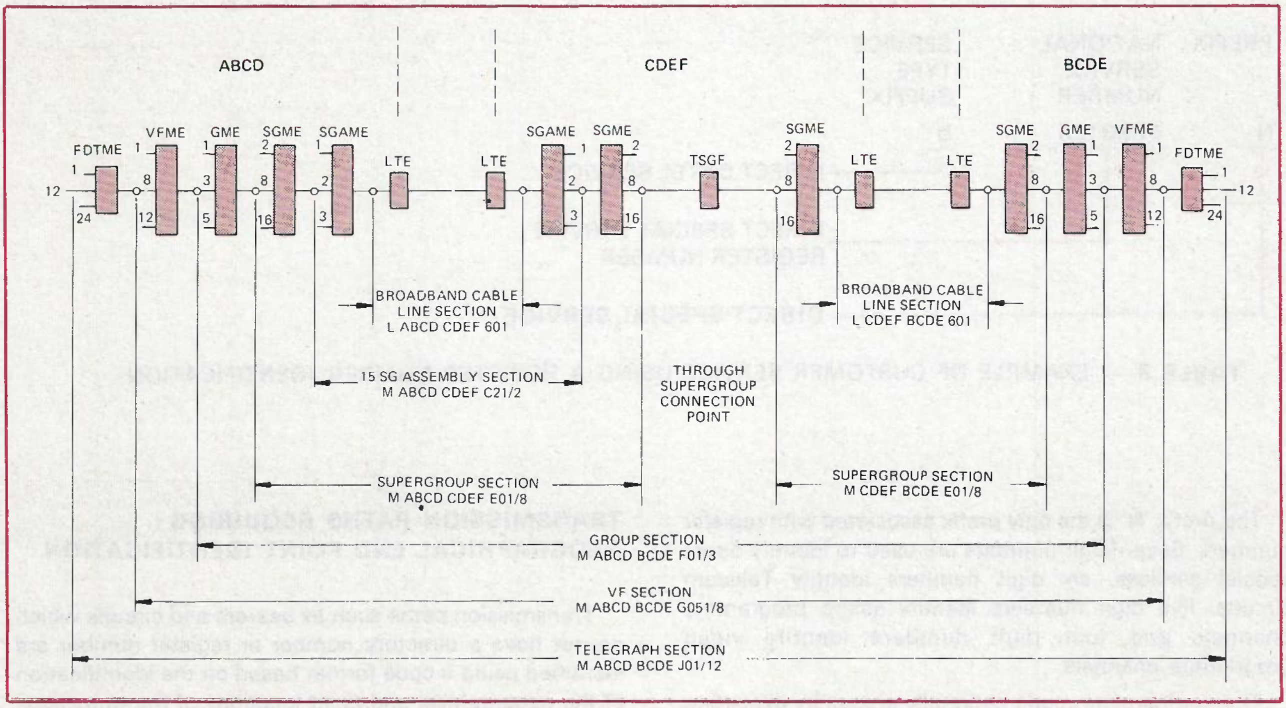


FIG. 1: LINE SECTION AND DERIVED SECTION TERMINOLOGY AND TYPICAL IDENTIFICATION CODES

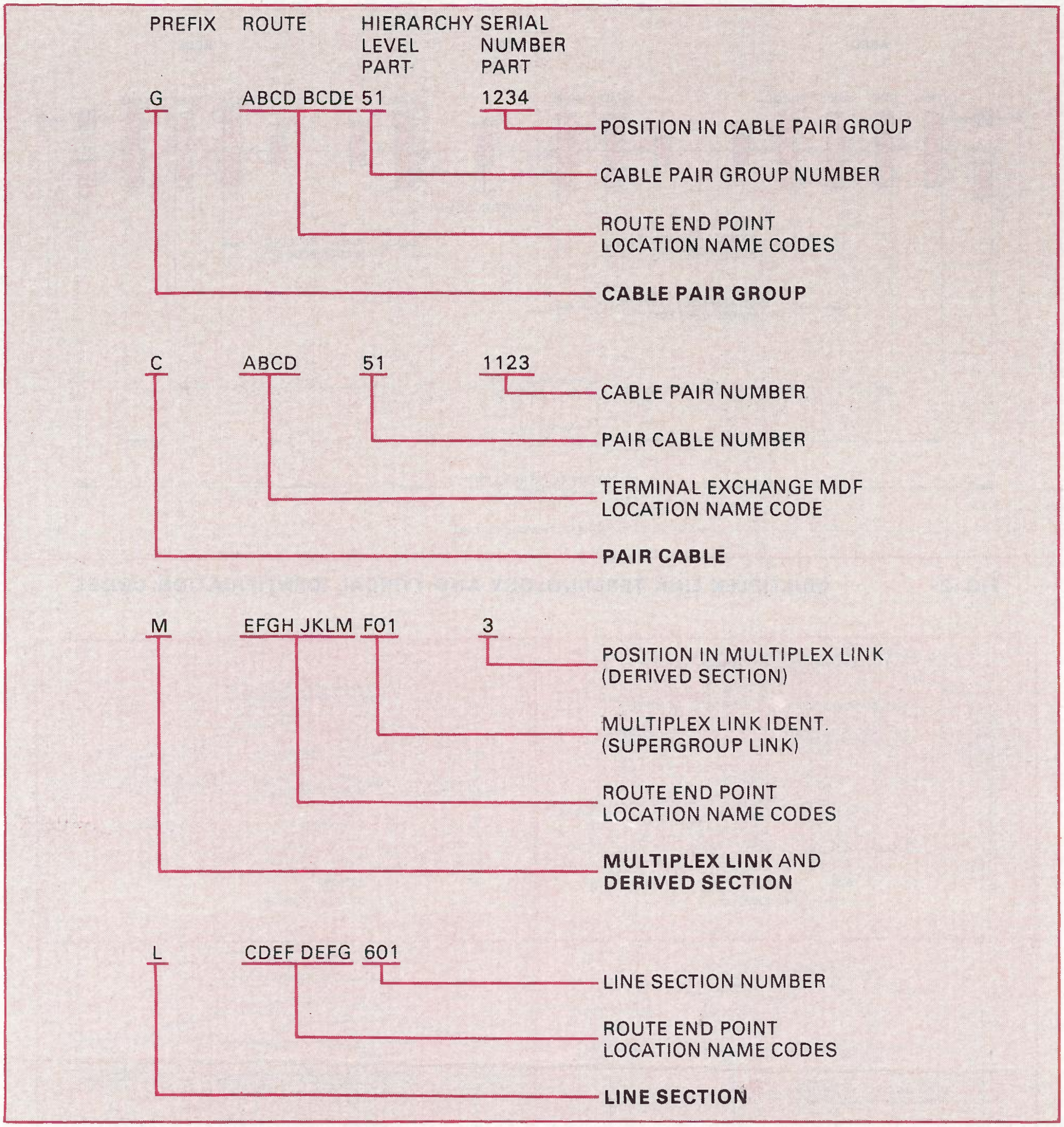


TABLE 5 — EXAMPLES OF BEARERS USING END POINT IDENTIFICATIONS

Character groups categorise the transmission paths by the following methods:

- their hierarchical relationship; e.g. by the different levels of multiplex links such as group, supergroup etc.
- capacity; e.g. line sections are sub-categorised as broadband, medium capacity or small capacity;
- switching function; e.g. circuit groups are identified as functioning between ARM, 10C and step switching equipment.

Within each sub-category the individual transmission paths are identified sequentially by a serial number character group.

Examples of identification of telephone circuits and switching stages are shown in **Table 4** and examples of transmission bearers are given in **Table 5.** The attached **Figure 1** and **2** illustrates the practical application of some of the identifications shown in Table 5.

Figure 3 illustrates the four basic code structures which have been used in the identification scheme. All transmission paths and services have been identified using one of these basic code structures.

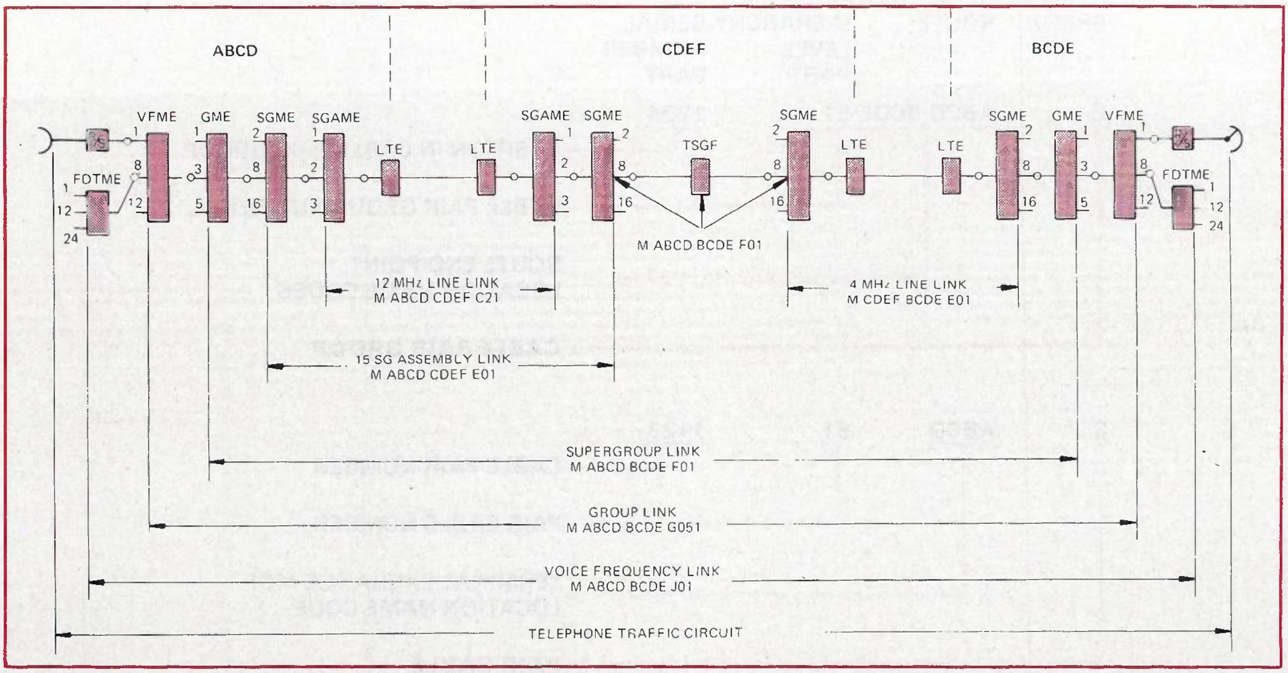


FIG. 2: MULTIPLEX LINK TERMINOLOGY AND TYPICAL IDENTIFICATION CODES

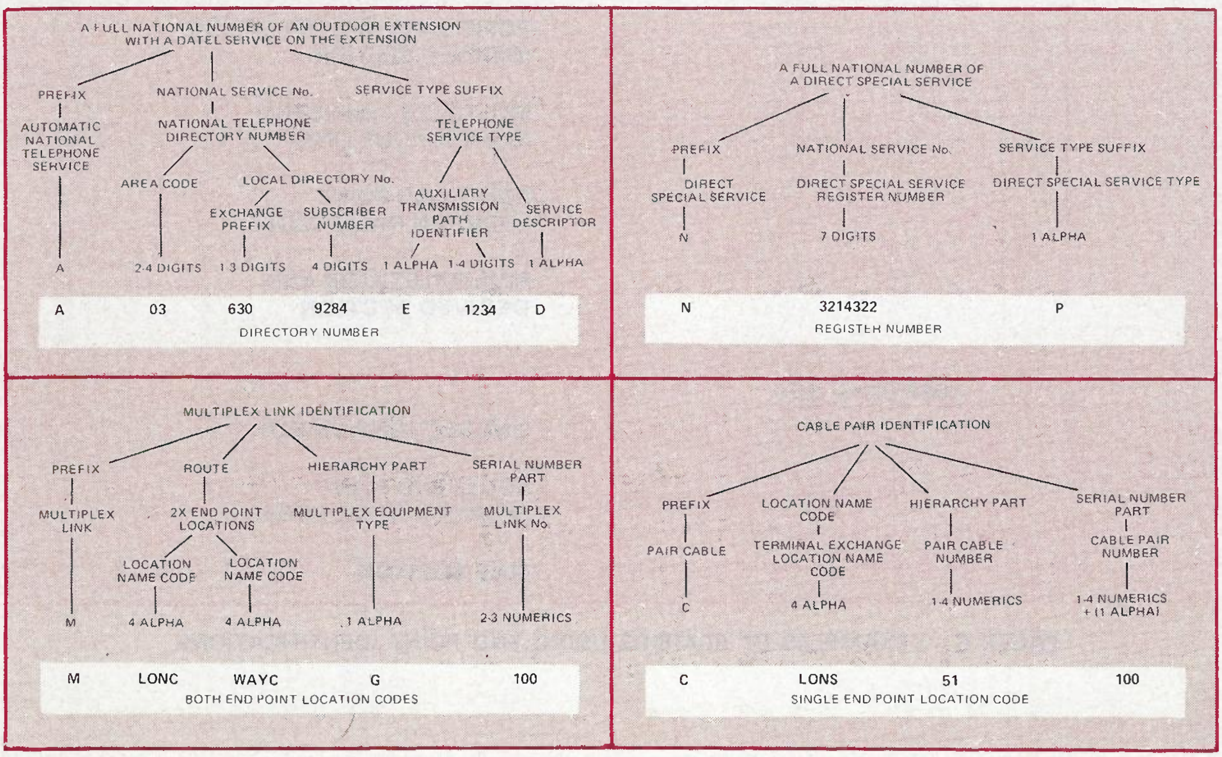


FIG. 3: APPLICATIONS OF FOUR BASIC CODE STRUCTURES

CURRENT AND FUTURE APPLICATIONS OF THE IDENTIFICATION SCHEME

The coding scheme outlined above has been progressively developed over a period of some ten years and is now used extensively for identifying transmission facilities of the main trunk network and also many customer special services. The scheme will require continuing development to meet the identification requirements of an ever-increasing range of new customer facilities which become available in a modern telecommunications network.

The Development of a PCM Multiplex Equipment with Loop Signalling Interface

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Telecom Australia is commencing the Transition from a purely analogue network, based on analogue exchanges and FDM and VF transmission networks, to an integrated digital network. Part of the transition includes providing transmission media between new digital exchanges and existing analogue exchanges. This, combined with an increasing need for pair gain on existing interexchange VF cables has prompted the introduction of an enhanced signalling facility version of 2 wire 30 channel 2048 kbit/s PCM equipment. This article summarises the Telecom story which has lead to an Australian produced equipment from two Australian manufacturers which is now being introduced into the network.

BACKGROUND

One of the most significant developments in modern telephone communications has been the introduction of digital techniques. Some years ago the use of Pulse Code Modulation (PCM) became common as a transmission technique between adjacent telephone exchanges. When combined with long haul digital radio, digital coaxial cable and optical fibre bearers the technique can be used in the whole transmission network. Parallel development of digital telephone exchanges is now merging with the inter-exchange networks to provide the concept of Integrated Digital Networks (IDN).

Telecom Australia decided in 1979 to follow this trend to an IDN. The techniques were already well understood. Manufacturing processes had reduced the costs of the hardware and the available designs were indicating the overall economy of the developing digital networks. The overall quality of the proposed IDN would be far better and there were many more user facilities that could be provided.

However the new IDN must co-operate with the existing analogue telephone network for many years yet. One of the techniques that was adopted was the use of a specially developed version of 30 channel PCM equipment operating on 2048 kbit/s bearers. The PCM technique was proven and growing **Ref. 1** as an inter-exchange system.

LOOP SIGNALLING PCM

The new digital exchanges were flexible in their interface requirements and could accommodate the 2048 kbit/s traffic directly. The existing analogue exchanges however posed serious problems. Designed to accept complex signalling processes that could be obtained on copper wire pairs directly, they required complex and expensive interface electromechanical relay sets when the older PCM equipment was used.

For the new PCM, rather than redevelop the older relay sets the signalling conversion was included with the PCM terminal equipment making use of the latest technology. In this way the PCM analogue interface was made to look like a copper pair of wires and the equipment became known as Loop-PCM. The interface to the analogue exchange was a conventional loop-signalling (L1 type) relay set, as used for transmission over physical pair cables. Thus there are a number of basic functions that become part of the PCM equipment.

- 2 wire-4 wire voice frequency conversion where the voice and multifrequency code signalling on the 2-wire interface are converted to the go and return paths necessary for transmission.
- DC conversion where the DC signalling conditions, loop and line reversal are sensed and assembled in such a way that the information for the 30 channels of each terminal are sent and received as data in time slot 16 of the 2048 kbit/s digital streams.
- Voice Frequency Coding, Multiplexing and timing which are virtually identical with all conventional 30 channel PCM multiplex equipment.

The second of these basic functions is an area which received the greatest attention in Telecom's preparation for a specification for this equipment. With the expectation that the European developed Ericsson AXE digital exchange would dominate future networks, the existing signalling schemes as used in Europe were investigated for possible use in the loop-PCM for Australia. Loop PCM equipment already existed in other countries but it was soon realised that the Australian network had some features, notably silent reversal metering pulses, which meant a complete redesign was necessary.

Nevertheless the CCITT specification of the European R2-D signalling system was used as a basis for the Australian scheme which was in turn called T6, part of an overall nomenclature for the Australian Trunk signalling schemes. It should be noted that the Telecom Australia specification for T6 refers to the data stream of time slot 16 as referred to above. The general arrangement is shown in **Fig. 1**.

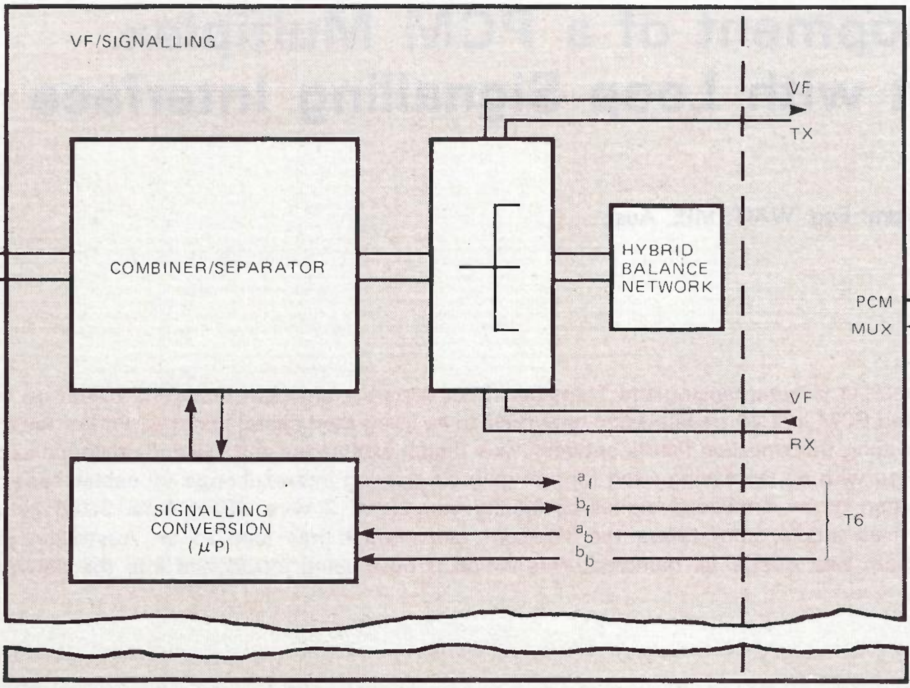

Fig. 1 — Basic Concept of PCM Multiplex Equipment with Loop Signalling Interface

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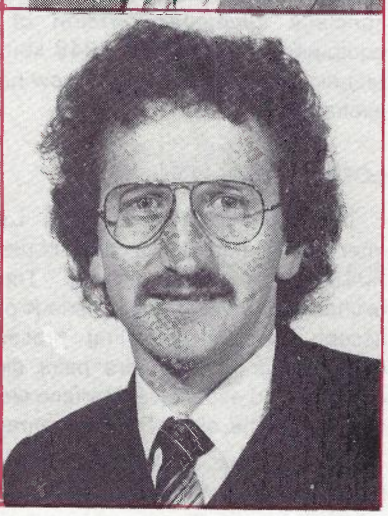
DES WILLIAMSON graduated from the Footscray Institute of Technology with a degree in Electrical Engineering in 1978, and joined Telecom Headquarters as a Engineer Class 1.

He is currently a Senior Engineer in the Digital Design Section of Line Transmission Equipment Construction Branch of Telecom Headquarters.



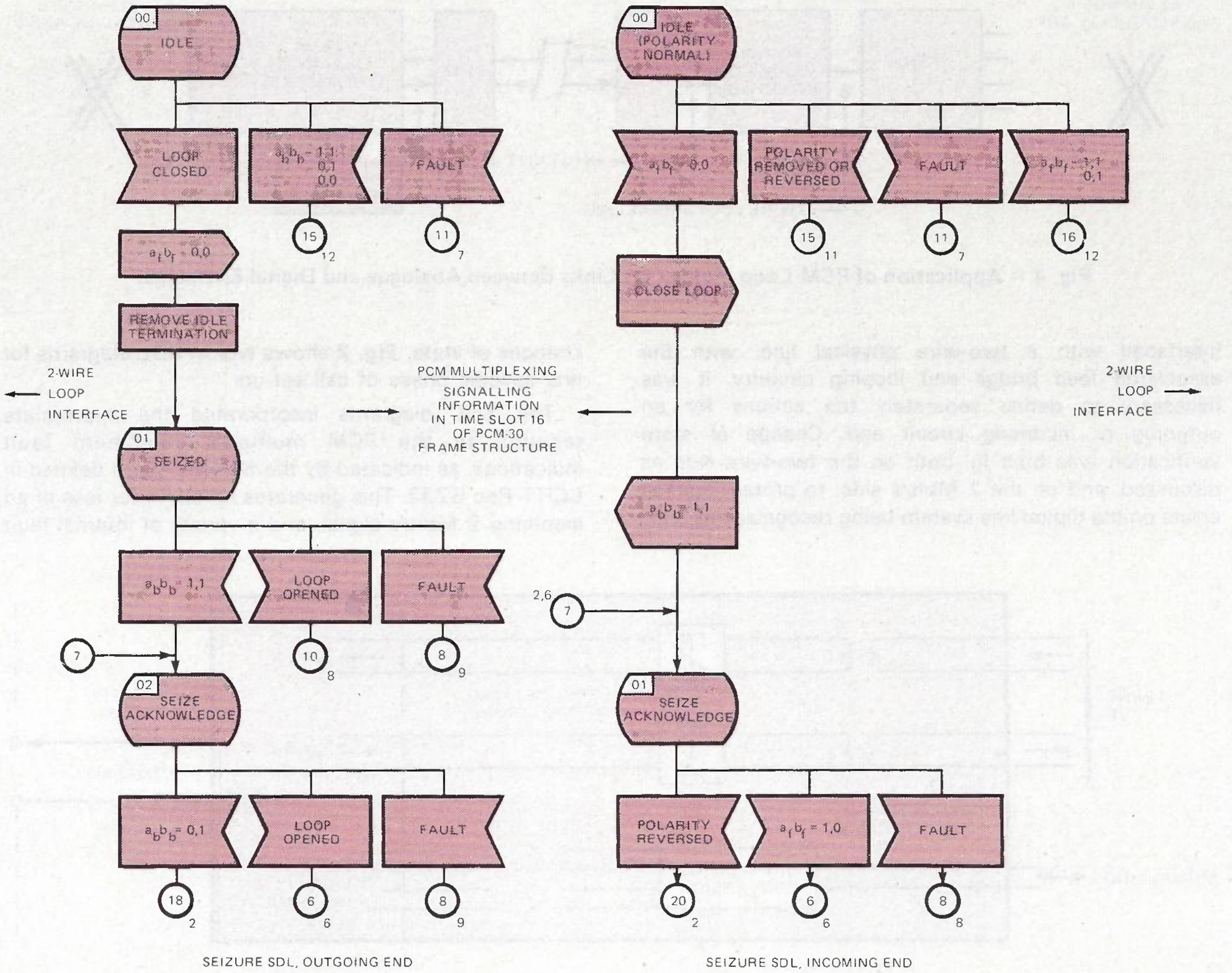


Fig. 2 — Example of SDL Diagram for the Seizure Process at Both Ends of a Circuit

A survey of existing designs indicated that it was likely that a microprocessor would be used in the loop PCM equipment so it was not necessary to restrict the specification. Self testing, change-of-state verification and alarm generation were possible as was the ability to bar false signals from the exchanges. By specifying the scheme in this way rather than as an end to end specification, two significant facilities were gained.

- Equipment of different manufacturer could be used at either end of a circuit. However interworking with conventional E&M equipment was not intended and is not possible.
- The equipment design and specification was independent of the exchange specifications with the exception of course of the interface structure.

The various phases of call set-up and clear-down were defined in a series of flow charts using the CCITT Specification and Description Language (SDL). These defined the action to be taken by the loop interface under all normal and abnormal conditions. Because the channel

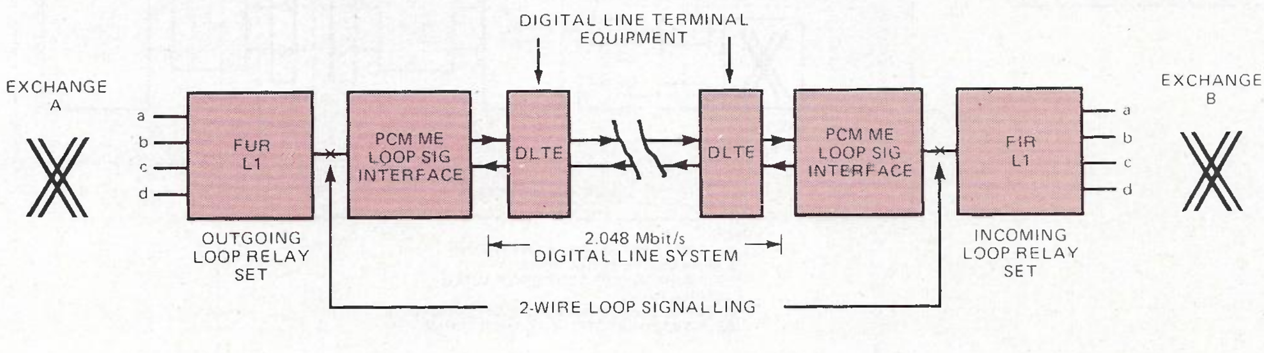


Fig. 3 — Application of PCM Loop Muldex on Links Between Analogue Exchanges

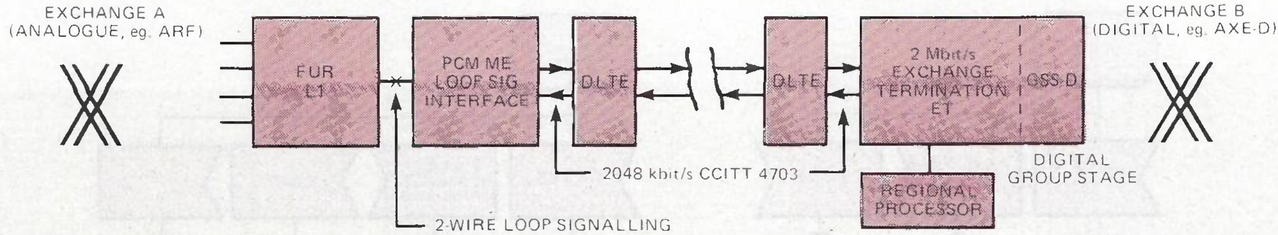


Fig. 4 — Application of PCM Loop Muldex on Links Between Analogue and Digital Exchanges

interfaced with a two-wire physical line, with the associated feed bridge and looping circuitry, it was necessary to define separately the actions for an outgoing or incoming circuit end. Change of state verification was built in, both on the two-wire side as discussed, and on the 2 Mbit/s side, to protect against errors on the digital line system being recognized as false changes of state. **Fig. 2** shows typical SDL diagrams for one specific phase of call set-up.

The SDL diagrams incorporated the appropriate reaction to the PCM multiplex equipment fault indications, as indicated by the Service Alarm defined in CCITT Rec G732. This generates an alarm for loss of an incoming 2 Mbit/s signal, and a variety of internal fault

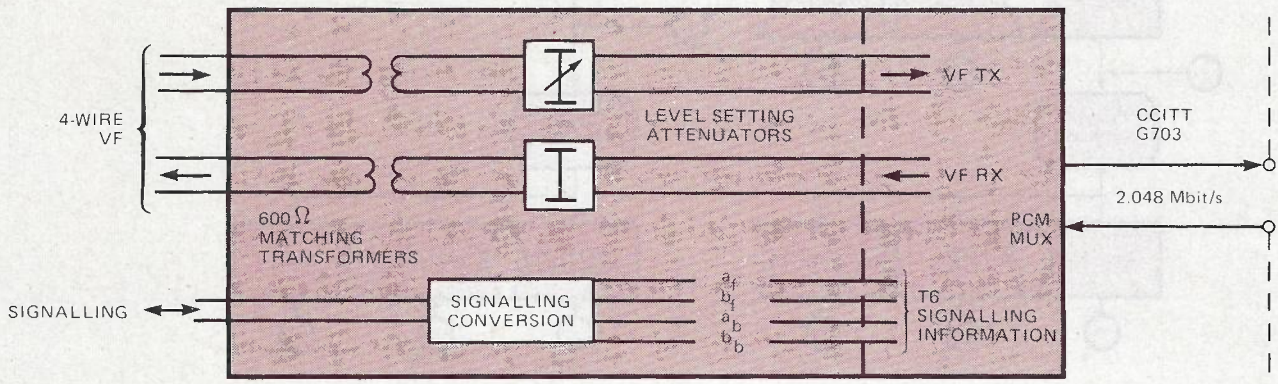
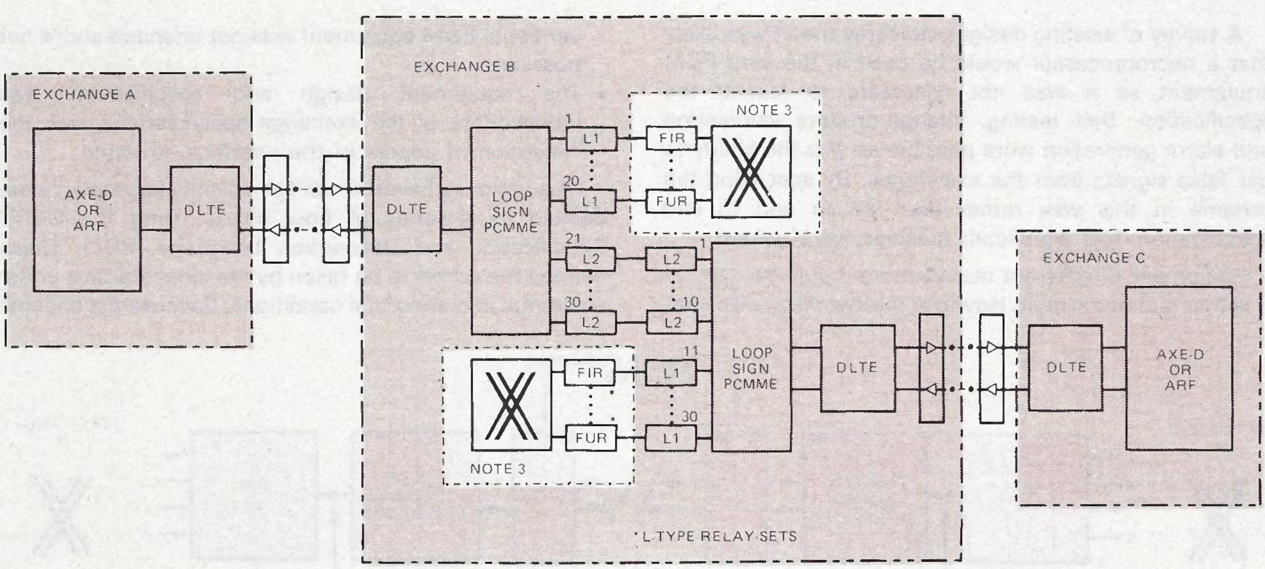


Fig. 5 — Basic Elements of a 6-Wire Loop Interface Unit



NOTES
(1) L1: 2-WIRE INTERFACE FOR DIRECT EXCHANGE TERMINATIONS
(2) L2: 6-WIRE INTERFACE FOR VF INTER-CONNECTIONS
(3) ALTERNATIVELY THESE CIRCUITS COULD BE INTERCONNECTED TO OTHER PCMME

Fig. 6 — Application of 6-Wire Loop-Muldex for VF Interconnection of PCM Systems

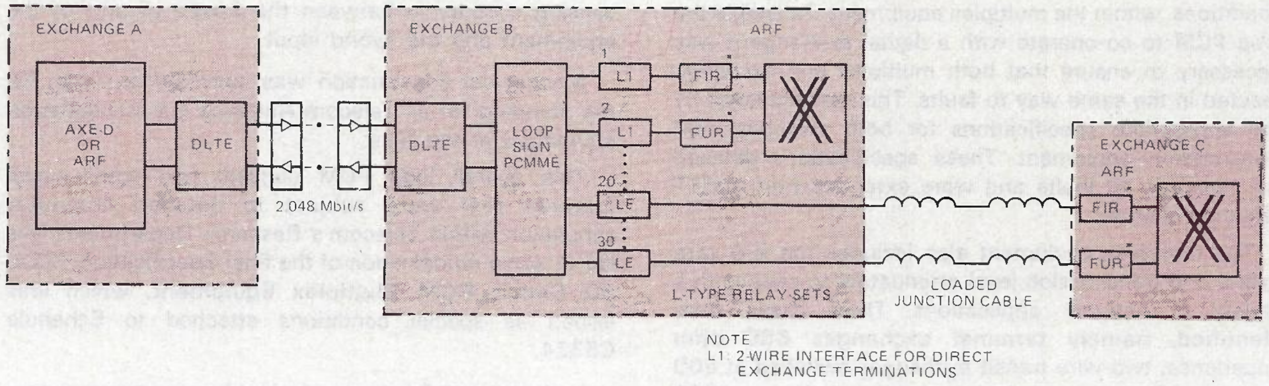


Fig. 7a — Through-Connection of Circuits Beyond a PCM Terminal Station

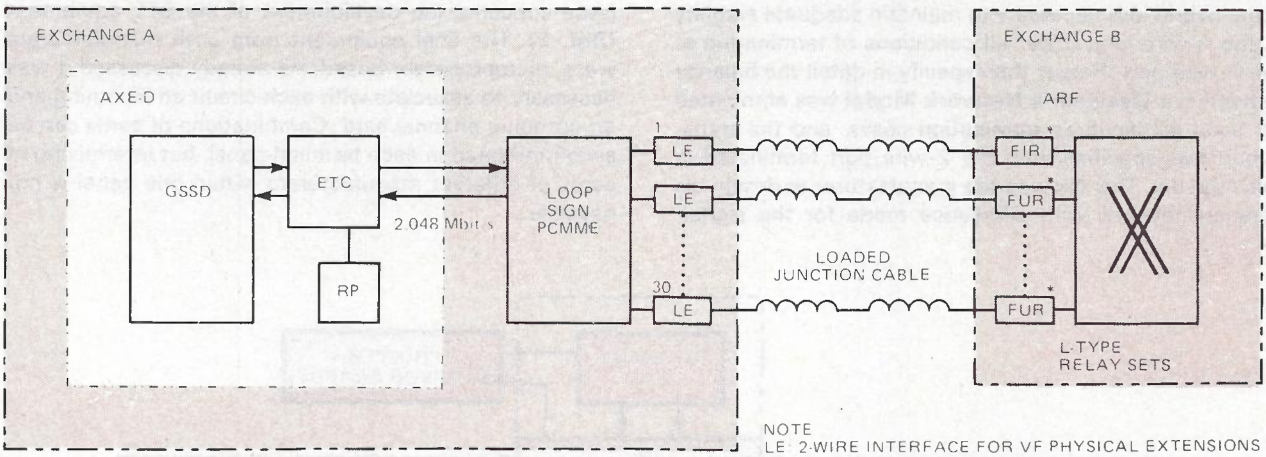


Fig. 7b — A Digital Exchange Line Interface

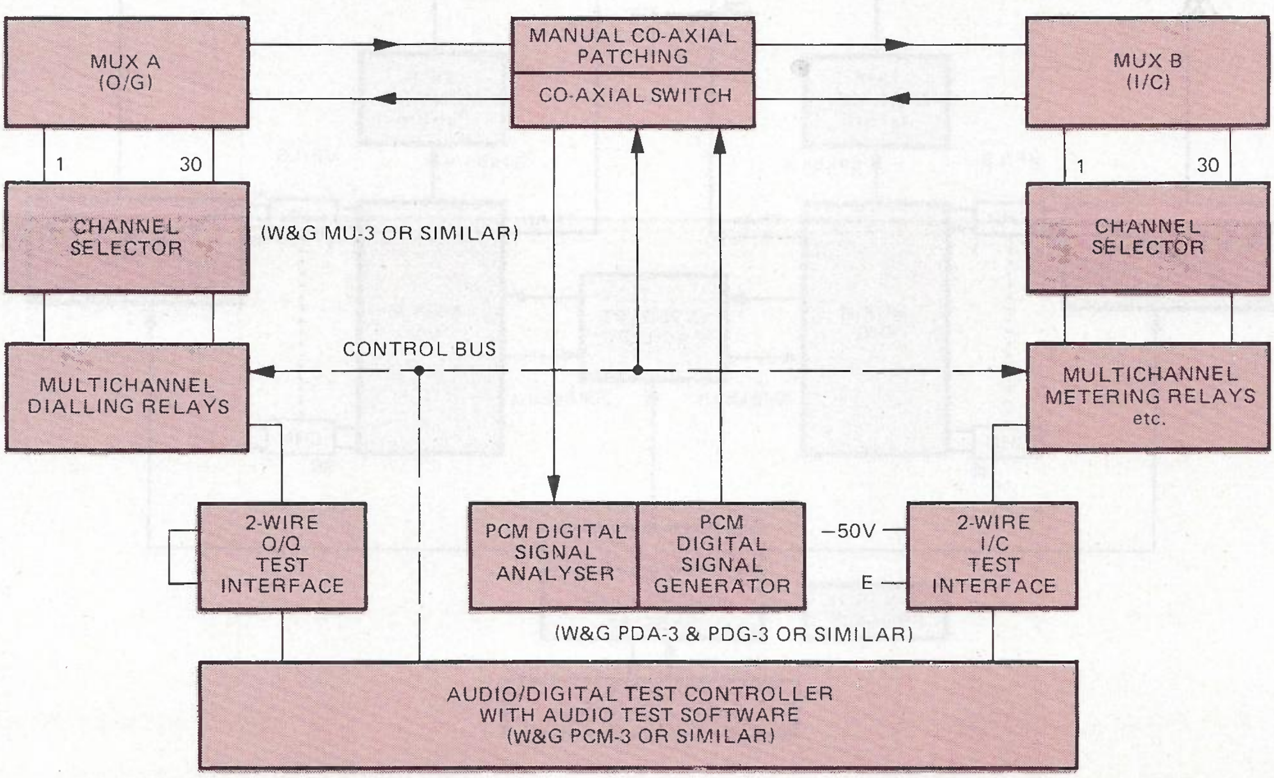


Fig. 8 — Block Diagram of VF Test Equipment.

conditions, within the multiplex equipment. To enable the loop PCM to co-operate with a digital exchange it was necessary to ensure that both multiplex and exchange reacted in the same way to faults. This was achieved by the appropriate specifications for both switching and transmission equipment. These specifications detailed the response to faults and were extended from CCITT recommendations.

The multiplex equipment also includes the 2-4 wire hybrid and transmission level attenuators to cope with a variety of network applications. Three cases were identified, namely terminal exchanges 600 ohm impedance, two-wire transit exchanges switched at 600 ohm, and two-wire transit exchanges switched at 1200 ohm. The performance requirement of the hybrid was examined by Telecom Research Dept., in terms of the trans-hybrid loss necessary to maintain adequate stability in the 4-wire loop under all conditions of termination at the 2-wire port. Rather than specify in detail the balance networks, a **Designer's Network Model** was nominated for each of the three termination cases, and the trans-hybrid loss specified with the 2-wire port terminated in this network. This allowed the manufacturer to design his balance network with allowance made for the signal-sensing circuitry in between the 2-wire of port of the equipment and the hybrid input.

Mechanical construction was specified as Type 72, the standard for all Telecom Australia line transmission equipment at the time.

This overall loop PCM concept had some novel features that were subject to detailed computer simulation within Telecom's Research Department. This led to some modification of the final Specification 1324, **30 Circuit PCM Multiplex Equipment,** which was issued as special conditions attached to Schedule C5324.

In due course Contracts were let for equipment to two manufacturers, Siemens Ltd and Standard Telephones and Cables Pty. Ltd. (STC). The companion article in this issue concerns the development of the STC equipment **(Ref. 2).** The final equipment from both manufacturers were microprocessor based. As already discussed it was necessary to associate with each circuit an incoming and an outgoing channel card. Combinations of cards can be accommodated in each terminal panel, but intermixing of cards of different manufacturers within one panel is not possible.

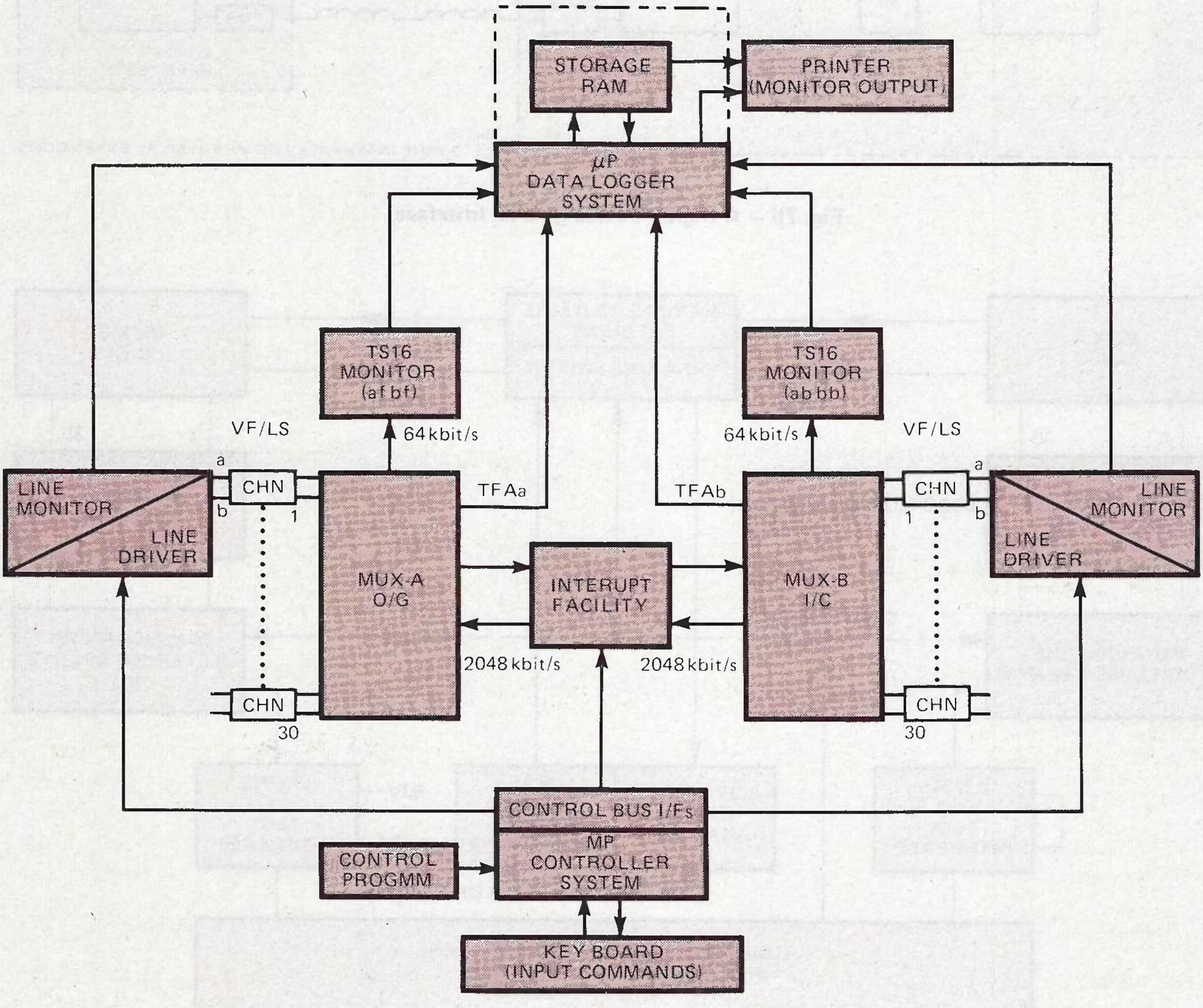


Fig. 9 — Block Diagram of a Signalling Test Facility

NETWORK APPLICATIONS

All combinations of analogue and digital exchange connections are catered for with digital exchanges able to accommodate either the VF loop interface for individual circuits or groups of up to 30 circuits by means of the 2048 kbit/s interface. **Fig. 3** and **4** give typical applications.

Situations occasionally arise where VF extension or the avoidance of the inbuilt hybrid is desired. A special version of the loop equipment has been developed for this application and **Fig. 5** and **6** show the concept known as the 6 wire equipment. **Fig. 7** shows possible application of 2 wire VF extension equipment.

TESTING OF PROTOTYPES

As this equipment was novel and based for the greater part on theoretical studies supported by computer modelling there was a need to perform more than the normal prototype testing associated with equipment for Telecom. Also for the first time in Australia transmission equipment performance was going to depend on the correct implementation of computer software. New techniques were to be developed. New measures of compliance were to be established. The testing programmes for each of the two manufacturers chosen were a combination of the manufacturers' knowledge of their system design and Telecom's ability to test the equipment in the real network environment.

There were essentially two categories of testing to be performed, testing against the specification, and now that prototype equipment existed, testing in the real network with further computer modelling to ensure that there were no unforseen problems. Tests therefore were set against five distinct phases.

- Transmission performance testing: The equipment was tested against the network and specification requirements. Temporary modifications to the terminal units were required to place the equipment in a transmission mode since the internal logic operations insert terminations across the hybrid under idle conditions. Interference to transmission from loop and reversal conditions within the channels under test as well as from other channels in the system was also tested. Where possible commercially available test equipment was used although custom test units were required for some specialised tests. **Fig. 8** shows the overall VF transmission test block diagram.
- Signalling Performance testing: The signalling facilities of the loop PCM are obviously complicated and some of the manufacturer development tools were used by Telecom as analysis methods. Tests were directed at the System Description Language, the system software, the interface conditions and the overall timing of operations. Both normal and abnormal conditions were applied, resulting in some cases in a need for changes in the loop PCM interface hardware. Extremes of operating voltages, looping resistance, and exchange battery voltage and noise were applied. **Fig. 9** shows the testing block diagram and **Fig. 10** shows a typical test sequence and result.

CHANNEL-1	SYSTEM INPUT				TIME	SYSTEM OUTPUT						
TEST COMMAND	LOOP	TFAa	POL	TFAb	(SEC)	LPIN	LOOP	POL	Af	Bf	Ab	Bb
*												
*TEST 3.1												
*												
*--$IDLE												
*												
*IDLE												
*												
OPEN	OPEN											
NORMAL			NOR									
WAIT 3000												
VERIFY OPEN NOR 10 10	OPEN		NOR		3.02	OPEN	OPEN	NOR	1	0	1	0
LISTON												
CLOSE	CLS											
SAMPLE 60,1	CLS		NOR		3.065	CLS	OPEN	NOR	1	0	1	0
					3.068	CLS	OPEN	NOR	0	0	1	0
					3.091	CLS	CLS	NOR	0	0	1	1
					3.124	CLS	CLS	NOR	0	0	1	1
REVERSE			REV									
WAIT 500												
VERIFY CLS REV 00 01	CLS		REV		3.925	CLS	CLS	REV	0	0	0	1
NORMAL			NOR									
SAMPLE 60,1	CLS		NOR		3.965	CLS	CLS	REV	0	0	1	1
					4.024	CLS	CLS	REV	0	0	1	1
OPEN	OPEN											
SAMPLE 2000,1	OPEN		NOR		4.35	OPEN	CLS	NOR	0	0	1	1
					4.617	OPEN	CLS	NOR	1	0	1	1
					4.639	OPEN	CLS	OFF	1	0	1	1
					4.642	OPEN	OPEN	OFF	1	0	1	1
					5.309	OPEN	OPEN	OFF	1	0	1	0
					5.333	OPEN	OPEN	NOR	1	0	1	0
					6.349	OPEN	OPEN	NOR	1	0	1	0

Fig. 10 — Typical Test Sequence and Corresponding Monitor Output.

- Operation in the telephone network. One of the major testing systems used was Telecom's model exchange where elements of all exchange types used in the network can simulate the real network. **Fig. 11** shows a typical test configuration. In this way some potential problems were identified and modifications made to both hardware and software. The final implementation overcame all the problems, thus demonstrating the value of thorough testing at the prototype stage.
- Environmental testing: Recent developments have indicated that equipment involving microprocessors and logic are very suceptable to interference. So along with normal environmental tests, special high impulsive field testing was performed by the manufacturers. The modifications that followed helped to produce a robust system software structure.
- Compatibility with AXE digital exchange equipment: The T6 signalling scheme was placed under close scrutiny to ensure compatibility with the digital exchange software.

CONCLUSION:

This joint project to produce an Australian loop PCM system has been very successful. Australian industry has demonstrated that it can respond to the requirements of a major user like Telecom producing equipment of the highest performance and quality in the commercial world environment.

REFERENCES

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2. M. P. Quigley, B. F. Orr and D. L. Neville 'PCM Loop Multiplex Equipment with T6 Signalling,' Telecommunications Journal of Australia Vol 33, No 3, 1983.

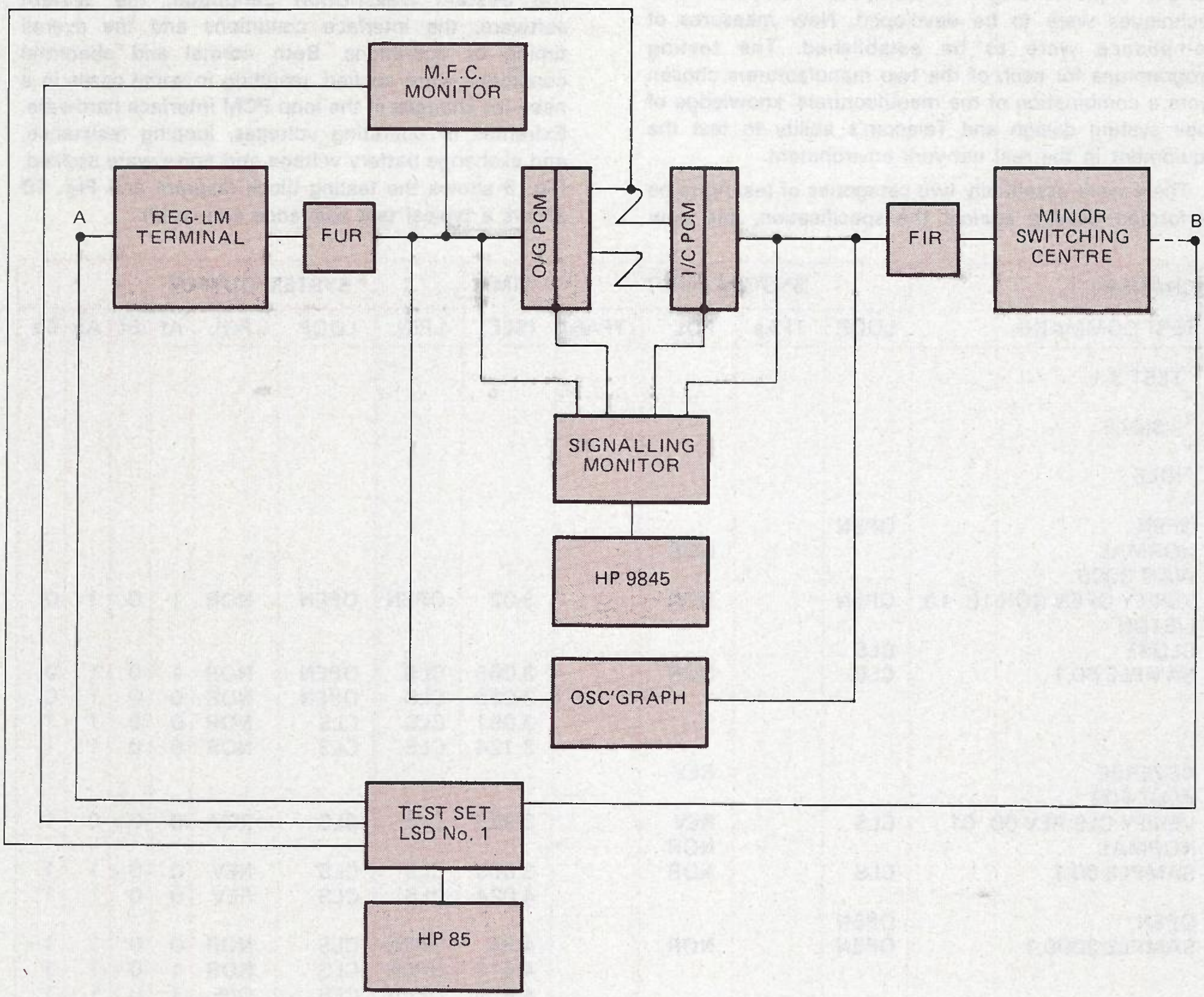

Fig. 11 — A Typical Network Test Configuration.

PCM Loop Multiplex Equipment with T6 Signalling

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The introduction of digital PCM 30 channel multiplex equipment into the Australian network is being accelerated as part of the trend towards an integrated digital network. 2-wire loop interface equipment for the Australian network and in particular its special signalling requirements had not previously been available. This gave the Australian manufacturing industry the opportunity to design and manufacture a new line of equipment to Telecom's specification for what is now known as the PCM Loop Multiplex Equipment. This article describes some of the design factors considered by Standard Telephones and Cables Pty. Ltd. (STC) and a summary of some of the innovative features as well as a general description of the resulting equipment.

INTRODUCTION:

Telecom Australia's requirements are for a 30 channel PCM multiplex equipment which can be applied directly as a replacement for physical pairs in the inter-exchange network without the need for additional relay sets or the high volume of wiring necessary with the existing double E & M signalling PCM systems. As outlined in the companion article in this issue **(Ref. 1)** there are some special signalling states used in the Australian network which are not provided for in the 2-wire PCM systems which are in general used overseas. This enhanced signalling scheme is known as T6. Simple modification of the available equipment types was not possible and several new techniques were introduced by STC in the process of the development. Extensive use of new technology including on-board micro-processors was necessary to overcome some of the problems which have plagued designers since the universal derived 2-wire line was first sought.

The equipment was designed in the Australian "Type 72" construction practice from the mechanical point of view and is compatible with the proposed "Type 84" modification of this practice. As outlined in the companion article, the design had to be able to co-operate with the internal signalling schemes of digital exchanges bringing even closer the concept of integrated switching and transmission. It is almost needless to record that there has been close co-operation between STC and Telecom in this development.

Junction Circuits and Line Signalling

Fig. 1 shows a diagram of a typical connection between a calling and called subscriber via two exchanges. The Loop Multiplex equipment provides the complete conversion process between the exchange relay sets and a digital line. In L type relay sets which are commonly used on 2-wire physical junction circuits, signalling information is conveyed by means of DC currents and voltages on the two-wire line. Forward signals, i.e. those in the direction of call set-up, are conveyed by opening and closing the current loop, whereas backward signals are conveyed by voltage polarities. A diagram illustrating this scheme is given in **Fig. 2.**

Signalling In 30 Channel PCM Systems

30 Channel primary PCM systems, as recommended by the CCITT **(Ref. 3)** provide a total of thirty two timeslots, of which 30 are used for voice frequency (VF) or data signals, one is used for synchronization and the remaining timeslot is used for conveying the signalling information associated with each VF channel.

Each 64kbit/sec timeslot comprises 8 bits and the signalling timeslot is divided into two groups of four signalling bits designated a, b, c and d., which provide each VF channel with four 500bit/sec signalling channels. The T6 signalling system makes use of only two of the four signalling channels available.

EQUIPMENT DESIGN:

The three basic functions performed by the STC Loop Multiplex Equipment, illustrated in **Fig. 3,** are:—

- Conversion of the 2-wire VF signals to and from a 4-wire format so that digital encoding and decoding can be carried out on a per channel basis by an integrated codec.

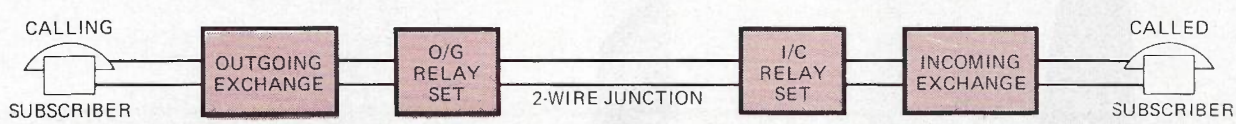


Fig. 1. 2-wire physical junction.

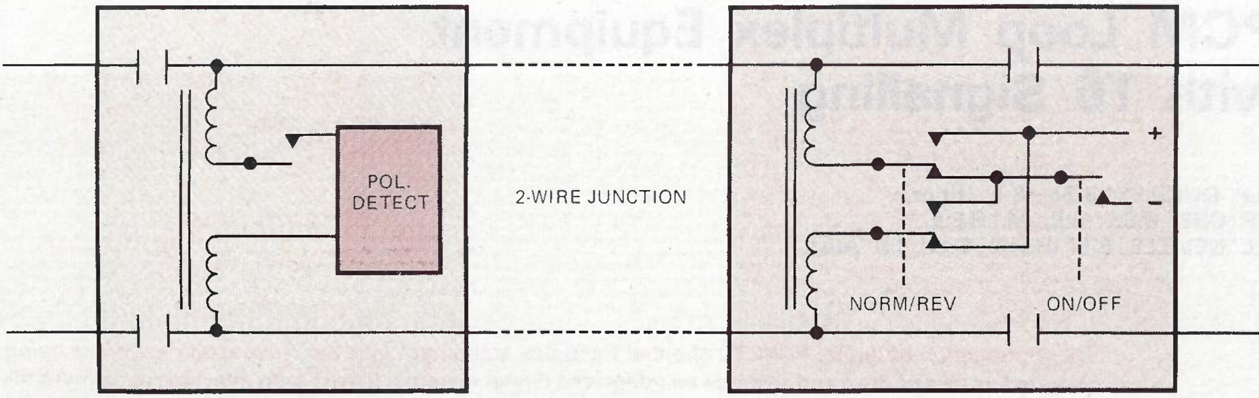


Fig. 2. Basic elements of L-type relay sets.

MICHAEL QUIGLEY (left) joined STC as a cadet engineer in 1971 and graduated from the University of New South Wales with a degree in Science in 1975 and an Honours degree in Electrical Engineering in 1977.

At the completion of his studies he joined the Line Transmission Division as a Design Engineer where he worked on the development of FDM transmission equipment including Channelling and Supergroup Modems and Carrier Supplies.

He was subsequently appointed Senior Design Engineer for Digital Multiplex equipment and was responsible for the development of the TSD-2 range of primary and higher order multiplex equipment.

Michael is currently Project Manager for Primary PCM and Higher Order Digital systems.

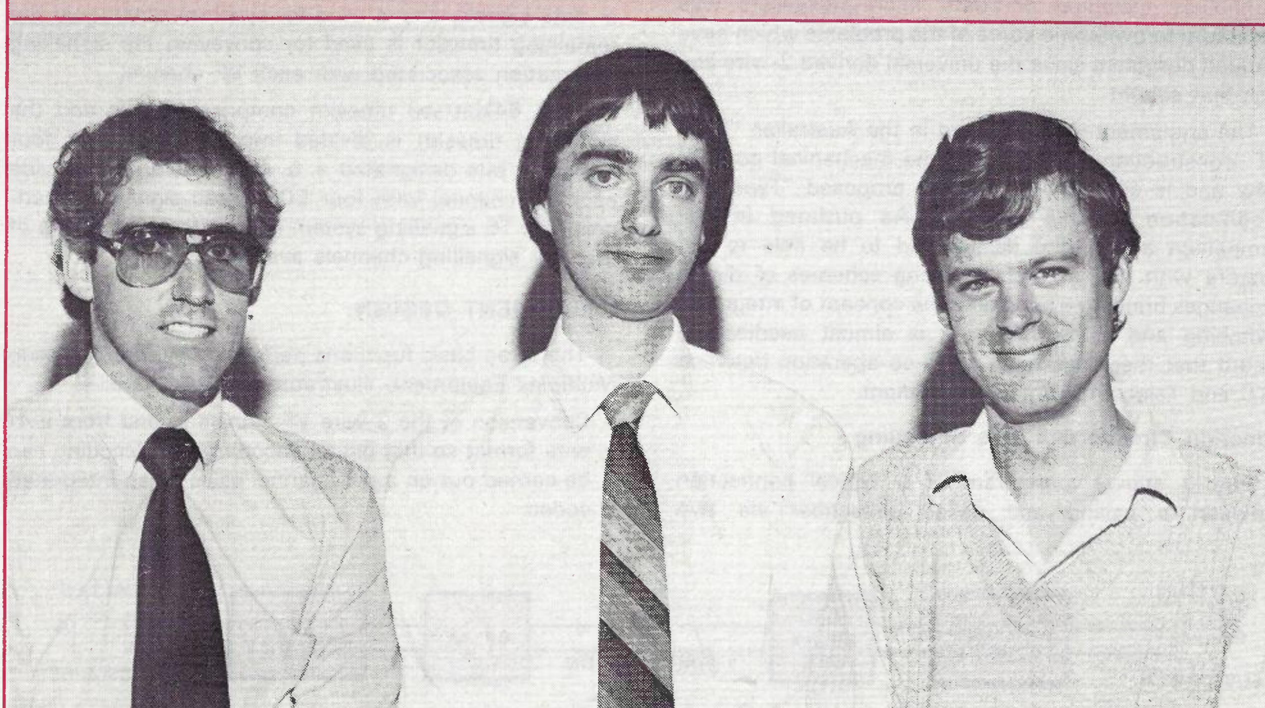
BRUCE ORR (centre) graduated from the University of Sydney, with a degree in Science in 1978 and a degree in Electrical Engineering (Communications) in 1980.

After completing his studies he joined the Data Systems Divison of STC where he was responsible for computer hardware/software support.

Bruce joined the Line Transmission Enineering Division in 1981 and became involved in the design and development of PCM signalling subsystems. He is currently Project Engineer responsible for Higher Order Digital Multiplex equipment.

DAVID NEVILLE (right) graduated from the University of Newcastle in 1981 with an Honours Degree in Electrical Engineering. During his final year he presented a thesis on a demonstration PCM system.

He joined the Line Transmission Division of STC as a Design Engineer in the same year. Since then he has had a continued involvement with PCM Loop Multiplex Equipment, including hardware design, prototype testing and system documentation.



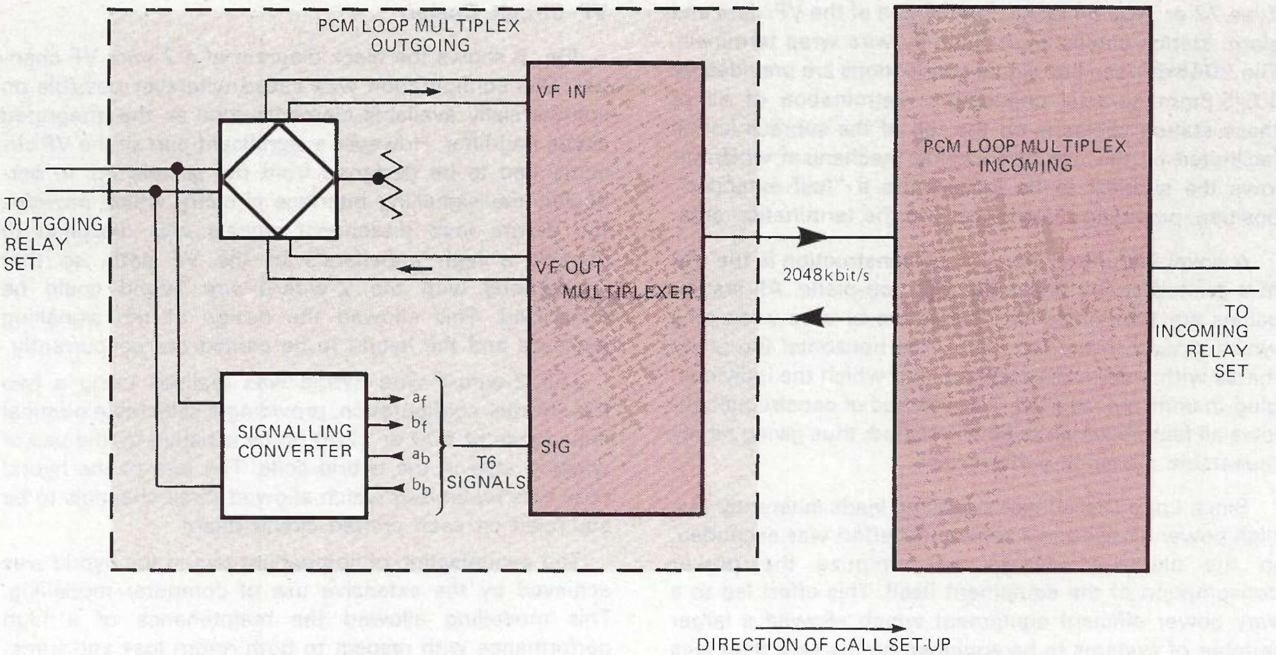


Fig. 3. Basic functions of a loop multiplex terminal.

- Conversion of the 2-wire Loop disconnect signals such as ***idle, seizure*** and ***answer*** into a digital format for insertion into the appropriate position in the signalling timeslot. Due to the complexity inherent in the T6 signalling system a microprocessor is used to perform the necessary signal processing required during the conversion process.
- Multiplexing and demultiplexing of the VF, signalling and alignment information to and from the 2048kbit/sec composite signal. This is a function which is common with that performed by a standard E & M Multiplex Terminal.

The design approach which was adopted by STC was to integrate the equipment needed to provide these three functions into one subrack. This leads to the most cost effective solution since it eliminates the considerable amount of interconnection wiring which would be required if the 2-wire/4-wire and signalling converters were housed in a separate subrack to the multiplexing equipment.

Equipment Configuration

The subrack, which is shown in **Fig. 4,** houses a total of 16 plug-in units of which 6 form the common equipment with the remaining 10 plug-in positions housing the channel units. There are four different types of channel units available, two 2-wire units which provide the interfaces to the outgoing and incoming relay sets at each end of ther junction, and two 6-wire units where 4-wire VF interfaces are required. All types of channel card are equipped with 3 channels which contain an integrated filter and codec and either an outgoing or incoming signalling circuit, and in the 2-wire varieties a 2-wire/4-wire hybrid is provided. The common equipment comprises a DC/DC converter operating at 60kHz from the 48V station battery supply, two logic units, an alarm unit and a signalling control unit. The two logic units provide the common multiplexing and demultiplexing functions as well as the coding and decoding of the composite binary signal to and from a HDB-3 format, which is the 2048kbit/sec interface for line and higher order multiplex equipment. The signalling control unit contains a microprocessor and associated memory and provides the processing required by the T6 signalling scheme. This unit will be discussed in greater detail in a later section.

In addition, an optional data access unit may be equipped which upon operation of two independent switches allows two timeslots to be used to convey 64-bit/sec data.

Mechanical Design

The STC Loop Multiplex Terminal, shown in **Fig. 4** is a 9 rack unit (400mm) subrack which mounts on Telecom

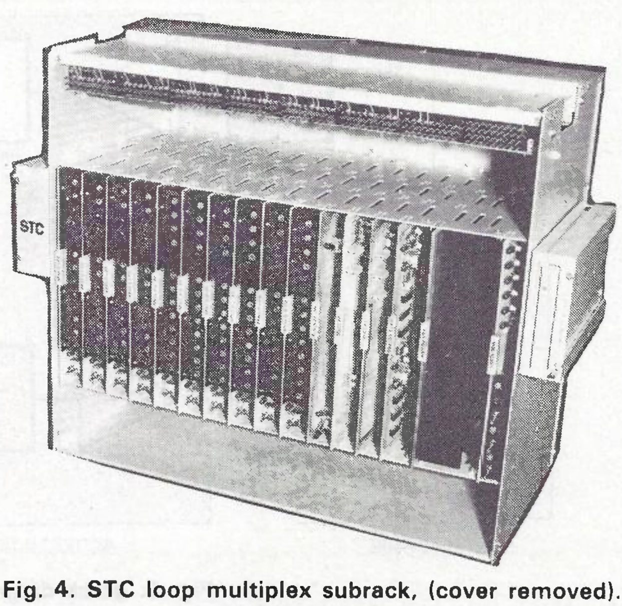


Fig. 4. STC loop multiplex subrack, (cover removed).

Type 72 or Type 84 racks. Connection of the VF, data and alarm station cables is provided by wire wrap terminals. The 2048kbit/sec line signal connections are provided by 1.6/5.6mm co-axial connectors. Termination of all of these station cables is on the top of the subrack and is facilitated by the use of a locking mechanism which allows the subrack to be locked into a "half extended" position, providing ready access to the termination area.

A novel feature of the subrack construction is the use of a printed circuit backplane and top-plane. All station cables are terminated on connectors or wire-wrap pins which mount on the top-plane. The horizontal top-plane mates with a vertical backplane into which the individual plug-in units are inserted. This method of construction allows all factory wiring to be eliminated, thus giving highly repeatable crosstalk performance.

Since Loop Disconnect signalling leads inherently to a high power dissipation a substantial effort was expended, in the electrical design, to minimize the power consumption of the equipment itself. This effort led to a very power efficient equipment which allowed a larger number of systems to be equipped on the rack than was originally anticipated. In addition, special consideration was given, during the mechanical design, to the problem of temperature rise within the subrack. Concurrently, the problem of shielding of electromagnetic radiation emitted from the equipment had to be considered. These two problems normally impose conflicting requirements upon the mechanical design.

A solution was found, which allowed both requirements to be met simultaneously, involving the use of thermal plenums (essentially open air spaces above and below the horizontal shelves containing the plug-in units). By the strategic placement of ventilation holes in the subrack front cover, and the selective placement of vents on the equipment shelves, controlled air flow was obtained which maintained a uniform temperature gradient across the subrack. These principles, although well-known in engineering areas such as air conditioning, do not seem to have been widely applied to transmission equipment.

VF Circuit Design

Fig. 5 shows the block diagram of a 2-wire VF channel. This configuration was based wherever possible on commercially available elements such as the integrated codec and filter. However a significant part of the VF circuitry had to be designed from the ground up. In particular, the signalling interface circuitry which provides the 2-wire loop disconnect signals was designed to present a high impedance to the VF path, so that interactions with the 2-wire/4-wire hybrid could be minimised. This allowed the design of the signalling interface and the hybrid to be carried out concurrently.

The 2-wire/4-wire hybrid was realised using a two transformer configuration, providing a selectable nominal impedance of 600 or 1200 ohms resistive by the use of winding taps in the hybrid coils. The size of the hybrid coils was minimised which allowed three channels to be equipped on each printed circuit board.

The minimisation of component size in the hybrid was achieved by the extensive use of computer modelling. This modelling allowed the maintenance of a high performance with respect to both return loss and trans-hybrid loss under worst case component tolerance values. A complete sensitivity analysis provided information as to the effect of each component value variation on the critical performance parameters.

Results of early simultations indicated the need to constrain component tolerances, particularly in the hybrid coils. A gapped core design was therefore used, and in order to overcome the resulting problem of reduced coil inductance on return loss, a DC blocking capacitor was used which was then included in the overall design.

Termination network components were shown, in further simulations, to require tolerances of better than 5%. The hybrid coils were therefore designed to perform an impedance scaling operation of 1 to 5 on this network, to allow the use of close tolerance low value polystyrene capacitors. Higher scaling ratios were avoided due to the increasing effects of leakage inductance.

The VF channel performance, as an outcome of careful design and use of proprietary filter and codec IC's,

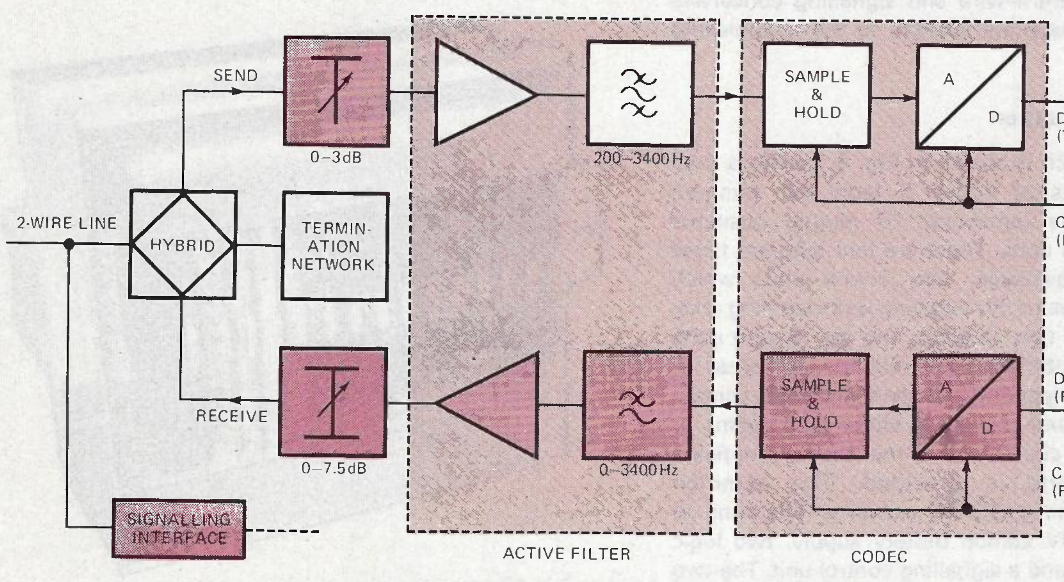


Fig. 5. Block diagram of channel unit.

surpasses all CCITT recommendations and special requirements for the Australian Network.

Signalling Interface Circuits

The main factor to be considered in the design of the incoming and outgoing signalling interfaces was the provision of multimetering capability. The multimetering system uses "silent" reversals of line polarity to convey meter pulses, with the frequency of pulses setting the charging rate on a time-metered call.

As metering pulses may occur during the progress of a call, they are required to be smoothed so as not to contain significant components in the audio frequency band which might cause distraction to the subscribers. In the past this smoothing has been achieved by feeding the metering pulses onto the line through low-pass filter sections consisting of large value inductors and capacitors. It has also been necessary to provide similar filter networks on incoming interfaces to isolate noises produced by any non-linearities in the current looping circuit from the VF path. While this conventional approach has proved to be moderately effective in reducing metering noise on trunk circuits to a low level, it requires the use of costly and physically large inductors and capacitors.

In order to overcome the problems of this conventional approach, high performance electronic replacements for these filters were developed. The new circuits occupy less than a quarter of the volume of the conventional filters, and use no costly components.

Spectral analysis tests on the outgoing interface have shown that, compared with typical inductor/capacitor style filters, reversal noise is reduced by 10 to 30dB for exchange relay loads and 600ohm resistive loads respectively. This reduction in metering noise is considered to be a worthwhile improvement, especially when the PCM link is used on a time metered call to carry datel traffic.

The incoming interface has been designed to provide a continuous path for loop currents undergoing reversal, while ensuring that harmonic generation during reversal is kept to a low level. In addition it provides a pulsed double current feature to ensure reliable operation of connected relay sets, while minimising power requirements.

Signalling Control Unit

While microprocessors have been used overseas in PCM loop signalling equipment for a number of years, local signalling requirements have required the development of enhanced control features and a level of processing throughput not previously achieved in equipment of this type. This high level of performance has been realised through the combination of novel hardware design and carefully structured real-time software.

Processing functions of the unit are performed by a single high speed 8085 microprocessor operating at a clock rate of 4MHz. Two high speed 4K byte EPROM memories are used to hold the control software (8K total), and a third EPROM may be fitted to expand the capacity to 12K if required in the future. The 8085 was selected from the wide range of microprocessors available because of its built in interrupt handling capability, its low cost, and the small number of support chips required. An address mapping circuit working in conjunction with the processor preformats signalling information associated with the 30 channels into an efficient virtual data structure. This feature considerably reduces the overhead associated with handling the signalling information and allows the single microprocessor to accept a greater workload.

The signalling control unit communicates with the channel units via a buffered extension of the processor's data bus which runs along the backplane. By judicious choice of channel addressing and control signals the amount of signalling interface logic required on the channel units has been minimised, leading to cost savings and reduced power requirements.

A supervision system has been provided to continuously monitor the performance of the signalling controller and will restart the processor in a controlled manner if a transient disruption should occur. Transients large enough to effect the equipment would be unusual in a normal exchange environment, however, fully automatic recovery is implemented as an additional safeguard. A first level of system protection is provided by two hardware circuits that monitor the execution of the software control program. The first of these circuits is a "watchdog" timer which will generate a "trap" interrupt if the control program fails to complete a processing cycle in an allowed time, or if processing halts completely. The remaining circuit will generate a "trap" interrupt if the processor attempts to fetch an instruction from outside the defined program memory space.

The trap interrupt has the highest priority and causes an immediate branch to the recovery section of the software. As it is important to preserve existing call status information whenever possible, the first level of recovery restarts the program with the contents of random access memory (RAM) being assumed to be valid. This type of recovery is referred to a ***warm start*** and will restore correct system operation in most cases. If correct operation is not restored and a further two warm starts occur in a 12 second period than a ***cold start*** is initiated. This discards existing data and the controller is re-initialised.

Additional monitoring facilities have been provided in software to detect some types of hardware faults. These include write/read checking of RAM memory, checksum verification of ROM memory, and checking for the presence of clock signals. If a hardware fault is detected then the 'signalling control fail' alarm is raised and held as long as the fault persists. This alarm will also be raised by hardware if the processor fails to respond to a trap interrupt.

Control Software

The primary function of the control software is to implement the Telecom T6 signalling scheme as defined in the Telecom Specification **(Ref. 2)**. This specification uses System Descriptive Language (SDL) charts to describe the T6 protocol **(Ref. 4)**. Through the use of time-sharing techniques this protocol is implemented simultaneously and independently for each of the 30 channels. In addition to this primary function, the software also performs a number of secondary or background functions such as continuous self-testing and

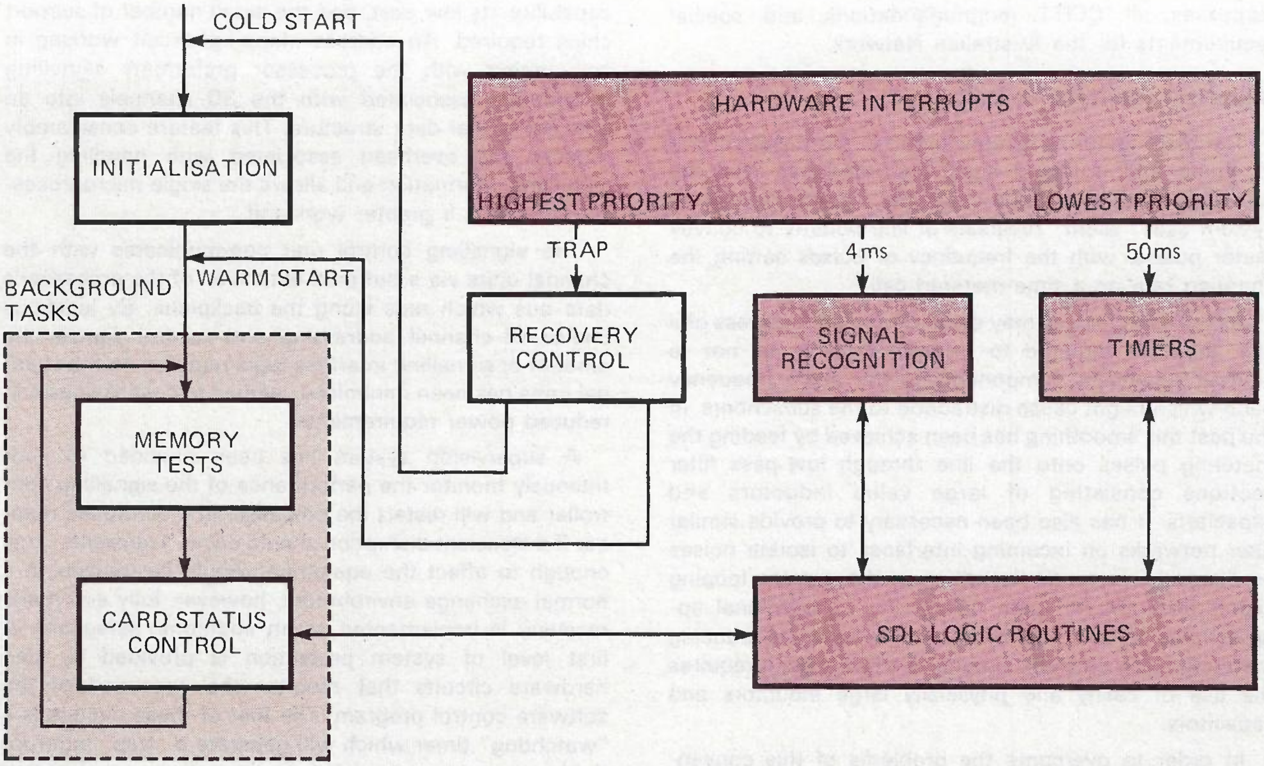


Fig. 6. Software functions.

card status control. **Fig. 6** gives a general overview of the software structure.

Periodic interrupts are used to initiate the primary system functions, with signal scanning and recognition performed every 4ms, and timer processing every 50ms. The use of interrupt driven software to implement the 60 timers required by the system eliminates the need for timer adjustments and allows the delays to be programmed in increments of 50ms as required.

The background functions of the software are performed in the remaining time periods when the primary functions are inactive. A channel blocking facility has been incorporated as part of the card status control routine to scan the blocking switches on the channel units. When one of these switches is operated, the control softrware blocks the channels on that unit as they become free. When all three channels are blocked an indicator on that unit is illuminated. The unit may then be removed for service without the risk of disrupting traffic.

One of the aims of the software development was to provide a simple means for the definition and updating of the signalling protocol. This was achieved through the development of an SDL compiler program, which takes the SDL logic in the form of simple tables and automatically produces an efficient machine code form.

Signal Recognition

The signalling reliability of a PCM system can be enhanced through the use of noise rejecting recognition procedures for signal inputs. By careful choice of these procedures the effects of noise on signalling performance in this equipment has been minimised.

In the case of recognition of T6 signals from the incoming bitstream an optimum recognition technique was derived using computer simulations based on the statistical nature of errors in PCM digital bearers. The recognition method employed for 2-wire line signals was modelled on a method employed by large stored program controlled (SPC) exchanges. In this case, the primary cause of noise is contact bounce in the feeding relay sets, and the method has been selected to minimise its effects on critical signals such as decadic pulses.

SYSTEM TESTING

Within the Line Transmission Laboratory of STC extensive testing is performed on all prototype equipment prior to commencement of large volume manufacture. In the case of the Loop Multiplex equipment, this prototype testing assumed even greater importance due to the following three factors:

- The equipment was being designed to a new specification.
- Very little of the equipment could be based on an existing product, hence a considerable amount of fundamental design was required.
- This was the first hardware implementation of the new T6 signalling scheme.

Although it could be argued that the tasks of equipment specification and equipment design can be readily separated, it was recognised at an early stage, by both Telecom and STC, that close co-operation during the specification and design phase would increase the probability of a successful, on time, introduction of this equipment into the network. This co-operation was a continuing aspect of the project and following discussions and testing in the laboratories of STC and Telecom a number of potential problems were identified and eliminated.

In order to perform the extensive testing required it was realised that special techniques and test equipment would be needed, particularly to verify the signalling performance and SDL logic. Hence a parallel development program was undertaken to develop test equipment which allowed both the 2-wire line conditions and the 2 MBit/sec digital stream to be monitored and also provided special facilities for generation of call states, simulation of a high level of traffic, an accurate recording of event times for later analysis and the controlled interruption of the digital bearer to simulate fault conditions. The resulting test system was based on the use of a desk top computer to control a variety of signalling interfaces, and is shown in **Fig. 7**.

A large amount of software was developed to provide real-time control of the various interfaces, allowing simulated exchange traffic to be generated and the results to be monitored. This software was designed to facilitate man-machine interfacing via a specially developed test language with commands resembling the desired test events. With the development of this test system it became feasible to perform quite complex signalling sequences requiring accurate timing and generation of special conditions such as transmission fault alarms.

As part of the testing phase a visiting group from Telecom spent a week at STC gaining familiarity and experience with the Loop Multiplex equipment and the testing system. During their visit a variety of normal and special call sequence tests were performed. When the equipment was later tested on the model exchange, the STC testing system was provided to supplement the model's testing facilities. In addition extra hardware and software was developed by STC to allow recording to be made of the 2-wire line conditions and the TS16 signalling bits during traffic tests. This allowed printed records to be obtained with all event times recorded, supplementing the graphs of 2-wire line voltages obtained using an oscillograph.

The companion article in this issue **(Ref. 1)** gives some examples of the outputs obtained using this testing equipment and outlines the testing performed by Telecom staff at the model exchange.

CONCLUSION

This paper has described the design approach adopted by STC in a fully Australian development to fulfil the requirements of Telecom Australia in respect to the provision of a new type of PCM multiplex equipment for use with the T6 signalling scheme.

The close co-operation between the various groups within Telecom Australia and STC has led to the development of a product which meets the needs of the Australian PCM network, at a minimum cost and within the timescale required.

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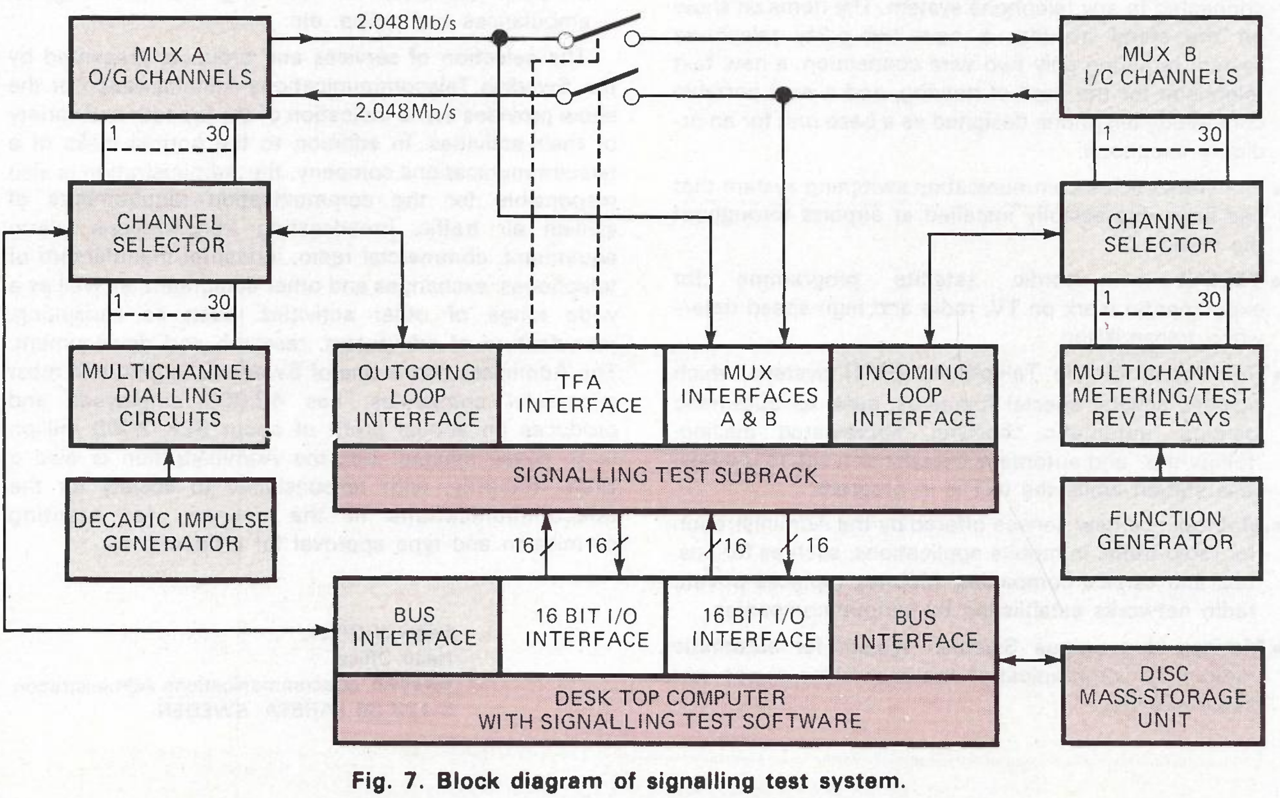

Fig. 7. Block diagram of signalling test system.

Information Transfer Industry News
Focus on Swedish telecommunications

An entirely new generation of products and services offered by the Swedish telecommunications administration will be on show at Telecom 83 in Geneva. They are as follows:

- A new computer system for all types of subscriber services and designed to handle sales routines, invoicing, network planning, fault notification and so on. The system covers all of Sweden's subscribers and is continually updated.
- **Ellemtel** — the research and development company owned jointly by the Swedish Telecommunications Administration and L.M. Ericsson. One of the achievements of Ellemtel is the successful AXE digital exchange system.
- The management training programme of the Swedish Telecommunications Administration for key personnel in telecommunications administrations of developing countries.
- **Swedtel** — a subsidiary of the Swedish Telecommunications Administration — offers its consultancy services to telecommunications administrations throughout the world, for project design of telecommunications networks and exchanges, for digitalisation projects, etc.
- **Swedcom** — the international sales company of the Swedish Telecommunications Administration — will be showing various facets of its activities.
- A number of new telephone accessories is presented by **Teli** the manufacturing unit of the Administration. The accessories are designed as separate units that can be connected to any telephone system. The items on show on the stand include: a new two-party telephone system requiring only two-wire connection, a new text telephone for the hard of hearing, and a new portable conference telephone designed as a base unit for an ordinary telephone.
- The **Garex** voice communication switching system that has been successfully installed at airports throughout the world.
- **TELE-X** — Nordic satellite programme for experimental work on TV, radio and high-speed data/-video transmission.
- The Nordic Mobile Telephone (NMT) system which includes several special functions, such as automatic roaming, automatic charging, abbreviated dialling, "follow-me" and automatic transfer of a call to the best base station while the call is in progress.
- **Mobitex** is a new service offered by the Administration for radio traffic in mobile applications, such as for bus, taxi and service companies. Mobitex replaces private radio networks established by various companies.
- **Maritex** is a unique Swedish system for automatic radio telex communication between ships at sea and coast stations.
- **Infocoast** is a traffic and information handling system for coast radio stations, although it can also be used for other purposes. At the TELECOM show, Infocoast can be used to obtain information on the systems and services the Administration have on show.
- **MBS** and **PI** are radio data systems designed for the transmission of digital information in parallel with normal FM radio transmissions on a sub-carrier wave.

  MBS is an advanced paging system that can reach you wherever you can listen to an ordinary radio. The information is transmitted inaudibly throughout the country in parallel with the normal radio programmes, and the paging unit of the person being paged will then show the telephone number of the caller.

  PI stands for Programme Indication and is a radio data system designed for the transmission of text and control information to radio receivers. A display gives the listeners information on the programmes, and the receiver simultaneously obtains information on how it is to tune itself for best reception. The PI system is virtually infinitely variable and can be used for a wide variety of applications, such as transmission of spoken "newspapers" to the blind, transmission of data programmes and remote control of alarm processes. The PI system has been adopted as a European standard for the EBU radio data system.
- **R85** is an integrated communication system for text, data, telephony and radio, in addition providing administrative computer support and log books of the traffic. The system can be used for applications such as in alarm centres, for directing the fire brigade, ambulances and police, etc.

The selection of services and products presented by the Swedish Telecommunications Administration at the show provides some indication of the breadth and variety of their activities. In addition to the normal tasks of a telecommunications company, the Administration is also responsible for the communication requirements of civilian air traffic, broadcasting transmissions, alarm equipment, commercial radio, industrial manufacture of telephones, exchanges and other equipment, as well as a wide range of other activities, such as consulting, manufacture of computers, research and development. The Administration is one of Sweden's largest and most successful companies, has 43,000 employees and produces an annual profit of about SEK 2000 million (U.S. $260 million). But the Administration is also a State authority, with responsibility to society for the telecommunications in the country, for granting permission and type approval for products, etc.

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Economic Analysis — Uncertainty and Risk

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Following a brief introduction of general principles, this series of articles discussed some aspects which cause problems when telecommunications projects are being evaluated. The opportunity has been taken in these articles to explore somewhat contentious areas, by discussing advantages and disadvantages of various approaches, leaving the reader to decide which approach is relevant to a particular economic evaluation.

INTRODUCTION

This is the final article in a series of three which discuss the principles and practices involved in economic evaluation of project proposals. In this article the techniques known as Sensitivity Analysis and Risk Analysis will be discussed, and the requirements of a post-implementation review or audit of capital expenditure will be considered.

SENSITIVITY ANALYSIS

The problem of uncertainty dogs every investment decision, as each such decision involves an assessment or prediction of future events relevant to the investment. Typical hedges against uncertainty involve the imposition of stringent hurdles on projects. A very limited pay-back period may be set, or the notional discount rate imposed may be increased, thereby raising the required internal rate of return of a project.

Such measures do not really overcome the problem of uncertainty in investment evaluation. Rather, they avoid the problem and simultaneously make it more difficult for projects to gain approval.

Sensitivity analysis is the generally accepted approach which is used to allow for uncertainty and involves varying one or more input variables to determine the impact on the final result (Net Present Value or Internal Rate of Return). In other words sensitivity analysis provides answers to 'what if . . .?' questions, e.g. 'What if equipment installation and testing costs increase by 100%?'.

In order for sensitivity analysis to be usefully applied it is first necessary to determine broadly which input variables (e.g. annual operating costs, timing assumptions used for staged implementation, labour savings) are most likely to have a critical effect on the result of the economic evaluation criterion and/or which input variables are most likely to be subject to considerable uncertainty. Sensitivity analysis is then performed by varying the input values of one or more critical variables and noting the effect of this variation on the answer.

By this approach it should be possible to determine how crucial to the project's success different variables are, and the tolerance afforded by these variables to enable the project to remain economically viable. Attention can then be focussed on the critical elements to see if they have been considered adequately when formulating assumptions.

Any critical elements identified by use of sensitivity analysis should be highlighted. The possible impact of the critical elements on the economic viability of the project should also be stated.

Assume that it is proposed to upgrade an existing register of stores holdings. Currently the register is maintained on an external computer bureau and run in batch mode. The proposal is to upgrade this system, having an estimated seven-year life, to on-line operation on the in-house computer.

The only directly measurable benefits of the proposed new system are the savings of running costs on the external bureau's computer and the reduction of labour costs. The relevant costs and benefits for the proposal are summarised in Table 1.

	$ (1983 prices)
1. Systems Development, Testing, and Implementation	73,140
2. Annual Systems Operating Costs	18,150 p.a.
3. External Bureau Savings	26,180 p.a.
4. Labour Savings	29,820

TABLE 1 — Assumed Costs and Benefits

It is uncertain however, if in fact the labour savings will be achieved. Further, the estimated systems development, testing and implementation costs could

	Systems Development Costs ($)	Operational Savings ($)	NPV at 28% ($)	IRR (%)
Original Proposal	-73,140	28,820 p.a.	85,605	67.07
No Operational Savings	-73,140	0	-47,413	-3.68
Increased Development Cost	-109,715	28,820 p.a.	49,033	43.91

TABLE 2 — Sensitivity Analysis Results

well be 50% higher than shown above. Sensitivity analyses have been performed to estimate the impact of the uncertainty surrounding the labour savings and development costs on the economic viability of the proposed system.

The results of the sensitivity analysis are summarised in Table 2.

Hence the achievement of the stated labour saving is very critical to the economic viability of the proposed upgraded system. The sensitivity analysis has also shown that provided all other claimed costs can be contained and benefits achieved the proposed system is still economically viable even with an increase of 50% for systems development costs.

RISK ANALYSIS

Risk analysis is a somewhat more complex approach to the same problem of uncertainty. Whereas sensitivity analysis tells us how the result of our study varies as the various inputs change, risk analysis attempts to quantify the risks involved. That is, probabilities are assigned to a range of possible values of the input parameters, and probability theory is applied to determine the expected outcome as well as the variability of that outcome.

For example, a company has decided to launch a new product. Their economic study was based on five variables; advertising expenses, total market, market share for new product, operating costs, and new capital investment. On the basis of most likely costs the project should return a healthy 30% return on investment. Each variable has been estimated, and a 60% chance of being correct is acceptable for such items. However, this means that the final result has only a chance of:

$$60\% \times 60\% \times 60\% \times 60\% \times 60\% = 8\%$$

of being correct. In fact the "expected" return depends on a rather unlikely coincidence! The company needs to know a lot more before making a decision on this matter.

Risk analysis provides a method of analysing outcomes when the input variables take on a range of values, and a large number of possible combinations. By associating a probability with each value of the input variables, the probability of the overall outcome can be estimated, giving a quantitative assessment of its variability.

The steps involved in a risk analysis simulation can be shown schematically as follows:

Risk analysis is generally performed using a computer program to enable numerous simulations of the project to be performed. The large number of repetitions of steps 4 & 5 may be as low as 100, or as high as several thousand, the latter clearly requiring the use of a computer.

Risk analysis does not replace sensitivity analysis nor does it overcome the problem of risk in the project. Sensitivity analysis identifies the areas of uncertainty which have the more crucial impact on a project and draws attention to the fact of uncertainty, highlighting the real lack of precision in the final discounted cash flow results that are generated. Risk analysis on the other hand indicates the expected result for the project together with a measure of the dispersion around this expected value the dispersion reflecting the risks of the project as measured by the input probabilities.

The assessment of probabilities, however, requires the introduction of subjective judgements. These may cause more problems than the additional analysis answers.

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Barbara Yeoh (centre) graduated from the University of Melbourne in 1969 with an Honours Degree in Science majoring in Mathematics. She spent three years as a Research Officer with the Bureau of Statistics before joining the PMG Department as a Senior Statistical Officer. Barbara has been with the Finance Directorate since 1976 and is currently Chief Finance Officer in the Financial Studies Section.

Bill Parry (left) is a Project Officer in Plans & Programmes Branch, Planning Division, Telecom HQ. He worked in engineering and personnel training in the PMG Department, and in Establishments in the Department of Transport and Telecom before gaining his present position. Bill has completed a Diploma of Public Administration and an Economics Degree.

POST-AUDIT REVIEWS

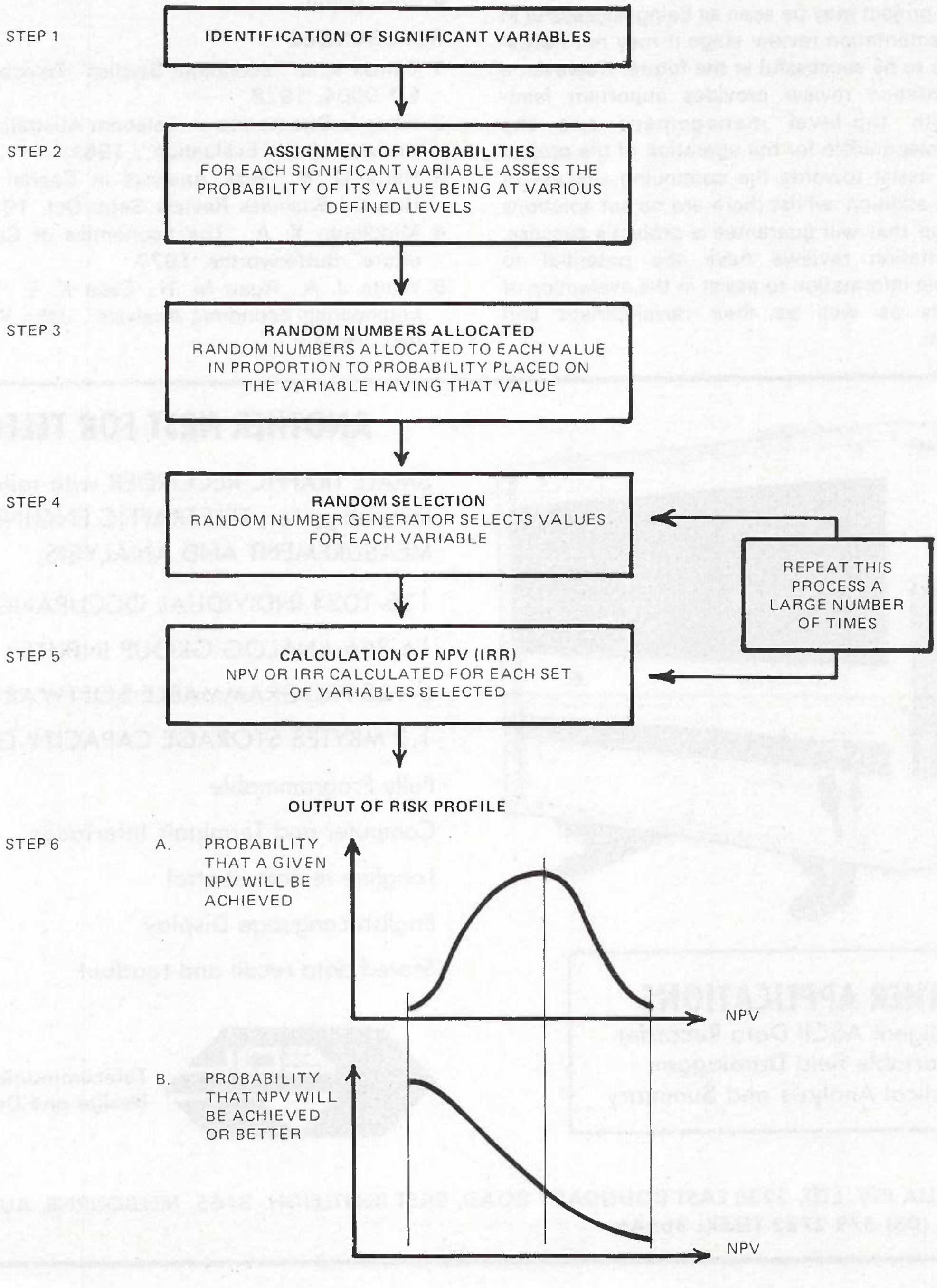
In the initial article of this series we stated that people feel they are too busy to undertake long term planning, and that such an omission can lead to inefficiencies. In the same way, people feel they are too busy to undertake post-audit reviews. "That is history, we have to make decisions now about tomorrow" is a typical response.

A post-audit, or post-implementation review is the monitoring and evaluation of a project's performance, including a comparison with the estimates made at the time the project was justified. Hence the prime objective of a post-audit review is to evaluate the success (or otherwise) of an investment decision, and to make this information available for future decision-making purposes.

Other objectives of a post-implementation review might include:

The identification and analysis of any problems encountered during the development, implementation and early life of a project and the subsequent recommendations for corrective action to enable the full potential of a project to be realised. Such an objective is particularly beneficial where staged development and implementation of a project is being undertaken.

The evaluation of management's abilities to formulate investment decisions through to their final implementation and control. Such an objective is not undertaken to criticise or emphasise what might have been done differently in the past but to indicate how things may be improved in future. Additionally, such an objective could assist in highlighting changes in organisational structure which will assist in the achievement of goals set by the organisation.



The selection of the objectives will be dependent on, inter alia, the type of capital expenditure being undertaken. Considerations will generally include the strategic importance of the project to the organisation, and the likelihood of similar projects being undertaken in the future.

The purpose of a post-implementation review is not to present a comprehensive history of the project but to evaluate concisely, at minimum cost, the extent to which the original project objectives and expectations have been achieved and to reassess the future economic viability of the project. Most post-implementation reviews will require the performance of a project to be compared with the original estimates supplied at the project approval stage. Hence data used in the original project will usually be the base on which review information is to be collected. Economic studies using the future price approach provide a suitable base for comparison with actual results achieved.

Although a project may be seen as being successful at the post-implementation review stage it may not necessarily continue to be successful in the future. However, a post-implementation review provides important feedback to both top-level management and the management responsible for the operation of the project which should assist towards the continuing success of the project. In addition, whilst there are no set solutions one can pursue that will guarantee a project's success, post-implementation reviews have the potential to provide valuable information to assist in the evaluation of future projects as well as their development and implementation.

CONCLUSION

This series of three articles has attempted to outline the techniques and problems associated with Economic Analysis studies.

Article 1 Outlined the basic techniques.

Article 2 Provided more detail on the assessment of input values.

Article 3 Discussed methods of allowing for uncertainty in estimates.

It is recognised that the series does not provide a full "course" in economic analysis, nor does it cover all the possible approaches that can be taken towards the analysis of alternative capital investment decisions. However, the material covered should provide sufficient information to enable the new analyst to undertake simple economic evaluations and, through reference to further articles and textbooks, to pursue this topic in greater depth.

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Telephone Traffic Measurement in the 1980s

G. A. BENJAMIN

This article describes a telephone traffic measurement philosophies and practices that have been developed for the Australian public telephone network to meet the requirements of network designers and to assist network management for this decade of the 80s.

INTRODUCTION

A range of traffic measurement philosophies and practices have been developed for the Australian public telephone network to meet the requirements of network designers and to assist network management for this decade of the 80s. The principles apply to any circuit switched network and it is of interest to note that most major Telecommunication Administrations are pursuing similar network traffic monitoring philosophies.

A telephone network consists of 2 major components:

- those elements which are dependent on the number of services connected. Examples of these are the terminal equipment in the customer premises and the cable pairs connecting them to their respective exchanges and those elements within the exchange which are provided individually for each service connected.
- those elements which depend on the number of calls or call durations i.e. the telephone traffic. These are generally referred to as "traffic dependent," and examples are the interexchange network (junction and trunk lines) and the switches and relay sets in the exchange which are used for interconnecting them. Also included are items of exchange common equipment which are used for setting up calls, although they are not held for the duration of the calls.

For proper design of the traffic dependent network element, measurements and forecasts of the network traffic are carried out. Two types of Telephone Traffic measurements are performed within Telecom Australia: traffic intensity, which is measured as the average occupancy of routes or groups of devices, and traffic dispersion, which is the distribution of calls or traffic from a particular origin to the various possible destinations.

These are quite fundamental traffic statistics for network designers and it is not envisaged that this will change in the foreseeable future.

This article describes changes which are now taking place in the Data Acquisition techniques, measurement practices and in the processing and storage facilities for the traffic data.

TRAFFIC DATA AND NETWORK DESIGN STANDARDS

The main application of traffic data is for the design of network configurations and plant quantities which are capable for carrying the offered traffic economically at an appropriate grade of service. In an existing network, it is used to check the adequacy of plant provision. For future networks, forecasts of telephone traffic are used for network design and for estimation of plant increments. Our traffic data acquisition practices must be oriented towards meeting both service and design philosophies.

One of the fundamental characteristics of traffic flows in the telephone network is the large variability in its intensity. Not only does it vary from minute to minute, but the average level is likely to vary from week to week and seasonally throughout the year (**Fig. 1**). Because of this variability, it is uneconomic and indeed impracticable to provide switched plant in the network to carry all calls at all times. What we attempt to do is to provide a network capable of giving an acceptable ***grade of service*** during the busy season of the year.

To quantify this quite broad objective, the following basic definitions have been arrived at:

- The ***busy season*** for any route or network is the four consecutive weeks of the year for which the average busy hour traffic is the highest.
- The ***busy hour*** is the Time Consistent Busy Hour (TCBH) which is the hour of the day for which the Monday-Friday average traffic is the highest.
- All routes from which traffic cannot overflow should be dimensioned to a specified grade of service (% of offered traffic lost) during the average TCBH for the busy season.

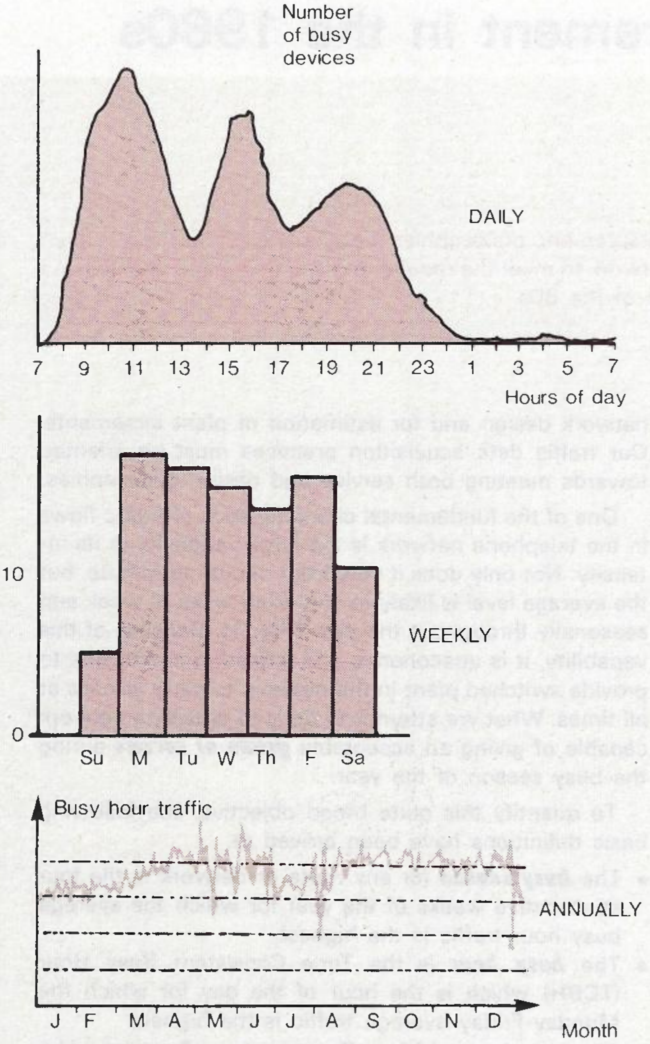
There are a number of features which characterise any comprehensive traffic data acquisition and processing system:

- large volumes of data must be collected to ensure that the information is statistically significant and reliable.
- the data manipulation and computational process are very complex.
- after processing and compression, the data storage requirement for past history, current measurements and forecasts is very large.

In the past, to meet the needs of network designers, traditional practice has been to regularly perform a complete measurement and audit of every traffic carrying device in each exchange measured. Such measurements are specified to be made for a one week duration, every two years, at terminal exchanges, and every year at tandem and trunk exchanges. This practice has been described in earlier articles (**Ref. 1, Ref. 2**).

Australian practice contrasted with many overseas administrations where the general practice is to take more measurements and, in some cases, obtain data for the whole network simultaneously.

A major weakness in our traditional system is that, to determine total network traffic in the busy hour/busy



TRAFFIC VARIATIONS

1. Typical Traffic Profiles showing Traffic variations.

season for dimensioning purposes, individual exchange traffic readings taken, of necessity, outside the busy season must be seasonally corrected before they are added. The accuracy of this correction depends on the availability of satisfactory data to determine correction factors. A means of monitoring total traffic levels on a continuous basis is the most desirable.

TRAFFIC DATA AND NETWORK MANAGEMENT

In addition to requirements of network planners for network traffic data, network operations analysis groups and network managers are also finding a need for continuous and immediate traffic flow information on a network-wide scale, as the telephone network becomes more complex and its control more centralised.

Telephone networks employing alternate routing and common control switching systems provide efficient use of facilities. However, this efficiency carries with it an operating penalty in that localised traffic overloads or equipment failures can cause the network to degrade in a disproportionately severe manner, and often in parts of the network that are remote from the disturbance.

This network management requirement is more stringent, though, since the information needs to be processed, and output, in real time, or near real time.

TRAFFIC MEASUREMENT PHILOSOPHY

In the late 1970s, recognising the need for continuous network traffic monitoring, the Engineering Department established a Working Party of traffic engineers and operations engineers from both Headquarters and the States to specify requirements for daily and weekly traffic load meausrements in local and trunk networks. This type of measurement is termed ***Daily Traffic Recording***.

There was seen to be a requirement for two distinct types of traffic measurement.

- **DETAILED TRAFFIC RECORDING** (the traditional system) — a comprehensive examination of the trunking, circuit quantities and traffic from a single exchange, performed for 1 week at intervals of 1-3 years.
- **DAILY TRAFFIC RECORDING** — continuous, or daily, monitoring of a small set of significant statistics from each exchange in the network, performed with a centralised automatic data acquisition system.

It was recognised that with ***Daily Traffic Recording*** the following benefits could be realised.

- Improved confidence in traffic study data.
- Improved short and long term forecasts.
- Improved detection and analysis of congestion.

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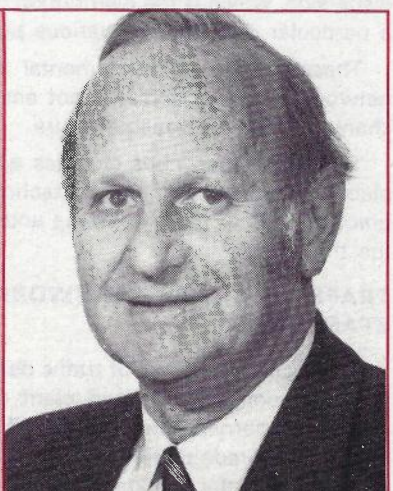
He joined the PMG in 1950 as a Technician's Assistant. He graduated as an Engineer in 1963 after completing studies at the Hobart Technical College and the University of Tasmania. After working in Planning and Exchange Construction in Tasmania, he joined the Headquarters Traffic Engineering Section in 1969 and has remained in related Sections working on the development of Traffic Acquisition and Processing Systems.



This was demonstrated from experience from a field trial of ***Daily Traffic Recording*** equipment, mounted in 1978 in all States.

The essential points of the specification for ***Daily Traffic Measurements*** are:

- the data describing traffic loads and congestion on all backbone routes should be collected. Backbone route traffic levels are sensitive indicators of congestion;
- the originating and terminating traffic levels from a significant sample of terminal exchanges should be collected;
- there should be on-line access to network traffic information and exception reporting of congestion. For operations personnel this information provides an early warning of technical problems, equipment misoperation and circuit shortages. The real time access to the data and exception reporting is of particular advantage to the Service Restoration and Network Performance Analysis Centres;
- there should be capacity to measure other traffic data from a limited number of other traffic groups at each exchange, determined on a needs basis;
- revenue data for Customer Services from erlang-hour meters in charging centres equipped with electromechanical switching equipment should be collected.

THE SYSTEMS USED TO COLLECT TRAFFIC DATA

New traffic data acquisition and processing systems are currently being implemented for all exchange types, to meet the requirements for both detailed and daily measurements. These are outlined in block schematic form in Fig. 2.

There are 3 major components in the overall system philosophy:

- Minicomputer based data loggers (the primary component).
- Centralised batch processing facilities for the output of the data logger (the secondary component).
- A Traffic Data Base and processing system offering both on-line and off-line interfaces for users of the Traffic Data tertiary component).

Primary data acquisition is performed by several minicomputers located at the Traffic Engineering Centre in each State. These systems also perform measurement control and data validation functions. They are operated by Traffic Engineering technical staff who take responsibility for the system operation and for the quality of the traffic data.

There are three separate minicomputer systems, one for each data source.

CENTOC performs **daily** traffic recording from electromechanical exchanges (ARF, ARE, ARM, Step-by-Step).

DETRAM processes data from **detailed** studies from electromechanical exchanges.

TRAXE performs **both** detailed and daily type measurements from AXE exchanges.

The **CENTOC** and **TRAXE** systems both receive traffic data in ***real time*** and provide on-line access to this

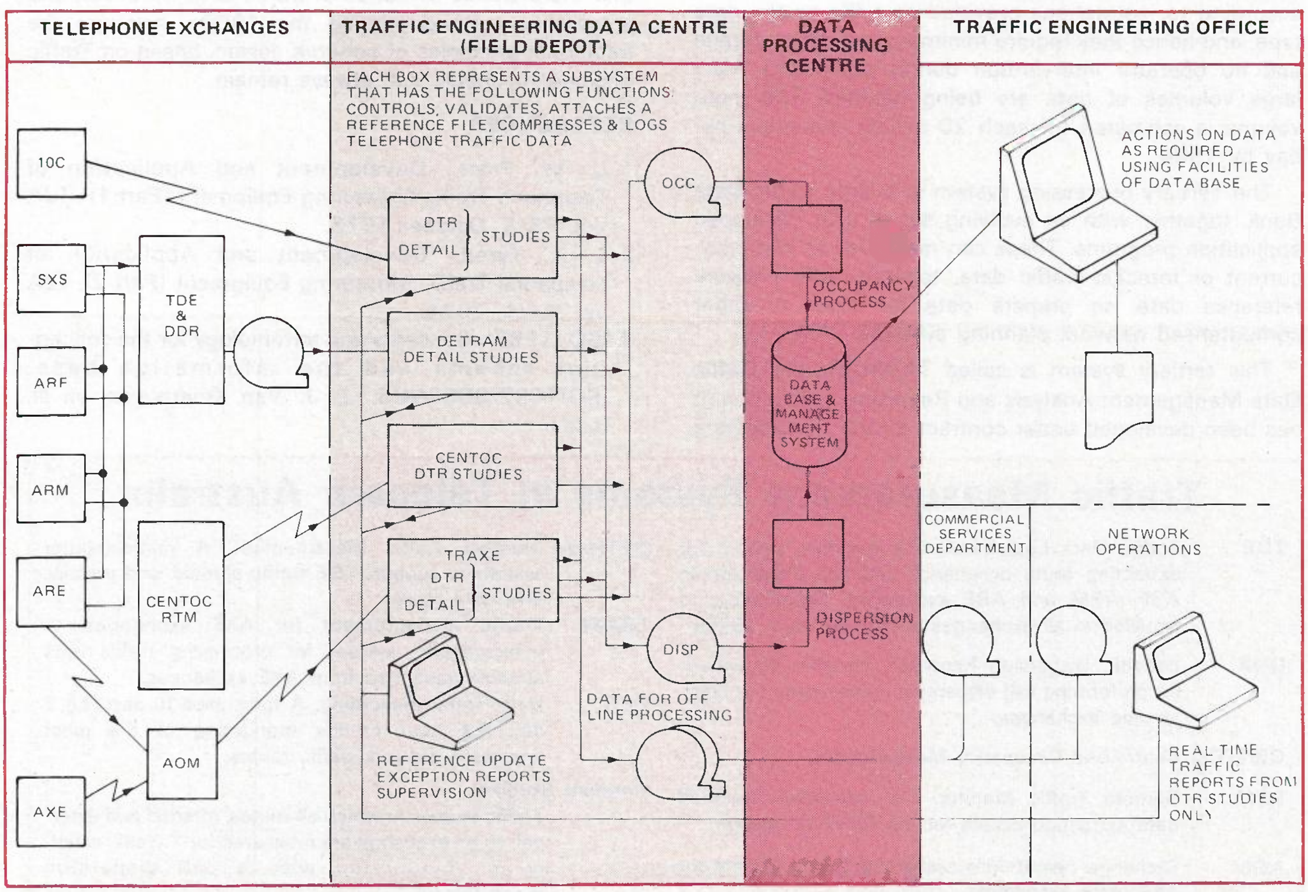


Fig. 2. New Traffic Data Acquisition and Processing Systems.

data for users. DETRAM processes magnetic tape inputs from Traffic Data Equipment (TDE) and provides on-line processing reports for field measurement staff.

Data is separated into two major streams for secondary processing — one for route occupancy data, one for call dispersion data. The data is forwarded in standard format from all of the primary systems:

Occupancy data is processed into a half hour summary, containing:

- Average traffic (Erlangs)
- Maximum circuits in use
- Minimum circuits in use
- Number of times maximum occurred
- Sum of squares (for variance calculation)
- From AXE exchanges there are other statistics, in addition to these.

Dispersion data is processed into call summaries, containing, for each call:

- Call commence time
- Up to 6 dialled digits
- Call origin code
- Call Hold Time (Duration)

Data extraction for SPC exchanges is by means of internal software. The data which is extracted from electromechanical exchanges is obtained by monitoring equipment installed within the exchange.

The Secondary Traffic Processing systems are batch type system which process one study at a time. For continuous (daily) studies data is processed weekly while detailed studies are processed as they occur. These systems provide simple straight-forward processing according to instructions provided as a file on the data tape, and hence they require minimal permanent storage and no operator intervention during processing. Very large volumes of data are being handled. The input volume is estimated to reach 20 million characters per day by 1984.

The Tertiary processing system is a large traffic Data Bank, together with an evolving set of user developed application programs. These can make use of historical, current or forecast traffic data, together with network reference data, to prepare data for input to other computerised network planning systems.

This tertiary system is called TADMAR: the Traffic Data Management Analysis and Reporting application. It has been developed under contract on the Control Data Australia (CDA) Cybernet Bureau and is able to interact directly with the other network planning systems also operating on CDA Cybernet equipment.

TADMAR is a large and powerful facility of very advanced design, using a three level schema architecture for data base standardisation. This approach has since been adopted in 1982 by the International Standards Organisation as the recommended philosophy of Database design. (**Ref. 3**).

Later articles in the Telecommunication Journal of Australia will describe individual subsystems in more detail.

Notwithstanding the progressive introduction of SPC exchanges into the network, for the rest of this decade most of the traffic data will still be extracted by ***add on*** equipment at step and crossbar exchanges. Ongoing development of data extraction methods can be expected because of the inevitable technical obsolescence of exchange equipment types, and also due to changes in network policies and planning philosophy. We will need to consider these questions:

- Is there a continuing need for detailed occupancy measurements on all individual circuit groups or will it be sufficient to use the continuous measurements of total traffic and key routes together with dispersion data?
- If a policy of timing local calls is adopted, will it be practicable to derive traffic data, particularly dispersion, from data collected for call charging purposes?

Whatever the answer to these questions, it is certain that there will be evolution of traffic data extraction and processing methods during the 1980s, however the traditional principles of network design, based on Traffic Engineering theory will always remain.

REFERENCES

1. C. W. Pratt, 'Development and Application of Telephone Traffic Measuring Equipment (Part 1)', TJA Vol. 23/3, October 1973.
2. L. A. Tyrell, 'Development and Application of Telephone Traffic Measuring Equipment (Part 2), TJA Vol. 24/1, 1974.
3. ISO (1982): Concepts and terminology for the conceptual schema and the information base, ISO/TC97/SC5/WG3, J. J. Van Griethuyen et al. (eds.).

Traffic Measurement Systems in Telecom Australia

TDE Traffic Data Equipment. The standard system for extracting route occupancy and call dispersion in ARF, ARM and ARE exchanges. Developed and installed in all exchanges during the early 1970s.

DDR Decadic Dispersion Recorder. Portable equipment for performing call dispersion measurement at step-by-step exchanges.

CENTOC Centralised Occupancy Measurement.

RTM Remote Traffic Monitor. The exchange mounted data extraction device for the CENTOC system.

AOM Exchange operation message switching system for AXE, ARE exchanges.

DETRAM Detailed Traffic Measurement. A minicomputer system to support TDE traffic studies, and process TDE data tapes.

TRAXE Traffic measurement for AXE exchanges. A minicomputer system for processing traffic data streams generated from AXE exchanges.

DTR Daily Traffic Recording. A term used to describe 7 day, 24 hour on-line monitoring of the most important network traffic routes.

Detailed Studies Traffic studies in which all routes, internal and external, to an exchange are measured for 1 week, usually in conjunction with a call dispersion measurement.

The CENTOC Daily Traffic Recording System

R. O. G. JACOBS B.Sc. B.E. (Hons)

CENTOC is a centralised telephone traffic measurement system, designed to continuously monitor route traffics in the electromechanical telephone network. Development of the system was performed by the South Australian Engineering Department, in conjunction with Headquarters Engineering Planning. This article gives a general description of the CENTOC system, and a brief overview of the traffic information which is available from the system.

INTRODUCTION

CENTOC (Centralised Occupancy measurement) is a minicomputer based telephone traffic measurement system for electromechanical exchanges, capable of continuously monitoring traffic levels on a large number of routes in the network. It is being implemented in the Australian telephone network in 3 stages, up to 1984/85.

CENTOC is part of the TDAS (Traffic Data Acquisition Systems) project to modernise traffic measurement in the Australian network, and provides Daily Traffic Recording facilities for ARF, ARM, and ARE telephone exchanges. In the TDAS philosophy, CENTOC is a primary data acquisition system, collecting raw traffic data, validating and summarising this data for input into the traffic data base system, TADMAR. Another TDAS primary system, TRAXE, will provide Daily Traffic Recording facilities for AXE exchanges.

The Daily Traffic Recording system is designed to continuously monitor the most significant traffics at each telephone exchange:

- macro traffic levels (e.g. total originating traffic)
- final choice route traffics
- selected routes of special interest.

In all, about 10-20% of all traffic groups in the network are monitored continuously, with half-hour traffic values stored by a minicomputer data logger. Selected (busy period) half-hour traffics for selected groups are output for long term storage in the TADMAR data base. This approach makes the measurement practical in terms of both data volume and monitoring cost.

SYSTEM OVERVIEW

The CENTOC system uses monitoring equipment, installed in each exchange to interface with the exchange traffic wiring, to sample the traffic levels on each traffic route and then transmit this data, via a digital telemetry network to a central site.

A minicomputer-based data logger at the central site receives the data, checks for errors, then summarises and stores the data on disk. The stored data is accessible to users via both local and remote terminals.

At the end of a weekly cycle, the data is off loaded onto magnetic tape for further processing on TACONET (Telecom Australia's Computer Network) by the processing program STRAP (Secondary Traffic Processor), to calculate busy hour statistics. All information is then transferred to the traffic data base TADMAR (Traffic Data Management Analysis and Reporting System).

THE CENTOC DEVELOPMENT

Network monitoring of the Adelaide metropolitan network has been performed with a simple system also called CENTOC, since 1972 (Ref. 1).

Experience with this early system, and the recognised need for improved network traffic information, led to a working party investigation of Daily Traffic Recording (DTR), in 1976. This working party considered the needs for DTR, and the benefits, and published a facility specification for general application in all exchanges in the Australian network.

For the electromechanical exchange network, a number of technical solutions for DTR were evaluated by the working party, including both CENTOC and Individual Circuit Monitoring techniques. It was recommended that the CENTOC system be further developed, and implemented into the Australian network. This received formal approval in September 1978.

The present CENTOC system evolved in South Australia from designs which explored techniques of remote data collection and digital telemetry of data to a data logger.

The measurement technique uses equipment installed in each exchange to interface to TKT leads, and digitise and store traffic data. This equipment, termed a Remote Traffic Monitor (RTM), transmits the data via a digital link, a telegraph circuit, in response to commands from a centrally located data logger.

A field trial of a prototype CENTOC system was mounted in July 1977, with RTM equipment installed at 15 exchanges in all States (later increased to 25 exchanges) measuring approximately 1100 traffic routes. The data was logged onto magnetic tape at the Adelaide Traffic Engineering Centre, and processed by batch on

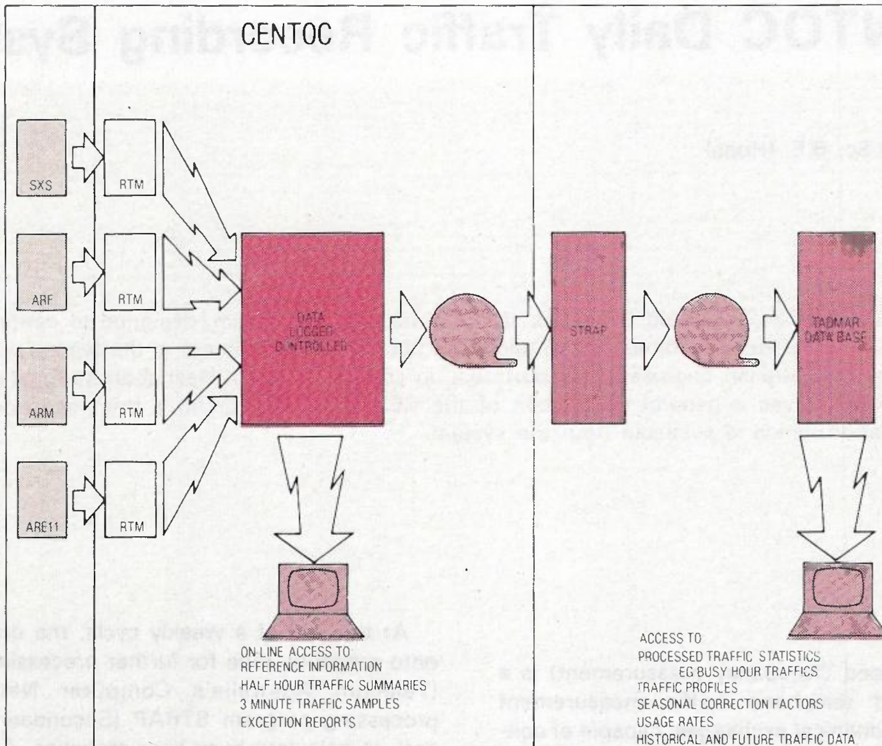


Fig. 1: CENTOC system overview, showing data flow through to the TADMAR data base, and the points at which data is available to users.

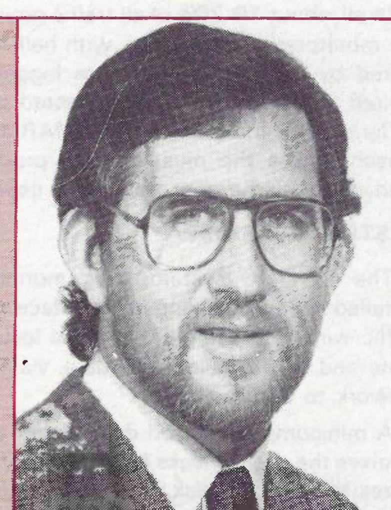
CYBERNET, to produce half-hour and weekly busy hour statistics.

This field trial demonstrated that large-scale network traffic monitoring was technically feasible, and provided insight into the practical problems of gathering such large volumes of traffic data. The field trial was extended, and became a routine traffic measurement until April 1982, just prior to the cutover of the national CENTOC system.

Development of the national CENTOC system proceeded in earnest following the conclusion of the field trial, with the awarding of a contract to L M Ericsson for the documentation and production of the remote traffic monitors, and the acquisition of a Data General 'Eclipse' S130 for development of the central data logger.

The data logger development was undertaken by the Engineering Department of Telecom Australia in South Australia, and was successfully completed in May 1982. Implementation of the national CENTOC system has followed, with the installation of Eclipse S140 minicomputers in each State, and the planned installation of approximately 700 RTMs by the end of 1984. This will provide traffic monitoring facilities for practically all of the electromechanical exchanges in the network.

BOB JACOBS joined the then PMG's Department in 1969 as a cadet engineer, and subsequently graduated from the University of Adelaide with B.Sc. (1970), and B.E. (Elec) (1971). After commencing with Telegraphs and Data Section, he transferred to the Traffic Engineering Section in Adelaide, in 1974, and has worked in this field since then, with a special interest in traffic data acquisition and processing techniques. Currently he is with the Traffic Engineering Applications Section of Headquarters Planning Services Branch.



THE CENTOC SYSTEM COMPONENTS

The CENTOC system is a remote data collection system, and has the following identifiable basic components:

- a central data logging device.
- remote sensors
- telemetry links, between the logger and the remote sensors.

THE DATA LOGGER

The CENTOC data logger is located at the Traffic Engineering Centre (TEC) in each state. The equipment comprises a Data General Eclipse S140 minicomputer with its peripherals:

50 Mbyte disk,
800/1600 bpi tape drive
300 lines per minute printer
Video display terminals
Interface equipment for networks of RTMs.

The decision to use a minicomputer based design was based on the cost of batch processing the projected volumes of data for Daily Traffic Recording, and the specified need for on-line access to the traffic information. On-line test and reporting facilities are also essential for the management of such a large data collection system.

The Data General Eclipse S130 was chosen, with all software written in DG FORTRAN 5 in a multitasking environment under the control of the Data General RDOS Real-time Disk Operating System.

THE DATA LOGGING PROCESS

Apart from system maintenance periods, the data logger operates continuously, logging data from all active RTMs.

The measurement is, in fact, a series of sequential 7-day measurement cycles, from midnight each Sunday. Major changes to the configuration of RTMs are not permitted during a measurement cycle, and the production of output tapes for processing into TADMAR

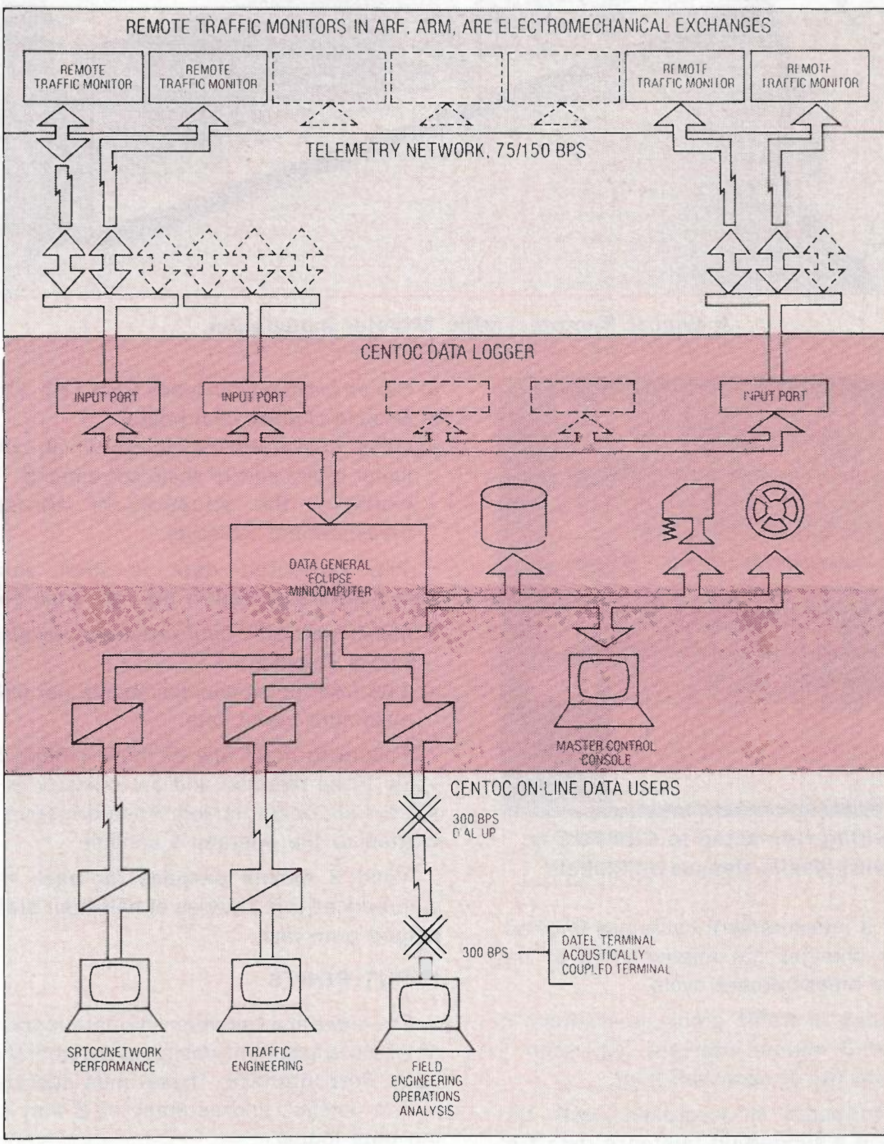
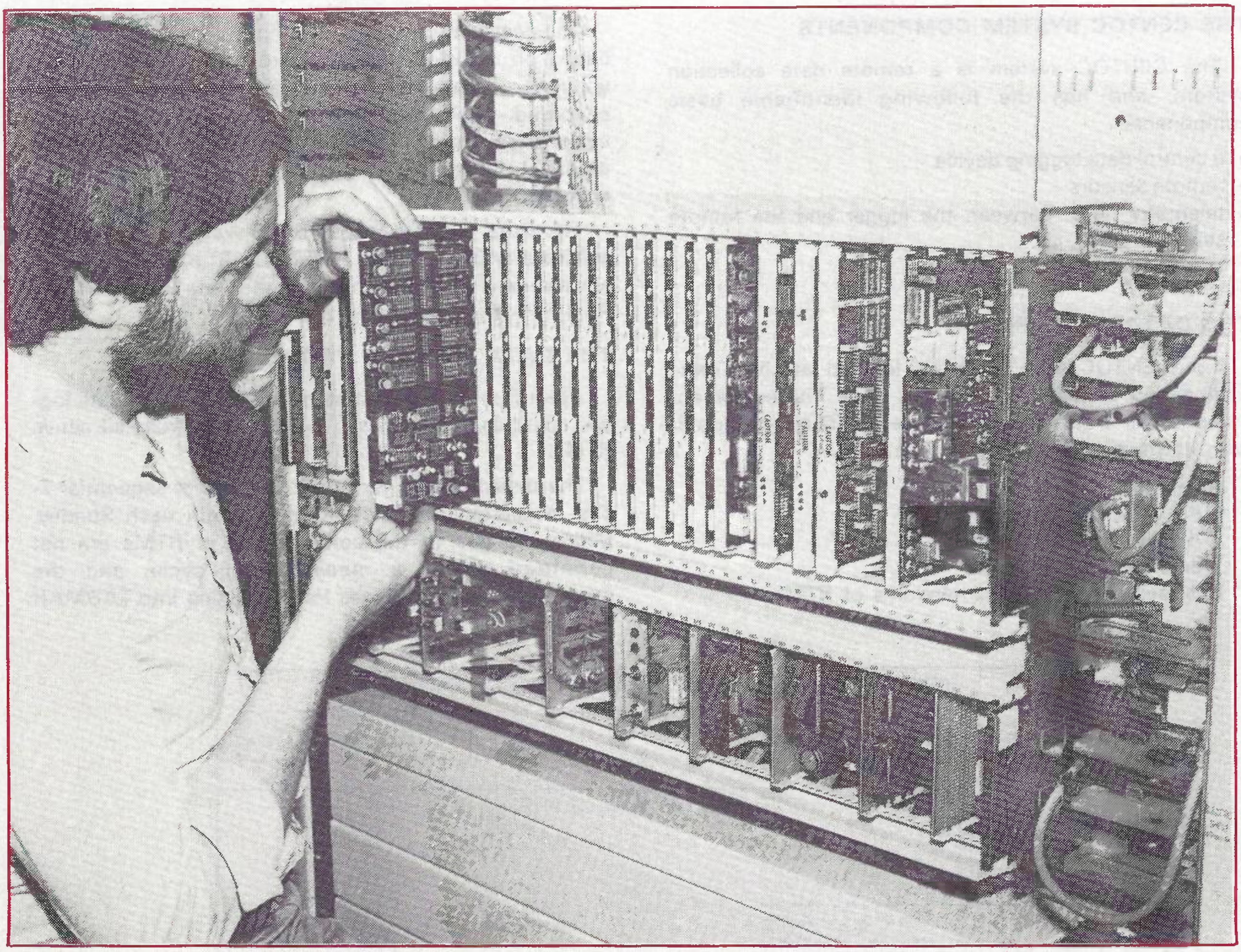
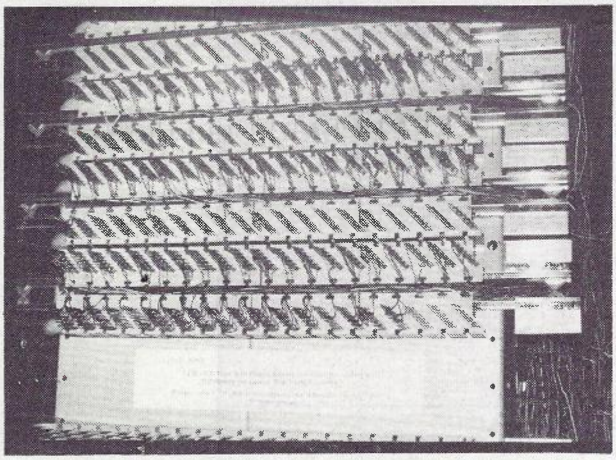


Fig. 2: CENTOC system hardware components.



A typical Remote Traffic Monitor installation.



Exchange traffic wiring connected to CENTOC is clearly marked, with plastic sleeves and labels.

may only occur after a measurement cycle has finished. Major RTM network changes are implemented at the changeover to a new measurement cycle.

Each RTM, consisting of traffic group, is scanned to obtain traffic data, at 3 minute intervals, with scan 1 commencing at minute 00 of each half-hour.

Logged data is corrected in accordance with the parameters specified in a supporting reference data file, to compensate for:

- Series resistance in leads from TKT, TKR, TKF groups.
- Scaling of pulse count data.
- Other measurement factors which can be defined as linear offset and/or scale corrections. This includes, for example, the situation of non-standard traffic measurement resistors.

The corrected data is then validated against parameters specified in the reference file. For example:

- measured traffic data should not exceed the number of trunks installed.
- data from pulse sources should not exceed a specified maximum count rate.

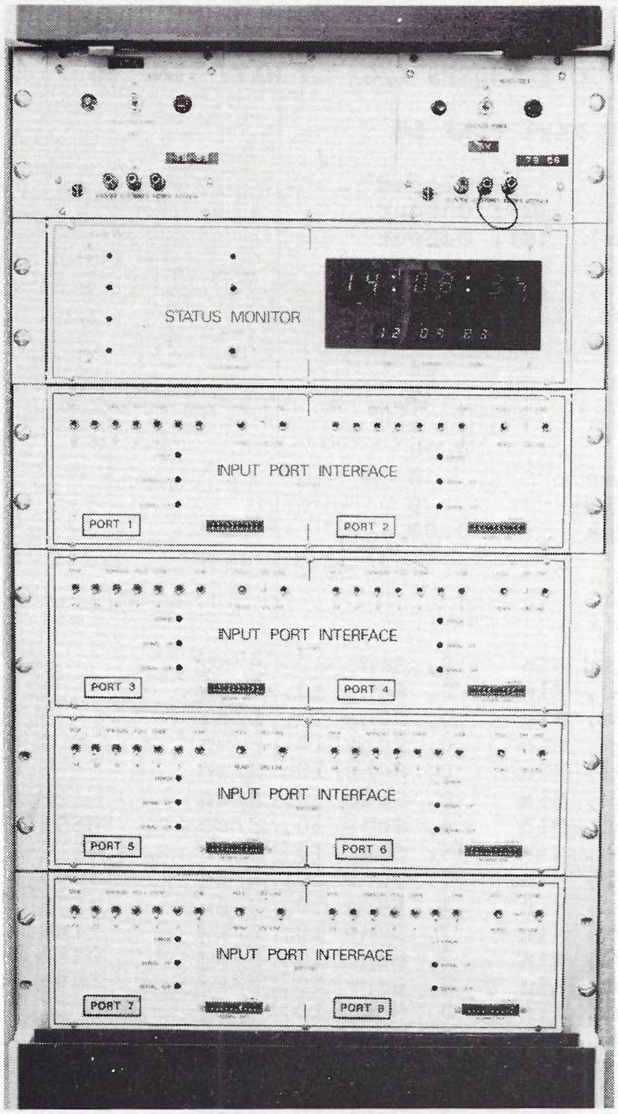
Failure to meet any of these criteria causes the data value to be rejected and an indicator to be written into the system operating log. An informative message is also written to the operator's console.

Valid 3 minute samples for each traffic group are summarised into a series of half-hour statistics which are logged onto disk.

INPUT PORTS

The interface between the data logger and a network of RTMs is a custom-designed peripheral device called an Input Port Interface. These units operate independently and in parallel, and as many as 8 may be connected to the data logger.

The total number of traffic groups associated with any



Input Port Interface equipment.

Input Port is limited by the amount of data that can be transmitted during a 3 minute ***scan***. At the data rate used (75bps), with effectively 165 seconds available for data acquisition in each 3 minute period, this limit is approximately 800 groups. Other system limitations impose an overall limit of about 4000 on the number of traffic groups monitored by the system.

DATA LOGGER SOFTWARE

The data logger software was designed and written by Telecom Australia staff, as a dedicated real time application, using DG FORTRAN 5 under the RDOS operating system.

The software has two separate functions:

- The data acquisition function. This is implemented in the RDOS foreground, where it is given priority over all other functions.
- A data base function. This is implemented in the RDOS background, and provides the facilities for on-line access to the information held in the data logger. This function includes a range of test and diagnostic software to enable the TEC staff to operate and manage the whole system.

THE REMOTE TRAFFIC MONITORS

The CENTOC Remote Traffic Monitor (RTM) was developed in the period 1975-1977 by Engineering Department in South Australia, and a total of 25 prototype RTMs were constructed in SA Telecom Workshops for a field trial of CENTOC.

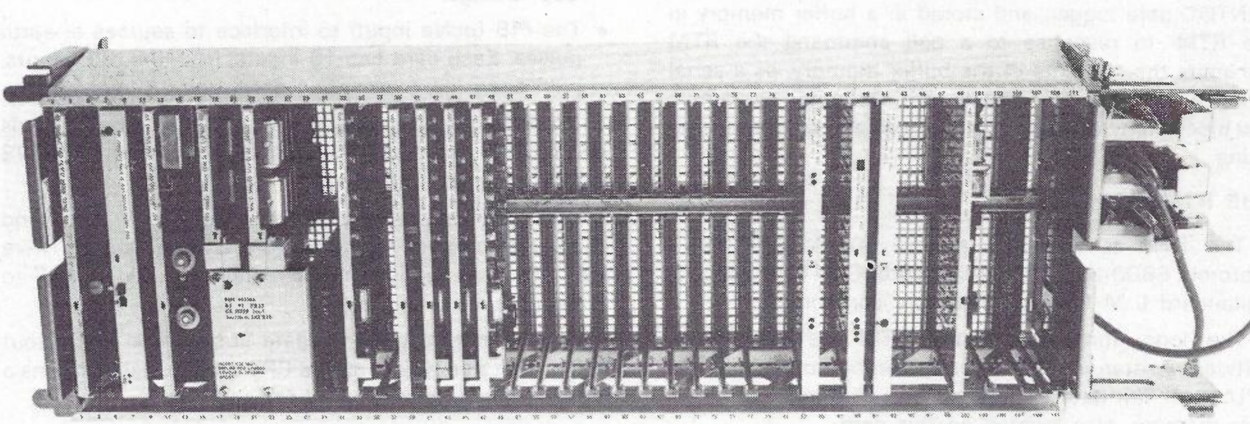
The RTM manufactured by L M Ericsson for the national implementation of CENTOC is a new design by LME, to overcome manufacturing problems with the earlier design.

The basic facilities of the RTM have not changed from the earlier design, however there are improvements in both accuracy and maintainability with the new RTM.

The essential features of the CENTOC RTM are:

- It is an exchange-mounted device, constructed from ROE equipment practice (as used for ARE-11), in a double height BCH 321 electronic shelf.
- It measures occupancy of groups of 100 K ohm TKT, TKR or TKF leads (Analog Inputs).
- It accumulates totals of pulses from Erlang-hour-meters, or from call count meters (Pulse Inputs).

Inputs are equipped in modules of 8 for either type (Analog or Pulse), up to a maximum of 128 inputs. Data



View of Remote Traffic Monitor.
Power supply cards are installed on the left hand side of the shelf, followed by Analogue and Pulse input buffer cards. Microprocessor and logic cards, with telegraph repeater cards are on the right of the shelf.

```
CENTOC Daily Traffic Recording System     Revision 1.50     12:37:06  09/12/1983
S.A. CENTOC LOGGER                                          User code 02     TEMC
Halfhour data for  2:01:053  WAYMOUTH TAN TO FLINDERS L/G    T WAYY FLNF L0

 53  WAYMOUTH TAN TO FLINDERS L/G           T WAYY FLNF L0
     Status flags are 00001100   Active
          Modification Access flag                  : Closed
          Planning Data (Busy Period)           (C): Output
          Planning Data (7 day, 24 hr)          (S): Output
          CSD Data                              (R): No output
          Engineering Ops Data                  (E): No output
     Group is type AI
     Group output order code  5555
     Validation parameters: # circuits              54
                            Series R                 0
                            Offset                   0
                            Scale                 0.00
     On-line parameters: TEC scan sequence           0
                         EOPS scan sequence          0
                         Traffic per trunk        0.00

Reference file : XTRP

5 06:00     0.00E Max   0, Read 10 times, Min   0, Scns 10, S/sq        0.0
5 06:30     0.00E Max   0, Read 10 times, Min   0, Scns 10, S/sq        0.0
5 07:00     0.00E Max   0, Read 10 times, Min   0, Scns 10, S/sq        0.0
5 07:30     0.00E Max   0, Read 10 times, Min   0, Scns 10, S/sq        0.0
5 08:00     0.50E Max   1, Read  5 times, Min   0, Scns 10, S/sq        5.0
5 08:30     1.20E Max   3, Read  2 times, Min   0, Scns 10, S/sq       28.0
5 09:00    26.40E Max  42, Read  1 times, Min   4, Scns 10, S/sq     8508.0
5 09:30    40.80E Max  48, Read  1 times, Min  35, Scns 10, S/sq    16812.0
5 10:00    11.00E Max  28, Read  1 times, Min   2, Scns 10, S/sq     1998.0
5 10:30     7.10E Max  14, Read  1 times, Min   4, Scns 10, S/sq      575.0
5 11:00    10.40E Max  16, Read  1 times, Min   7, Scns 10, S/sq     1168.0
5 11:30     8.10E Max  11, Read  1 times, Min   2, Scns 10, S/sq      713.0
5 12:00     5.30E Max   9, Read  1 times, Min   2, Scns 10, S/sq      329.0
5 12:30     1.90E Max   4, Read  1 times, Min   0, Scns 10, S/sq       51.0
5 13:00     3.90E Max   9, Read  1 times, Min   1, Scns 10, S/sq      229.0
5 13:30     3.60E Max   8, Read  1 times, Min   1, Scns 10, S/sq      178.0
5 14:00     7.60E Max  12, Read  1 times, Min   3, Scns 10, S/sq      634.0
5 14:30     7.90E Max  11, Read  2 times, Min   2, Scns 10, S/sq      689.0
5 15:00     3.90E Max   6, Read  1 times, Min   0, Scns 10, S/sq      181.0
5 15:30     6.17E Max  10, Read  1 times, Min   3, Scns  6, S/sq      263.0
```

Fig. 3: Typical CENTOC route traffic report, available from an interactive terminal.

is acquired in response to a 'read' command from the CENTOC data logger, and stored in a buffer memory in the RTM. In response to a poll command the RTM transmits the contents of the buffer memory, as a serial string of data, to the data logger. Delimiter characters and block parity are added to the head and tail of the data string.

THE RTM DESIGN

The RTM is designed around the APN16503, a Motorola 6800-based microcomputer CPU card which is a standard L M Ericsson inventory component.

The logic functions of the RTM are defined by software written into Read-Only memory located on the CPU card. The data buffers are provided in random access memory, also located on this card.

The RTM has 2 different input buffer cards:

- The AIB (analog input) to interface to groups of commoned 100K traffic leads. Each card has 8 buffers (inputs), each able to measure traffic groups with up to 255 Erlangs.
- The PIB (pulse input) to interface to sources of earth pulses. Each card has 16 inputs, in 2 lots of 8 inputs, with each input accepting earth-going (+ve) pulses.

An RTM can be equipped with AIB analog buffer cards and/or PIB pulse buffer cards to a maximum of 128 inputs, total, of both types.

The RTM operates only in response to command characters received from the CENTOC data logger There are two commands, a ***read*** command and a ***poll*** to transmit data to the logger.

After a ***read*** command, data is stored in the output buffer, part of memory on the CPU card, which contains a corresponding storage word for each input:

- for an analog input, this word contains the value N, the measured group occupancy of the input.
- for a pulse input, this word contains the value of the pulse counter, at the time of the read.

Each RTM recognises a unique character, a character strapped in the RTM logic, as a poll code. On receiving this character, the RTM outputs to the telemetry network:

1. A header character (the poll code).
2. The contents of the output buffer, as a series of 8 bit characters.
3. A longitudinal parity character.
4. An **End of Data** character.

The CPU checks the internal functions of the RTM at least once every ten minutes. Faults are indicated by a code on four LEDs at the front of the RTM. Any fault indication requires the replacement of faulty cards.

CENTOC TELEMETRY

Because of the relatively low data volumes, the CENTOC system is able to use low speed telemetry of commands and data between the logger and the RTMs. Standard Telegraph signalling techniques are used, similar to those used in the Telex system.

Features of the technique are:

- Low speed, 75 bits/second or 150 bits/second
- + 50v, — 50v, 25 mA line signalling
- Full duplex, i.e. independent send and receive paths.

This line signalling technique is termed **double current**, from the two line states:

The CENTOC telemetry circuits are split on the data logger outgoing side, and combined on the data logger incoming side.

This can be done either in the RTM chassis, using facilities of the Telemetry Repeater card, or, alternatively in a special Telemetry splitting/combining unit termed a **Hubbing Shelf**.

Information is telemetered as a series of 12 bit **characters**, transmitted serially, as follows:

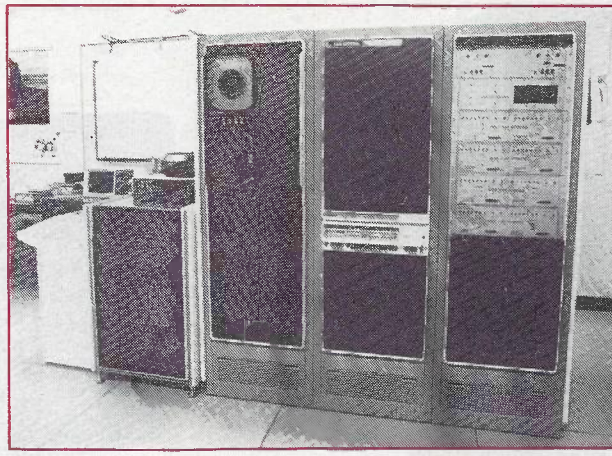
1 start bit (space)
8 data bits, LSB first
1 parity bit
2 stop bits

INFORMATION AVAILABLE FROM CENTOC

As traffic data is obtained from the RTMs, it is corrected and validated against reference information held by the data logger. Data from each input group is condensed into clock half-hour summaries and the following parameters are stored on disk:

1) For standard TKT traffic groups,
   average traffic (Erlangs)
   number of samples
   sum of squares of traffic samples
   maximum traffic sample
   number of times maximum occurred
   minimum traffic sample
2) For pulse data from Erlang-hour meters, the Erlang-hour total for each half-hour is calculated, and converted to traffic (by scaling up by a factor of 2) before being stored.
3) For other pulse count data, for example, from call count meters, the count total for each half-hour is calculated, scaled, and stored.

The data logger operates as a series of consecutive 7-day cycles, with the changeover at midnight Sunday each week. Data from a minimum of 7 days of logging is always held, i.e. the previous measurement cycle. Beyond this, the data is discarded. On disk, the logged data is stored sequentially for each port, monitor, group, for each clock half-hour.



The CENTOC data logger installation at Waymouth Exchange, Adelaide.

ACCESS TO STORED DATA

The data logger has two ways of presenting logged data to the data users:

1) Via the weekly output tapes

After the completion of a 7-day measurement cycle, one or more magnetic tapes may be generated, each containing specified half-hour data summaries for selected traffic groups, together with the relevant supporting reference information.

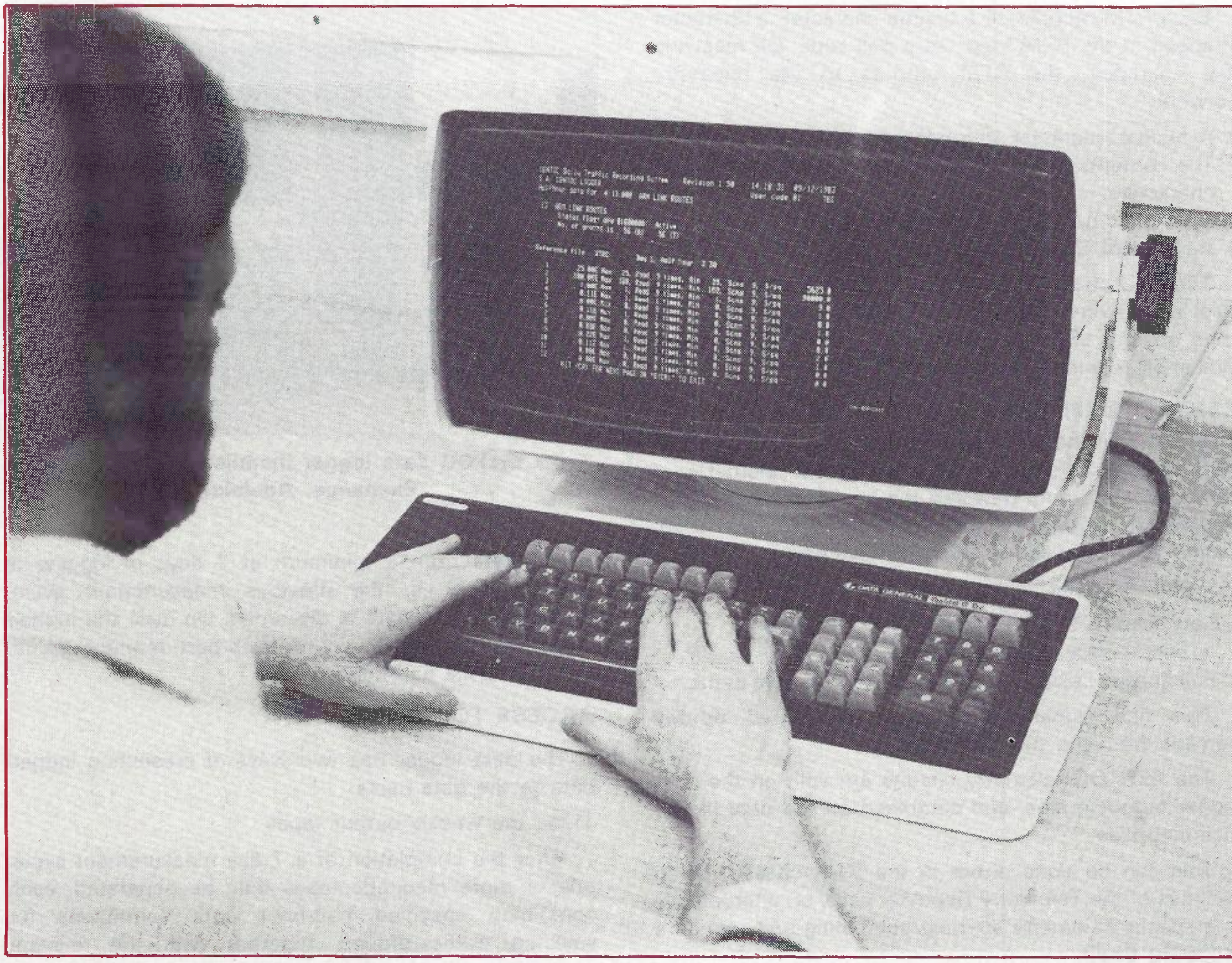
These tapes can be processed by the user on another computer, to obtain, for instance, busy hour traffic statistics, or detailed exception reports.

2) Via interactive terminals

The data logger provides interactive output to teletype or video terminals in each of the following functional areas:

(a) Traffic Engineering Centre (TEC) for operation and management of the data logger.
(b) Traffic Engineering Measurement Co-ordination (office based), for specification of the Engineering Planning output tapes, and for access to half-hour summaries of logged data.
(c) Engineering Department Operations (Service Restoration and Traffic Control Centre SRTCC), for access to logged data, traffic exception reports, and specification of parameters for the output data tape for Engineering Department Operations.
(d) Field Engineering Department (general purpose dial-up facility) to allow field-based Engineering Department staff to access half-hour summaries of logged data.

Any of the half-hour summaries of data from any group measured by the system is available for on-line examination. The data is identified by port/monitor/group ident, and half-hour commencement time, and is output with relevant supporting reference information. In addition, both TEC and SRTCC/Network Performance



All user interaction with the CENTOC system is via video terminals. Hard copy reports are normally produced from the TADMAR data base.

staff have facility to observe the individual corrected scan data for up to 20 specified traffic groups. The data for the last 2 hours is available, continually updated to provide a 'real time' traffic observation facility.

CONCLUSION

CENTOC is a powerful network traffic monitoring facility that has evolved from the work face needs of Traffic Engineering and Operations Analysis staff.

A large amount of accurate, and timely network traffic information is now available from most of the step-by-step and crossbar parts of the network.

To further exploit the potential of this traffic information, there is continuing work on development and refining of the data processing and reporting techniques, particularly for

- network traffic trend analysis
- network congestion analysis and reporting
- measurement of charged traffic.

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1. G. O. Marlow: 'CENTOC: Towards Network Monitoring', TJA Vol 26/1, February 1976.

Further Reading:

1. 'Traffic Engineering — Introduction to CENTOC' Telecom Australia Engineering Training Publication No. ETP 0914
2. 'Remote Traffic Monitor — Technical Handbook' Telecom Technical Publication No. TPH 0010 PS

The Data Communications Transport Service and Protocols

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The CCITT and ISO are currently developing international standards for a universal network-independent data Transport Service of uniform quality, and the Transport Protocols which will support it. This paper presents an introduction to the purpose and structure of the Transport Service and its relationship with communication networks. The Transport Service and Protocol standards being developed are also described.

INTRODUCTION

This paper gives an introduction to the Transport Service and Transport Protocols. The aim of the Transport Service is to provide a universal data transfer capability of uniform quality which can be used for data communication between different information processing systems attached to the same or different communication networks.

International standards are currently being developed by the International Organisation for Standardisation (ISO) and the International Consultative Committee for Telephone and Telegraph (CCITT) who are working in close cooperation. The draft standards (Ref. 1, 2, 3) are now very close to completion.

The presence of these standards will facilitate the development of distributed data processing systems.

This paper first discusses the need for a Transport Service, its structure and relationship with communication networks. Then, the Transport Service and Protocol standards are described, and finally an example of transport connection establishment is presented.

THE PURPOSE AND STRUCTURE OF THE TRANSPORT SERVICE

The Reference Model of Open Systems Interconnection (**Fig. 1**) (Ref. 4) provides the framework within which these standards are being developed. The upper three layers of the Reference Model support co-operation between two different end computer systems and the lower four layers provide data communications between the two systems. The lower three layers also provide relay and routing functions necessary to transfer data between the two end systems. The transport layer (layer 4) operates within the two end systems only, so the interfacing network is not aware of what is happening there. The transport layer is provided because there are many different existing networks which vary in quality. It enhances the quality of the underlying networks to produce a universal transport service of uniformly high quality for transporting data between end systems. The information processing application programs in the end systems are thus relieved of any responsibility for the reliable transmission of data.

Fig. 2 shows the underlying communications structure. The two users are in the session layer, but we can think of them representing the combined application, presentation and session layer entities from the point of view of transmitting data reliably between the two ends. The transport layer provides a network independent interface to the users. The transport entities communicate via the underlying Network Service. There could be several networks involved in transmitting the data (e.g. an international call or a call from a public network to a private network), but the users need not be aware of this. The different underlying networks could use different technologies. For instance, Network 1 may be an X.25 (virtual circuit) based packet switching network like Transpac in France or Austpac in Australia, Network 2 could be a datagram based network with connection oriented facilities provided by a network enhancement protocol, like Datapac in Canada, and Network 3 could be a circuit switched network. But irrespective of what type these networks are, the users do not want to be concerned with the different ways they operate. They merely require a consistent service.

The transport layer is built on the service provided by the underlying networks. It consists of a transport entity within each end system which implements the functions of the transport layer. These transport entities talk to one another via a Transport Protocol. The Transport Protocol is shown (Fig. 2) in dotted lines because it is a logical connection between these two entities. In reality it must use the connection services provided by the network service below to pass any data. The Transport Service is the facilities and functions provided to the user. The Transport Protocol is not visible to the user, but implements the functions between the two end systems necessary to provide the Transport Service on top of the underlying Network Service.

It may appear at first that the Network Service provides the same sort of functions that the Transport Service does. It provides the means for connection establishment and it provides facilities for transporting data. In that sense the two are similar, but the Transport Service may provide higher quality connections. For instance, with several different underlying networks as

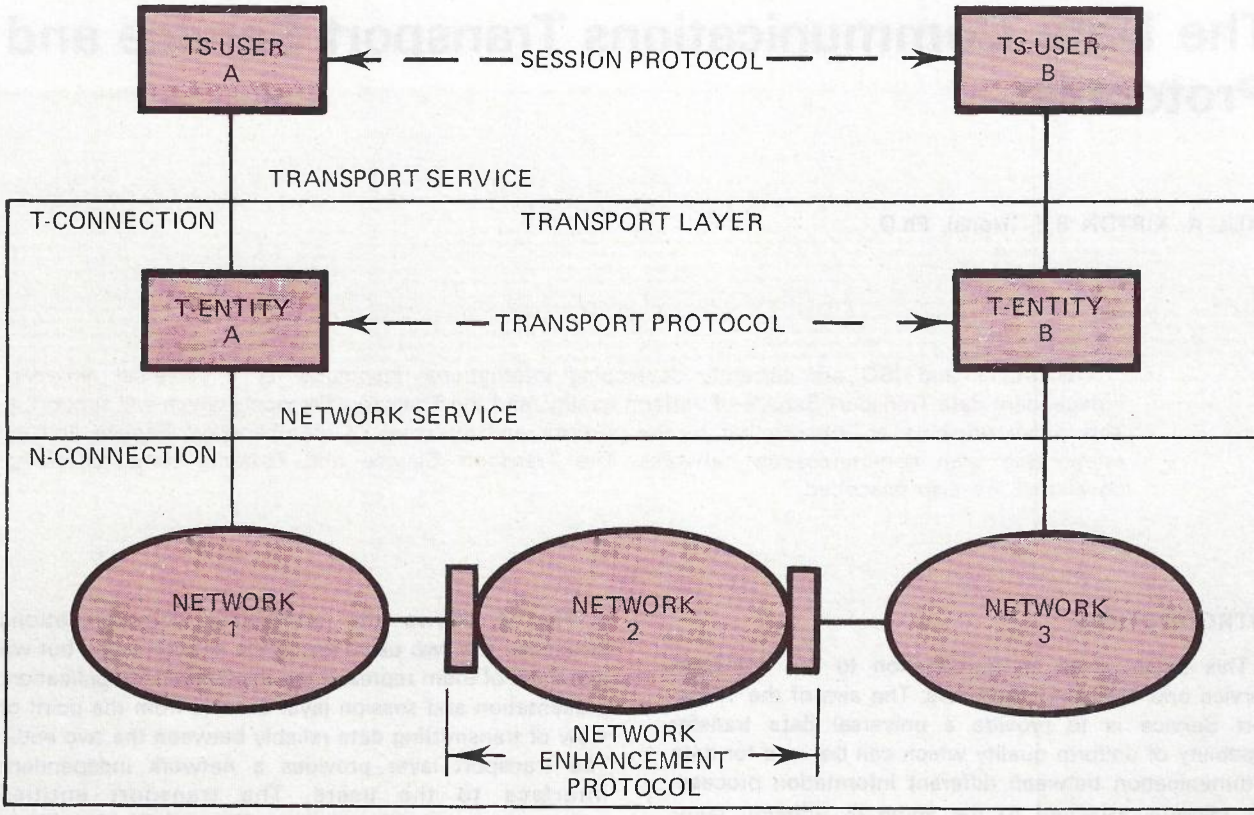

Fig. 1 How the Transport Service fits into the Reference Model.

shown in Fig. 2, the quality of the resulting network connection between the two transport entities is no better than the quality of the poorest network. Typical quality service parameters are the reliability of the connection in terms of how long the connection will last before a failure occurs, and also the accuracy with which the data is transported. If the user would like a higher quality than provided by the network service, some sort of quality enhancement must be provided in the transport layer. For instance, additional error checking facilities and reconnect procedures could be provided. For the latter, if the network connection is disconnected, procedures could be provided within the transport entity to set up a new network connection without the users' knowledge. The users' transport connection remains established. The functions provided by each underlying network must be the same if they are to provide a consistent Network Service. If a network does not provide certain functions, a network enhancement protocol may be required as shown for Network 2 of Fig. 2. A typical example would be the provision of a connection oriented service using a datagram sub-

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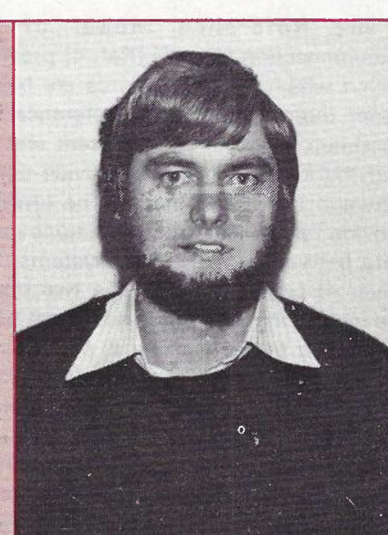

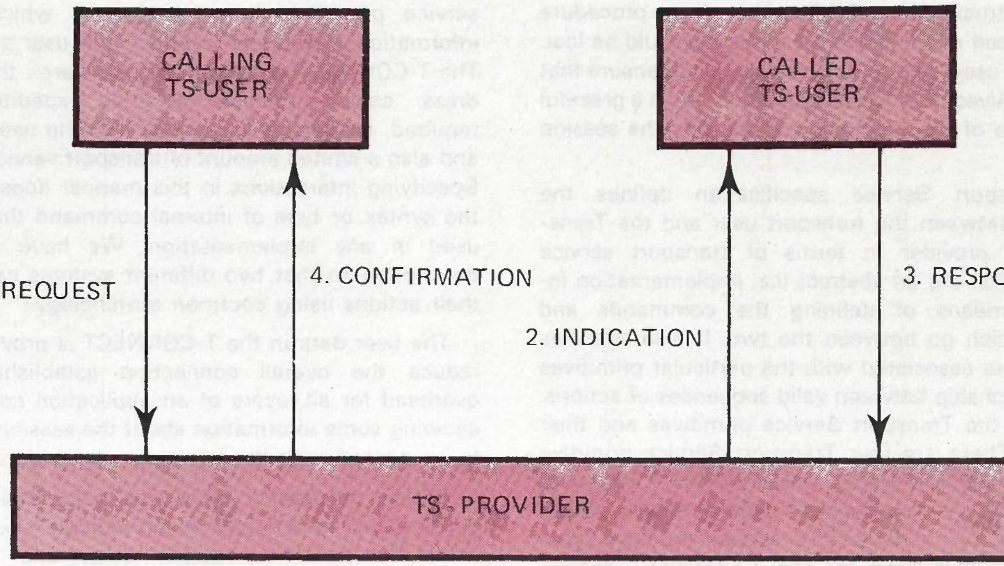

Fig. 2 Transport Service and the underlying network structure

network. The network enhancement protocol operates between Networks 1 and 3 across network 2 and is considered to be a network layer function.

Another function of the transport layer is to optimise the cost of the network connection. For instance, some networks charge on the basis of call connect time (e.g. circuit switched networks), others charge for call connect time as well as for the number of packets sent. Therefore it may be advantageous to be able to multiplex serveral transport connections on top of one network connection. It may also be cost effective to be able to suspend a particular transport connection. For instance, the user may want to send data periodically to one particular party in another system. He may want to set up the transport connection and leave it set up for a long period of time, maybe for the whole of the working day. The transport entity could automatically take care of monitoring the level of traffic and disconnect the network connection if there has been no data for a certain time to reduce the cost.

In summary, the Network Service provides end-to-end connections between the transport entities in the two end systems, it provides the necessary addressing of the transport entities to set up the connection between the two, and it provides any routing and relay functions. The transport layer exists in the end systems. It provides any quality enhancement of the connection to build the network quality up to a standard required by the user. It also provides cost optimisation and another level of addressing for addressing different session entities.

At this point it is beneficial to clarify the distinction between the term "network" as defined in the Reference Model and "network" as commonly used to describe the services provided by an administration such as Telecom Australia. The ISO/CCITT Reference Model defines the network layer as a set of functions (e.g. routing) that are required to support data communications. This is an abstract description which is meant to be independent of any particular implementation. An Administration's "network" typically includes all the physical equipment such as computers and transmission media as well as operation support services such as network management, accounting and directory assistance. These include application layer functions for both internal use (e.g. network management) and external use (e.g. automated directory assistance). Thus an Administration would need to implement all layers of the Reference Model for certain applications.

THE TRANSPORT SERVICE DEFINITION

The Transport Service currently being defined is connection oriented. By connection we mean that a logical path is initially set up between two end users. Any data units which are then transmitted, follow the same path and stay in sequence.

Another form is the connectionless Transport Service. In this case each transport message is routed independently even for the same destination. Therefore messages may get out of sequence. This is a datagram type of facility and is "for further study." The connectionless service is useful in situations such as credit checking where only a limited amount of data is to be sent in each direction and the overhead in establishing a connection is not warranted.

Within the connection oriented service, there are three basic phases to a transport connection: the establishment phase, the data transfer phase and the release phase. The transport service provides specific services to the session entities which are the users of the transport service. These are the connection establishment service which provides facilities for the user to select the required connection quality, data transfer service which provides transparent transfer of data between the end systems, an expedited data service whereby a limited quantity of data can bypass the normal flow control (e.g. to abort an application that is not accepting data — this is similar to the interrupt packet in X.25), and a connection release service which will terminate a call irrespective of the current state of the call (e.g. partly established or during data transfer). The release is destructive. That is, once the release procedure has commenced any data that is in transit could be lost. It is up to the users of the transport service to ensure that all data is received prior to disconnection. Such a graceful release is one of the functions provided by the session layer.

The Transport Service specification defines the interactions between the transport user and the Transport Service provider in terms of transport service primitives which are an abstract (i.e. implementation independent) means of defining the commands and responses which go between the two. It also specifies the parameters associated with the particular primitives and the relationship between valid sequences of actions. Table 1 lists the Transport Service primitives and their parameters. There are four Transport Service primitive types; T-CONNECT, T-DATA, T-EXPEDITED-DATA and T-DISCONNECT, — one for each type of service. There can be up to four variants of a service primitive type, which will be illustrated for the T-CONNECT service primitive. **Fig. 3** shows the Transport Service provider and two users. A T-CONNECT request is a command from the calling user to the transport service provider requesting the establishment of a connection. A T-CONNECT indication is from the provider to the called user indicating that a connection has been requested. A T-CONNECT response from the called user to the transport service provider to the initiating transport service user completes the connection establishment. The service primitives have parameters which represent information transferred between the user and provider. The T-CONNECT request parameters are : the called address, calling address, whether expedited data is required, the quality of service that the user would like and also a limited amount of transport service user data. Specifying interactions in this manner does not specify the syntax or type of internal command that would be used in any implementation. We have an abstract description so that two different systems can represent their actions using common terminology.

The user data in the T-CONNECT is provided to help reduce the overall connection establishment delay overhead for all layers of an application connection by allowing some information about the session connection to be passed with the transport connection request.

Within the quality of service parameters there are performance parameters which indicate speed, such as establishment delay, transit delay and throughput; reliability, such as connection establishment failure probability; and accuracy such as residual error rate (the number of errors in the data being transported which go undetected). These are listed in Table 2.

The Transport Protocols are designed to enhance the reliability and accuracy of network connections but not their speed. From a user's point of view it may be desirable to group the quality of service parameters to reflect the requirements of typical applications. For

Phase	Service	Primitive	Parameters
Connection Establishment	Connection Establishment	T-CONNECT request	(called address, calling request, expedited data option, quality of service, TS-user data)
		T-CONNECT indication	(called address, calling address, expedited data option, quality of service, TS-user data)
		T-CONNECT response	(quality of service, responding address, expedited data option, TS-user data)
		T-CONNECT confirmation	(quality of service, responding address, expedited data option, TS-user data)
Data transfer	Normal data transfer	T-DATA request T-DATA indication	(TS-user data) (TS-user data)
	Expedited data transfer (X)	T-EXPEDITED-DATA request	(TS-user data)
		T-EXPEDITED-DATA indication	(TS-user data)
Connection release	Connection release	T-DISCONNECT request T-DISCONNECT indication	(TS-user data) (Disconnect reason, TS-user data)

X) service provided only upon TS-user request

TABLE 1. TRANSPORT SERVICE PRIMITIVES

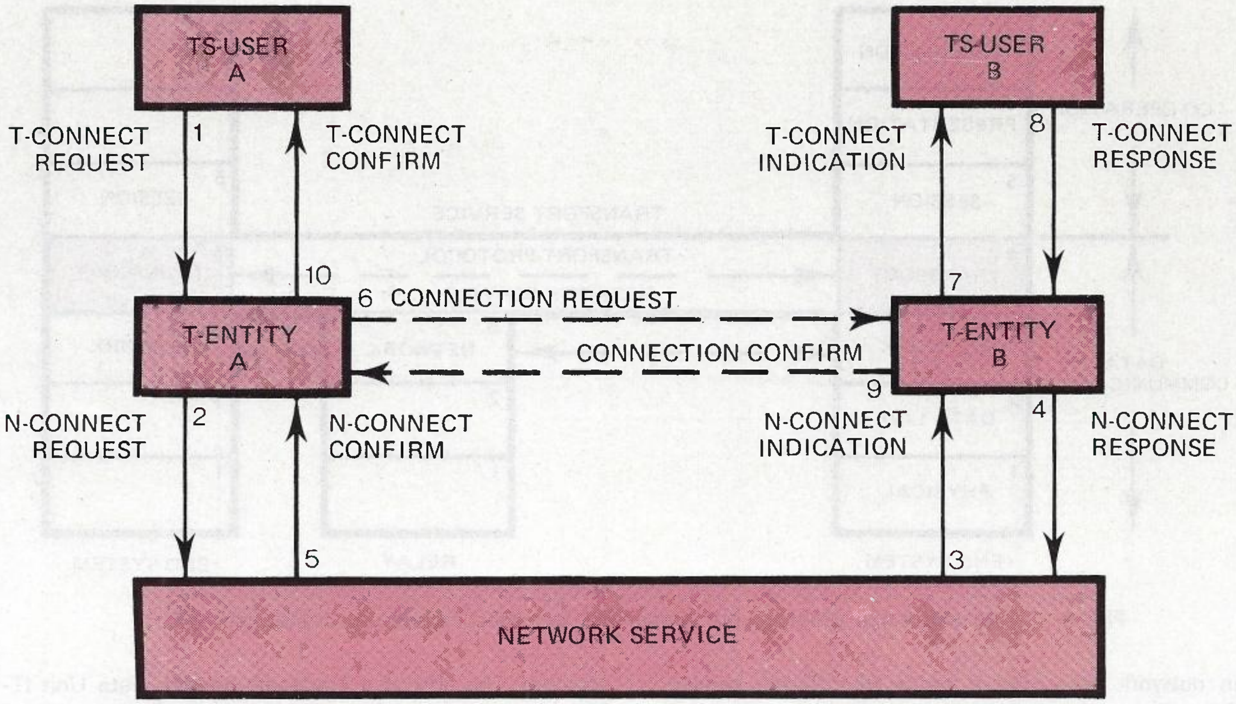

Fig. 3 The four variants of a service primitive

example, real time transactions such as credit checking require low establishment and transit delays but high throughput is not necessary. Whereas for a large file transfer high throughput is required but establishment and transit delay are of less concern.

The relationship between the service primitives at the two ends of a connection must be specified. Time sequence diagrams can be used to do this in an informal manner. **Fig. 4** illustrates their use for a successful connection establishment. The arrows represent service primitives. The left vertical line represent time sequence within System A and the right vertical line that's in System B. The dashed lines indicate a casual relationship between events in the two systems.

The above description methods for the Transport Service are informal as they rely heavily on natural language. In order to have a complete and unambiguous specification a formal description technique must be used as the authoritative specification. Suitable specification languages are currently being developed by both ISO and CCITT. They use a limited set of precisely defined language constructs so that a specification can only be interpreted in one way.

THE TRANSPORT PROTOCOL

The Transport Service is composed of a Transport Protocol sitting on top of the Network Service. It is the Transport Protocol that implements the functions of the transport layer. The functions of the Transport Protocol are listed in Table 3. During the connection establishment phase, the Transport Protocol must select the appropriate Network Service. There could be several networks via which one user may call another, and a

PHASE	PERFORMANCE CRITERION	
	SPEED	ACCURACY/RELIABILITY
ESTABLISHMENT	Establishment delay	Connection establishment failure probability (misconnection)
DATA TRANSFER	Throughput	Residual error rate (corruption, misdelivery, duplication/loss)
	Transit delay	Transport connection resilience
DISCONNECTION	Clearing delay	Disconnection failure probability

TABLE 2. CLASSIFICATION OF PERFORMANCE QUALITY OF SERVICE PARAMETERS

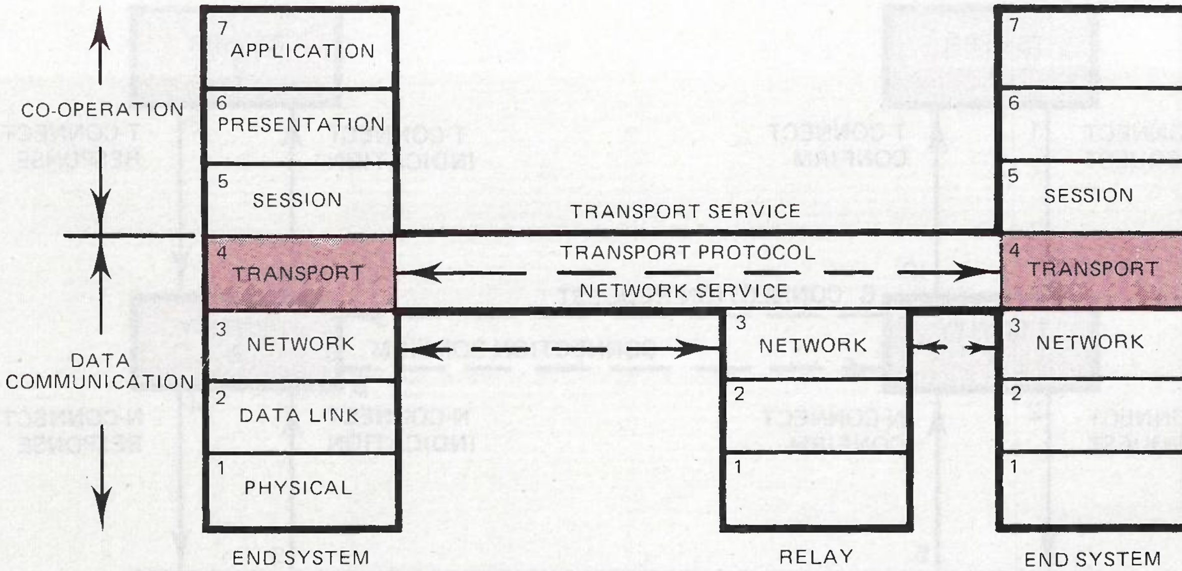

Fig. 4 Time sequence diagram for successful transport connection establishment

given network may offer a range of different service qualities. The network service which best matches the request from the user should be selected. A decision must be made whether or not to multiplex the transport connection onto an existing network connection. This is based on cost optimisation and performance factors. The appropriate transport protocol data unit size must be selected. The size of a Transport Service Data Unit (T-SDU) being passed from the Transport Service user is independent of the size of the Transport Protocol Data Unit (TPDU) transmitted over the network connection. The transport address must be mapped to the appropriate underlying network address. This implies that directory and address translation functions exist within the transport entity. We would like these to be transparent to the user. For instance a user may be able to address a remote entity by name. The transport entity translates this to a network number internally without the user having to do so.

Within the data transfer phase, blocking, segmenting and concatenation functions are provided. Because the TSDU and TPDU size may be different several TSDU's may be blocked into a single TPDU or a single TSDU may be segmented and transferred by several TPDU's. Similary several TPDU's may be concatenated into a single Network Service Data Unit (NSDU). When multiplexing several transport connections onto a single network connection a mans of identifying the individual transport connections must be provided. Flow control is provided to match the data receiving rate and sending rate at the two ends. Error detection and recovery functions may be needed in cases where the network service quality is not sufficient. Also an expedited data transfer service is provided.

Release functions can be invoked irrespective of the current state of the connection.

There are certain additional functions which have not been completely specified as yet, but are recognised as being valid transport layer functions. Examples are security checks on users, data encryption, connection priority, accounting functions and quality of service monitoring. Some of these functions may be provided by other layers.

Service primitives provide the interactions between the users and the transport service provider, i.e. between adjacent layers. The units of interaction between the transport entities within the transport layer are called transport protocol data units and are listed in Table 4.

Connection phase:

- select network service
- decide whether to multiplex
- select optimum TPDU size
- select data phase functions
- map transport address to network address
- distinguish between T-connections

Data transfer phase:

- concatenation
- segmenting
- TSDU delimiting
- multiplexing
- T-connection identification
- flow control
- error detection
- error recovery
- expedited data

Release phase:

Disconnection regardless of current state.

Additional functions:

- protocol version identification
- security checks
- encryption
- checksum
- priority
- accounting
- quality of service monitoring

TABLE 3. TRANSPORT PROTOCOL FUNCTIONS

CONTROL
CONNECTION REQUEST AND CONFIRM
DISCONNECTION REQUEST AND CONFIRM
DATA ACKNOWLEDGEMENT
EXPEDITED DATA ACKNOWLEDGEMENT
REJECT
TPDU ERROR
DATA
DATA
EXPEDITED DATA

TABLE 4. TRANSPORT PROTOCOL DATA UNITS

They are divided into two types, control and data. The control TPDU's provide connection establishment and release. There are also Data Acknowledgement and Reject TPDU's to support error recovery procedures. The Reject TPDU requests a retransmission when loss of data is detected. If a TPDU cannot be recognized an Error TPDU is returned. The Data and Expedited Data TPDU's transport the data and expedited data of the user.

There are many functions provided by the Transport Protocol. Depending on the quality and cost of a network connection not all of them may be required. To facilitate interworking the possible functions have been organised into five classes with options. A class is a specified set of functions. Thus users can implement a specific class and know that the same functions will be implemented by a correspondent user of the same class. The five classes are: simple class (which corresponds to Teletex), basic error recovery class, multiplexing class, error recovery and multiplexing class, and error recovery and detection class.

The choice of which class to use is based on the quality of service required by the user and the quality of the network connection that has been established. Different network connections are classified broadly into three categories. A type A network connection is one where the residual and signalled error rates are satisfactory to the user. Residual errors are the errors that go undetected by the network such as bit errors, out of sequence TPDU's and lost TPDU's. Signalled errors are those that the network has detected but cannot recover from. There are two types of error signals from the network. A RESET indicates that data may have been lost but the connection is still intact and a DISCONNECT indicates that the connection has been lost and possible data lost also. Any recovery must be done by the Network Service user. A type B network connection is one where the residual error rate is satisfactory but the signalled error rate is unsatisfactory. For instance, the network connection may collapse too often and the user doesn't want to be concerning himself with re-establishing the connection all the time. We would like the transport entity to look after this automatically. Finally the type C network connection is one where the residual and the signalled error rates are unsatisfactory to the user. To use a type C networks the user could require a more complex transport protocol capable of automatically detecting and recovering from errors.

The matrix of Table 5 shows the relationship between the different types of network connections (N-connections), the different Transport Protocol classes and whether or not multiplexing is provided. Classes 0 and 1 have no multiplexing or end-to-end flow control, whereas Classes 2, 3 and 4 provide multiplexing and flow control (optional in class 2). Classes 0 and 2 provide neither error recovery nor detection and hence are only suitable for use over Type A network connections. Classes 1 and 3 provide error recovery and are hence suitable for use over Type B network connections and class 4 provides error recovery and detection and is hence suitable for use over a Type C network connection.

5 CLASSES

0 : SIMPLE (TELETEX)
1 : BASIC ERROR RECOVERY
2 : MULTIPLEXING
3 : ERROR RECOVERY AND MULTIPLEXING
4 : ERROR RECOVERY AND DETECTION CLASS

CHOICE BASED ON:

— USER REQUIREMENTS QUALITY AND COST
— QUALITY OF NETWORK CONNECTION

NETWORK CONNECTIONS CLASSIFIED AS:

TYPE A RESIDUAL & SIGNALLED ERROR RATES O.K.
TYPE B RESIDUAL ERROR RATE O.K. — SIGNALLED ERROR RATE TOO HIGH
TYPE C RESIDUAL AND SIGNALLED ERROR RATES TOO HIGH

NETWORK TYPE	CLASS WITH NO MULTIPLEXING	CLASS WITH MULTIPLEXING
A	0	2
B	1	3
C	—	4
	CCITT	ISO

TABLE 5. TRANSPORT PROTOCOL CLASSES

In order to avoid duplicated effort in developing these protocols the CCITT is taking prime responsibility for Classes 0 and 1 and the ISO for Classes 2, 3 and 4.

The Class 0 Transport Protocol is the same as CCITT Recommendation S.70 for Teletex. Teletex is a high speed (2.4 kb/s) enhanced form of Telex designed for communication between word processors. This will provide a first sort of electronic mail facility between different business offices whereby documents that are typed up on one word processing system can be transmitted directly to another. The Teletex Recommendations also include Session (S.62) and Presentation Layer (S.61) procedures required to support document transfer. The Class 0 Transport Protocol only includes the transport layer functions of the Teletex procedures. The functions of the Class 0 Transport Protocol are summarised in Table 6. The Class 0 Transport Protocol only provides connection establishment and data transfer services. It does not provide explicit disconnection, i.e. using a Disconnect TPDU; but relies on the release service of the network layer to inform the remote transport entity of disconnection. It does not provide expedited data or user data during a connection establishment, and therefore does not support the full Transport Service. Other functions not provided include multiplexing, end-to-end flow control, error recovery and error detection. End-to-end flow control refers to explicit credits passed between the Transport entities indicating the number of TPDU's that may be sent. In the absence of this function the Class 0 protocol relies on backpressure flow control. That is, when a transport entity cannot receive any more data it applies local flow control at the network connection interface. As the buffers within the network connection fill up the correspondent transport entity will then be informed by its own network interface that the connection cannot accept more data.

SIMPLE CLASS (0)

- CCITT Rec. S.70 — telex
- Use with type A network-connection

- **Provides:**
- connection establishment
- data transfer with segmenting
- protocol error reporting

- **Does not provide:**
  - — multiplexing
  - — explicit disconnection
  - — flow control
  - — error recovery
  - — expedited data
  - — user data in connection establishment

BASIC ERROR RECOVERY CLASS (1)

- Use with type B networks (typically X.25 based)
- Recovery from network disconnect and reset
  - — TPDUs have sequence numbers
  - — copies retained until acknowledged
  - — REJECT command
- User data in connect
- expedited data
- explicit disconnection
- no flow control or multiplexing

TABLE 6. TRANSPORT PROTOCOL CLASSES 0,1

The functions of the Class 1 Transport Protocol are also summarised in Table 6. Class 1 has been designed to recover from network signalled errors such as resets and disconnects and to take advantage of Network Services such as Receipt Confirmation and Expedited Data which are usually provided by networks with X.25 access. The recovery function works by allocating each TPDU a sequence number and saving a copy until acknowledged by the correspondent transport entity. On receipt of a reset or disconnect from the network, retransmission can be commenced from the last unacknowledged TPDU. In the case of a disconnect a new network connection must first be established. TPDU acknowledgement can either use a Data Acknowledgement TPDU or take advantage of the Network Receipt Confirmation Service if available. Retransmission may be requested by sending a Reject TPDU.

The Class 1 protocol also provides user data transfer during connection establishment, expedited data (using either the Expedited Data TPDU or the network Expedited Data Transfer Service) and explicit disconnection using the Disconnect TPDU. It does not provide multiplexing or end-to-end flow control.

The function of the Class 2, 3 and 4 Transport Protocols are summarised in Table 7. Classes 2, 3 and 4 form a hierarchy in that all functions of Class 2 are provided by Class 3 and all of Class 3 are provided by Class 4. They all support multiplexing of several transport connections onto a single network connection. The individual transport connections are identified by a Destination Reference number in the header of each TPDU. To prevent domination of the network connection by any one of the multiplexed transport connections these classes also provide end-to-end flow control (optional in Class 2). The detail of the flow control mechanism varies for each class but broadly works as follows. The data TPDU's are sequentially numbered for each direction of transmission. The receiving entity indicates the next expected sequence number in the Data Acknowledgement TPDU together with a credit which indicates the number of additional data TPDU's the entity is prepared to receive. The sending entity may send TPDU's with sequence numbers up to the next expected plus the credit, but must then wait for further acknowledgement and credit. Class 2, 3 and 4 all provide expedited data which has separate flow control from nor-

MULTIPLEXING CLASS (2)

- Use with type A network connections
- Multiplexing — uses destination reference
- Flow control optional
  - — transmit window provided using sequence numbers and credit
- No error recovery
- expedited data allowed

ERROR RECOVERY & MULTIPLEXING CLASS (3)

- Use with type B network connection
- Class 2 functions included
- Error recovery similar to class 1

ERROR RECOVERY & DETECTION CLASS (4)

- use with type C network connection
- class 3 functions included
- detects loss, out of sequence, duplicate TPDU's by use of sequence numbers, retransmission on time out
- checksum option

TABLE 7. TRANSPORT PROTOCOL CLASSES 2, 3 AND 4

mal data. However only one Expedited Data TPDU may be unacknowledged at any time and the quantity of user data is limited to 16 octets. Expedited data allows the normal data flow control to be bypassed. For example, consider a text file transfer from a computer system to a remote printer. Because the printer is much slower than the computer the printer would accept a block of data and then use flow control to prevent the computer from sending further data until it is ready. Consider the case where the sending user decides to abort the file transfer. Without expedited data the user's abort command would not be received until the previously sent text had all been printed, but expedited data allows this flow control to be bypassed and the abort command to be passed on immediately.

Class 2 provides neither error recovery nor detection, Class 3 provides error recovery similar to that provided in Class 1 and Class 4 provides error detection as well. The error detection function utilises the sequence numbers of data TPDU's to detect out of sequence and duplicate TPDU's. Time outs on acknowledgements are used to detect lost TPDU's which are then retransmitted. A checksum may optionally be added to TPDU's if bit errors are considered a problem. Most public data networks have a satisfactory residual error rate so that Class 1 or 3 protocols will probably be the most commonly supported. Many North Americans tend to favour Class 1 as it can take full advantage of existing network facilities, while European manufacturers are giving more support to the Class 2, 3 and 4 hierarchy because they are more network independent, provide multiplexing, which suits the European tariff structure, and can be implemented in a unified manner.

To facilitate Open Systems Interconnection it is desirable to have a common protocol class implemented within all open systems. Class 0 has been proposed by CCITT because it is the simplest class. However, it does not support the full Transport Service.

TRANSPORT CONNECTION ESTABLISHMENT EXAMPLE

In this section the different functions are put together to see what happens when a transport connection is successfully established. the different signals that pass between the users, between the transport entities and to the network service will be described.

Fig. 5 shows two transport service users who wish to communicate with one another. Their respective transport entities and the network which does all the routing and relay functions between the two end systems are also shown.

The first thing that happens is that transport user-A, who is requesting the conmmection, sends a transport connection request command (1) to his transport entity (A). This command will include the necessary addressing information and any quality of service requirements of the user. The first thing the transport entity must do is to examine the addressing information to determine the network address of the called transport entity. A directory function may be utilised. The quality of service and cost requested by the user must be examined in order to decide whether to multiplex onto an existing network connection or set up a new network connection.

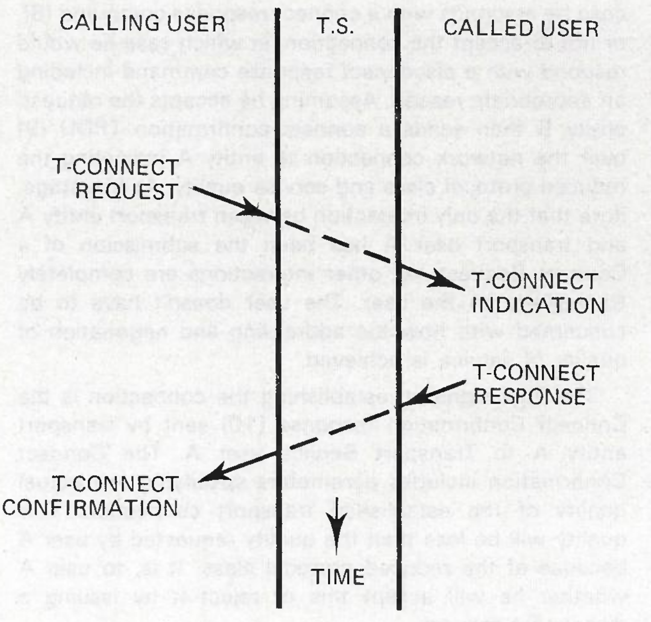

Fig. 5 Transport Connection establishment

Assuming that a new network connection is required a network connect request command (2) is sent to the network service to set-up a network connection to the transport entity (B) at the other end. The network does all the necessary routing functions and then notifies transport entity B that there is an incoming network connection (3). Transport entity B can accept the network connection with a network connect response (4) which results in a network connection confirmation (5) at transport entity A. At this point in time a network connection is set up between the two transport entities and that means that we can now transfer information between the two end systems. The network service informs transport entity A about the network connection quality using parameters of the N-CONNECT-Confirm.

Transport entity A now knows the quality requested by the user and the quality provided by the underlying network so that any difference in quality must be provided by appropriate transport layer functions. Transport entity A can now select the appropriate class of Transport Protocol to build the quality up to that requested by the user. Let us assume Class 1 is selected. This information is included in a connection request TPDU (6) and sent from entity A to entity B via the network connection. On receipt of this TPDU entity B notes the protocol class requested and decides whether it can support that particular class or must negotiate the use of a lower class.

Let us assume that entity B only supports Class 0 and is prepared to accept the connection. It must determine the resultant transport connection quality on the basis of a Class 0 protocol using the previously established network connection. It notifies Transport Service user B of the incoming connection by sending a Connect Indication (7) which includes the quality of service as parameters. Note that the quality of service indicated to user B is that determined by entity B not that requested by user A. The former will be less than the latter because of the reduced protocol class.

User B can decide to accept the connection, in which case he responds with a connect response command (8), or not to accept the connection, in which case he would respond with a disconnect response command including an appropriate reason. Assuming he accepts the request, entity B then sends a connect confirmation TPDU (9) over the network connection to entity A indicating the reduced protocol class and service quality. At this stage, note that the only interaction between transport entity A and transport user A has been the submission of a Connect Request. All other interactions are completely transparent to the user. The user doesn't have to be concerned with how the addressing and negotiation of quality of service is achieved.

The final signal in establishing the connection is the Connect Confirmation response (10) sent by transport entity A to Transport Service user A. The Connect Confirmation includes parameters specifying the actual quality of the established transport connection. This quality will be less than the quality requested by user A because of the reduced protocol class. It is, to user A whether he will accept this or reject it by issuing a disconnect request.

This example provides a summary of the interactions involved in establishing a transport connection and how the transport service makes many of the functions transparent to the user.

FURTHER WORK

Because the transport protocols are implemented in end systems many different implementations throughout the world will need to interwork. It is therefore necessary to formally specify the Transport Service and Protocols in a complete and unambiguous manner so that different implementers will interpret the specifications identically. Some of the protocol procedures are quite complex. It is necessary to verify these procedures against the service specification. It is also desirable to analyse the performance of these protocols under a variety of operating conditions.

The ultimate test of any standard is experience with implemented systems. It is desirable to conduct interworking experiments between different systems across multiple networks to see what the real performance of these protocols is.

CONCLUSION

The implementation of an international standard data Transport Service will open the way for the rapid development of distributed data processing applications and for universal data communications between businesses and eventually households.

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USE OF PERSONAL COMPUTER FOR THE TJA/PAM SYSTEM

The articles appearing in this Journal go through a number of phases. An author plans a paper, puts pen to paper or composes an article on a personal computer using a word processor, and the life of the article begins. The milestones of an article include drafting, editing, galley proof reading, page composition, printing and finally distribution of the Journal to end users. In order to control and monitor the production of the Journal, it is essential that certain actions be taken before critical time points. In order to monitor and control the production of this Journal, a computer system titled Telecommunication Journal of Australia Proposed Article Monitoring System TJA/PAM System was introduced in July 1983. Written in compiled BASIC and operating under the CP/M operating system, the package runs on an ECS 4500 microcomputer. The TJA/PAM System is Menu driven and a number of user options are available to the Editor-in-Chief.

The options include:

- production of timing report
- edit of proposed article file
- listing of editors
- backing up of disk files

W. R. Deitch, Computer Assisted Planning Systems, Telecom Australia

The Australia/Japan Field Trial of CCITT No. 7 Signalling

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Kokusai Denshin Denwa (KDD) Co. Ltd. of Japan, Overseas Telecommunications Commission of Australia OTC(A) and Telecom Australia are currently engaged in the first phase of a field trial of the CCITT Signalling System No.7.

The common overall objectives of this field trial are to further the work of CCITT Study Group XI in 1983/1984 in its consolidation of the 1980 (Yellow Book) Signalling System No.7 recommendations and to extend the technical expertise of the three participating administrations concerning No.7 signalling link design, monitoring and testing. Of particular interest is the functional testing (in which one tests whether the independently developed signalling equipment will properly interwork) and the performance testing (in which the capacity and reliability of the signalling system is compared using three permitted alternative error protection techniques).

In carrying out this field trial KDD is using No.7 signalling equipment within the International Digital Switch (IDS) developed by the KDD Research and Development Laboratories and Japanese Industry whereas Telecom Australia and OTC(A) are using No.7 signalling equipment designed and developed in Telecom Australia Research Laboratories.

The field trial consists of two test periods: the first test period lasts from August to October 1983 and the second lasts from February to March 1984.

The first test period covers level 2 (point-to-point signalling data link) tests at 48 and 4.8 kbit/s and possibly some level 3 (signalling network management) testing. It is planned that at the end of this test period, a joint submission of results will be sent to CCITT Working Party XI/2 meeting to be held in Geneva from 31 October to 18 November 1983.

The second test period will accommodate any tests, particularly level 3 tests, which have not been completed during the first test period and any additional experiments agreed to between the three participating organizations, following discussion of the preliminary results at the November '83 CCITT Working Party XI/2 meeting. A joint contribution of the results will be made to the Study Group XI meeting in Geneva from 24 April to 5 May, 1984.

The schedule of the experiments was mutually agreed to by the three organizations at various co-ordination meetings and correspondence. Emphasis was placed on testing the 'data link' functions (levels 1 and 2) with limited opportunity for testing basic network recovery functions in level 3. It was agreed that no 'live traffic' testing will be attempted. The general consensus on the time schedule is a family of tests listed below in priority order:

1. Level 2 at 48 kbit/s using a satellite link and all three methods of error correction;
2. Level 2 at 4.8 kbit/s with Basic error correction method only and using:
   (a) satellite link;
   (b) submarine cable.
3. Level 3 at 4.8 kbit/s with Basic error correction method only and using:
   (a) two satellite links; followed by
   (b) two submarine links; and then
   (c) a combination of both.
4. Level 2 at 4.8 kbit/s using PCR (Preventive Cyclic Retransmission) error correction method on:
   (a) satellite link; and then
   (b) submarine cable.
5. If time permits, Level 3: changeover between 48 kbit/s satellite link and 4.8 kbit/s satellite or submarine, using the Basic error correction method.

The Australia/Japan No.7 Field Trial is proceeding according to schedule. **Fig. 1** depicts the 48 kbit/s level 2 test configuration for the field trial. It is also proposed to use two 4.8 kbit/s satellite links and two 4.8 kbit/s submarine cable circuits.

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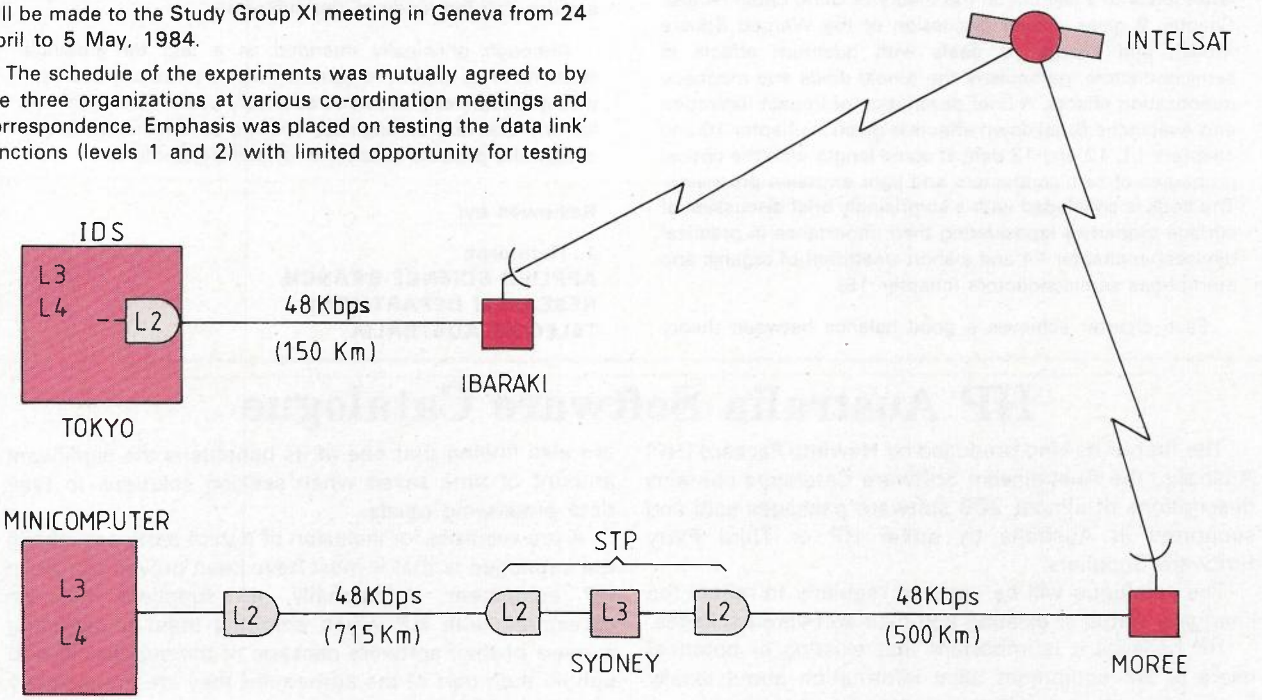
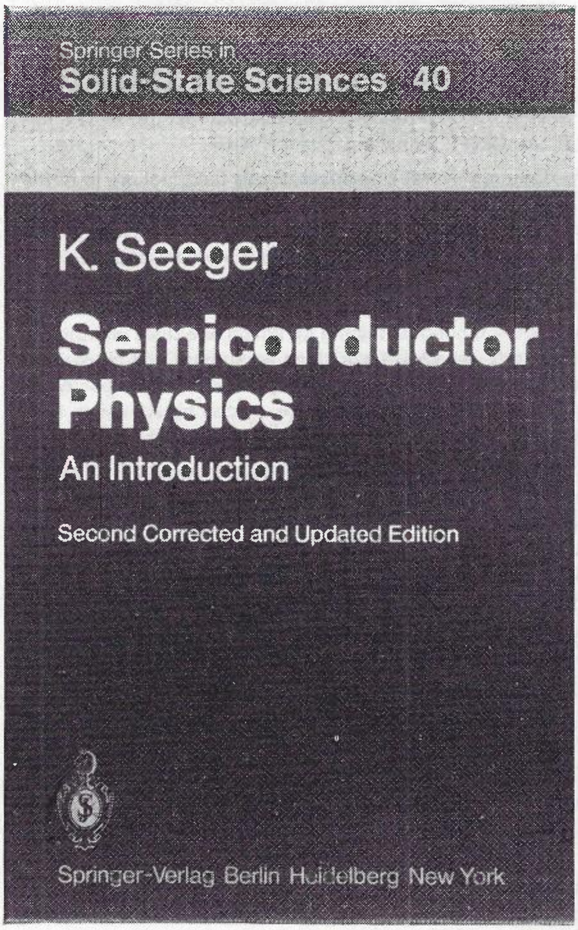


NOTES 1. L2, L3, L4, REFER TO LEVELS 2, 3 AND 4 FUNCTIONS WITHIN CCITT NO. 7 SIGNALLING.
2. I.D.S. INTERNATIONAL DIGITAL SWITCH

Fig. 1 — One of the Level 2 Test Configurations for the No. 7 Signalling Field Trial.

BOOK REVIEW

Semiconductor Physics — An Introduction
K Seeger, Springer - Verlag



Although titled Semiconductor Physics — An Introduction, this book would be better described as an intermediate level text which succeeds in compressing as much of the whole subject of the physics of semiconductors as possible into a volume of 450 pages or so. It is a slightly shortened and updated edition of the original 1977 version which greatly benefits from improved layout and printing style.

This book does not attempt to compete with the greatly expanding range of volumes on the physics of semiconductor devices which is currently available but largely confines itself to the physical properties of semiconductor materials. The properties of these materials are explored in some depth and consequently much of the text is highly mathematical. Also a wide knowledge of modern physics, especially quantum mechanics and solid state physics is assumed, perhaps making the book difficult for the casual reader.

The first chapter contains a short qualitative discussion of basic semiconductor concepts, with chapters 2 and 3 covering the theory of energy bands and energy level occupation statistics. The material in these chapters is covered rather briefly and some familiarity with the subject by the reader would be an advantage. Charge and energy transport effects, particularly those involving magnetic fields such as the Hall effects are covered in chapter 4, with chapter 5 being devoted to carrier diffusion processes along with carrier transport in practical devices (e.g. bipolar transistor and M.O.S.F.E.T.) Almost one quarter of the book is taken up with a discussion of scattering processes, both in a One-Valley Model (chapter 6) and in the Many-Valley Model (chapter 7). The somewhat mathematical treatment of the latter leads to a section on the theory of Gunn Effect diodes. Chapter 8 gives a brief discussion of the Warped Sphere Model, and chapter 9 deals with quantum effects in semiconductors, particularly the tunnel diode and magnetic quantization effects. A brief description of Impact Ionization and Avalanche Breakdown effects is given in chapter 10 and chapters 11, 12 and 13 deal at some length with the optical properties of semiconductors and light emission processes. The book is concluded with a surprisingly brief discussion of surface properties (considering their importance in practical devices) in chapter 14 and a short treatment of organic and amorphous semiconductors (chapter 15).

Each chapter achieves a good balance between theory and a description of current experimental techniques and results, and each is provided with a comprehensive list of references, making this book a very useful starting point for a more detailed study of the subjects.

Although principally intended as a text for graduate students to be read in conjunction with a university course, I would recommend the book as a very useful reference text for any scientist or engineer wishing to understand more deeply the physical properties of semiconductors.

Reviewed by:

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HP Australia Software Catalogue

The first of its kind produced by Hewlett-Packard (HP) Australia, the Australasian Software Catalogue contains descriptions of almost 200 software packages sold and supported in Australia by either HP or Third Party Software Suppliers.

The catalogue will be updated regularly to reflect the changing status of existing and new software packages.

HP believes it is important that existing or potential users of HP equipment have information about locally supported software. Users need to be able to go to a single reliable source when searching for software. That is the aim of this catalogue. DP managers and end-users are also finding that one of its benefits is the significant amount of time saved when seeking solutions to their data processing needs.

A pre-requisite for inclusion of a third party package in the catalogue is that it must have been proven to run on HP equipment. Additionally, all suppliers sign an agreement with HP which commits them to on-going support of their software package. If the supplier fails to uphold their part of the agreement they are immediately excluded from the program.

The Australasian Software Catalogue may be purchased through any Hewlett-Packard sales office.

Optimizing Communications : Relating the Roles of Voice, Text and Video

M. CASSIDY, B.Sc., M.E., Dip.Pub.Admin., F.I.E. Aust., F.I.E.E.

Communication and its real costs are significant factors in a business enterprise, and there is an optimum mix of the use of voice and text in all circumstances. Wideband video as an adjunct to voice and text is not justifiable on current evidence, and may be distracting in teleconferencing applications, where however graphics is universally needed. Educators have a duty to identify, utilize, adapt, and disseminate communications user guidelines and to encourage the use of optimizing principles.

Philosophers have agonized about speech for a long time.

"Sprechne ist Silbern, Schweigen ist Golden"

says the Swiss inscription. Thomas Carlyle (Ref 1) interpreted this inscription to mean:— "Speech is of Time, Silence is of Eternity."

What did other writers have to say on this topic?

"Speech is the small change of silence."

says Meredith. And Shakespeare expresses a similar thought more pungently in Macbeth (Ref 2)-

"Life's but a walking shadow, a poor player
That struts and frets his hour upon the stage
And then is heard no more : it is a tale
Told by an idiot, full of sound and fury
Signifying nothing"

All of the writers cited above are conveying the idea that speech is the "noise" of civilization. When literally all has been said and done, only the products of silence, golden silence, remain. Golden, because silence can foster serious thought, and with it, production of the written word with purposeful intent.

The thesis of this paper is firstly that speech is not just noise. Human communication is clearly important in the activities of a modern industrialized society. A business-oriented society cannot afford to multiply activities that signify nothing. Secondly, the effective use of time-consuming speech demands that we use the golden, the eternal, attributes of silence to generate relevant written prose. Thirdly, written prose, sent in advance of speech, makes it possible to use a combination of speech and text to form an efficient medium of communication; well-suited to our times.

Speech **is** of time, and time costs money in a business enterprise. What is the nature of business? And what is the nature of the cost of communicating?

THE ROLE OF COMMUNICATIONS IN BUSINESS

Business embraces the processes of commerce and industry, and in essence is concerned with shifting physical objects, or information, or both. So business is concerned with control of the flow of goods and information. In other words, a business enterprise is concerned with the control of a number of factors of production to achieve a business objective. A typical objective is to maximize profit. See **Fig. 1**.

Typical factors of production include raw materials, labour, machinery, buildings, finance and accounting, transport, stores, administration, marketing and communications.

The real cost of all factors of production is significant to the business. Failure of communications can mean that the business fails to maximize the degree to which its objective is attained. This cost, measured in dollars, constitutes the real cost of communications. It is an opportunity cost which may be several times the cost of the communications apparatus that it uses.

To run a business, the businessman needs a suitable control mechanism, which engineers would represent by a model such as in **Fig. 2**.

The businessman optimizes output by a process of monitoring, evaluation and correction using a communication system. In the model, the communication system is said to provide a feedback path, via which control of the business is exercised.

In real life there are numerous feedback paths. For instance, in many businesses, manufacturing, transport and sales are typical factors of production which require feedback paths as illustrated in **Fig. 3**. The dominant requirement is an appropriate response time. For example an airline ticket enquiry station must respond in a matter of seconds, while the manager of a Northern Territory cattle station could tolerate perhaps a few days delay in getting a response from the Head Office in Sydney.

Modern computer-controlled, integrated production systems embody, literally on the shop floor, devices with very fast response times, which result in rapid production of products to a pre-set program. This relatively new phenomenon transfers to the associated office area (top of **Fig. 4**) a need for a matching response time. In the office area correspondingly swift and timely control decisions have to be made.

In simple terms, control of the business can be exercised in at least two modes:—

- by telephone, an interactive means with potentially fast response time; and

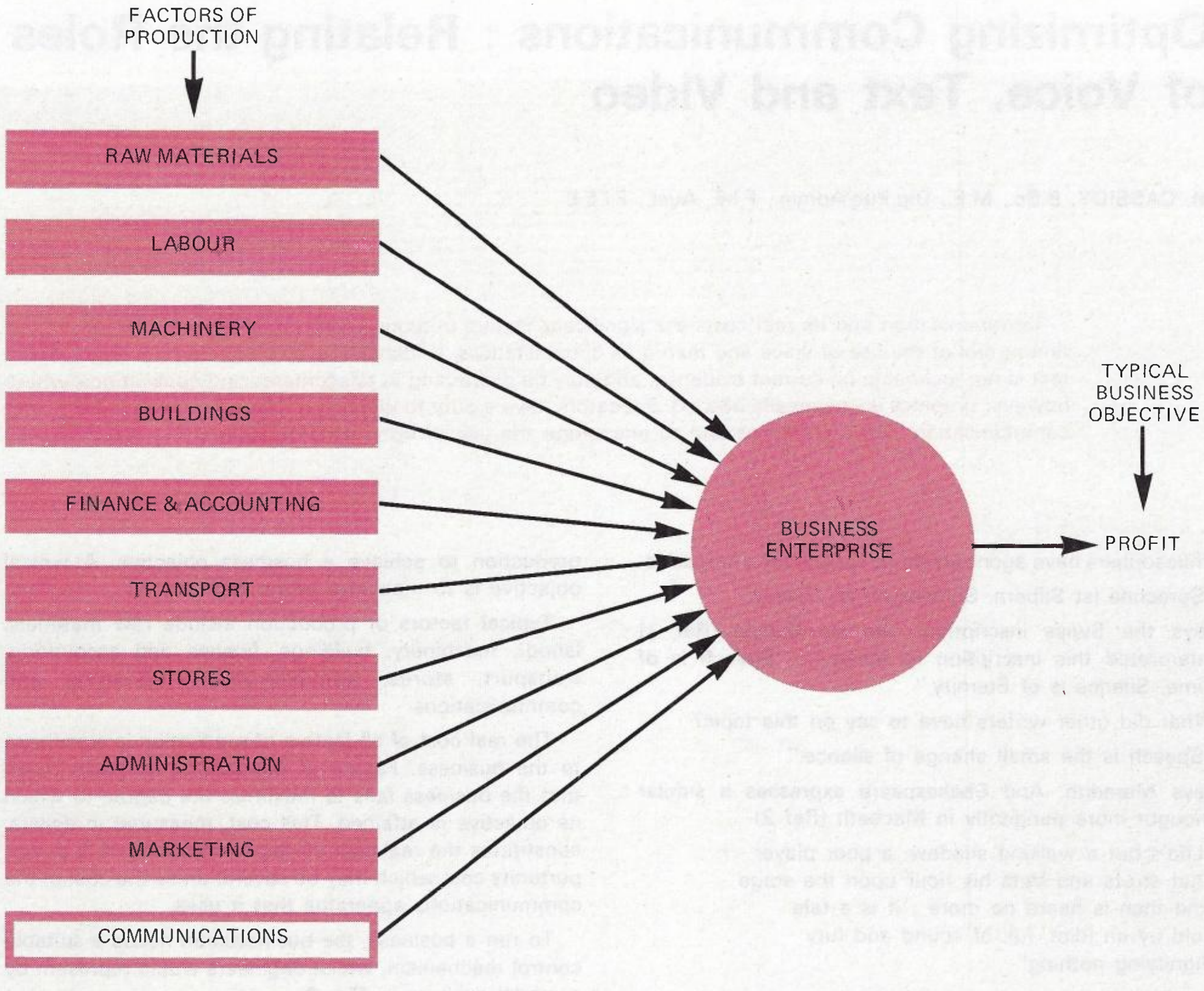

Fig 1 Typical Factors of Production in a Business Enterprise

MAX CASSIDY joined Royal Melbourne Institute of Technology 18 months ago from Telecom Australia, Research Laboratories, where he was head of the Business Communication Section. For three years, he led research in business communication terminals, systems and services.

This followed more than 30 years experience covering a range of aspects of communications engineering, with applications in civil aviation, meteorology and Telecom Australia. Work towards a major and significant report on communication for air traffic services in Australia kindled his interest in communication networks. A particular interest has been human factors aspects, and the rational utilisation of services available to air traffic controllers. More recently, his paper on terminal integration for a range of services in the business office, was presented at an international symposium in Paris in November 1981.

Max is presently Industrial Projects Officer, of the Faculty of Engineering at RMIT, engaged in liaison and interaction between RMIT and industry. He retains an abiding interest in communications.

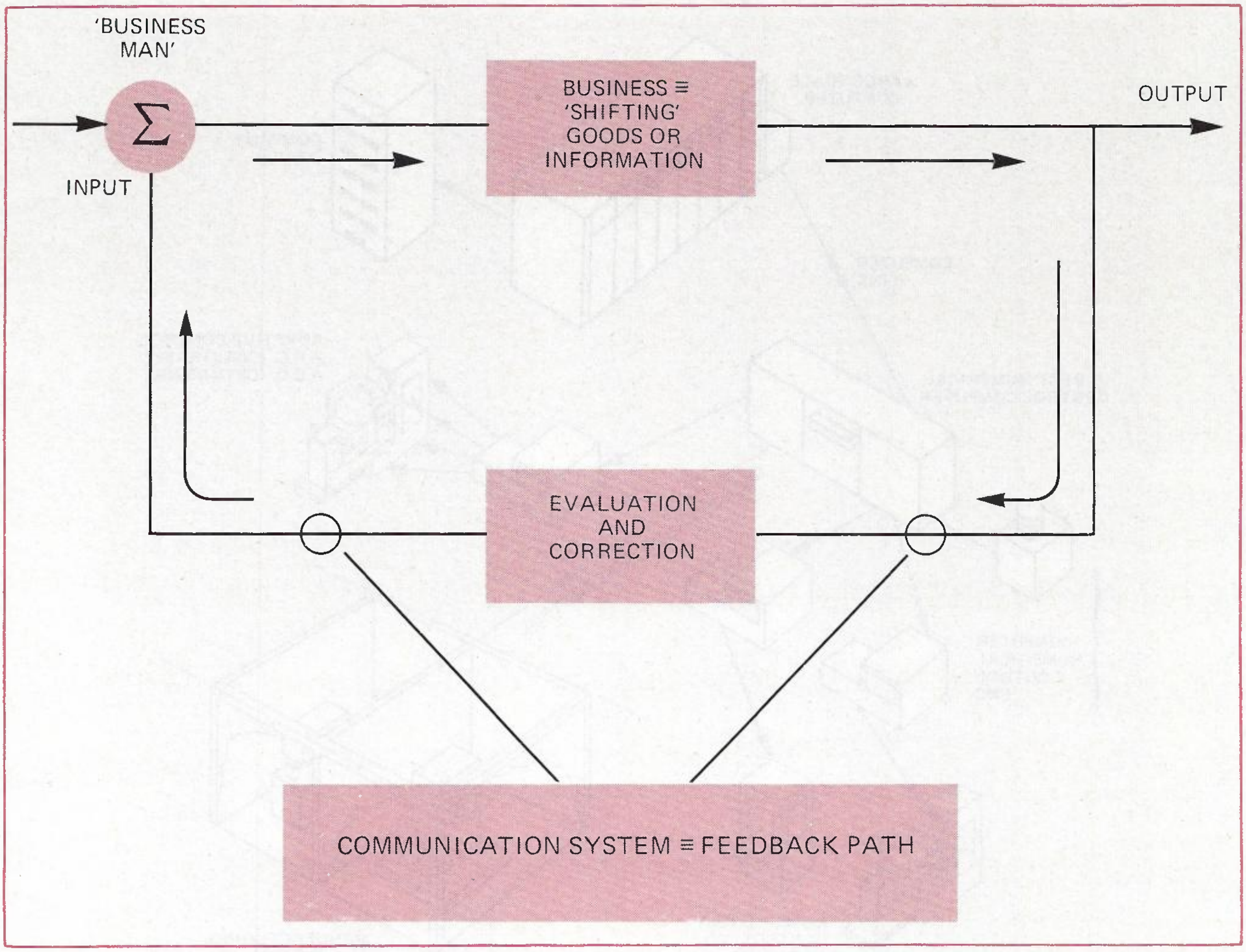

Fig 2 Crude Model of Business Enterprise

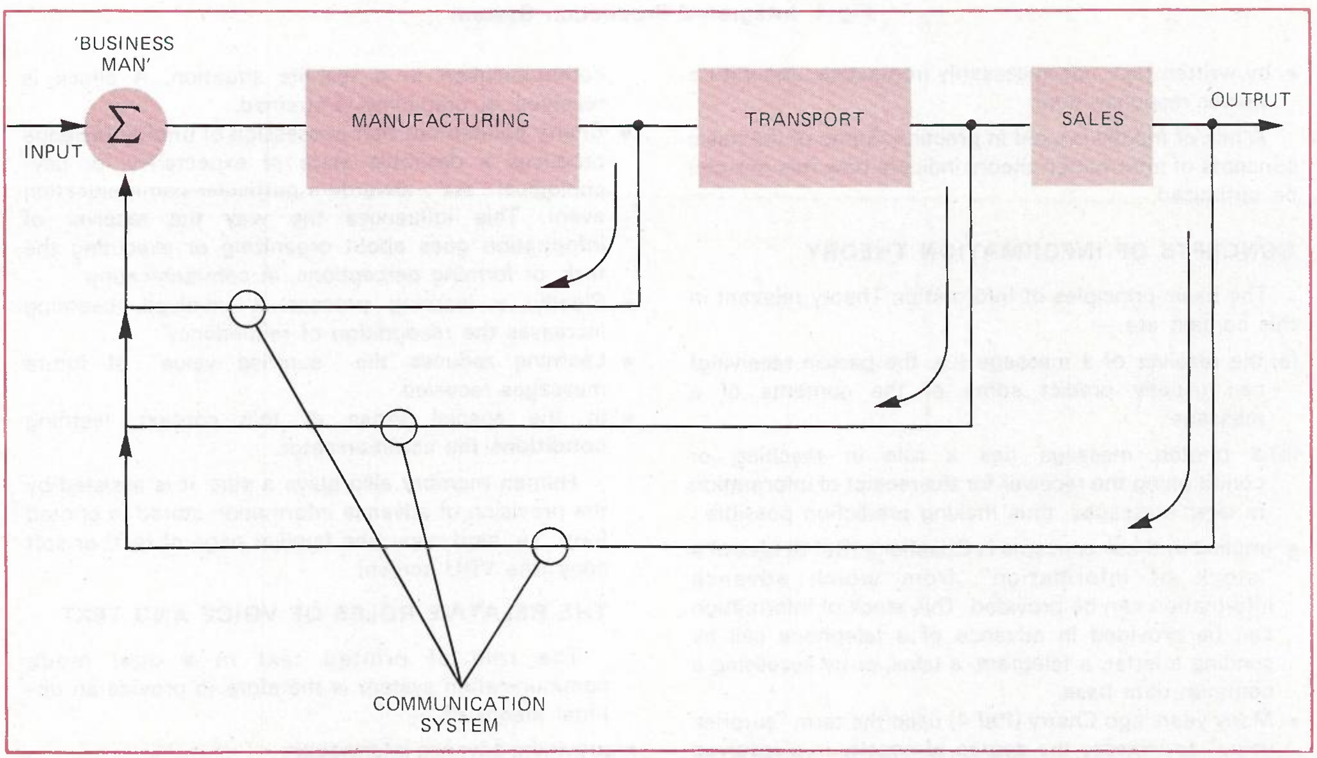

Fig 3 Secondary Model of Business Enterprise

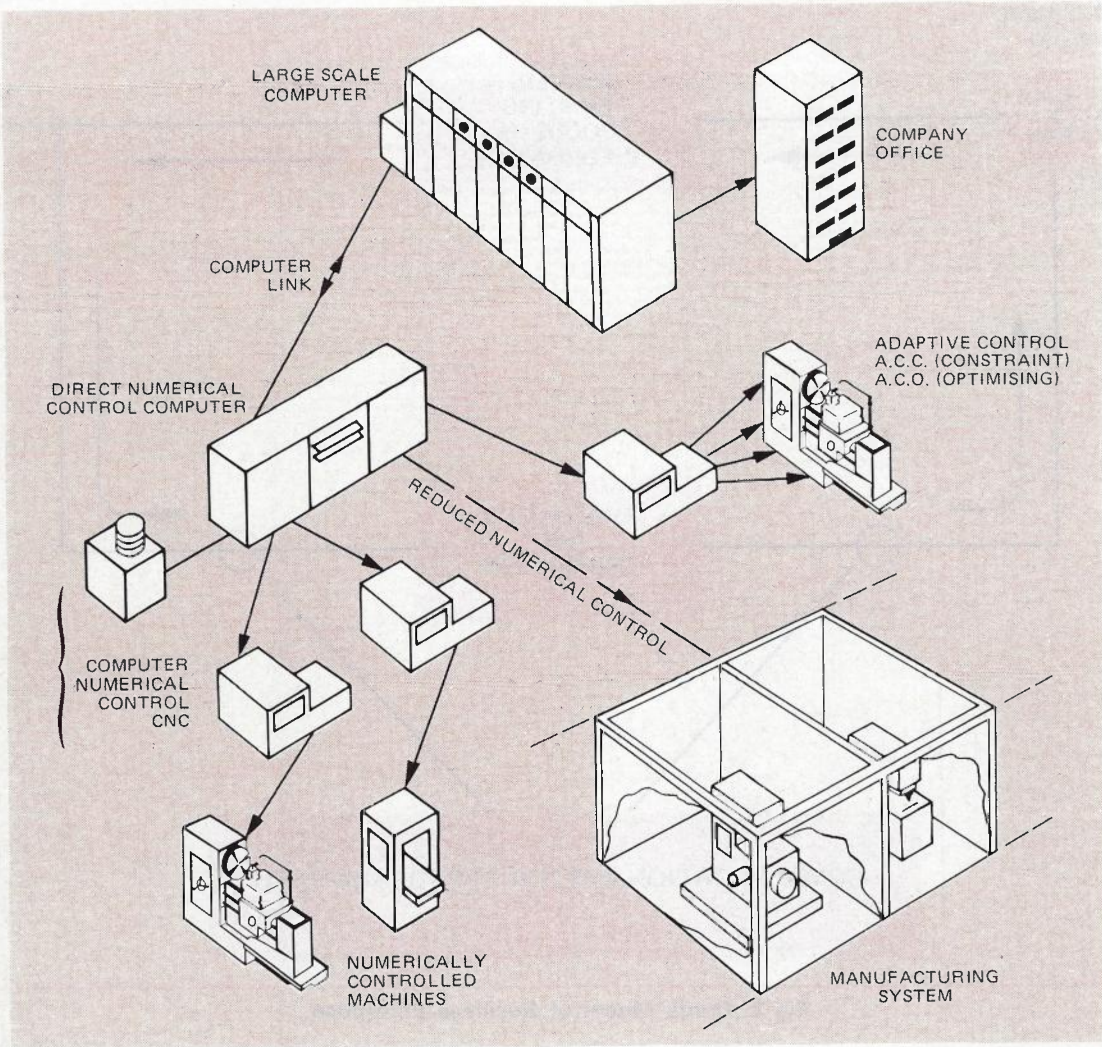

Fig 4 Integrated Production System

- by written text, not necessarily interactive, and with a slower response time.

A mix of modes is used in practice. Some of the basic concepts of information theory indicate how this mix can be optimized.

CONCEPTS OF INFORMATION THEORY

The basic principles of Information Theory relevant in this context are:—

(a) the receiver of a message (i.e. the person receiving) can usually predict some of the contents of a message;

(b) a printed message has a role in teaching or conditioning the receiver for the receipt of information in later messages, thus making prediction possible.

- Implicit in these concepts is Quastler's (Ref 3) idea of a "stock of information" from which advance information can be provided. This stock of information can be provided in advance of a telephone call by sending a letter, a telegram, a telex, or by accessing a common data base.
- Many years ago Cherry (Ref 4) used the term "surprise value" to indicate the degree of novelty in a received message. Too great a surprise can inhibit effective communication in a real-life situation. A shock is received, or credibility is strained.
- Cherry pointed out that possession of prior knowledge produces a desirable state of expectancy, or psychological "set", towards a particular communication event. This influences the way the receiver of information goes about organizing or executing the task, or forming perceptions, in communicating.
- Clearly, a learning process is involved. Learning increases the recognition of redundancy.
- Learning reduces the "surprise value" of future messages received.
- In the special sense of this context, learning **conditions** the communicator.

Human memory also plays a part. It is assisted by the provision of advance information stored in printed form; i.e. hard copy (the familiar page of text) or soft copy (the VDU screen).

THE RELATIVE ROLES OF VOICE AND TEXT

The role of printed text in a dual mode communication system is therefore to provide an optimal means of:—

- providing advance information;
- transmitting information which must be stored to —

VOICE AND HEARING	HARD COPY
1. Volatile 2. Real time 3. Information sequentially presented 4. Poor referability because less convenient working memory or storage 5. Can use audible tones as symbols 6. Flexible e.g. voice inflexion, and cheap 7. Can select by ignoring redundant material 8. Slow — depends on rate of speaking voice and dynamic comprehension 9. Attention-demanding read-out	1. Non-volatile 2. Stored time 3. Information presented spatially or sequentially 4. Good referability because of storage characteristics 5. Wide variety of form of display including symbols 6. Flexible methods are more expensive, e.g. television, facsimile, or videotex 7. Must search for relevant information 8. Rapid scan possible, particularly if symbols are used 9. Secondary alerting is needed

Table 1 Contrasts between Voice and Text as Media of Communication

ROLE OF VOICE	ROLE OF PRINTED TEXT
Should be used primarily for — • updating text, • ad hoc and unpredictable messages, • warning and alerting, • resolution of conflicts	Should be used for — • routine and non-volatile information required for future action and/or reference • a faster rate of presentation

Table 2 The Roles of Voice and Text.

— assist human memory
— avoid the need for memorizing;
- conditioning the receiver of information.

A review of the contrasts between printed text and voice summarized in **Table 1** leads to a set of inferences which categorize the roles of voice and text, as set out in **Table 2**.

ROLE OF VIDEO IN COMMUNICATION

Turning now to the role of video in communication, it is found that video images do not fit as an extension of the voice/text dichotomy. Video is prominent as an adjunct to voice in video conferencing, and this is the dominant application considered in this paper. Both video and audio conferences should be set up by sending text in advance, using the principles just discussed. Also, in both video and audio conferencing, a graphics facility is essential. Graphics does not necessarily require costly wideband transmission in real time; for example, facsimile transmitted over the telephone network could suffice.

A crucial question is : what does video add to audio, in tele-conferencing? The question arises because video facilities can be costly, even though transmission costs are declining as optic fibres displace coaxial cable.

There are three principal teleconferencing options utilizing video.

The first is to simulate, as realistically as possible, the conference table situation used for typical face to face conferences. The second is to make available to conferees close-ups of the distant speaker, selected at the will of each conferee. The third is to use Slow Scan Television (SSTV) to provide these images.

A fourth teleconferencing option, of course, is to use no video at all.

The first option, to simulate a conference room, was developed more than a decade ago in Australia by the late Albert Seyler of Telecom Research Laboratories. Dr Seyler sought and achieved a sense of realism in simulating the conference table by developing the split-screen video technique. This allowed one video channel to deliver the images of six conferees to the distant end, and display them on two TV screens mounted side by side, or in stacked format. See **Fig. 5**.

Only 312 scan lines were displayed on each screen, adequate for a head and shoulders image. This system has been well received internationally.

Seyler was keenly aware of the limitations of the simulation approach, for instance, it is impossible to

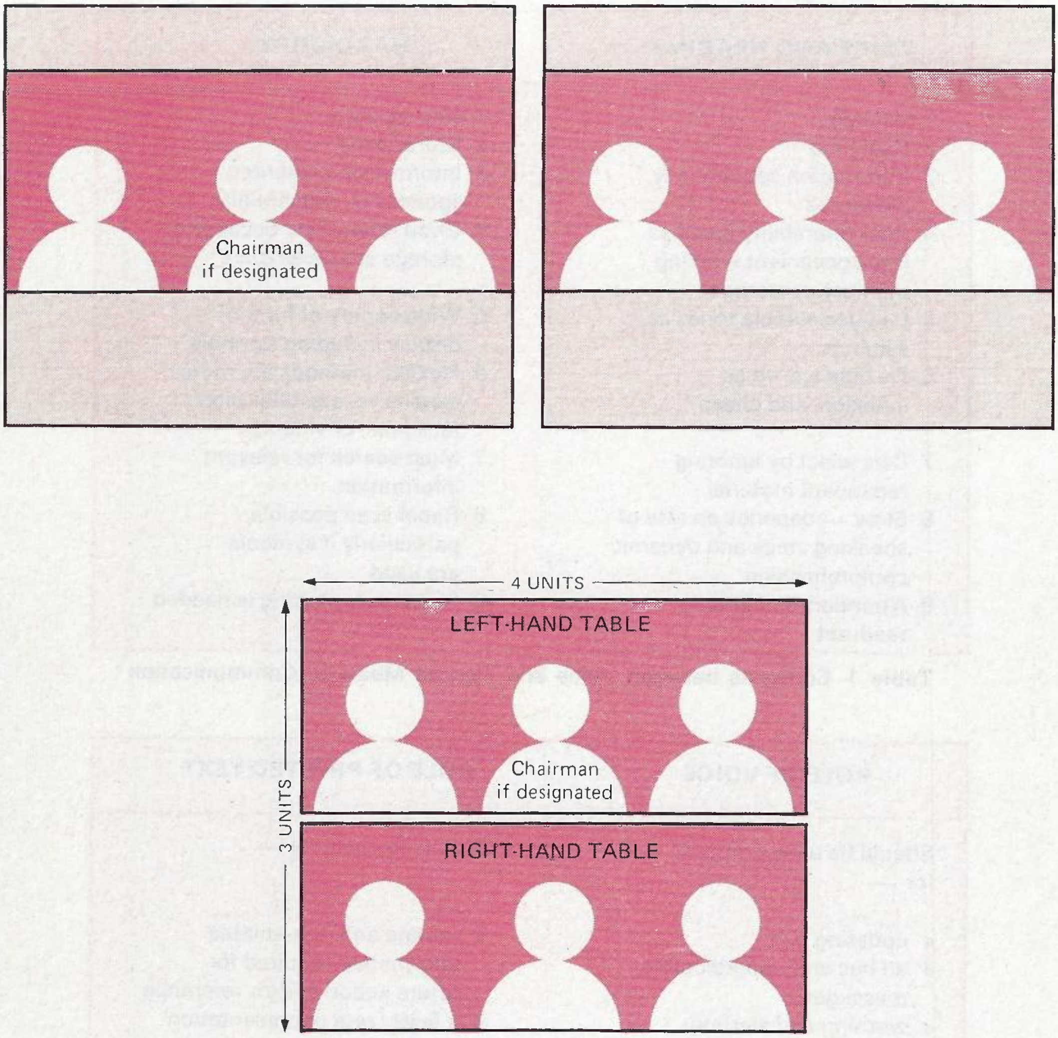

Fig 5 (a) Stacked Picture Format
(b) Unstacked Picture

exercise the social graces by offering one of the distant conferees a cigarette, or a cup of coffee! Now a review of the conference room simulation approach is due because costs are significant and fixed conference studios can be inconvenient to the user. At about $0.5 Million per studio, costs of fixed studio facilities tend to dominate when buildings and services are taken into account. Transmission costs could fall when optic fibres become commonplace and satellite channels are more freely available. As fixed studios are inconvenient to occasional clients of a publicly-available service, lower grade of service could be provided by a mobile trolley-mounted terminal in an ordinary conference room. Some acoustic treatment of conference room walls and adequate, specially adjusted lighting would be needed.

The second option, namely, close-ups of speakers, could be off-putting to the occasional user. The ill-fated video telephone of the mid-1960s testifies to customer resistance at that time. The third option, SSTV is positively distracting and is unlikely to be adopted. The speaker image is often frozen in mid-gesture, with sometimes grotesque results.

The inference is that video has conflicting aspects in teleconferencing:—

- It is vital if simulation of face-to-face conferencing is worthwhile — but we have seen that simulation has limitations.
- Video, of course, conveys some "body language".

Television interviews reveal the mannerisms of well known and experienced personalities. However, as the typical video teleconference displays only the head and shoulders of conferees, it seems unlikley that the costly wide bandwidth is warranted to convey only limited body language.

- As experience shows that the video picture is not used intensively for most of the time, the wide bandwidth is fully utilized during relatively few crisis moments in a conference. It is questionable whether it is justified to have video on hand, as it were, to judge the significance of facial reactions as distinct from other less dramatic body language, and whether the cost of making these judgements is warranted.
- If the conferees have never met in person, video can be

positively distracting. On a first occasion, the conferees seem to devote much attention to learning the body language transmitted, to the detriment of the voice discussion which is the primary purpose of the conference.

Resolution of the role and contribution of video has been an object of studies in which subjects are given problem-solving tasks to perform via various conferencing modes. The studies seem to have been rather inconclusive largely because the significant role of text as an adjunct to voice is overlooked. A pragmatic resolution of the role of video requires a review of reasons why people meet face to face in conference. These reasons are:—

- There are social contact aspects — the handshake, the offered cigarette, the cup of coffee.
- A well-planned meeting is documented in advance, and the meeting is held to try to resolve conflicts for which voice is appropriate, and adequate.
- There are deeply ingrained cultural reasons for meeting when conflict is probable.

Face to face meeting, accompanied by perhaps heated discussion, may well be a sublimated derivation of resolution of conflict by physical fighting.

The author's judgement is that there is no really good reason for using video in conferencing apart from providing graphics. But graphics need not use video band-width.

Audio conferencing is a practical and optimal version of teleconferencing. It uses:—

- a micro-processor controlled signalling system, for conference control by the conference chairman;
- a menu of conference protocols;
- appropriate graphics.

Inflections of voice can provide "colour". Voice inflections constitute an additional source of information which is a formal feature of many Asian languages, and are used by English-speaking people perhaps more than they realize.

APPLICATION IN TELE-EDUCATION

Tele-conferencing techniques have potential applications in tele-education. Tele-education is a term which covers the use of a tele-conferencing facility to provide interactive communication between:—

- the lecturer and a class of students;
- the lecturer and individual students in a class;
- students, in a range of class-room situations.

Graphics is important in this application. The adaptation of audio conferencing facilities to tele-education is an exciting field of development to which all interested parties should endeavour to contribute. In accordance with the thesis of this paper, documentation should be delivered in advance of the "tele-class". This documentation should include still pictures of the lecturers — and all of the students — to assist in personal introductions. But probably there is no substitute for one or two personal encounters between the lecturers and each student.

VIDEOTEX

Concern with the pros and cons of orthodox wideband video should not blind users to the merits and applications of videotex. Videotex is an interactive information service in which pre-formatted information from a computer data base is displayed in textual and graphic form on terminals. These terminals are either modified domestic television receivers, or dedicated business terminals. Communication with the data base can take place at relatively low data rates over normal telephone circuits.

Videotex presents information a page at a time. It allows for rapid scanning, and visual cross-referencing, as with a printed page. These qualities make the voice counterpart of videotex, called 'Heardata", not a viable alternative. Indeed, Heardata is in breach of the principles of the communications model espoused in this paper. Videotex systems can be publicly available (like the U.K. Prestel), or private (like Control Data's CYBERTEL; or PLATO, already used extensively for educational purposes).

Videotex is a narrow-band system with widespread applications. The challenge to the educator is to apply videotex as an educational tool, as has been done with the Telidon system by the Ontario Education Department in Canada. Educators should alert students to its applications, for example, in tele-shopping.

Tele-shopping is a term used to describe the use of a central data base to order goods or services from a retail store, warehouse or central agency. It could well provide a substitute for much time consuming suburban travel.

In using videotex for tele-shopping, the first step is to consult an index page to locate material describing the goods to be purchased. A next step is to examine graphically presented details of a prospective purchase, then by calling up the ordering page the shopper can order the goods and arrange delivery.

THE DOMESTIC SCENE

Videotex is one of the facilities which bridges the area between business, on which attention was concentrated in developing a communications model, and the domestic scene — house, flat, apartment, family, or commune. The domestic scene has two segments. Running a household is a business in which a judicious mix of voice, and text or image, can save time and frustration. In addition, members of a household engage in social intercourse. Relationships are built up by a complex of exchanges of gifts, letters, and outings with other members of the social group. These activities serve to "condition" group members and their role is the counterpart of the role of text communications in the business model. Likewise the telephone is used to update arrangements and to resolve conflicts.

RECAPITULATION

Speech is of time; time is money. The real cost of business communications is an opportunity cost, the cost to the business of failure to communicate optimally in a timely and effective manner. Communications users should resist the blandishments of salesmen who advocate a trial and error approach to discovering the optimum way to use communication facilities.

The salient aspects of optimal communications are as follows:—

- Text and speech are partners;

- Text is for **conditioning** the intended listener;
- Speech is for resolution of residual conflicts, following this conditioning;
- On balance, pictures of people in conference are distracting and not worth the cost of presentation;
- Graphics facilities have definite value in tele-conferencing and tele-education.

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The ITU: Its Formation and Its Work

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The history and structure of the International Telecommunication Union is briefly traced from its beginnings in 1865 to the present, outlining in this context the significance of key stages in the development of telecommunications. The paper also describes two current ITU projects in the South Pacific Area and in Papua New Guinea as examples of the role the ITU fulfills as a specialised agency of the United Nations.

It is appropriate in World Communications Year — 1983 to examine the beginning of the International Telecommunication Union (ITU) and some of the typical aid projects for which it is responsible.

A BRIEF HISTORY OF THE ITU

Early Telegraph Systems

There are many famous names scattered along the path that led to the invention of the electric telegraph, e.g. Oersted, Gauss, Weber, Cooke, Wheatstone, Morse & Chappe to name but a few.

Telegraph systems were used to great effect in the UK where Cooke & Wheatstone established their Electric Telegraph Company after successful installations, mainly with the British Railways, of their 1837 patented system. By 1852 it was estimated that there were some 6500 km of telegraph lines in England. In the USA the development of telegraph did not proceed as smoothly as it had in Europe and it was not until 1865, when many private companies were consolidated into the Western Union Telegraph Company, that there was any real and rapid expansion.

However, by the mid-1800s, the telegraph had become the first truly international communications system. The first treaty on record designed to link the telegraph systems of two States was signed on 3 October, 1849 between Prussia and Austria. In 1850 Bavaria and Saxony joined these two and created, at Dresden, the 'Austro-German Telegraph Union' which remained in existence until 1872.

THE FIRST ITU — The International Telegraph Union

In 1865 twenty states accepted the invitation of the French Imperial Government to attend a conference to negotiate a uniform international telegraph system and after deliberating from 1 March to 17 May they signed the first International Telegraph Convention. This was the birth of the International Telegraph Union and unbeknown to them they had started a period of over 100 years of uninterrupted universal co-operation in the field of Telecommunications, despite the disruption of two world wars. Much of the credit for this must go to the 'Administrative Conferences' which met at London in 1879, at Berlin in 1885, Paris 1890, Budapest 1896, London 1903 and Lisbon in 1908. By this time the membership of the Union had risen to 52 countries and 25 private companies.

The method of funding the Union is worth noting. Each Member chose a class for the payment of its obligations, there being then six classes: Class I with 25 units, II with 20, III with 15, IV with 10, V with 5 and VI with 3 units.

The number of Members paying each class was multiplied by the units in that class, and the totals of these six multiplications was added together; thus the total number of units available for that financial year was arrived at. The total expenses of the Union were then divided by the total number of units available and thus the value of each unit was determined. Hence each Member's annual payment was not only its own choice but was also related to the expenditure of the Union as a whole during that year.

Telephony

The development of the telephone probably began when Robert Hooke (1635-1703) suggested how speech might be transmitted over long distances, but it was not until 1860 that Philipp Reis of Friedrichsdorf transmitted a musical melody electrically over a distance.

In 1876 applications for a patented telephone were filed in the United States by Alexander Graham Bell and Elisha Gray. Both applications were filed on the 14th February, but after much bitter legal dispute the patent rights were awarded to Bell. It may be recalled that a similar co-incidence occurred with the development of calculus.

Although these early cabling devices were crude and communications were poor, development was rapid in the USA. Bell widely publicised his invention and the first telephone and switchboard for commercial service was installed at New Haven, Connecticut, in 1878, with 21 subscribers. Long distance trunk lines connecting the major centres followed quickly over the next few years.

The development of the telephone in Britain was hampered by the virtual monopoly of telegraph. The Telegraph Act of 1869 gave the British Post Office a monopoly on all telegraphic communications and an 1880 High Court decision held that a telephone was a telegraph within the meaning of the act. The situation was similar throughout Europe and it was not until the end of last century that the Federal Authorities took over control of telephones in most European Countries.

In 1885 the International Telegraph Union took official notice of the telephone. The two significant events in the next few years were the development by Strowger of his step-by-step switching system during the period 1889 to 1896 and the patenting by Pupin of his method of regular spacing of inductance coils to increase the transmission efficiency of long telephone lines.

At the 1903 London conference a set of 15 different articles on international telephony were drawn up and incorporated in the Telegraph Regulations. They remained virtually unchanged until the Paris Conference in 1925.

Wireless Telegraphy

The late 1880s also saw the beginnings of radiocommunications with names such as Rontgen, Becquerel, Curie, Henry, Maxwell, Hertz, Lodge and Marconi standing out.

Lodge, an Englishman, worked extensively in the field of electromagnetic waves and was the first to comment on the phenomenon of resonance or tuning. Marconi's first patent for a radio system was accepted in 1897 and Lodge took out a patent in 1898 on an adjustable inductance coil in the antenna circuit of a wireless transmitter or receiver, or in both, in order to tune one with the other. It was Marconi, however, who invented a highly successful system of wireless telegraphy. He also personally inspired and supervised its application until it spanned the world.

In spite of the very elementary state of radio the First International Radiotelegraph Conference was held in Berlin in 1906 where a Convention modelled on the International Telegraph Union Convention of 1875 was adopted.

The New ITU

A milestone in the history of telegraphy, telephony and radio occurred when the 13th International Telegraph Conference and the 3rd International Radiotelegraph Conference met simultaneously in Madrid in 1932. These two separately legal entities were merged for the first time and the name finally selected for their new bod, was the "International Telecommunication Union" or ITU. A single new Convention covering all three technical fields was signed on 9 December, 1932 by all 80 countries present, with the exception of one, which apparently had not received the necessary powers.

What was the state-of-the-art in the three fields at the birth of the new ITU in 1932?

- Telegraphy, the oldest of the services, was employing the latest frequency division multiplex techniques and was benefiting from the advances in telephone carrier transmission and the laying of underground and even submarine telephone cables for reliable direct communications over long distances.
- Radio Radiotelegraphy, both for maritime mobile services and aeronautical services had become firmly entrenched with, for example, a circuit between London and Sydney (17,000 km). The British Administration had just inaugurated a start-stop public subscriber telegraph service which it christened "telex". Telegraphy was providing major services for aeronautics with the shortcomings of radiocommunications between airports being made good by overland links where possible, incorporating teleprinters. Telephotography was also a reality.

  Radio growth had exploded in the years prior to 1932 and it was reported that in that year there were 1113 broadcasting stations in the world, 235 of them in Europe and 771 in America. There were an estimated 35 million receivers world wide. Television was more a promise than a reality, but it was only a short time later, in 1935-1936, when regular television services were introduced into Germany and Great Britain.
- Telephony was well established by 1932 and automatic switching covered 70% of subscribers in such countries as Germany (2,960,500 telephones) and Austria. In the USA there were 15.6 telephones per 100 inhabitants with a total of 19,602,000 telephones installed. The number of telephones worldwide was 35 million and the disparity between developed and developing countries was dramatically obvious even then with only 238,000 telephones in Africa. Trunk and international telephony had received a considerable boost with the development of multiplex carrier systems and intermediate repeaters. Intercontinental radio services had linked the USA with various European countries since 1927. But, apart from USA and Sweden where 65% of telephones were private in 1932, the telephone had not yet reached most homes in the rest of the world. It was far from being regarded as a normal means of communication in family and social relations.

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He started his career as a Technician-in-training in 1954 and qualified as an engineer in 1967. After two years in Traffic Engineering he spent 7 years developing the network performance group in Tasmania. He became Supervising Engineer, Network Service, in 1977 and transferred as Supervising Engineer, Services in 1981.

His role in PNG includes the provision of a consultancy service on matters relating to network management and traffic engineering and the establishment of an Engineer Development Programme.

After the devastation of World War II the 'Big Five' victorious powers, China, France, the UK, USA and USSR met in Moscow to prepare for the next International Telecommunication Conference. The United States Government, after hearing the report from its delegates, issued invitations to all ITU members to attend a Plenipotentiary Conference in Atlantic City in 1947. This proved to be an extremely important conference which laid down a Membership article, created an Administrative Council to carry on the work of the Union between Conferences and laid down that the Secretary-General and the Staff of the ITU's secretariat "in the performance of their duty must not seek or receive instructions from any government or from any other authority external to the Union", thus guaranteeing its exclusively international and politically free character.

At this Conference the unit-class system of financing the Union was retained and extended. The question of languages was resolved with English, French, Chinese, Russian and Spanish being the official languages and English, French and Spanish the working languages. French was chosen as the language to be adopted in the case of disputes. Geneva was chosen as the new seat for the Secretariat of the ITU since it was a subsidiary headquarters of the United Nations and a French-speaking city.

In discussions at the Atlantic City Conference between the United Nations and the ITU it was agreed that the ITU be recognised as **the specialised agency**, in telecommunications, of the United Nations.

The foundations laid at Atlantic City have proved to be successful and in the 45 years since then the ITU has kept pace with the rapid advances which have taken place in Telecommunications.

In the fifty years from the formation of the new ITU in 1932 its membership grew from 80 to 157 members.

The history of the ITU is not complete without mentioning its two consultative committees. The 'Comite Consultatif International Telegraphique et Telephonique' (CCITT) was created in 1956 from two separate consultative committees established in 1925, namely the CCIF which dealt with telephony and the CCIT which dealt with telegraphy. The CCITT operates through Plenary Assemblies, which assign specific technical questions to its various Study Groups for resolution.

The 'Comite Consultatif International technique des communications Radioelectriques' (CCIR) was established at Washington in 1927 and operates in the same mode as the CCITT.

A PRACTICAL VIEW OF THE ITU'S AID TO DEVELOPING COUNTRIES

Australia and Telecom Australia in particular, has every reason to be proud of the election of Mr Dick Butler as the new Secretary-General of the ITU at the 1982 Nairobi Conference. In his message on the occasion of the 15th World Telecommunication Day on 17 May, 1983, under the theme 'One World, One Network', Mr Butler made it clear that "the purpose of World Communications Year (1983) is to promote the development of communications infrastructures throughout the world".

This task assumes a new and urgent meaning as the gulf separating the technically developed and the developing countries has become wider with each successive decade.

It may help readers to translate this idealistic statement into practical terms if two projects on our back doorstep are examined.

The South Pacific Area

In 1975 a four-year project was commenced to establish and develop to full local operations.

- A major telecommunications training centre in Fiji catering for
  - regional needs at the middle and higher levels,
  - national needs at the lower level for Fiji and Vanuatu.
- Three basic telecommunications training centres catering for
  - national needs at the lower level in Cook Is., Tonga and Western Samoa.

The project, managed by the ITU in conjunction with the United Nations Development Programme (UNDP) with support from Australia and New Zealand was to be implemented in conjunction with the Telecommunication Administrations of the participating countries through the South Pacific Bureau for Economic Co-operation (SPEC). Bilateral support for the project to complement the UNDP/ITU input was then arranged through SPEC, mainly in terms of Adviser (Expert) Staff, training materials and fellowships. The ITU Project Manager was Mr Brian Crutcher from Telecom Australia.

The magnitude of this project increased from 4 to 8 years with significant increases in both dollar aid and man-months of expert services.

In addition to the above, substantial cash inputs towards the cost of the new Training Centre building complex were received from the European Economic Community, Australia and New Zealand. Support in terms of students' fellowships was also received from the Commonwealth Fund for Technical Co-operation.

The major activities of the projects were:—

- The design and establishment of training courses to meet the staffing needs of the telecommunication authorities of the region.
- The establishment of major training activities in Fiji; oversighting the design, construction, and setting up of training in a new Telecommunications Training Centre with a total teaching capacity of 176 students and with hostel facilities for 92 students.
- The establishment of three minor (basic) training centres in Cook Is., Tonga and Western Samoa, each with a capacity of 10 students.
- Development of local instructional staff to carry on the training duties at all four training centres.

The training facilities developed by the project are being utilised to a high degree and the countries' demands continue to grow.

All of the objectives of the upgraded version of the original plan were achieved with one exception — that of full counterpart development in all specialities.

A further 5 year project commenced in 1982 with the development objective of providing adequate, efficient and reliable telecommunication services for the island countries of the Pacific.

Papua New Guinea

A project under the control of ITU/UNDP was commenced in conjunction with the PNG Government in 1976 to construct, equip and staff a new Telecommunications Training Centre with a capacity for 210 students at Lae. The centre, which was completed in September, 1978 has male and female dormitories. It also has a fully equipped kitchen and mess staffed by nationals capable of serving some 750 meals per day.

Fig. 1 Trainee linemen at Lae Training Centre (Papua New Guinea)

The ITU/UNDP input consisted of a project management and expert advisor team to supervise the project and to develop course material for the teletechnician and lineman courses, as well as substantial contributions of technical equipment. The current annual graduation rate from the Centre is 48 teletechnicians and 24 linemen. The total investment in the Centre was almost US$13.0 million of which the ITU/UNDP contributed almost US$2.5 million.

A new project commenced in April 1982 to enable the Centre to rapidly increase the numbers of qualified Technical Officers, Senior Technical Officers, Lines Supervisors and Line Technical Officers to fill the large numbers of vacant positions and ultimately to reduce the numbers of expatriates who have been recruited on short term contracts, mainly from Telecom Australia, to guide the network through this transition period. In addition the project calls for the research, design, development and introduction, in accordance with established ITU course development procedures, of schemes to enable engineers and senior technical staff to train as network managers. The ITU expert staff, under the terms of the project document, will provide technical advice and consultancy services to the Post & Telecommunication Corporation operational divisions in the evaluation of equipment and the development of new works techniques.

The relative inputs to the project, which is scheduled

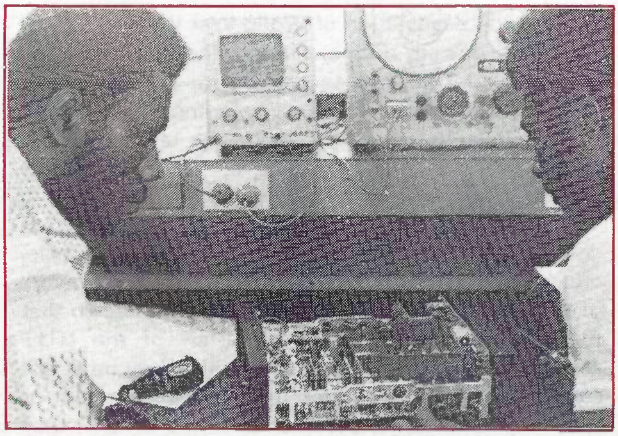

Fig. 2 Trainee Teletechnician at Lae Training Centre (Papua New Guinea)

to be completed in 1985, are PNG Govenrment approx. US$0.5 million and ITU/UNDP approx. US$1.5 million.

The ITU Project Team in Lae is truly international in character. The Project Manager, Mr Gordon Austin, is from the UK, the Senior Expert from Australia, Experts from Australia, UK, Norway and India, one Associate Expert from the Netherlands, and two UN Volunteers, one from USA and one from Tanzania.

CONCLUSION

It is only when one becomes involved with a project, such as the above, that one fully appreciates the gulf that does exist between the developed and developing countries' communications services. Even with such assistance it is unlikely that the developing countries will ever keep pace in all aspects of communications networks. But it is pointless for an emerging nation to have the most modern hardware available if it does not have the trained staff to maintain it, the management skills to manage it or the engineering skills to develop the network. These all require long lead times to achieve, and require, on the part of ITU staff and expatriate contract workers, much skill, perseverance and dedication to the ultimate goal of localisation and self reliance. It is hoped that World Communications Year will create a greater awareness of the problems of the developing countries and of the excellent work that is being done, and must continue to be done, by the ITU.

This sentiment was well expressed by Dick Butler in his address to the Pacific Telecommunications Conference in Hawaii this year. He said "... the harmonious and well-balanced development of an ever-closer knit world communications network is a major historical event in keeping with the emergence of a collective awareness among mankind as a whole. Following its development, no-one should any longer be isolated from the national or international community. Communications should be a right, not a privilege".

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The "Central" Telephone Exchanges of Adelaide

by M. J. GOOLEY OAM

It is 100 years since the first telephone exchange was opened for service in Adelaide, South Australia. This exchange, ***Central***, was located in the General Post Office, King William Street. It, and the ***Central*** exchanges which followed it at two other locations within the GPO precincts, were manually operated. The first two were magneto signalling types but the last one was of the common battery type. ***Central*** exchange was closed in 1955, several automatic exchanges having finally taken over all of its subscriber services.

In 1881, the South Australian parliament passed "The Telephone Act — A Bill to provide for the establishment of Lines of Telephonic Communication and for other purposes". The Act provided for the Post and Telegraph Department to have exclusive rights to construct and maintain telephone lines and telephone exchanges. Privately owned lines already in existence were purchased as appropriate and added to the system.

Prior to the opening of Adelaide Central exchange, a number of private lines used exclusively between the offices of particular businesses, and a system of 11 public telephones located at city and suburban telegraph offices were established. The fee for the use of the public telephones was one shilling and six pence for the first 10 minutes and six pence for each additional five minutes, which fee was paid at the telegraph office counter.

THE FIRST ADELAIDE *CENTRAL* EXCHANGE

The first exchange was opened on May 14, 1883 with 27 subscribers (**Fig. 1**). The switchboard had been made by Western Electric Manufacturing company of Chicago (USA) and was installed in the north-western corner of the Chief Telegraph Office which was on the first floor of the General Post Office.

This switchboard operated on the magneto non-multiple principle with capacity for 400 subscriber lines.

Businesses, doctors, and professional men were generally the first to share in the benefits attached to the use of the telephone. The subscription of 12 Pounds per year did not, as a rule, attract ordinary domestic subscribers. However, special rates were introduced in 1890 as an incentive to this end. Private residences, 'where no business or profession was carried on', within a one mile radius from the nearest telephone exchange, paid only six pounds per year. In 1895, there were 60 domestic subscribers.

The telephones had the same type of signalling component as the few magneto telephones remaining in service today, that is, a hand-cranked generator. Their battery of two cells — glass jars containing aqueous chemical solution, metal electrodes and other materials — housed in a wooden box separate from the telephone instrument was very different in construction from the modern pair of 1.5 volt dry cells now in use.

At the switchboard,

- each subscriber line was connected to an annunciator and a jack-knife switch (***jack***) — arranged 50 per panel about 45 cm wide.
- for processing calls, there were a number of pairs of plugs and cords, each pair associated with a speaking/ringing key and a clearing out indicator.
- electricity for ringing was obtained from a mains water-powered alternator by operating a ringing key.

When a subscriber wished to make a call, he gave a brisk half-turn of the generator handle of his telephone. The electricity so generated caused the shutter of the annunciator at the exchange to drop. The attendant plugged into the corresponding jack and pulled the speaking/ringing key giving a reply ring to the subscriber. The subscriber gave the name and number of the subscriber to be called and hung up.

The attendant rang that person, alerted the caller and completed the connection with a second plug. This process did not, as a rule, occupy more than a few seconds. When the conversation was finished, the caller gave a generator signal which dropped the clearing-out shutter and the attendant withdrew the plugs in readiness for the next call. At the same time, other calls were connected between other pairs of subscribers using additional cord circuits provided for the purpose.

The initial switchboard of 400 lines filled quickly as had been expected. It was replaced with 700 lines of magneto non-multiple equipment in 1888 in the same room but facing the western wall. This switchboard was built in the Postal Department workshops.

The larger installation was greeted with concern by telegraphists who had now lost more of their telegram checking Room (**Ref. 1**), and the wisdom of further extensions was strongly questioned.

A notable feature of these first two non-multiple switchboards was that for much of the three hour shift of duty, the attendants were standing in order to reach the plugs and cords as well as to move along the switchboard when necessary to plug into the jack of the called subscriber's line. The practice of releasing the caller while ringing the called subscriber meant that the connection of the two could be made using a pair of plugs and cords about midway between the two of them.

THE SECOND *CENTRAL* EXCHANGE

The extension of the General Post Office along King William Street (replacing the early Police building) was completed in 1894. It included an exchange room of about 69 feet by 25 feet in the north-eastern corner on the ground floor. A new magneto switchboard built on the multiple system made by the Western Electric Manufacturing Company (USA) was opened in August 1894.

The new exchange provided for 1100 subscribers but could be extended to 3000. The operation of a multiple switchboard differed from that for the earlier switchboard in one important respect. The attendant could connect any two of the 1100 subscribers to the exchange without moving from her place. Within her reach were indicators (as the ***annunciators*** were now called) and jacks for 200 subscribers. Above them, jacks (only) for all the 1100 subscribers to the exchange were closely clustered together in a ***multiple field*** and there was space above for up to 1900 more.

This ready access to all subscribers' lines through a ***multiple*** considerably reduced connection times. At the busiest periods, the white-aproned monitors would call the number of a subscriber awaiting an answer and another operator nearby would answer the call, but in the multiple field, with the monitor manually restoring the shutter of the calling indicator.

During the 15 years to 1910, ***Central*** exchange was extended to fill the space along the northern wall and auxiliary positions were placed along the southern and western walls (**Fig. 2**). In addition to both-way junction lines from suburban exchanges, this ***Central*** exchange was the place where trunk lines from country exchanges terminated for access to the metropolitan network. "Transfer" circuits were used between the main switchboard and the auxiliary positions. The exchange became increasingly difficult to operate and keep in service, so much so that the then Assistant Engineer (Mr L. H. Griffiths) described it as "a nightmare to keep in action", in its latter stages.

THE THIRD *CENTRAL* EXCHANGE

This exchange was located at No. 2 Franklin Street near the GPO in a new building completed in 1909. The common battery (C.B.) manual switchboard was located on the first floor with staff amenity rooms adjoining and on the floor above. The ground floor accommodated the main frame for termination of street cables, line and cut-off relays, test desk, trunk line equipment and other apparatus. The basement was allotted to power plant — lead acid batteries for the C.B. exchange system, air conditioning equipment (1921) and blowers for the pneumatic tube system from the Chief Telegraph Office to several nearby buildings.

The decision as to the type of equipment to be used in the exchange was the result of inspections made by Mr John Hesketh, PMG Electrical Engineer, Queensland, during an official visit to Europe and America in 1905. He had reported unfavourably on the cost and reliability of a then recent innovation — the "girl-less" or automatic exchange.

The common battery (C.B.) principle obviated the need for heavy and expensive magneto generators and "local" batteries at subscribers' telephone instruments, which were thereby reduced in size and cost. Signalling to the exchange was achieved by lifting the hand piece from its rest position and the resultant flow of direct current in the subscribers' line caused a lamp to glow on the switchboard. However, the new system did pose problems in regard to the insulation of the subscriber line which needed to be much improved over that required by the magneto system.

The cutover from magneto to C.B. working proceeded from January 10, 1910 to March 31, 1911. The demand for telephone services at that time was so great that within 7 months of the completed cutover, two additional temporary positions were installed in another part of the room requiring the use of transfer circuits. During the next year, nine permanent positions with 1,400 more lines replaced these.

The operating positions on the first floor included a number of **B** positions at the northern end where junctions (suburban) and trunk lines (country) terminated. Interconnection between lines on the **B** positions and ***Central*** subscriber lines was made through one-way lamp signalling ***order wire*** circuits.

Growth of the ***Central*** network was met by extending the two parallel rows of operating positions northwards along the exchange room. Until 1919, observation (of traffic) positions had been the only positions in the middle of the room. In that year, a row of ***key set senders*** was added (**Fig. 4**) to work in conjunction with the new

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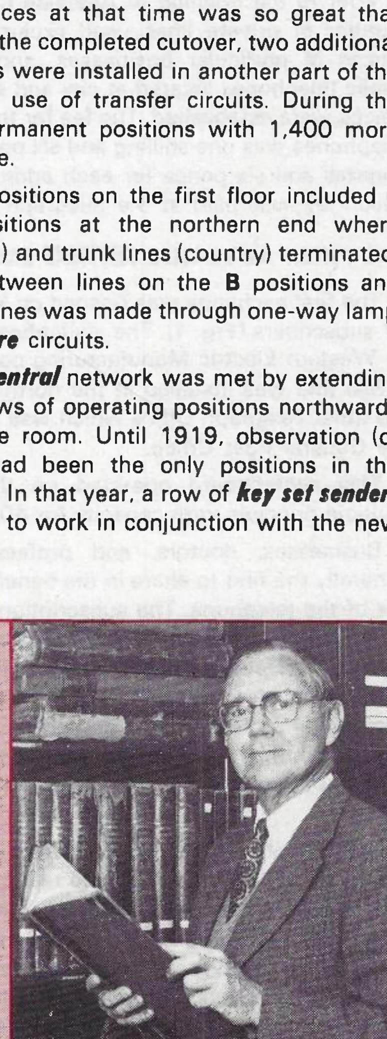

semi-automatic exchanges at Unley and Norwood. Telephones connected to these exchanges did not have dials fitted and all traffic from them was switched by uniselectors to ***Central*** because 80% of calls were for ***Central*** subscribers and the balance were reverted to Unley or Norwood by the manually-operated key set senders.

The period 1922-27 saw the addition of 15 **A** positions in ***Central,*** trunk lines were separated from junctions on **B** positions and the number of trunk

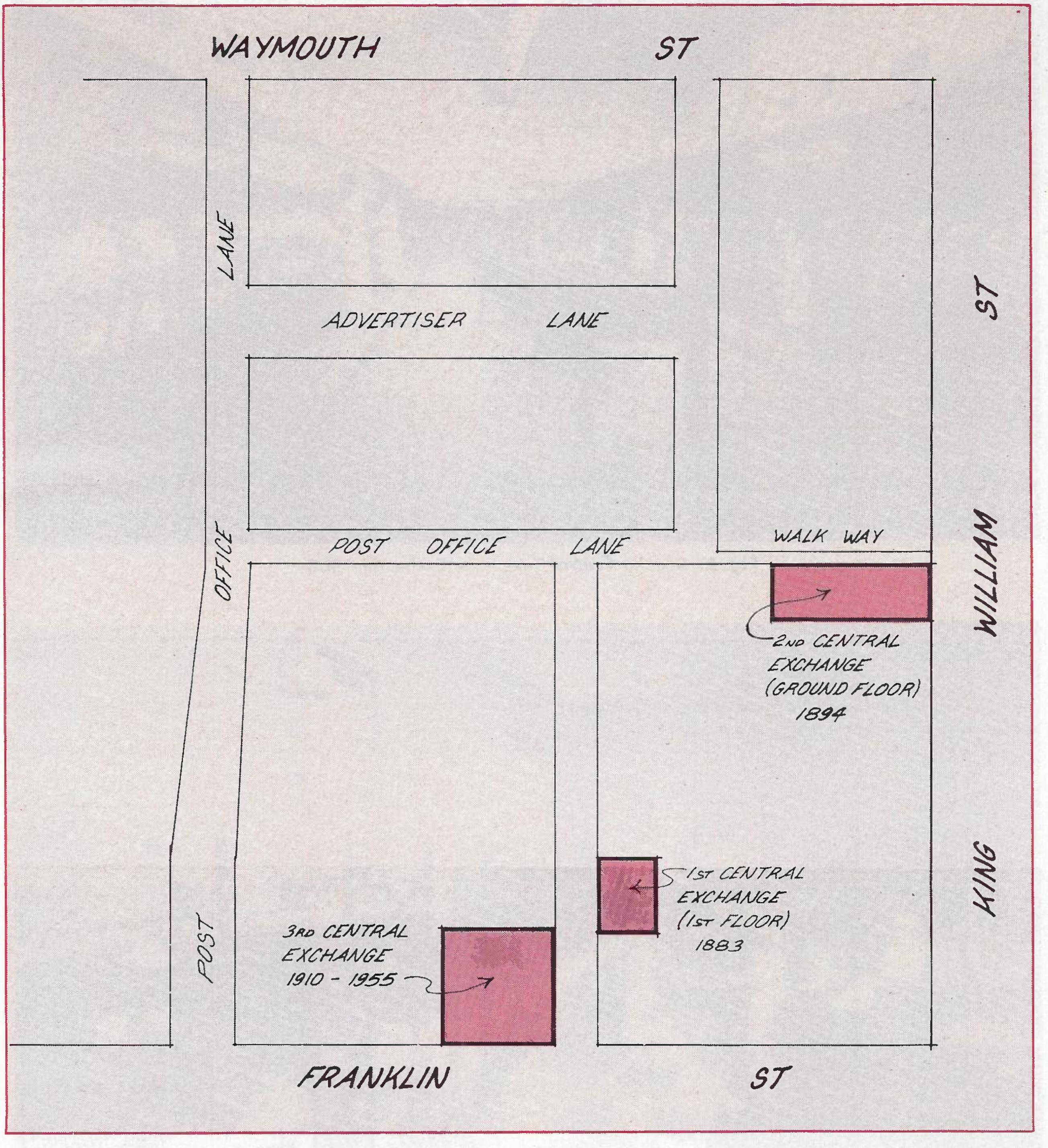

Fig. 1. Locations of the several ***Central,*** Exchanges.

Fig. 2. Second *Central* Telephone Exchange 1908.

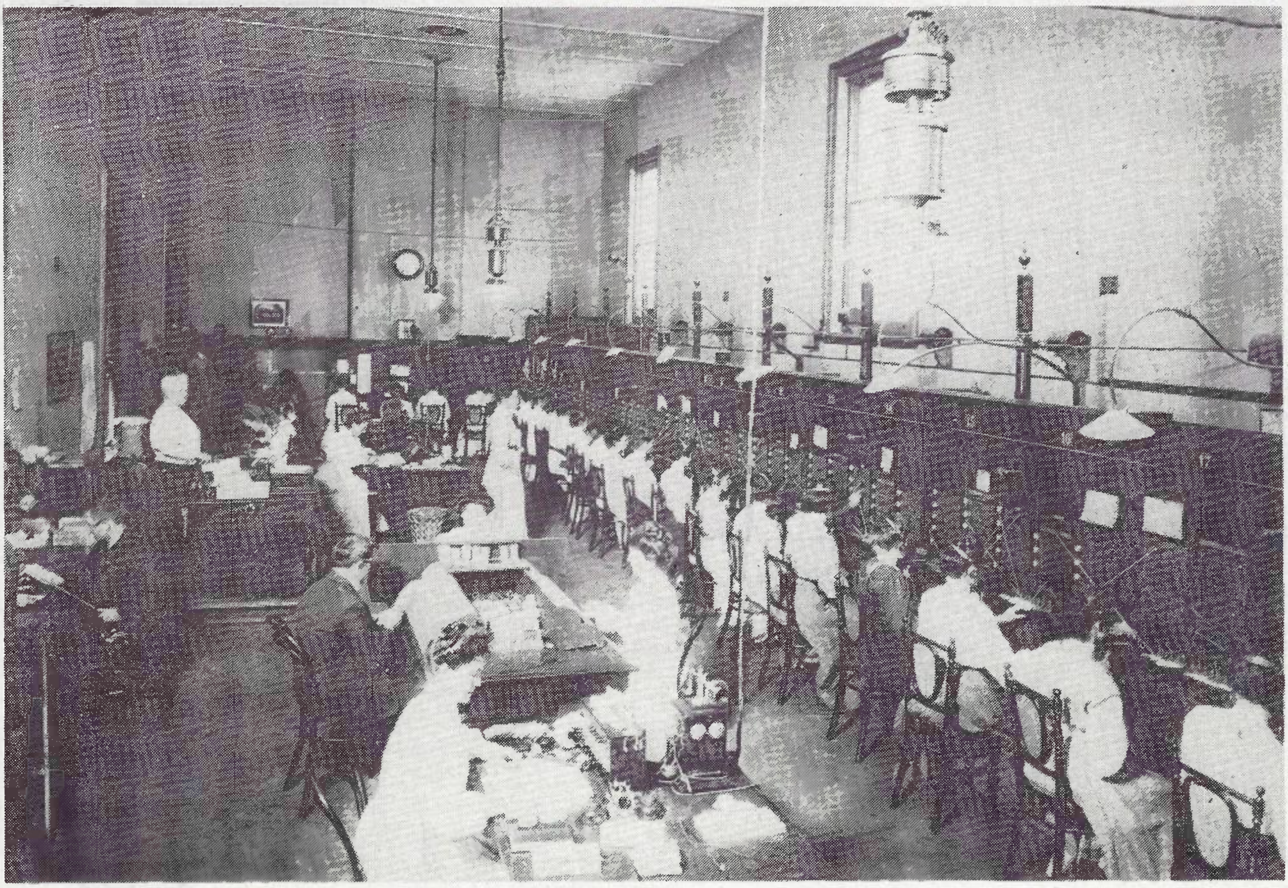

Fig. 3. Third *Central* Telephone Exchange 1925.

positions increased to 15. Two public telephone positions were installed.

In 1925 and again in 1927, the number of subscriber lines reached a peak of about 8,600 and, because of the development of suburban exchanges and diversion of ***Central*** services located in the suburbs to the new automatic exchanges, this peak was never again reached.

In 1929, a policy was adopted that ***Central*** should serve only the 2¼ km square area of the inner city surrounded by parklands, and further transfers of services at suburban locations were made. At this time, the trunk positions were removed to an adjoining room which had recently been vacated by the Accounts Branch.

The "order wire distributor" installed in 1930 automatically fed calls from **A** positions to the next free key set operator, thus equalizing the loading of these positions.

THE END OF *CENTRAL*

The demise of ***Central*** began in 1947 when the trunk exchange was removed to a new address thus reducing the telephonist staff using the staff amenities and the first automatic exchange in the inner city area (Wakefield) was opened for service (on 25/8/47). The residual area served by ***Central*** was further decreased by the establishment of Franklin exchange on 30/1/51 with 3900 lines of step-by-step equipment.

The transfer of ***Central*** subscriber services continued until the final ceremonial last call through the manual equipment was made on May 14, 1955, exactly 72 years after the first ***Central*** exchange was opened for service. Mrs F. L. Bundey (nee Jeanie Goode), a former telephonist, made the connection. And so closed an era in which a large number of telephonists, technical staff and many others rendered sterling service with a manual exchange in Adelaide, South Australia.

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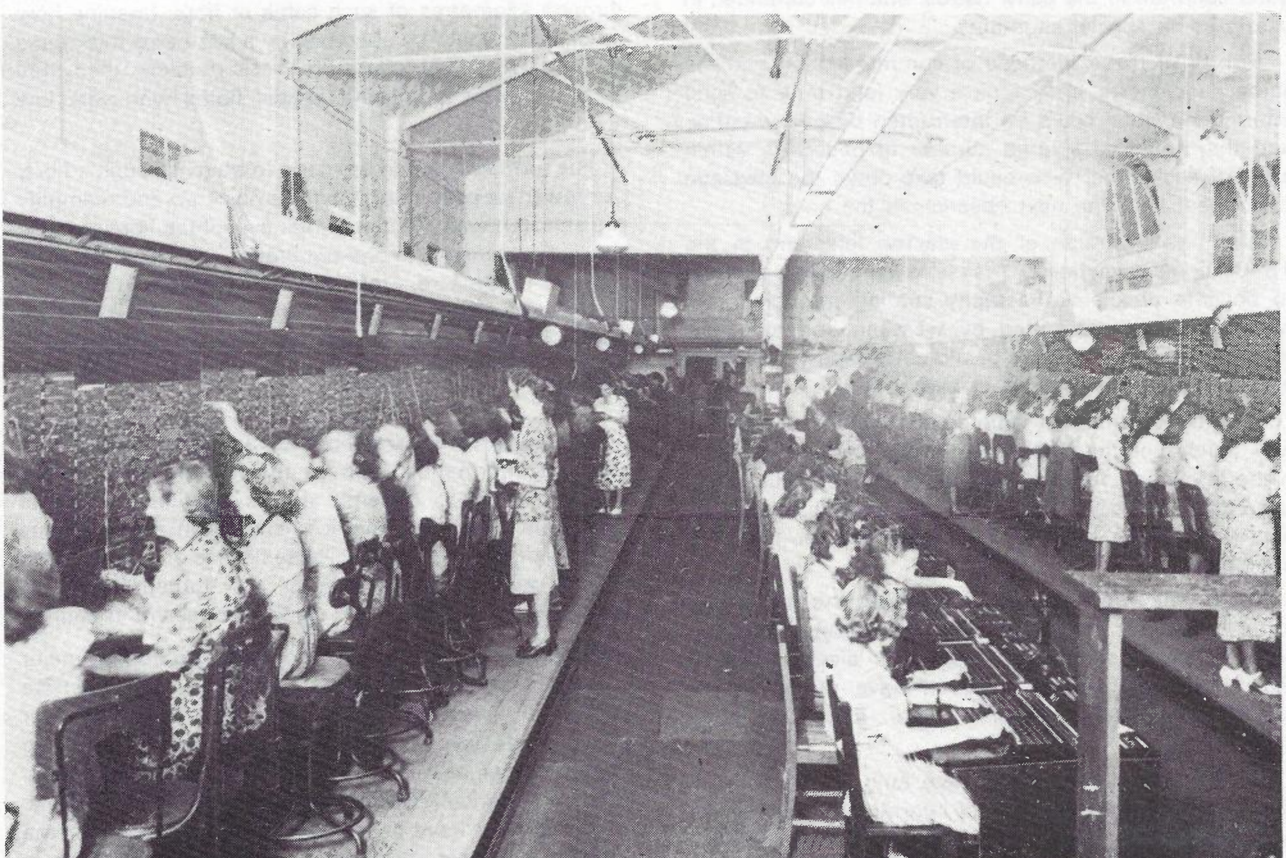


Fig. 4. ***Central*** Exchange looking north showing key-set senders.

OPTICAL COMMUNICATIONS Pt. III

The Promise of Optical Communication

The idea of using light to send messages is a very old one, far older than Alexander Graham Bell's photophone. The news of the Greek victory in the Trojan War, about three thousand years ago, is said to have been communicated to Greece by a chain of bonfires on the tops of neighbouring hills, lit one after the other. The light from one bonfire sped far more rapidly to the next hill than any messenger could have gone. But it carried only a pre-arranged signal, one piece of information: the war was over.

There were a number of other methods of using light to communicate, for example the heliograph, where a mirror was used to flash the light of the sun in a particular direction to send a message in code. Semaphore signalling using flags, wooden arms or light was also quite common in the early 1800s, and has continued in use in some special situations.

But all of these methods of communication had the same deficiencies: they took a very long time to send information, they could be interrupted by bad weather, and they required a large number of observers within sight of each other who could take down the message and repeat it to the next observer in the chain.

With the invention of the electric telegraph in the 1840s, communication by means of light signals seemed to become obsolete. Electricity surging through metal wires was not interrupted by weather, and repeating stations could be hundreds of kilometres apart, instead of needing to be within sight of each other.

After the invention of radio around the turn of the century, such communication could be carried on even without wires. Indeed, today, much of Australia's telephone traffic is carried across long distances by microwave radio beamed from one repeater tower to another.

Yet in one way it could be said that the wheel had turned full circle, for microwaves are closely related to light waves, both being aform of electromagnetic radiation. Light waves, however, have much shorter wavelengths (and therefore higher frequency) than microwaves.

Communication scientists have long known that, in theory at least, the amount of information that can be carried by radio waves increases as the wavelength becomes shorter and the frequency increases. Microwaves with wavelengths around half a metre can carry much more information than broadcast radio with wavelengths typically of hundreds of metres. But light waves have wavelengths on the order of a ten-millionth of a metre! It was therefore obvious that light should be able to carry a vast amount of information, far more than could be carried by the equivalent radio channel or on a copper wire.

There are also other advantages of using light to communicate: light is not affected by electrical interference, and would be very difficult for an eavesdropper to tap. The problem was how to utilise this potential.

The first real breakthrough in optical communications came in 1960 when the laser was invented. A laser is a source of very intense, non-spreading light rays, all of exactly the same wavelength. Scientists were quick to see that the laser could be used for communications, and some preliminary experiments were done in firing a laser beam through the air between two towers many kilometres apart. But just as with the photophone, fog and rain often blocked communication. The only solution seemed to be to try to send light along some kind of pipe or cable.

Eventually it was found that light entering a solid cable or fibre of glass surrounded by a suitable cladding can be confined within the glass even if it is bent because rays which strike the sides at a shallow enough angle are reflected back within the glass. One modern use of such flexible glass cables is in medicine, to photograph the inside of a patient's organs.

Although it was found possible to pipe light in this way, there were still difficulties in trying to send light through kilometres of such cable or fibre. Imagine how much light would be absorbed by a kilometre-thick pane of ordinary window glass! The basic problem, then, was to find a way of making optical fibres with very low absorption of light.

The further light can be made to travel through a fibre, the fewer repeaters are needed to pick up and reamplify the signal. It was calculated that even if the fibre reduced the light entering it to one-hundredth its original intensity over a kilometre, this would be acceptable for communications purposes. But during the 1960s it seemed that even this target could only be achieved with great difficulty: the intensity was dropping much faster than this.

Another problem was how to vary the light source to transmit information such as the human voice. It has proved easiest to transmit signals as digital pulses of light, sent by turning the light source on and off many millions of times a second. These flashes of light are then picked up by a photodetector and turned back into smoothly varying electrical signals representing sound.

Finding a suitable light source has also been a major research problem. Early lasers were large and expensive and often unreliable. In recent years, semi-conductor light sources have been developed, such as light emitting diodes (LEDs), and more recently, semi-conductor lasers, which are gradually becoming cheaper and more reliable. These sources have been designed to emit light at the frequencies least absorbed by silica — the basic ingredient of glass.

In 1971, scientists at Australia's CSIRO suggested a new kind of fibre for communications. This was a hollow glass fibre with a liquid core, which proved to have very low absorption of light, reducing the original intensity of the source only to one-tenth over one kilometre. The Postmaster-General's Department which was at that time responsible for Australia's communication network became involved very early with development of such fibres.

However, liquid-filled fibres proved difficult to manufacture and to handle, and eventually interest shifted back to solid-core fibres, which new techniques had improved to the stage where they had similarly low light absorption. AWA Ltd. began developing a facility to make such fibres for the PMG in 1975.

These fibres had a core diameter of about one eighth of a millimetre, and transmission along such fibres is in what is technically known as multimode rather than single mode transmission. Single mode transmission requires fibres which have cores only one two-hundreth of a millimetre in diameter and are hard to make and handle. But multimode transmission also has a number of limitations, the major one being reduced information capacity compared to single mode transmission.

Various ways were found to overcome these limitations. One major problem, for example, was that those light rays travelling inside a fibre which zig-zag back and forth at a relatively sharp angle must travel further than those which strike the sides at very shallow angles. Obviously these rays must therefore take longer to arrive at the other end. This tends to 'smear out' the intial sharp pulse, and this degradation becomes greater the longer the fibre.

The solution to this problem was ingenious. It was found possible to make fibres so that the refractive index of the material was greatest in the centre of the core and less towards the sides. The lower the refractive index, the faster light travels in that material, so that in such a fibre, those rays which diverge further from the centre can travel faster. If the variation in the index is chosen properly all rays will arrive at the same time at the other end.

In Australia, AWA began to make such graded index fibres for Telecom in 1978 by a process known as chemical vapour deposition. In this process, vapours which will produce materials of varying refractive index are deposited in layers on the inside of a hollow silica tube, which is then collapsed under heat and drawn out into a long fibre.

Technology has now advanced to the stage where optical fibres can be made with such low absorption of light that the intensity of the source is only reduced to a half or a third after travelling for a kilometre. This means that 150 metres of such material absorbs less light than an ordinary window pane only a centimetre thick! Such fibres can be joined together at the ends to make long cables that require repeaters to be installed only about every 10km or so. Eventually, it seems likely that repeater spacings of at least 50km will be possible.

America's Cup — The Information Transfer Technological Support

Data General technology played a large part in helping the 12-metre yacht Australia II, win the America's Cup.

Two computers and peripheral equipment, donated by Data General Australia Pty. Ltd. were used by the skipper and crew of the yacht Australia II, to collect, compile and analyse sailing data and other statistical information.

The computers, a Data General NOVA 4X (based on shore) and a Data General microNOVA MP/100 (situated on board the tender vessel 'Black Swan') were used by the Syndicate for almost 12 months prior to the challenge.

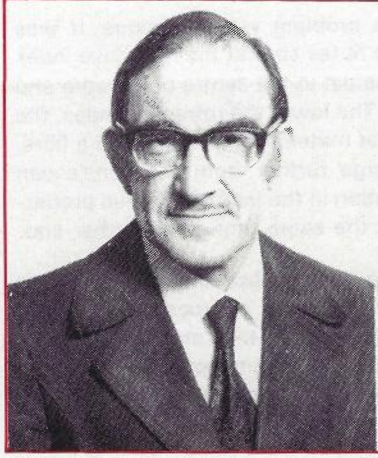
It was the first time an Australian challenger for the 132-years-old coveted America's Cup, had a fully computerised system, adapted specifically for 12-metre sailing purposes, at its disposal. But the computerisation was kept a secret, so as not to alert the Americans to the scheme.

To ensure the total success of the unusual computer application, Data General also donated the services of one of the senior computer engineers, Glen Read, who also just happens to be the current world-class soling yachtsman.

One computer, the microNOVA MP/100 which was on board the tender vessel travelling close behind Australia II, received the vital statistical information from the various instruments on board the 12-metre yacht. It collected and stored the information on magnetic tape, which was later transferred to another Data General computer, on shore. The data fed into that computer (the NOVA 4X) was analysed by the crew and strategists. It consisted of statistics and data on the effectiveness of all equipment on Australia II, timing and efficiency of sailing procedures and a host of other crucial data.

Data includes such statistics as boat speed, apparent wind angle (the actual wind angle plus the effect of the boat's motion), apparent wind speed, heel angle, heading (direction of the boat) rudder position, trim tab position, water angle, pitch and time. As well as providing analytical data, the system also accepted navigational input on such crucial details as information on the tides, the yacht's initial position, and the position of marks, for crew purposes.

Data General Australia Pty. Ltd., Box Hill, Victoria



Retirement of Editor Duncan A. Gray

After 16 years of service, Duncan Gray recently retired as a member of the Board of Editors of the Telecommunication Journal of Australia. During this period he was responsible for the papers originating in the Research Laboratories of Telecom Australia and has thus had early contact with many of the new technological developments that have been introduced since 1967. The Board of Editors and the Council of Control thank Duncan for his contributions to the Telecommunication Society and wish him a happy retirement.

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 overseas. 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 of 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 leadership of Mr Bob McKinnon the Chairman of the Council of Control, a major Corporate Strategy Review took place. The initial review was undertaken by a Strategy Sub-Committee. The future role of the Society was critically examined and a strategy for achieving the objectives devised. A number of points considered by the Sub-Committee included the following:

- future of Society activities
- the Society's role in the Information Age
- benefit of the Society to its members
- industry participation

The Corporate Strategy Review culminate to a historic Extra Ordinary Meeting of the Council of Control with Chairman/Representatives of State Divisions (see photo opposite page). Held in Melbourne on the 29th July, 1983, the meeting arrived at the following resolutions:

- Widen the scope of the Society to include information transfer in general.
- The Society is not a learned Society. Thus the Society should not only cover the traditional technical areas, but also topics which may have an impact on the information transfer industry.
- The appeal of the Telecommunication Journal of Australia should be widened by having articles with wider appeal.
- Articles on the same subject but with appeal to different groups should be included in the Journal.
- Lecture programmes organised by the State Committees should cover a wider spectrum of interest.

As a result of the Melbourne meeting, appropriate action is now in hand to change the Constitution of the Society to facilitate the coverage of a wider technology horizon by the Society. State Committees are also considering ways of gaining wider industry support for the Society. But more importantly to the readers of this Journal, the Board of Editors has now been given the mandate to include articles with broader appeal through widened scope and by inclusion of technical based articles at differing levels.

We are moving into the Information Age and the Society has a duty to adapt to changing times and respond to the needs of its members. Hopefully, in conjunction with the other activities of the Society, this Journal will fulfil this role.

Editor-in-Chief

Appointment of new Editor-in-Chief

Mun Chin, B.Sc.Hon. Elec.Eng., M.Sc., Chartered Engineer, MIEE

Recruited from London in December 1971, Mun Chin started his career with Telecom Australia in New South Wales Planning and Programming Branch. In 1978 he moved to Telephone Switching Planning Branch, Headquarters where he was attached to the National Trunk Network Section. He is now working in the Computer Assisted Planning System Section where he is responsible for the operational aspects of engineering planning software packages such as SWITCHNET, MARC and Exchange Reference File.

Since 1981 he has been a committee member of the Telecommunication Society of Australia, Victorian Branch, and an Editor of this Journal on Planning and Computing topics. In July 1983 he took up the position of Editor-in-Chief.

Telecommunication Society of Australia Council of Control meeting with State Chairman/Representatives: 29th July 1983.

Front row, left to right: Fred Scott, Representing Queensland Div.; Ian Mackechnie, General Secretary; Bob McKinnon, Chairman; Gordon Martin, Chief General Manager, Telecom Australia; Mun Chin, Editor-in-Chief, TJA.

Back row, left to right: David Watson, South Australia Councillor; Brian Rice, Chairman South Aust. Div.; Laurie Bennett, Chairman, Victoran Div.; Geoff White, Representing West Australian Div.; David Mattiske, Treasurer; Clem Pratt, Vic Chairman; Ric Mount, West Australian Councillor; Andy Young, Representing West Australian Div.; Andrew Robertson, Secretary, Victorian Div.; Garth Jenkinson, Editor-in-Chief, ATR; Mike Topfer, Representing Tasmanian Div.; Keith Hardy, Chairman, New South Wales Div.; Bill Parry, Queensland Councillor; Tom Langenheim, Tasmanian Councillor.

ABSENT: Brian Fuller, New South Wales Councillor; Earnie George, Victorian Councillor.

New Rates for 1984

To our Members and Subscribers

Due to increases in the cost of production of journals it has been necessary to increase the Society's subscription rates as set out in the table below.

The Council of Control approved the increased rates after consideration of the costing details and the financial plans for both the Telecommunication Journal of Australia and Australian Telecommunication Research. Regrettable as these increased rates may be, the Council of Control believes that both publications represent excellent value for money and the end results are two fine journals which enjoy a high international standing and which cost far less than would be possible for an equivalent commercial journal.

Costs are contained at the current low levels by:

- authors providing their services free of charge;
- Council of Control, editors, and Society office bearers providing their effort on a voluntary basis;
- Telecom Australia generously providing assistance by way of a subsidy, which in 1983 amounted to $15,000.

The Society looks forward to your continuing support in 1984 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
Hon. Treasurer.

Telecommunication Society of Australia Publications Rates for 1984

Telecommunication Journal of Australia

Member (Aust only)	1984 Subscription $8.00 Telecom Payroll Deduction 31c/pay back copies or single current copies $5.00 each
Non-Member (Aust)	1984 Subscription $13.50 back copies or single current copies $8.00 each
Non-Member (Overseas)	1984 Subscription $20.00 (unchanged) back copies or single current copies $12.00 each

Australian Telecommunication Research

Member (Aust)	1984 Subscription $10.00 Telecom Payroll Deduction 38c/pay back copies/single copies $7.50
Non-Member (Aust)	1984 Subscription $20.00 back copies/single copies $12.50
Non-Member (Overseas)	1984 Subscription $24.00 (unchanged) back/single copies $15.00
Monographs	Aust Member — $4.00/Aust. Non-Member $6.00 Overseas $10.00

Information Transfer Industry News

Australian Government Endorses Telecom Australia's Monopoly Position in Telecommunications

On 20 October, 1983 the Government endorsed Telecom's monopoly position as the national telecommunications common carrier by rejecting the major thrust of the Davidson Inquiry Report concerning telecommunications services in Australia.

The Report recommended a much larger role for private enterprise in the provision of telecommunications services.

Mr Michael Duffy, the Minister for Communications, said that the Inquiry's terms of reference, set down by the previous Government, had been deliberately slanted to a wider involvement of the private sector.

The terms of reference had not adequately taken into account the effect such a move would have on the public. As a result, the Committee's recommendations had had a strong "free market" thrust.

Mr Duffy said: "This Government's policy is to ensure that the best possible services are available to the Australian public, and that universal access is provided to the national telecommunications system at a price all can afford.

"The Government's decision to reject the major thrust of the Davidson Report confirms Telecom's role as the national telecommunications common carrier.

"Now that the Government has made its decision on the major recommendations of the Davidson Inquiry, Telecom can get on with the job of providing, and continually developing, efficient and responsive telecommunications infrastructures and services in Australia."

Mr Duffy said that in this connection it is worth noting that Telecom, at the time the Davidson Inquiry was established, was already taking a number of decisions and initiating actions which ultimately proved to be consistent with many of the recommendations of the Davidson Report.

The Government recognised that these decisions and actions were completely compatible with Telecom maintaining its traditional role as the national telecommunications common carrier.

"As the responsible Minister I intend to take an active part with Telecom in ensuring that Australia's telecommunications infrastructure and services are developed in a timely and responsive fashion in accordance with the highest technical standards."

Mr Duffy thanked Mr Jim Davidson and his Committee for the report which was tabled in Parliament in October 1982.

Press Release:
Minister for Communications
The Hon. M. J. Duffy, M.P.

OBITUARIES

Ron Keighley

Editor-in-Chief (1981 — June 1983)

The Telecommunication Society of Australia was saddened to hear of the recent death of Ron Keighley after a long illness.

Ron had served Telecom Australia for 32 years prior to his retirement through ill health last year. At the time of his retirement, Ron was responsible for the planning and development of the Directory Assistance Service DAS/C project.

He had a varied career with Telecom with experience in telephone maintenance, construction, customer equipment design and industrial engineering, marketing and directory services management.

For three years from 1974 Ron represented Telecom with the Australian High Commission and visited most European countries studying engineering approaches. He represented Telecom at international meetings of the ITU and OECD.

He was appointed Editor-in-Chief of Telecommunication Journal of Australia early in 1981. He had previously been the Editor for Commercial Services Department at Headquarters.

In his brief service as Editor-in-Chief, he did much to enhance the Journal. He stimulated advertising in the Journal and he brought to bear his extensive knowledge of publication techniques to improve the image of the Journal.

He placed particular emphasis on making the Journal of interest to a wide spectrum of readers.

The enthusiasm and expertise which Ron brought to the task was very much appreciated by the Council of Control and the Board of Editors.

Keith Vawser

Members of the Telecommunication Society of Australia and Telecom staff in South Australia were saddened by the untimely death of Keith on the 16th July, 1983 at the age of 53.

He joined the PMG Department in 1954 after completing his BE degree at the University of Adelaide and worked in the Wallaroo and Training Divisions during the early period of his career. Between 1963 and 1977 he held a number of Engineering positions in the Planning & Programming Branch where he made a considerable contribution in his role as Supervising Engineer, Traffic Engineering. Subsequently he was appointed Supervising Engineer, Design & Practices Coordination in the Network Service & Design Branch. He was in this position at the time of his death.

Keith was granted a two year Public Service Board post graduate scholarship to study mathematics and computing science, and in 1969 was awarded his BSc degree with first class honours.

From 1964 to 1967 he was the South Australian representative on behalf of the Journal Board of Editors then he took up this position again during 1982.

His loss will be felt by members of the Society and Telecom.

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The Telecommunication Journal of Australia

ABSTRACTS: Vol. 33, No. 3

COMMUNICATIONS — ELECTRONICS IN THE RAAF; R. J. Noble, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 189.

The use of telecommunications and the broader field of communications — electronics for operations, command and control in the Royal Australian Air Force, is described.

PLANNING THE USE OF OPTICAL FIBRE IN THE AUSTRALIAN TELECOMMUNICATION NETWORK; J. Burton and A. Dubberley, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 195.

In the past few years, important changes have occured in the application of fibre optics in transmission systems. This paper reviews the progress which has been made by Telecom in the use of optical fibres.

A STANDARD IDENTIFICATION SCHEME FOR TRANSMISSION PATHS; A. J. Hart and F. W. Hayes, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 205.

A standard system of code identification is an important step in providing a uniform approach to identifying all types of transmission paths and services. This paper outlines a standard identification scheme for transmission paths in the Australian network.

THE DEVELOPMENT OF A PCM MULTIPLEX EQUIPMENT WITH LOOP SIGNALLING INTERFACE; A. Y. Gunzburg and D. P. Williamson, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 211.

Telecom Australia is commencing the transition from a purely analogue network to an IDN. The transition includes providing transmission between digital exchanges and existing analogue exchanges. This, combined with an increasing need for pair gain on existing inter-exchange VF cables has prompted the introduction of an enhanced signalling facility version of 2 wire 30 channel 2048 Kbits/sec PCM equipment. This article summarises the development of such a facility.

PCM LOOP MULTIPLEX EQUIPMENT WITH T6 SIGNALLING; M. P. Quigley, B. F. Orr, P. L. Neville, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 219.

The introduction of PCM30 into the Australian network is being accelerated as part of the trend towards an IDN 2 wire loop interface equipment for the Australian network and in particular its special signalling requirements had not previously been available. This gave the Australian industry the opportunity to design and manufacture a new line of equipment known as the PCM Loop Multiplex Equipment. This article describes some of the design factors considered by STC.

ECONOMIC ANALYSIS — UNCERTAINTY AND RISK; C. W. A. Jessop, B. M. Yeoh, C. W. Parry, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 227.

This series of articles (see also Vol. 33 Nos. 1 and 2) discussed some aspects which cause problems when telecommunications projects are being evaluated. This concluding article deals with uncertainty and risk in investment studies.

TELEPHONE TRAFFIC MEASUREMENTS IN THE 1980s; G. A. Benjamin, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 231.

This article describes a telephone traffic measurement philosophies and practices that have been developed for the Australian telephone network to meet the requirements of network designers and to assist network management for the 1980s.

THE CENTOC DAILY TRAFFIC RECORDING SYSTEM; R. O. G. Jacobs, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 235.

Centoc is a centralised telephone traffic measurement system, designed to continuously monitor route traffics in the electromechanical telephone network. This article gives a general description of the Centoc system and a brief overview of the traffic information which is available from the system.

THE DATA COMMUNICATIONS TRANSPORT SERVICE AND PROTOCOLS; P. A. Kirton, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 243.

The CCITT and ISO are currently developing international standards for a universal network independent data Transport Service of uniform quality, and the Transport Protocols which will support it. This paper presents an introduction to the purpose and structure of the Transport Service and its relationship with communication networks. The Transport Service and Protocol standards being developed are also described.

THE AUSTRALIA/JAPAN FIELD TRIAL OF CCITT NO. 7 SIGNALLING; I. P. W. Chin, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 253.

This article describes the Australia/Japan field trial of CCITT No. 7 Signalling. The parties involved are KDD, Japan, OTC (A) and Telecom Australia.

OPTIMIZING COMMUNICTIONS: RELATING THE ROLES OF VOICE, TEXT AND VIDEO; M. Cassidy, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 255.

Communication and its real costs are significant factors in a business enterprise, and there is an optimum mix of the use of voice and text in all circumstances. Wideband video as an adjunct to voice and text is not justifiable on current evidence, and may be distracting in teleconferencing applications, where however graphics is needed.

THE ITU: ITS FORMATION AND ITS WORK; G. T. Hyland, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 263.

The history and structure of the International Telecommunication Union is briefly traced from its beginnings in 1865 to the present, outlining in this context the significance of key stages in the development of telecommunications. This paper also describes two current ITU projects in the South Pacific Area and in Papua New Guinea as examples of the role the ITU fulfills.

THE "CENTRAL" TELEPHONE EXCHANGES OF ADELAIDE; M. J. Gooley, Telecom. Journal of Aust. Vol. 33, No. 3, 1983, page 267.

This article traces the history of the "Central" telephone exchanges of Adelaide.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

POLICY. The Journal is issued three times a year (February, May, and November) by the Telecommunication Society of Australia. 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 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.

Information on how to prepare and submit manuscripts and contributions for the Journal is available from members of the Board of Editors.

SUBSCRIPTION AND MEMBERSHIP RATES. Residents of Australia may order the Journal from the State Secretary of their State of residence, others should apply to the General Secretary.

RATES. All rates are post free (by surface mail). Remittances should be in Australian currency and made payable to the Telecommunication Society of Australia. The 1984 subscription fee is $8.00. Non-members may secure copies of the Journal for an annual fee of $13.50 within Australia or $20.00 for overseas. Single copies of the Journal may be purchased by members for $5.00, non-members 8.00 and overseas $12.00. Reprints of papers are also available at $1.00 per copy. Bulk orders will attract special quotations.

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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, Tel. (03) 67 5622.

Advertising Contractor: ADTEL — Contact B.H. Worrell. Tel. (03) 772 9398. Address: P.O. Box 67, Mentone 3194. 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

In the next issue of the Journal

- The Gold Phone
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- Exchange Reference File
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