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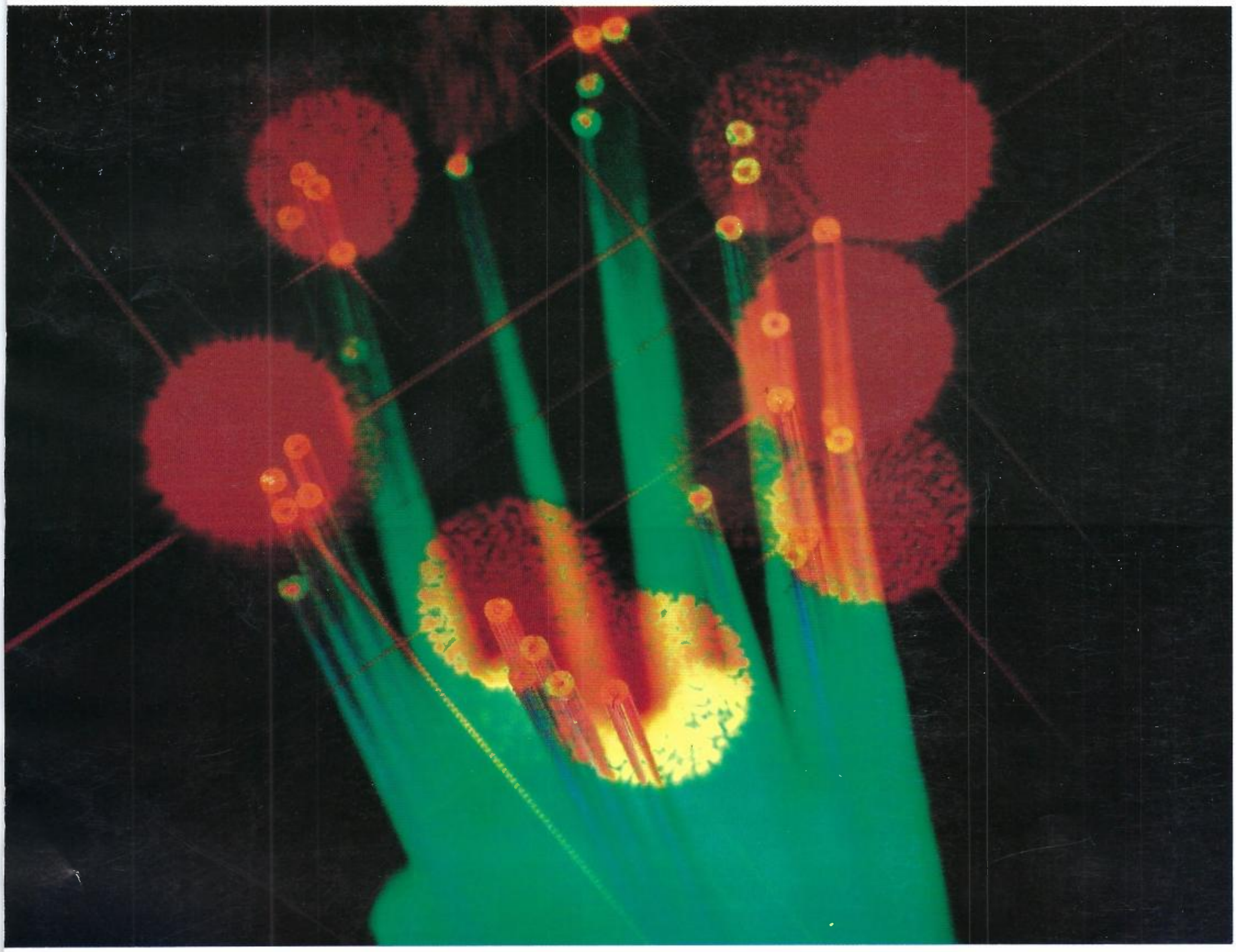

FEATURED IN THIS ISSUE

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Editorial

KEN REED

Chief State Engineer
Victoria

In 1986 Telecom's Network Engineering Department in Victoria experienced the trauma of its biggest reorganisation and staff relocation in recent history. The new organisation is structured to better meet the challenges and demands of customer expectations, business targets and ever-increasing advances in technology. In 1987 we start to reap the benefits.

Network Engineering can look forward to many exciting challenges as we move towards Telecom's objective of being the best enterprise in Australia. The following briefly describes some of the current engineering developments.

NETWORK EXPANSION

Victoria's integrated digital overlay network is growing steadily. By December 1987 some 120 AXE digital exchanges will be operational, including 33 of 46 major nodes; the installed digital capacity will then exceed 200,000 lines. Within the year the network will be enhanced by common channel signalling (CCITT No. 7), an AXE 104 exchange designed to meet rural community requirements will be piloted at Miners Rest, near Ballarat, and work to provide the initial ISDN nodes at North Melbourne and Exhbition Exchanges will be well underway. Our Construction teams will have installed close to 30,000 fibre kilometres of cable (including the Victorian end of the 30 fibre trunk cable to Sydney) and 170 digital radio bearers.

CUSTOMER ACCESS NETWORK

The Forward Planners are planning to further extend advanced digital facilities to customer premises. In the Melbourne Central Business District an optical fibre loop, together with reticulation spurs and loops, has already been installed to interconnect telephone exchanges and major city buildings. In the suburbs, optical fibre feeders are being planned for 15 district growth centres which have high retail, commercial and residential development; the fibre cables and remote terminations will provide advanced communications and free existing copper reticulation for adjoining residential areas. A pilot installation of 2 fibre reticulation to each of 90 customers in a Melbourne suburb and a general review of cable proposals to determine the feasibility of optical fibre and remote switching alternatives are also underway.

NEW NETWORK CENTRE

This year will see the opening of the advanced network management and control centre at Exhibition. Developed by the Network and Support Systems Unit, the centre will be the focal point for network management in Victoria. Support systems such as NEXIS and INTELLINK will enable the centre to monitor network performance, correct traffic flow and introduce pre-planned strategies as necessary to counter the effects of plant outages. Displays will illustrate up-to-the-minute network status and spot traffic congestion and major failure points.

ADVANCED DATA SWITCHING NETWORK

ESSNET, a wide area data switching network developed by our Operations Support Systems Section, is highly suitable for a number of important applications. For Office Automation, its low cost modular design gives it strong potential for marketing alongside LAN/optical fibre products. Incorporating packet switching with X25 standard and hardware distribution over a number of network nodes, it enables desk top terminals to be efficiently interconnected by pair cable to various host mini and mainframe computers as though they were all made by the same manufacturer and provided in the same building. It can be readily interconnected to other networks, including the CBD LAN, AUSTPAC and future ISDN.

Using 'dumb' terminals extensively, the initial Engineering system will be extended from 70 to 300 terminals at an incremental cost of about $2500 per terminal, including cost of terminal, processing capacity (mini computer), network switching and software licence. The system will also be used to obtain wider access to LEOPARD customer records and to provide LEOPARD/SULTAN facilities in country districts.

CELLULAR SYSTEM

A modern and sophisticated mobile communications system, the cellular Mobilenet, will be introduced to Melbournians in 1987. This high capacity system with its automatic roaming (customer tracking) feature will service a range of hand held and vehicle mounted phones. Within 2 years the system will be expanded along the major highways and to areas such as the Mornington Peninsula, Geelong, Morwell, Warragul, Bendigo and Ballarat.

NETWORK INVESTIGATORS

The provision of the Network Investigations Section is one of the big pluses for the new organisation. This small team of switching and transmission specialists has unravelled a number of complex (or persistent) congestion, switching and degraded transmission problems that have troubled our maintenance staff and annoyed our customers. The team has initiated a number of developments to improve its testing capability, including the highly successful remote data acquisition system used in conjunction with portable Individual Circuit Monitoring and Multi Frequency Code analysers.

BIRTH OF PRODUCT ENGINEERING

Establishing a new Workshops complex at Virginia Park, East Bentleigh, will be a major effort. The purchase of the site and buildings for $10.5m was the single largest property transaction ever handled by Telecom in Victoria. The activities of the Victorian Telecom Workshops, to be renamed Product Engineering Victoria, will be centralised at the 12.55 ha site, vacating seven poor quality inner Melbourne properties. Aided by modernisation of plant and processes, including the provision of a modern computer-based real time control system, the relocation of the 650 people into modern well equipped premises should substantially improve morale, conditions, productivity and profitability.

Optical Cable Systems for the Melbourne Digital Network

J. K. RICHARDSON, M.E., M.B.A.

The Melbourne Digital Network is being established progressively to achieve digital integration of both switching and transmission in a co-ordinated manner. The transmission paths will be increasingly realised by optical systems which will enable a more rapid response to customer needs and enhance the security of the network.

1. Background

Melbourne is strategically located in the South Eastern part of Australia, with a population of almost 3 million, representing slightly more than 70% of the total Victorian population. The Melbourne Telephone District currently has approximately 1.2 million telephone services, spread over an area of radius 40 km and connected to 154 exchanges. The Melbourne telecommunications network is becoming progressively digital, with approximately 25 digital nodes envisaged. The need for large numbers of circuits and the extended nature of suburbia has made optical cable systems attractive for the interconnection of these nodes. Of the Australian capital cities, Melbourne has the most advanced plans for the development of an optical cable network, both within the Central Business District (CBD) and for the outlying suburban areas. The implementation of this new network is now well under way.

2. Introduction

Digital transmission systems using primary PCM (2 Mbit/s) on metallic cable pairs were first installed in 1977/78 in some of Melbourne's north western suburbs. The aim was to provide for junction relief by deferring cable augmentation and avoiding expensive conduit installation as well as to improve transmission performance. The primary PCM network has been extended to cover most of the metropolitan area and provides a sound transmission base for the expanding Integrated Digital Network. Until 1986/87 the rapid growth of digital transmission will be mainly achieved by 2 Mbit/s systems on symmetric pair cable. From that time onwards growth in transmission capacity will be predominantly realised with higher order digital systems on optical cable.

The first optical cable in the Melbourne network was installed in 1981/82 between exchanges in the south eastern suburbs of Clayton and Springvale, over a distance of 7 km. It is completely non-metallic, contains six fibres and was used for experimental purposes, making connection with the nearby Telecom Research Laboratories, which are located close to Monash University. In 1982/83, two field trials on optical cables were undertaken. One of the cables lies along a key junction route, between Exhibition Exchange in the Central Business District and Dandenong, an eastern suburb 35 km distant. The other functions as a link between Exhibition Exchange and Maidstone, a western suburb 15 km distant, where an important microwave radio terminal is located. Both cables contain 12 fibres, are completely underground, operate in multimode at 850 nm wavelength, and have metallic components — steel core, copper pairs and aluminium moisture barrier. Following their successful installation, digital systems were then introduced in 1983/84, with a 34 Mbit/s path on the Dandenong route and a 140 Mbit/s path on the Maidstone route; both are now integrated into the Melbourne digital network. **(See Fig. 1)**

3. Digital Transmission Development

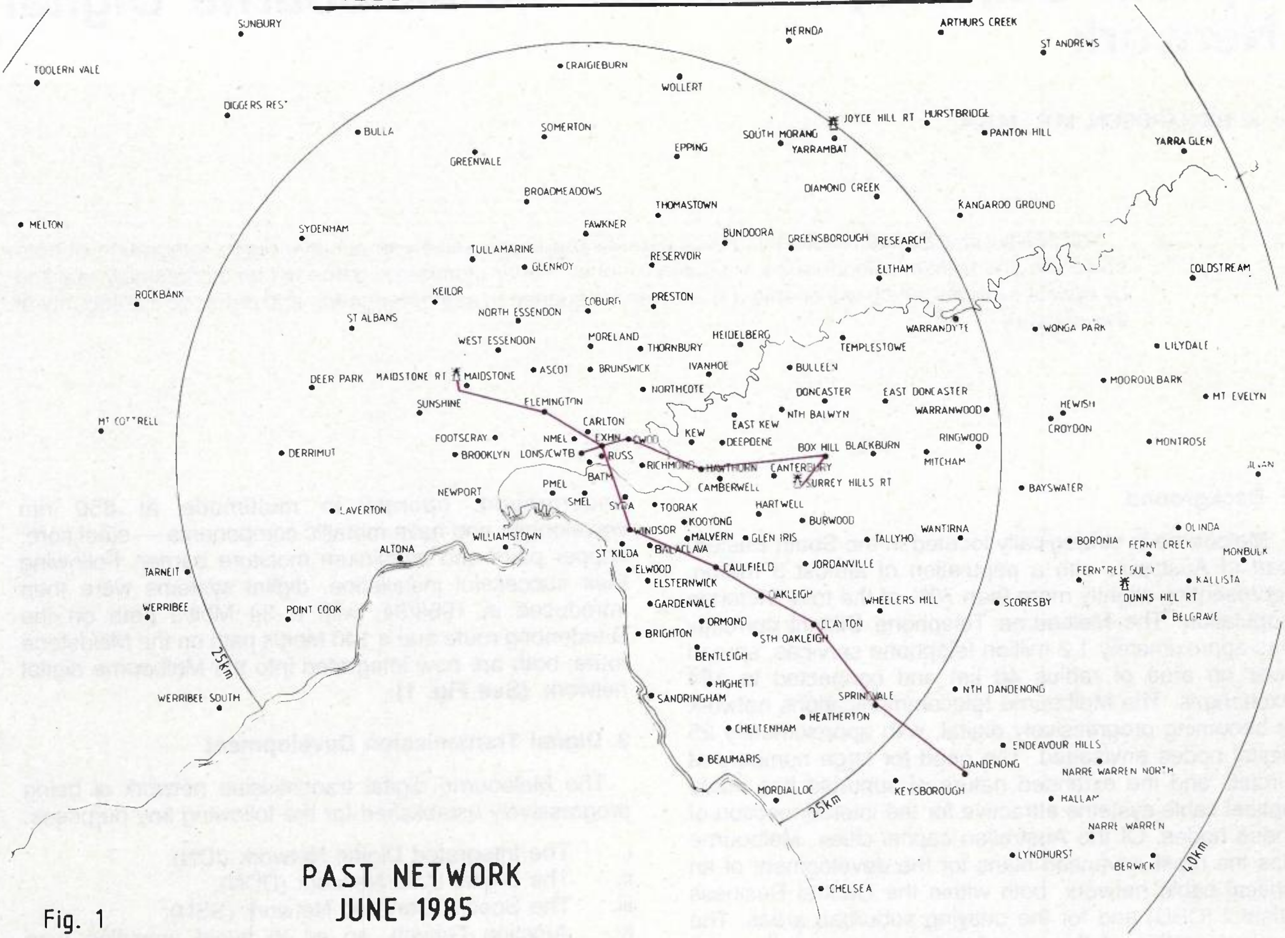
The Melbourne digital transmission network is being progressively established for the following key purposes:

i. The Integrated Digital Network (IDN);
ii. The Digital Data Network (DDN);
iii. The Special Services Network (SSN);
iv. Junction Growth, so as to avoid providing new (metallic) pair cables and further conduits;
v. Provision of Indialling and Tie Lines for PABX;
vi. Provision of cable links for high capacity radio systems terminating at the Maidstone and Surrey Hills Telecom Towers;
vii. Special Connections, such as wideband links for the International Exchange at Scoresby and for the Earth Station at Tally Ho;
viii. Network Improvement, in order to meet new transmission standards for loss, level and stability;
ix. Network Security, by providing alternative routes, which will also improve responsiveness to customer needs; and
x. The formation of a sound base for the merging Integrated Services Digital Network (ISDN).

Included in this digital transmission network is the Telecom Optical Fibre Pilot Network for the Melbourne CBD, detailed in another paper at this conference. The proposed interstate optical cable link between Melbourne and Sydney, scheduled for completion in 1987/88, does not form part of the junction network and is not detailed in this particular paper.

Optical cables and systems have been chosen to form the major part of the digital transmission network for Melbourne because of the economical and technical advantages of optical communication. However, in addition to systems on optical cable (mainly at 140 Mbit/s) and on pair cable (2 Mbit/s), there will be several systems on existing coaxial cable (140 Mbit/s) where spare tubes are available. Furthermore, there are a number of systems on microwave radio (2 Mbit/s and 34 Mbit/s) and several more will be constructed in situations where the terrain

MELBOURNE OPTICAL CABLE NETWORK



PAST NETWORK
JUNE 1985

Fig. 1

renders this medium an attractive option, or where convenience and/or diversity encourage its use.

4. Optical System Selection

In order to determine the structure of Melbourne's optical cable network, there are a number of relevant factors to consider. Generally speaking, 140 Mbit/s systems on optical cable are selected in preference to 2 Mbit/s systems on pair cable whenever there are sound economic, technical or strategic reasons for so doing. The main factors are as follows:

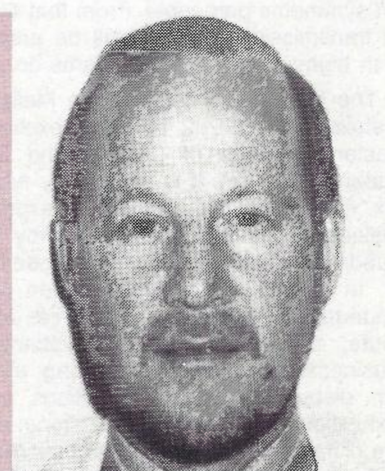
i.	route length	(distance between terminals);
ii.	circuit capacity	(number of primary systems);
iii.	growth rate	(dependent on subscriber and traffic increases);
iv.	existing plant	(availability of other cables and ducts); and
v.	diversity needs	(two different routes for each node).

From these considerations it is possible to determine the cable length, fibre number, fibre type (multimode or monomode), completion date and the type of sheath (suitability for hauling through ducts or for ploughing into ground). The completion dates are critically dependent on exchange cutovers (especially the digital transit and nodal exchanges), on timing of radio terminal links (particularly for interstate systems) and on the needs of major

JIM RICHARDSON joined the Australian Post Office in 1962 after graduating at the University of Melbourne as a Bachelor of Science and as a Bachelor of Engineering. He commenced work in the Research Laboratories and developed mixer amplifier equipment for radio propagation studies. This was followed by an investigation of strip line technology and the determination of practical design formulae for directional couplers and for band pass filters.

In 1972, after three years in Radiocommunications Construction Branch, he was promoted to the Engineering Planning Division, Headquarters. Here, he worked on profitability studies of new telephone services, tariff determinations of leased lines and revised the Engineering Instruction on Economic Comparisons, Present Value Studies.

He transferred to the Planning and Programming Branch, Victoria in 1980 and planned the development of the Melbourne Optical Cable Network after work on PCM junction relief. Subsequently he completed several sections of the Victorian IDN Plan on Transmission and Switching. Currently he is Engineer Class 5 and the National Co-ordinator of the New Transmission Plan in the Network and Support Systems Unit, Victoria.



customers (mainly OTC and AUSSAT). It is also necessary to determine the number of regenerators for an optical cable system, with the need to locate all regenerators within exchange buildings. The maximum regenerator spacing for an optical cable system depends upon the following factors:

a. system bit rate (transmission capacity);
b. type of mode (multimode or monomode);
c. type of source (output power, wavelength, bandwidth);
d. allowable error rate;
e. receiver sensitivity;
f. fibre performance (attenuation and dispersion);
g. joint and connector losses; and
h. margins for cable equipment.

For multimode transmission, 140 Mbit/s capacity and 1300 nm wavelength, the regenerator spacings are limited by dispersion, not attenuation. The maximum recommended values, as determined by Telecom for three fibre grades, using current technology, are as follows:

BANDWIDTH	ATTENUATION	SPACING
MHz km	dB/km	km
600	1.3	9
800	1.0	15
1000	0.8	22

Taking into account the costs of these fibre grades, the distance between exchanges and the mesh nature of the Melbourne network, it has been agreed to standardize on the 1.0/800 fibre type, with 15 km regenerator spacing. This permits a great flexibility in system design, allowing a particular cable between exchanges to form portion of several possible optical transmission links. In some situations, however, a departure from this fibre type has been sought, in one case a higher quality fibre to avoid an additional regenerator and, in another case, a lower quality fibre for a short spur link. **(See Fig. 2)**

For monomode transmission, 140 Mbit/s capacity and 1300 nm wavelength, regenerator spacing is limited by attenuation with a current maximum design value of 50 km. This distance is significant for the Melbourne network, as it permits an optical system to be installed between the centre and the periphery without need for a regenerator. (In 1986/87, monomode cables will be introduced into the network, and no multimode cables will be installed after this year). Apart from longer regenerator spans, the other main advantage of monomode transmission over multimode transmission is higher capacity, well in excess of 140 Mbit/s which is the practical limit for multimode operation. On the Sydney-Melbourne optical cable link, four systems of 565 Mbit/s capacity are planned; in the Melbourne network, some 140 Mbit/s capacity links may be subsequently upgraded to this higher rate.

In an economic comparison between a 2 Mbit/s system on pair cable and one derived from a 140 Mbit/s system on optical cable (which is equivalent to sixty-four 2 Mbit/s systems representing a total of 1920 telephony channels), a break even distance of approximately 5 km is obtained using current material and labour costs. (Above 5 km, optical cable systems are less costly, whereas below 5 km, pair cable systems are less costly). This figure assumes that the 140 Mbit/s system is fully equipped, that the cost of the pair cable is excluded, as it represents a sunk cost, and that average costs are used throughout. As the distance of 5 km is also the average length between exchanges in the Central Melbourne Telephone Zone, there are obvious applications for optical cable systems, especially between nodes and tandems, where circuit requirements are substantial. **(See Fig. 3)**

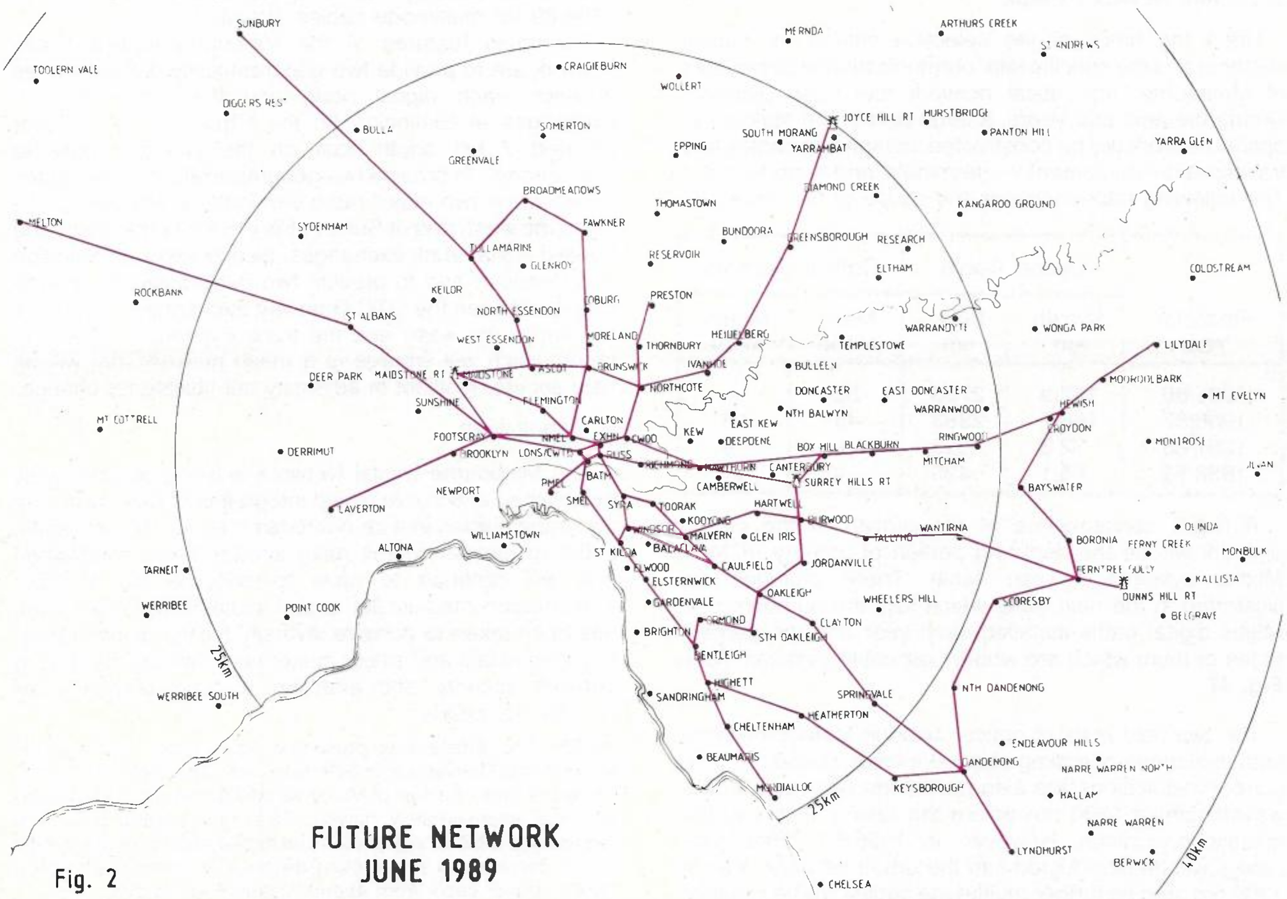


Fig. 2

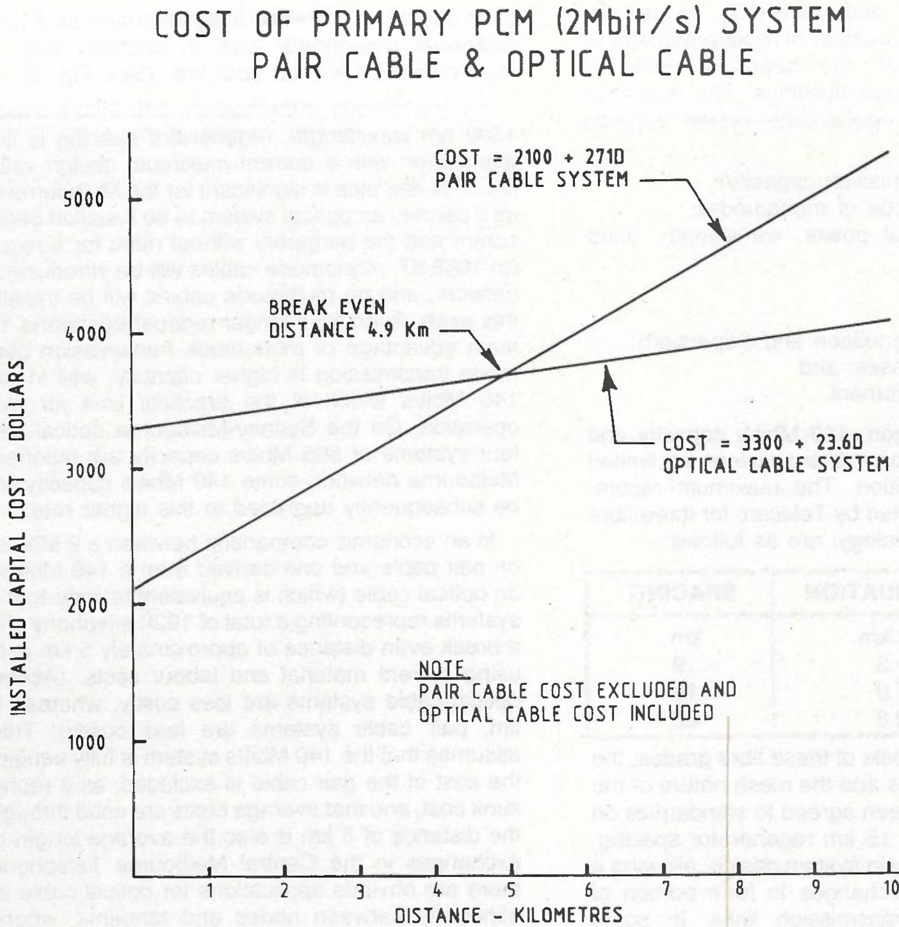


Fig. 3

5. Optical Network Plans

Upon the basis of the selection criteria for optical systems and the specific telecommunication requirements of Melbourne, an optical network has been planned. During the next four years, a large part of the Melbourne optical network will be constructed, comprising cables and transmission equipment — terminals and regenerators. The following table indicates the scope of the network:

Financial Year	Optical Cable		Optical Systems	
	Sheath km	Fibre km	Multi-Mode	Mono-Mode
1985/86	142.6	2793	52	—
1986/87	166.2	2333	45	13
1987/88	72.3	598	6	8
1988/89	65.1	423	4	11

A major consequence of the growth of the optical network will be the declining portion of primary PCM (2 Mbit/s) systems on pair cable. These changes are illustrated in the next table which lists the numbers of 2 Mbit/s digital paths installed each year and the percentages of them which are wholly pair cable systems: **(See Fig. 4)**

The two field trials of optical cable in Melbourne were both multimode operating at a wavelength of 850 nm. The current installations are also multimode but operate at a wavelength of 1300 nm where the loss is less and the dispersion minimal. However, in 1986/87, monomode cables will be introducted into the urban network, also at 1300 nm, and no further multimode cables will be installed afterwards, although some systems are scheduled in 1988/89 for multimode cables already in place.

The main features of the Melbourne optical cable network are to provide two geographically diverse routes between each digital node and the digital tandem exchanges at Exhibition (in the CBD) and at Windsor (located 7 km south east on the junction route to Dandenong); to provide two geographically diverse routes between the two major radio terminals, at Maidstone (15 km to the west) and at Surrey Hills (18 km to the east), and the two digital trunk exchanges, also located at Exhibition and Windsor; and to provide two geographically diverse routes between the OTC Gateway Exchange at Scoresby (30 km to the east) and the trunk exchanges. The nett result which will emerge is a mesh network that will be very secure, resilient in adversity but flexible for change.

6. Conclusion

The Melbourne Digital Network is being progressively established to achieve digital integration of both switching and transmission in a co-ordinated manner. Transmission paths on optical cables have already been established and will continue to grow to become the principle transmission medium for digital systems by 1990. Care has been taken to achieve diversity for the digital nodes, radio terminals and major customers, thereby enhancing network security and enabling a rapid response for commercial needs.

NOTE: This article was presented as a paper to the IREE International Convention in 30th Sept.-4th Oct. 1985 (No. 0320). Since that time, the cost of Muldems (Multiplexers & Demultiplexers) has approximately halved. This has resulted in a cost reduction of 2 Mbit/s digital paths on higher order optical systems and a decrease of break even distance in comparison with 2 Mbit/s on pair cable from approximately 5 km to zero.

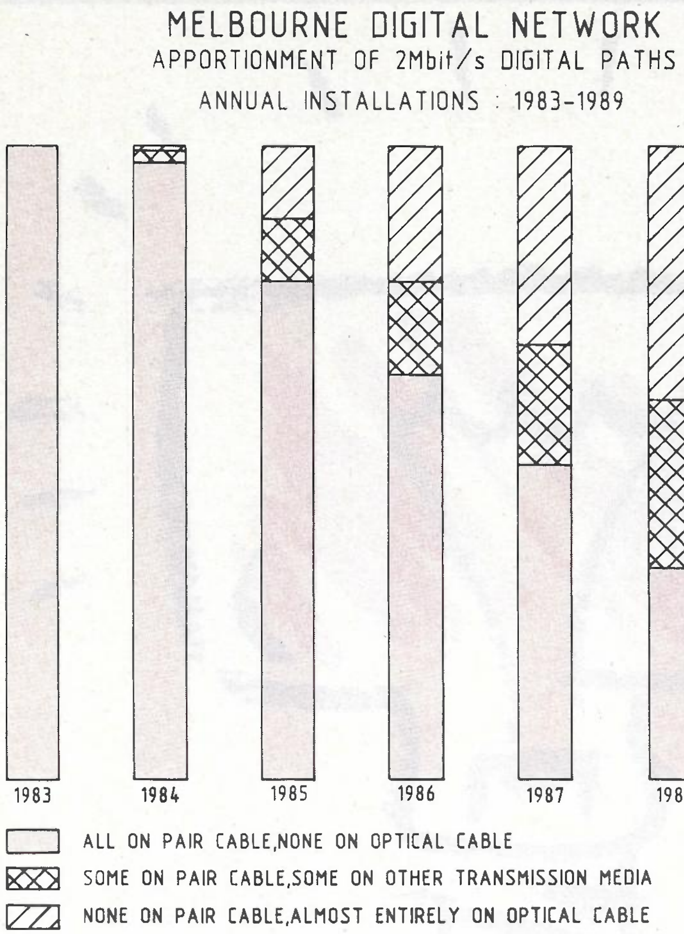


Fig. 4

TRANSMISSION MEDIUM	1983/4	1984/5	1985/6	1986/7	1987/8	1988/9
All on Optical Cable	1	64	248	430	660	800
Some on Optical Cable	3	50	170	270	425	390
None on Optical Cable	188	420	780	710	540	400
Portion of Systems Fully on pair Cable	98%	79%	65%	50%	33%	25%
TOTAL SYSTEM NUMBERS	192	534	1198	1410	1625	1590

A detailed illustration of the network application of these 2 Mbit/s digital paths is also tabulated:

DIGITAL PATH CATEGORY	1983/4	1984/5	1985/6	1986/7	1987/8	1988/9
Integrated Digital Ntwk	104	362	852	765	991	950
Digital Data Network	64	90	132	250	230	240
Special Services Network	14	43	91	150	100	60
Tie Lines for PABX	10	39	88	107	164	214
Indialling for PABX	0	0	35	138	140	126
TOTAL SYSTEM NUMBERS	192	534	1198	1410	1625	1590

New Tariff Pulse Generator

ALAN WALTER
ROBERT JOHNSTON

A new Tariff Pulse Generator is to replace the present interim tariff Pulse Generation equipment in all electro-mechanical STD charging centre exchanges. This equipment generaties pulses at pre determined rates required for charging of STD calls. The system hardware and software is described and the design considerations and maintenance features are outlined. The new equipment is a flexible, reliable and cost effective replacement embodying the latest hardware and software design practices and maintenance aids.

INTRODUCTION:

On 4 January 1984, Telecom's General Manager, Engineering, gave approval to call tenders for replacement of the Interim Tariff Pulse Generation equipment in all electro-mechanical STD charging centre exchanges. Tenders closed for the supply of this equipment on the 18 September 1984. This paper describes the equipment chosen and provides details of its proposed introduction into the Telecommunication's network.

The tariff equipment generates a range of predetermined pulse rates. The rates cycle on a daily and weekly basis. The exchange selects the appropriate rate to meter an STD call.

BACKGROUND:

The charging equipment in electro-mechanical exchanges consists of three main subsystems as illustrated in **Fig. 1.** This paper refers to the subsystem which is the replacement for the Interim Tariff Scheme. The existing Pulse Generator is required to provide charging pulses and supervisory pulses. The charging pulses consist of the eight possible charge rates as specified in the National Charging Plan (2), and the supervisory pulses range from a 1 second pulse used for the time clocks to a 360 second pulse used for tariff supervision. The Interim Tariff Pulse Generator automatically changes between the five charging scales at the appropriate times of day as required.

The actual charge determination and application of charging pulses is performed by the common control equipment and the line relay sets respectively.

The decision to replace the equipment was based on the following factors:

- Replacement parts for the ageing time of day reference clocks were becoming difficult to obtain.
- Specialised paper tape punching equipment used in the preparation of tariff scale paper tapes, for the existing clocks could not be kept operational for many more years.
- Reliability of the equipment was decreasing and maintenance costs were rising.
- There was a need for a more flexible tariff system which could not be provided with the existing equipment.

OVERVIEW:

The tariff equipment which is to be superseded was described in a Telecom Journal article (1). It used electro-mechanical clocks and a mylar/paper tape loop to control the scale changeovers. For example, day rate to intermediate rate. The existing equipment consists of several racks of equipment, including the scale change pulse source rack and the Pulse Control Rack as illustrated in Figure 1. This equipment will be replaced by a single electronic shelf, with a relocatable console for the Man-Machine communications. The shelf and console are illustrated in **Fig. 2 & 3** respectively.

SYSTEM DESCRIPTION:

The new Tariff Pulse Generator (TPG) is a stand alone, microprocessor controlled system for generating timed pulses for use in existing crossbar electro-mechanical exchanges. The pulses are reticulated to charging relay sets for meter pulse generation and to supervisory equipment which monitors the exchange functions, eg, the timeouts on relay sets.

The Pulse Generator System comprises three separate units, two Pulse Generators and the Display Unit as illustrated in **Fig. 4.** The units are connected to each other via a communication link.

In addition to pulse generation a number of other facilities are included in the Pulse Generator system, these include —

- Adjustment of the clock time
- Correction of clock drift
- Reclassification of fault status urgent/non-urgent.
- Display of all stored data, current and future tariffs with change over date and time, charging cycles, daylight saving dates and holiday dates up to thirty entries.
- Automatic adjustment of the outputs and system clock in accordance with the stored data.

The various aspects of the design are described below in greater detail:

- **Hardware**

The system hardware consists of one CPU card, two Relay Driver cards and a DC/DC Converter Power Supply card. For security purposes this entire sub-unit is fully duplicated within the shelf, with an automatic software controlled switch-over occurring under failure conditions in the operating unit.

- **Display Unit (DU)**

A portable Display and Control Unit (DU) is also provided to allow man-machine interaction with the system. The DU consists of a portable box containing a liquid crystal display, 16 digit key pad, a CPU/display controller and DC/DC Converter. The DU can be either

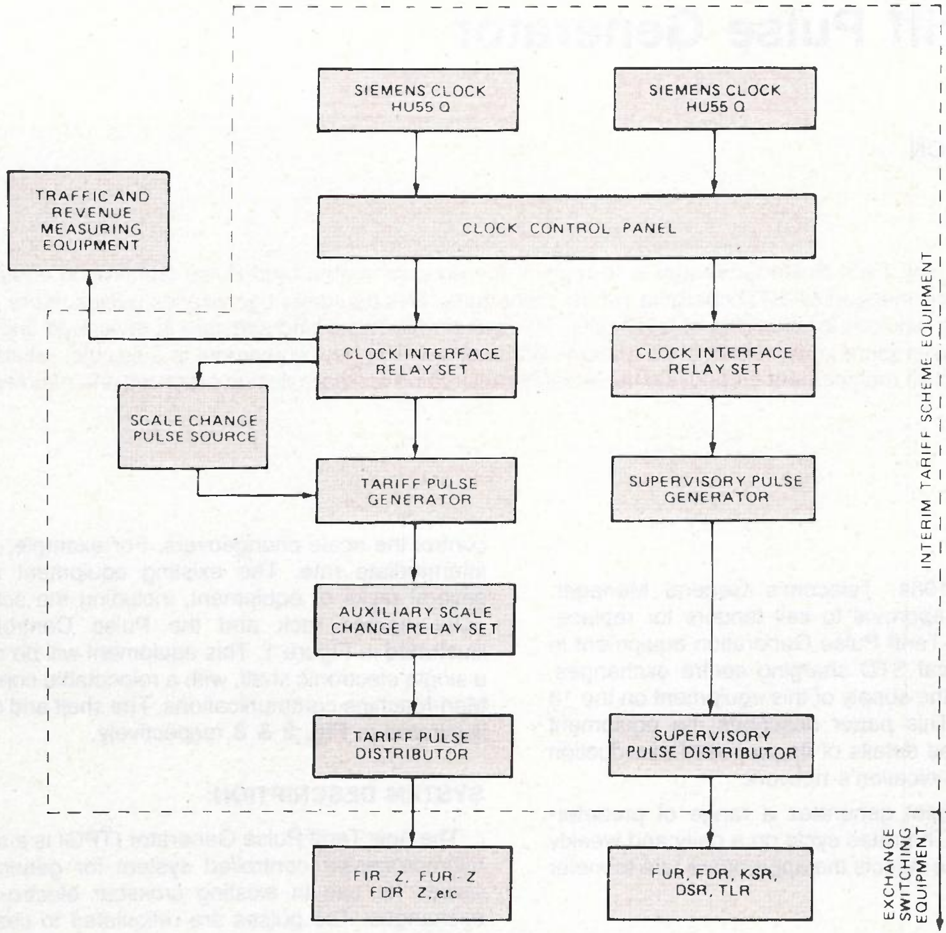
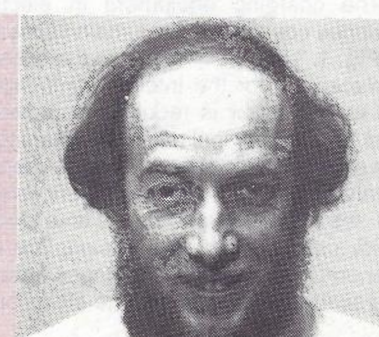


Fig. 1 Interim Pulse Generator Overview

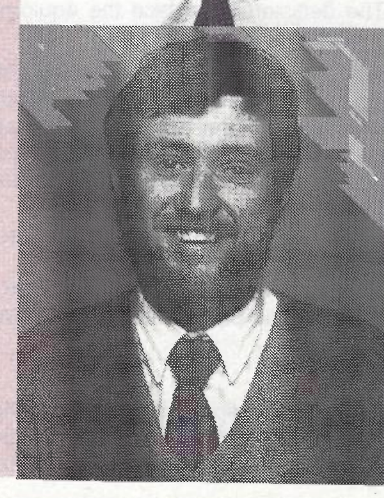


ALAN WALTER is the Manager of the Trunk & Network Interface Systems Group in the Switching Development and Support Branch, Telecom Headquarters.

He joined Telecom in 1968 as a Technician-in-Training, in the Headquarters Switching Laboratory. He moved to the National Support Centre for ARE-11 as a technical expert and supported the cutover of the first ARE-11 exchanges. He qualified as an Engineer in 1979 and joined the 10C National Support Centre.

In this area his work has included capacity improvement projects and overload control studies. He is currently studying part-time for his M.E.

He was promoted to his present position in 1985.



ROBERT JOHNSTON joined Telecom in 1985 after working in the SECV for several years. He graduated from the South Australian Institute of Technology (Adelaide) in 1981 and is currently completing a post graduate Diploma in Digital Control.

His position in Telecom's Switching Development & Support Branch involves the design and co-ordination of Network interfacing projects.

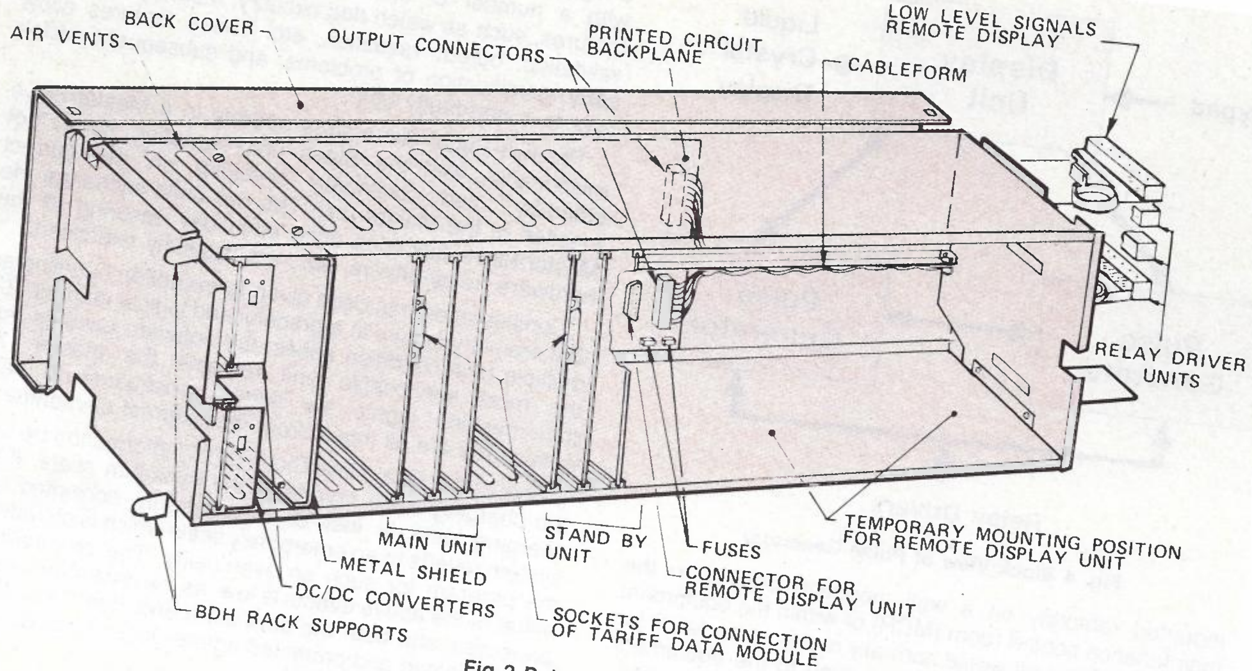


Fig 2 Pulse Generator

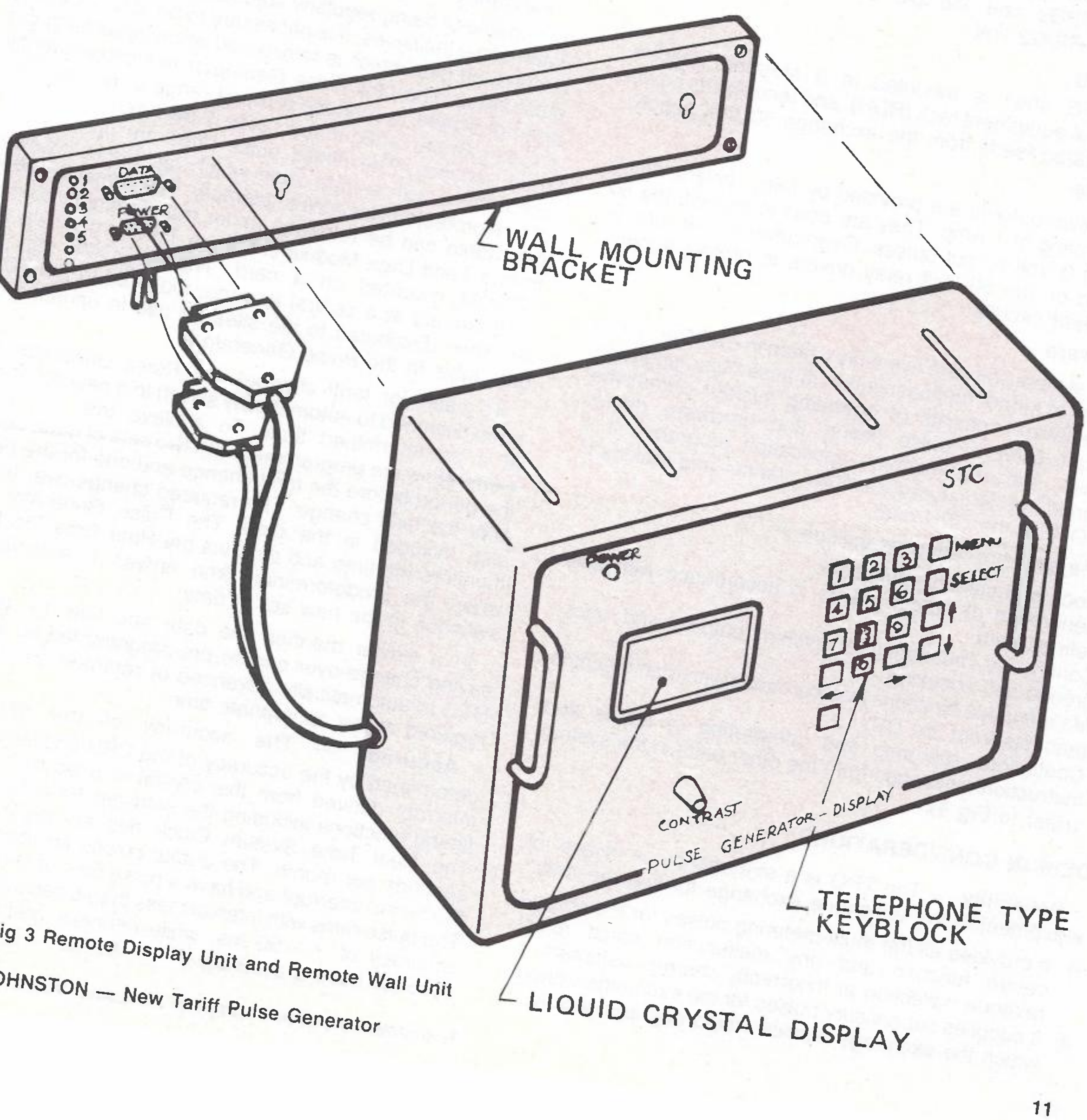


Fig 3 Remote Display Unit and Remote Wall Unit

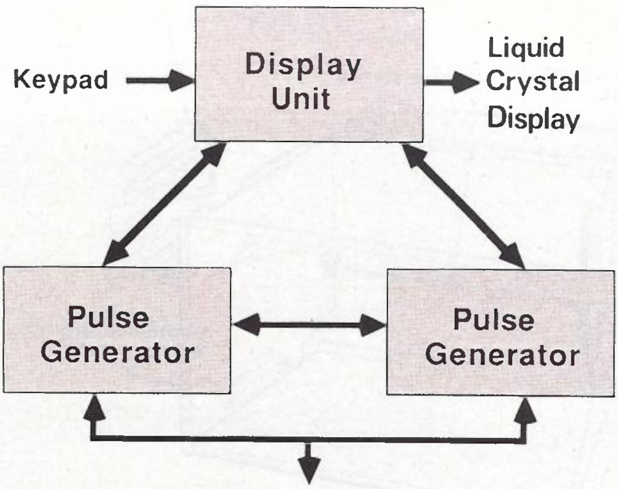


Fig. 4 Block View of Pulse Generator

mounted remotely on a wall mounting bracket in the maintenance control room (MCR) or within the equipment shelf itself. The unit would normally reside in the MCR for day to day operations, and be moved to the equipment shelf to allow data updating or equipment maintenance. The two TPGs and the DU communicate via a bi-directional RS422 link.

- **Mounting**

The TPG shelf is mounted in a standard electro-mechanical equipment rack (BDH), and receives its power via duplicated feeds from the exchange 50 Volt supply.

- **Outputs**

The pulse outputs are provided by relay drivers which have a rating of 1 Amp. They are used to provide the 50 Volt and 0 Volt output pulses. Over-current protection is provided on the 50 Volt relay drivers to protect against earth short circuits.

- **Software**

The system software is mainly written in PASCAL with a number of kernel routines written in assembler language. The software consists of operating system primatives, interrupt servers, pulse timing and hardware driving routines, and man-machine application programs. It is designed in a structured, modular manner and resides in EPROM on the CPU card.

The software functions include:—

- Clock and calendar functions.
- Generation of output pulses in accordance with user defined data.
- Continuous monitoring of system outputs and background self checking.
- Maintenance functions in accordance with Man Machine requests from the DU.
- Continuous reporting and interpreting of status and instruction messages from the other units in the system (refer to **Fig 4).**

DESIGN CONSIDERATIONS:

Reliability — The TPG is a strategic piece of iece of equipment in the telephone exchange for two reasons:

i) It provides all the multi-metering pulses for the charge centre function and any malfunction could affect revenue collection or incorrectly charge customers.
ii) It supplies supervisory pulses for the exchange without which the exchange service would degrade rapidly.

The Pulse Generator has therefore been designed to be a highly reliable system. It has full hardware redundancy, with a number of software and hardware monitoring features, such as watch dog circuitry, memory checksum validation, output validation, etc. These features allow early identification of problems, and subsequent switch over to a non-faulty unit.

The two Pulse Generators operate in a Master/Slave relationship, with the Slave unit operating as a "hot stand-by," and continually checking on the correct function of the Master unit. The two units exchange the Master/Slave functions once each day ensuring all the hardware, relay-drivers, etc., are regularly exercised.

Consideration has been given to exception handling so that recovery occurs in a graceful and logical manner. If a multiple fault condition arises, the software ensures that the most serviceable unit remains the master. All man-machine inputs are tightly constrained to valid options, as are all inputs from the external environment.

Should the Real Time Clock (RTC) information be lost, the charging scale reverts to the minimum scale. If the charging data is lost or irrecoverably corrupted, the system reverts to an emergency scale which is provided in the program for such an eventuality. The probability of either of the above events is low, as the data store is write protected, and both the data store and Real Time Clock are duplicated and protected against loss or power for 24 hours.

Flexibility — Because telephone call tariffs need to be capable of being regularly adjusted in accordance with commercial initiatives, it is necessary to be able to flexibly change the data which is referenced when generating the pulse rates. The new Pulse Generator has consequently been designed to produce a broad range of pulses. The pulses can be varied in the range 1 per second to 1 per 1024 seconds. The actual pulse rates are produced in accordance with a data table which resides in a power failure protected Read/Write Memory. The contents of this data table can be reloaded under man-machine control from a Tariff Data Module (TDM). A TDM is basically an EPROM mounted on a card. The EPROMs can be programmed at a central location, mounted in the TDM, and then distributed to the sites for use in updating the data table in the Pulse Generators.

To cater for tariff changes the Pulse Generator has been designed to automatically switch to a new set of data at a predetermined time. To achieve this, the Pulse Generators are programmed with two sets of data, one for the period before the tariff change and one for the period after the tariff change. The required change-over time is also included in the data. The Pulse Generator then monitors the time and data via the Real Time Clock and when the predetermined time arrives it automatically switches to the new set of data.

In a similar manner, the date and time for daylight saving change-over can be pre-programmed so that the RTC is automatically advanced or retarded one hour as required at the appropriate time.

Accuracy — The accuracy of the system is determined by the accuracy of the CPU crystal. A 50 ms interrupt derived from this crystal is used to control all timing functions including the software Real Time Clock. The Real Time System Clock has an accuracy of 3 seconds per month. The output pulses are derived from the 50 ms interrupt and have a pulse time of 150+ 10 ms. The pulse rates with intervals less than 5 seconds have an accuracy of +/- 50 ms, while intervals greater than 5 seconds have a accuracy of +/- 0.1%.

MAINTENANCE FEATURES

The Display Unit provided is the systems main maintenance aid. It allows display of all relevant information on request, modification of certain system parameters, and control of data reloads from the Tariff Data Module.

All input commands are entered via the keypad of the Display Unit. Some of the commands provided include setting of the RTC, requesting display of the alarm log, and ordering switch-over of the Master/Slave function.

Other aids include LED indicators on all boards, which indicate the status of the relevant board, and provide an indication of the charge scale which is currently operative.

The system is provided with a complete set of manuals, including a Maintenance Manual. The Maintenance Manual includes a set of diagnostic aids which assist the operator in determining the failing sub-unit, and correcting the system.

The equipment will be maintained using the sub-module replacement technique, ie no problems will be localised below the card level. The failing sub-unit will then be sent to the manufacturer for factory repair.

SUMMARY:

The Tariff Pulse Generator has provided Telecom with a flexible, reliable and cost effective replacement for the Interim Tariff Pulse Generator equipment. The technology implemented embodies the latest design practices in both hardware and software and provides comprehensive maintenance aids in line with current practices.

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Quality Assurance Plan for External Plant

E.H. CHUI B.E. (Elec.), B. Ec.

Significant improvements in the fault performance of Telecom Australia's external plant network will result from the operation of the Quality Assurance Plan for External Plant. This paper describes the development, procedures, application and recent operational results of the QA Plan.

The structuring of the QA Plan to gather specific cause information, and future directions to be taken in further development of the plan to improve the process of building quality into the external plant network are also discussed.

BACKGROUND

The commitment to provide a high quality service to its customers has been one of the main corporate thrusts of Telecom Australia.

In 1978 a detailed review was made of the installation and performance of the distribution plant network with the aim of reducing costs and improving performance. An important recommendation arising from the review was the development of a 'planned field Quality Assurance Programme' (Ref. 1).

The emphasis on distribution plant was due to:

- expenditure on customer distribution plant was approximately 21 per cent of all capital expenditure and increasing
- distribution plant was performing poorly and accounted for 96 per cent of all external plant faults — clearly, improvements made in plant performance will result in major maintenance and plant replacement cost savings
- difficulty of meeting service restoration targets in some areas
- short plant life achieved in comparison with design life
- need for closer scrutiny in the determination of reconstruction (upgrade) projects to maximise return on reconstruction investment
- need to obtain reliable feedback to correct design and practices defects which cause failure.

Development work for a Quality Assurance Plan for External Plant (QA Plan) commenced in 1980 with field trials following in 1981/82. It was also determined that main cable and conduit installation should be included to complete the coverage of the Customer Access Network.

During development references were made to similar Quality Control Programmes in AT&T (Ref. 2 and 3).

Implementation commenced in 1983 and an Operations Manual (Ref. 4) was published.

EXTERNAL PLANT QUALITY CONTROL AND QUALITY ASSURANCE IN TELECOM AUSTRALIA

A good working definition for quality is 'Fitness for Purpose' (AS 1057) or 'Conformity to Requirements'.

Quality Control (QC) can therefore be described as a regulatory process whereby the actual conformity to requirements is measured (at stages if necessary), compared with a set standard, and the difference acted upon.

This procedure should be carried out from the time raw material is processed, right through the production phase to the inspection of the final product.

In the context of distribution plant installation the 'raw material' includes the actual hardware (cables, joints, terminating blocks etc.), tools, skill and the practices used. First line supervisors usually carry out the QC function (even though in the past this has not been termed as such) in the field through direct supervision of work. This QC function has therefore been performed by the Operations Department.

Quality Assurance (QA) on the other hand can be described as the activities of providing the evidence needed to establish confidence (assurance; formal guarantee) of the quality achieved.

These activities cover a much wider area than that of production and QC and usually include product specification, design, material purchase, installation, maintenance and a feedback system. QC is therefore a sub-system of QA.

Technically QA involves identifying those attributes affecting performance, the measurement of these attributes on a sample basis and relating the sample measurements to the 'lot' with the required degree of confidence.

As it is essential to have QA measurements made in a fair and unbiased manner the QA function should be separated in line management and independent of the production process. In Telecom Australia the QA function is performed by the Network Engineering Department.

Fig. 1 summarises the application of External Plant QA and QC in Telecom Australia.

THE QUALITY ASSURANCE PLAN FOR EXTERNAL PLANT (QA PLAN)

Objectives

Besides being an inherent function of the Network Engineering Department to meet the needs as expressed above, the QA Plan fulfils another important function in the development of external plant.

Fig. 2 shows the external plant development cycle and the routine and QA feedback paths in the cycle. It is clear how QA provides additional feedback information and contributes towards the overall optimum design of the external plant system.

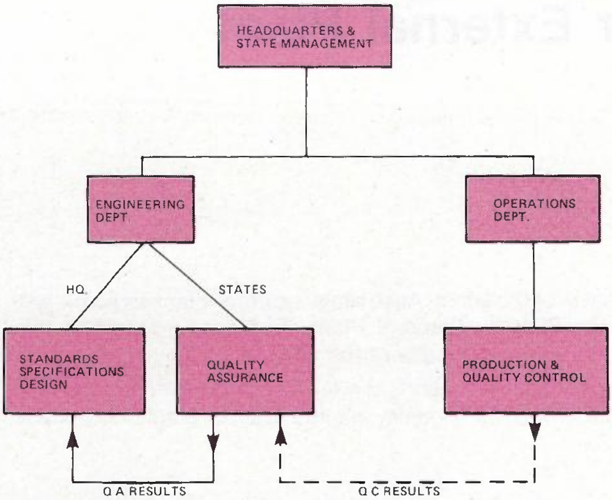


Fig. 1 External Plant QA and QC in Telecom Australia.

Specifically, the objectives of the QA Plan are:

- to measure the quality of new installations of distribution and major cable plant compared to set standards and specifications
- to measure the quality of existing plant and maintenance work so that improvements in methods, practices and design can be made
- to identify deficiencies in plant installation methods and hardware design that affect safety, service and costs; and to measure the effectiveness of improvement programmes
- to increase the level of awareness of staff of the standards of work required and the need to maintain these standards
- to detect and correct any inadequacies in staff training.

System Overview

The QA Plan obtains information on external plant installation quality by examining a cross section of the work projects undertaken. These projects come in the form of works authorities (major and minor), telephone service orders and fault repair reports.

A list of projects of each predominant construction type, called plant categories (e.g. underground, aerial etc.), is compiled prior to each measurement and a random sample is then selected for quality measurement in accordance with the appropriate sampling plan. In general, measurements are conducted every three months. However, the QA Plan provides for a reduced number of measurements once a consistent quality trend has been established. This provision is in line with other quality programmes, where the resource devoted to measurement is adjusted in accordance with achieved quality.

Field Measurements are carried out by specially trained Quality Assurance Measurement Officers (QAMOs) experienced in conduit, jointing and fault repair work. Their decisions are expected to be impartial, consistent and soundly based on current approved specifications, practices and instructions.

QAMOs are members of the Network Engineering

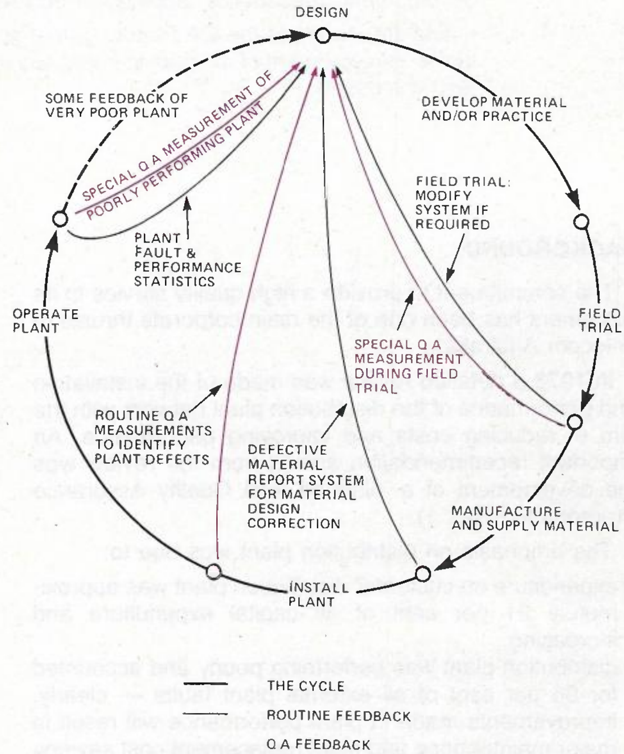


Fig. 2 The External Plant Development Cycle and its Management.

Department and as such are separated from the line control of the Operations Department.

The QA Plan does not set out to score as defects every minor variation from accepted practices. Only defects of safety, operational and performance significance are listed in the Defect Classification Lists (DCLs) for attention.

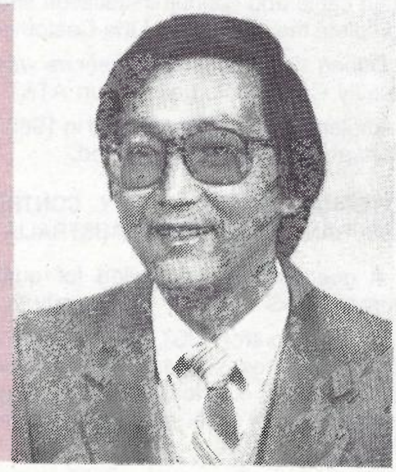
EDWARD CHUI joined the Australian Post Office in 1970 after graduating in Electrical Engineering at the University of Queensland.

He worked in a variety of areas, including Country Lines Planning in Queensland, and then Special Services and Transmission and Lines Planning in NSW.

In 1980 he joined the Lines Construction Branch at Telecom Australia HQ in the newly created Sydney Office of the Development Division.

He was the project leader of the Quality Assurance Plan and he also undertook a number of development projects on cable jointing methods and practices.

Currently he is the national project manager (Principal Engineer) of the Filled Distribution Cable Project.



Also, DCLs are structured in a way that reliance on judgement by the QAMOs is minimised, but it is recognised that there will be situations where judgement is necessary and must be exercised. The only category of defect where matters are not left to judgement is safety. In this case standards regarding safety are strictly observed.

The measurement process involves the comparision of identified attributes of installed plant with attributes detailed in the specification for the installation of plant. In this case the specification takes the form of Defect Classification Lists or 'Check Lists'. The output of the measurement process is a quality level for each or group of attributes of the installed plant.

The quality level is then compared with a preset Acceptable Quality Level (AQL) expressed in terms of maximum allowable defects per 100 units measured. The comparison identifies those defects exceeding the AQL which are then analysed to determine the cause(s). Corrective actions of an engineering nature, such as equipment design, methods and practices, material specification, supply, instructions, trainings etc. are then determined and implemented. Equally, corrective actions in the operations area are determined and undertaken.

SCOPE OF QA PLAN

The QA Plan is divided into two parts, each using the principles described above.

Part 1 — Distribution Areas.

1A New work in distribution areas.

This covers all new works carried out by the Operations District under Major and Minor Works Authority (including recoverable works) and telephone service orders. Distribution plant is divided into three main categories

- fully underground
- underground cable and ITP (isolated terminal pole)
- aerial cable and ITP.

Units of construction, called plant units, include pillars, pit and pipe reticulation, cable, joints, customer lead-ins, poles etc.

1B Existing installations in distribution areas.

This covers all of the existing plant in the distribution area. Measurement of the quality of existing plant are made on a selective basis and for specific purposes. The most common purpose would be that of providing supportive information towards the decision to upgrade a part or whole of a distribution area.

The quality of the existing network, obtained from a systematic field measurement and examined in conjunction with plant performance statistics, provide a ready source of information on which to base the extent of upgrade and the resources required to achieve it.

1C Maintenance (fault repair) in distribution areas.

This covers fault repair work in the distribution area. It is well recognised that plant disturbance in general and fault repair in particular are major contributors to poor plant quality after the initial installation. The problem is accentuated when, after service restoration, the plant item or equipment is not restored to the standard condition. While this could be mostly attributed to poor workmanship there are many instances where plant design, material design and practices etc. are such that the task of restoring existing plant (some of which could have deteriorated due to ageing) to the standard operating condition could be extremely difficult.

Part 2 — Major Cables Plant

This part of the QA Plan covers new installations, existing installations and maintenance work on major cables and conduits. The plant types covered include subscribers' main cables, junction cables and trunk cables (including coaxial and optical fibre cables). The plant units covered include manholes (normal, loading, repeater), major conduit routes, cable joints, cable pressure alarm systems, cable entries into exchanges etc.

OPERATION PROCEDURES

The four main steps in the operation of the QA Plan are:

- preparation — project listing
- sampling
- field measurement
- review of quality measurement results.

Fig. 3 shows the sequence of these steps in operation.

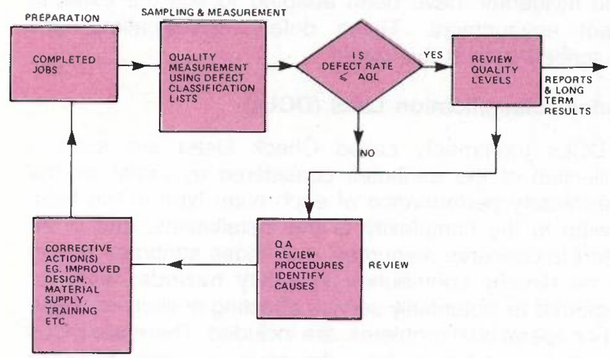


Fig. 3 QA Measurement Procedures.

Preparation

A listing of all works authorities, telephone service orders etc. is obtained for each Lines area (local area) within each District for the previous quarter. This list is then divided in accordance with the plant category such as fully underground, aerial etc. and the percentage of projects in each category calculated.

The division into these categories render the measurement results more specifically based and make the comparison of the same plant unit in different plant categories possible.

Sampling

The number of projects appearing on the list is defined as the 'lot size' and a random sample is selected from this for field measurement using the appropriate random number tables.

The size of the sample is obtained from sampling tables that have been derived from typical Quality Assurance Sampling Tables (see Ref. 5, 6 and 8) and adapted to suit the type of projects being sampled. The following are some extracts of the sampling tables used in field work:

Lot Size	Sample Size
2-8	2
9-15	3
16-25	5
26-50	8
51-90	13
91-150	20
151-280	32
281-500	50
501-1200	80

Table 1 Sampling table for Works Authorities

Lot Size	Sample Size
2-15	2
16-25	3
26-90	5
91-150	8
151-280	13
281-500	20
501-1200	32
1201-3200	50
3201-10,000	80

Table 2 Sampling table for Telephone Orders

Field Measurement

The measurement of Quality

Attributes essential to fulfil performance requirements are identified for the purpose of field measurement.

The five categories defined in AS 1057 for the seriousness of defects; viz., critical, special, major, minor and incidental; have been adapted to suit the external plant environment. These defect classifications are described later in this paper.

Defect Classification Lists (DCLs)

DCLs (commonly called Check Lists) are each a collection of the attributes considered essential for the satisfactory performance of each plant type in the field. Owing to the complexity of the installations, and in an effort to conserve resources, only those attributes known to be directly contributing to safety hazards, faults or regarded as potentially service affecting or likely to cause other operational problems, are included. Therefore DCLs are not intended to be exhaustive in terms of listing defects.

A typical DCL as used in the Distribution network part of the QA Plan is shown in **Fig. 4.**

The DCL is divided into three parts — the attribute, the defect classification and the feature/details. This last part is intended to give the QAMO a guide as to what minimum standards of construction are to be met. References are made to Technical Publications, Engineering Instructions and Practices Handbooks. Every Lineserviceman and his supervisor is given a complete set of the DCLs so that there is complete awareness of what the QAMO is checking.

Measurement

Field measurements of completed jobs are carried out only by QAMOs. In-progress checks and measurements are made as part of the QC function by Operations Department supervisors. The QAMO takes along a set of work plans and carries out quality measurements on all of the plant units installed on that project.

QA Measurement Forms (see **Fig. 5**) are used to record defects at each location. The location information has been included for ease of future reference should an on-site re-examination be necessary. Defects affecting or are likely to affect the safety of staff and public alike are immediately reported so that corrective measures can be carried out. Defects are totalled at the bottom of each QA Measurement Form for further processing.

Measurement results for the total District are then summarised in a 'Tally Sheet' which contains information on plant type, plant unit, number of plant units measured, number of each of the defect types, their defect classifications and number of defects for each assigned cause (Ref. 4). Further processing of the collected data by computer is then carried out.

UNDERGROUND CABLE & JOINTING	Defect Classf'n	FEATURES/DETAILS
1. If cable has been hauled and left unjointed, have all cable ends been sealed correctly?	S2	1. Sealing of cable ends - refer CC/P5 * correct size polyethene or neoprene cap * caps secured PVC tape (polyethene or neoprene cap * caps secured PVC tape (polythene cap)/ hose clip (neoprene cap).
2. Are cables identified?	D2	2. Identification of cables - refer CJ1/E10, G6 * Cable tag * Identifying card must show size of cable and range * Identifying card must be attached to inside of OJ container.
3. Have cables of the correct size/ type been used?	D3	3. Cable size/type - refer Job Plan
4. Have plans/transfer sheets been amended? (cables)	D3	4. Amendments of Plans/Transfer sheets - refer W&A/G Section
5. Are joints the required separation from HV Earths, Substations etc. perimeter	S1	5. Joints separation from HV Earths Substations etc. Perimeter - refer State Practices.
6. Have correct connectors been used?	S2	6. Correct connectors - refer CJ1/D15-D34, especially D25 and D31 * correct size connectors for conductor diameter * correct hand tools used eg. crimping tool, sheath stripper.
7. Is openable joint standing vertical?	S2	7. Standing joint vertical - refer CJ1/E12-13 * Support bracket pushed through bottom of pit and firmly in place * OR support bracket held vertical by clamp-wall mounting or cable bearer * if shroud support bar, must provide firm fit at pit rim, CJ1/E22-26.
8. Does epoxy appear to provide effective water barrier?	S2	8. Epoxy pour to achieve water barrier - refer CJ1/E9, Large Screw Type OJ - refer CJ1/E17-21 * check butyl rubber seal at entry nozzle, drain hole and upright joint * epoxy must cover sheath ends and fill within 5 mm of top of water barrier compartment rim.
9. Has OJ been correctly sealed?	S2	9. Sealing OJs - refer CJ1/E11 * butyl putty pressed firmly into seam * PVC tape wrapped over putty to rim of OJ base.
10. Have correct brackets been used?	D2	10. Fitting support brackets - refer CJ1/E6 * small bracket for small OJ & large bracket for large OJ * the main nozzle of OJ base must be fitted into the mounting claw of support bracket * cable correctly formed around support bracket.
11. Has epoxy been correctly mixed?	D2	11. Epoxy mix - refer CJ1/F1-F3 * epoxy must be mixed in accordance with Instruction * if epoxy is incorrectly mixed it will not cure, have a cloudy appearance and/or presence of air bubbles, and/or be tacky.

Fig. 4 A typical defect classification list.

QUALITY ASSURANCE MEASUREMENT FORM

U/G CABLE JOINTING PIT AND PIPE	UNDERGROUND CABLE JOINTING	CABLE ENDS SEALED	CABLE IDENTIFIED	CABLE SIZE/TYPE	PLAN AMENDED	O.J. SEPARATION FROM H.V. EARTH	CORRECT CONNECTORS USED	JOINT VERTICAL	EPOXY SEAL	O.J. SEAL	BRACKET	EPOXY MIX		
Defect Code		S2	D2	D3	D3	S1	S2	S2	S2	S2	D2	D2		
Location		1	2	3	4	5	6	7	8	9	10	11		
Defect Total														
Plant Unit TOTAL		CABLE			JOINT									

PIT AND PIPE	PIT REINSTATEMENT	PIT H.V. WARNING SIGN	CORRECT PIT-SIZE TYPE	PIT INSTALLATION	PLAN AMENDED	PIPE REINSTATEMENT	PIPE 0 TO<300) DEPTH	PIPE CORRECT SIZE/TYPE	PIPE ALIGNMENT	PIPE ENTRY	PLAN AMENDED	PIPE 300 TO<450mm) DEPTH			COMMENTS
Defect Code	S1	S1	D2	D2	D3	S1	S2	D2	D2	D2	D3	D2			
Location	1	2	3	4	5	6	7	8	9	10	11	12			
Defect Total															
Plant Unit TOTAL	PIT					PIPE									

Work Authority No. Job Title/Location Sheet No.
Completed by:

Fig. 5 A typical QA Measurement Form.

Quality Indicator

At the end of each measurement period a 'Quality Indicator' is calculated for the plant unit measured.

The Quality Indicator is expressed in terms of defects per 100 plant units and can be calculated for each plant unit type (e.g., joints, pits etc.) and for all plant units in total. This latter figure is the Quality Level of all plant units installed for a particular measurement period and when calculated over a full year it becomes the achieved Quality Level for that year.

The Acceptable Quality Level (AQL)

For the purpose of the QA Plan the AQL has been expressed as the maximum number of defects per hundred plant units. AQLs are set for each plant unit with the aim of seeking realistic and achievable improvements in plant quality. They are revised from time to time to reflect improvements in plant installation quality brought about by analysing feedback and implementing corrective action.

Samples which do not meet the set AQL are examined by the QA Review Team under the Quality Review Procedure. Fig. 6 shows the overall AQL of 9 defects per 100 plant units for each District after five years of operation of the QA Plan. It also shows the intermediate target Quality Levels prior to the achievement of this AQL.

In addition, the AQL for each plant unit is also specified (see Ref. 4). The individual and overall AQLs are reviewed from time to time as part of the maintenance of the QA Plan and adjusted in accordance with changes in technology and work skills etc.

Defect Classification

As mentioned earlier the defect classification normally used in quality assurance work has been adapted to suit the external plant installation environment. These defect classifications are listed below, in descending order of priority.

1. Safety — defects which actually or are likely to endanger the safety of staff and/or the public.
2. Service affecting — defects that are, or potentially are, service affecting.
3. Public relations — defects that have or are likely to result in unfavourable public reaction.
4. Practice standards — defects relating to constructions that are at minor variance with accepted standards, but not service affecting.
5. Job plan — defects where the installed plant is of a different size or type to that specified on the job; or when the design of the job is clearly in error.

Each attribute appearing on a DCL has a pre-determined defect classification in accordance with this set of definitions. Where an attribute fits into more than one classification the one with the highest order of priority is listed in the DCL.

Defect Causes and their Assignment

In general, defects encountered in QA Measurements can be divided into two categories:

- those which can be corrected by attention to Quality Control at the local level; and
- those where other factors are considered to be involved; e.g., design, work methods, practices, manufacture, instructions, training.

The identification of causes is the responsibility of the QA Review Team and their task is assisted by a system of coding used to indicate the likely cause(s) of a defect.

This coding is done by the QAMO at the point of measurement so that maximum information is gathered and entered on to the QA mesurement form. Some cross checking later may be required to confirm certain causes; e.g., shortage of a certain plant item.

The coding process also enables the incidences of defect causes to be quantified, leading to:

- observation of emerging trends — even though the incidences may be small to begin with, and
- for those defects occurring at levels higher than the AQL, the process permits a grading of issues requiring corrective action in terms of priority.

Collectively, the information gathered in this way will assist State and Headquarters design and practices Sections in developing and formulating programmes of work at their respective levels.

The coding system is detailed in Ref. 4 and attributes a cause to each defect. These causes include supply, training, design, practice instruction and 'other'.

In cases where a defect can be attributed to more than one cause the QAMO needs to gather all relevant information and then make a judgement and select the predominant cause.

Review of Quality Measurement Results

This is a vital part of the QA Plan. It provides essential feedback information to the Engineering Department at both State and Headquarters levels to determine corrective actions. The Review Procedure has three main components:

- **The QA Review Team** — This normally comprises the QAMO and the External Plant Manager of the District; an Engineer responsible for line plant may also be involved.
- **The QA Review Meeting** — This meeting is held after field measurements in each District have been completed and the results summarised. The meeting is attended mainly by the QA Review Team, but other officers having a relevant input into the Review procedure may also attend.

The objective of the meeting is to examine the QA measurement results, confirm the causes of the defects (based on the coding by the QAMO), identify specific operational and engineering weaknesses and to initiate corrective actions as required.

Corrective actions can be implemented at the local, state or national levels as appropriate. Expert areas; e.g., State Line Plant Support or Headquarters Branches are involved as necessary.

The effectiveness of previous corrective actions are also discussed at this meeting.

The QA Review Team Report — This is essentially a summary of the QA Review Meeting and records all defect types exceeding the AQL, the frequency of occurrence, confirmation of the causes of the defects and the corrective actions (and responsible officers) decided upon by the Review Team. This report also serves as a vehicle for channelling information to the QA management areas.

Long Term Results

QA Measurement results; i.e., the achieved Quality Level and its components (e.g., safety, service affecting)

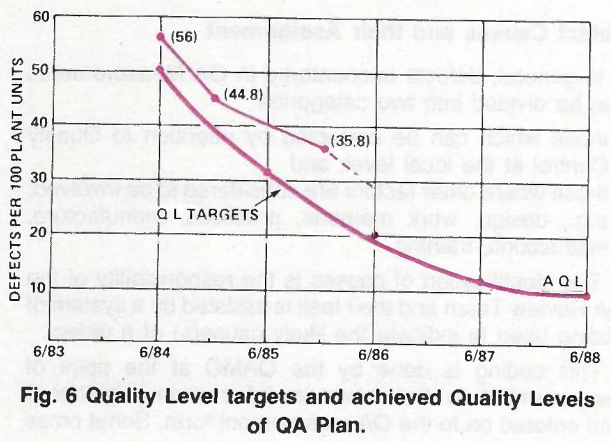


Fig. 6 Quality Level targets and achieved Quality Levels of QA Plan.

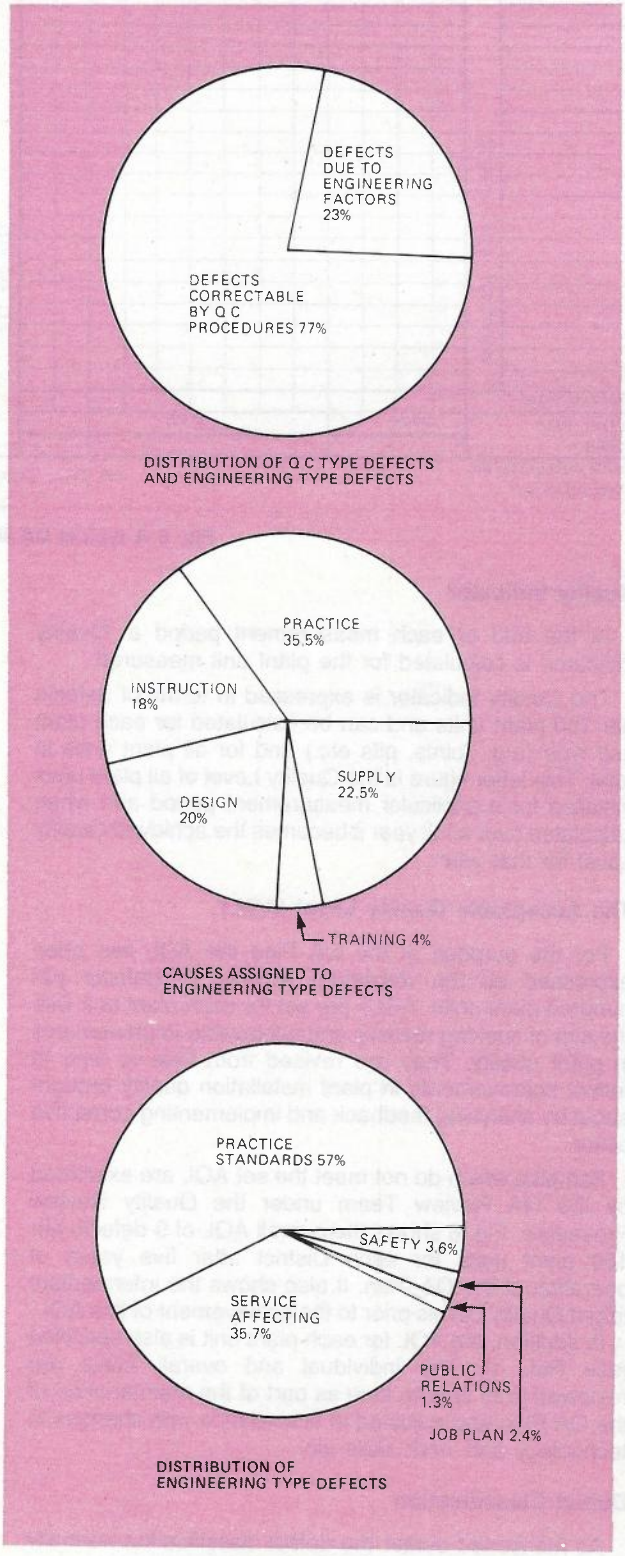


Fig. 7 Distribution of defect types.

are plotted to show general movements of Quality Levels achieved in installation and fault repair work.

These movements are also plotted at district, state and national levels over consecutive measurement periods.

Recent Operational Results

The QA Plan commenced field trial in four states, involving a total of twelve districts, from February, 1981, and continued through 1982. Quality measurements during this period showed substantial reductions in the number of installation defects per hundred plant units over successive measurements.

Implementation of the QA Plan throughout Telecom Australia commenced from June 1983. **Fig. 6** shows the Quality Level targets in June of each of the following years and the achieved Quality Levels (Ref. 7). The AQL is 9 defects per 100 plant units after 5 years of full operation.

Fig. 7 shows the distribution of defects according to type, causes, and categories resulting from the measurement.

Some districts have already shown a significant reduction in the number of plant faults since 1983.

APPLICATION OF QA MEASUREMENTS TO FIELD TRIALS

It is well recognised that field trials of new equipments or practices is an important step in the development of external plant. Field trials provide valuable feedback under actual field operating conditions to the designers so that modifications to design and specification can be made before manufacture and supply.

The QA Plan and the measurement techniques developed can reinforce this feedback process in two ways:

- by ensuring that the initial installation in a field trial is to specification, so that any biasing of the result, whether by above or below standard installation, is eliminated; special DCLs are designed for the equipment or practices under trial for this purpose.
- by ensuring that feedback information on plant installation over the duration of the field trial is complete — special QA measurements can be designed at various stages of the field trial.

ASSESSMENT OF REHABILITATION EXPENDITURE FOR DISTRIBUTION PLANT

The principles and techniques developed for the QA Plan in measuring plant quality have been utilised in the development of a method to dimension the capital expenditure required for plant rehabilitation in the Distribution network.

Areas considered to require rehabilitation as indicated by plant performance data will have a sample measurement made on the quality of the plant using a special set of check lists.

During the measurement the number of plant units requiring repair or replacement are noted. The results on the sample measurements are then scaled up to arrive at the required rehabilitation for the local district in terms of plant quantities, manhours and cost.

After dimensioning the capital expenditure for plant rehabilitation, it is then possible to convert this into an estimated impact on (improved) fault performance and hence provide an indication on the return on investment.

FUTURE DEVELOPMENT

Measurements on the distribution of defect types have consistently shown that defects correctable by QC procedures account for three quarters of all defects. The need for the development of a formal QC Plan is clearly indicated and this will be pursued in the near future.

Furthermore, it is planned to check the design and layout of distribution areas and plant items specified so that plant dimensioning is kept at an optimum level.

CONCLUSION

The quality assurance of external plant is an inherent function of the Network Engineering Department. The QA Plan contributes substantially to the development and management of the external plant network and is expected to improve the overall quality and reliability of service provided to customers. Improvements in productivity will occur at the same time through reduced return visits, faults, and maintenance costs.

These improvements are achieved by the early detection and correction of weaknesses of an engineering and operational nature, through feedback provided to the appropriate design areas to ensure that quality is built into products.

For ongoing success, the QA Plan requires the continuing commitment, at all levels of management and staff concerned with external plant. The momentum generated by the early years of implementation must be maintained through regular quality awareness programmes and refinement of the QA Plan itself.

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Information Transfer News

THE POWER OF THE RING

If a small ring shaped piece of metal is immersed in liquid helium it becomes a superconductor, having no electrical resistance. If a small pulse of current is injected into it the current, once established, will stay there forever because there is no resistance to impede it as it travels around the ring.

If the ring is placed in a not too powerful magnetic field, while virtually no lines of magnetic force will actually flow within it, many will be threaded through its central hole and along its length to form a series of independent magnetic hoops.

Once the ring is forced into its superconducting state, the magnetic hoops, like the flowing current, will become trapped in position and stay there for as long as current flows. This is the so called Meissner effect. The strength of the magnetic field created by the circulating current within the ring will be exactly equal to that existing outside but of opposite polarity.

It is the mutual cancellation of these two fields that prevents the existence of a magnetic field within the structure of the ring but allows the existence of the magnetic hoops which pass through the central hole.

Unidentified Properties

When a tiny section of a superconducting ring is squeezed to form a very narrow constriction, the ring takes on some quite remarkable properties which are currently being investigated by researchers at the University of Sussex, on England's south coast. Narrow constriction introduced into the ring is known as a Josephson weak link, named after its inventor Brian Josephson of the Cavendish Laboratory at Cambridge University.

Superconducting rings containing a weak line were first developed nearly 25 years ago in the United States of America, where they were called magnetometers. They were, and still are, widely used in geological surveys to detect and measure variations in the intensity of the Earth's magnetic field. However, the devices currently being studied at the University of Sussex possess hitherto unidentified properties and have been named superconducting quantum interference devices (SQUIDS).

Although a SQUID ring can be operated as a magnetometer with the ability to detect magnetic field changes as small as a 10,000 millionth of the Earth's magnetic field, it can also be operated as an electrostatic voltmeter by detecting electric instead of magnetic fields.

First applications of the SQUID ring were confined to the laboratory as a research tool. Recently, however, more practical applications have been considered, particularly in the medical field where it is hoped one day to detect and pinpoint the minute magnetic fields created by the tiny electric currents flowing in the brain, heart and other organs.

Better Diagnosis

This is no easy task, bearing in mind that the strength of these fields is many millions of times smaller than that of the Earth itself. Nevertheless, a team of researchers at Imperial College, London, is already constructing an assembly of SQUID rings to do just that.

The planned experiments, if successful, will lead to a better understanding of epilepsy and other disorders of the human nervous system, and result in better diagnosis and more effective treatment.

Released by
British Consulate, Sydney.

Information Transfer News

ARTECH HOUSE BRINGS THE BRITISH TELECOMMUNICATIONS INDUSTRY WITHIN REACH

Newly released by Artech House, Communications is a comprehensive directory to the entire British telecommunications industry. Featuring easy-access, alphabetical listings of every British telecommunications company and organization, Communications represents a valuable reference for anyone who wishes to expand their pool of telecommunications associates.

Telephone and telex numbers, addresses and descriptions of products and services of over 2000 companies are listed. Each of the listings is indexed by a multiple industry classifcation, based on eighty categories and subdivided into 320 divisions. To give further insight, five articles detail the state of the UK telecommunications industry. This guide facilitates the qualification of sales leads, the procurement of mailing addresses for direct mail, accuracy in telemarketing efforts and competitive analysis.

Communications is available from Artech House 685 Canton St., Norwood, Ma. 02062, USA.

Book # PR178 ISBN: 0-89006-168-8.
Softcover. 290 pages. 1986. $96.00

The Strategic Role of Information

R. HORTON, BSc (Hons) Ph.D.

This paper attempts to summarise the influence and importance of information technology, as it applies to an individual company within an industry, and as it applies to a communications service provider. Relevant statistics appropriate to Australia are highlighted, as are some of the tools available for successful corporate survival in a world where information technology is rapidly changing methods of doing business, and relationships with customers and competitors.

1. INTRODUCTION

The telecommunications industry has in the past been fostered by an era of predictable demand and orderly development which concentrated on providing basic telephone services at affordable rates. However, advances in underlying technology have now brought a range of customer demands for computerised equipment and services as we proceed further into the Information Age. The long term implications are clear — that companies in the communications service provision role should recognise that they are now in the information business: Businesses in general need to recognise the relevance of information services and act accordingly if they are to sustain efficient operations and a cutting edge against competition.

Perhaps the best example of this realisation comes from AT&T's acquiescence to divestiture, and why this came about. Under a 1956 decree entered into with the Department of Justice, AT&T was allowed to provide only common carrier services, with the rates being subject to regulation. But this arrangement was out of step with the changing technology of telecommunications, and AT&T saw that if it were to flourish it must be free to provide, on a deregulated basis, the new computerised information services that involve data processing. In the words of AT&T's counsel **(Ref. 1).**

"The technology of telecommunications has so merged with the technology of data processing that if we end up with the 1956 consent decree we are a withering corporation waiting for its demise and nothing more — (the) Penn Central of the 90's".

... (Railroads such as Penn Central had gone broke because they failed to recognise that they were in the transportation business and needed to become integrated with other modes of transportation). The 1982 decree is now history, as are the fortunes of another major U.S. player — IBM — which, with its software and computer expertise, the hardware of Rolm, and the long distance network of MCI is well positioned to offer sophisticated information services to large business customers worldwide. It is interesting to contemplate that whilst world sales of telecommunications hardware amounted to US$60b in 1984, the annual domestic market in the U.S. alone for information services, including voice and data, amounts to US$115b and currently doubles every six years. On a worldwide basis, shipment values of the information industry amounted to US$500 billion in 1985, and are forecast to exceed US$2,000 billion in ten years time. **(Ref. 2).**

Reflecting on the longer term nature of the business we are in, and picking up the concept that "money is information", it is predicted in some quarters **(Ref. 3)** that by the year 2000, the surviving U.S. global banks will include IBM, AT&T, General Motors and Sears and Roebuck in their ranks. This is the logical deduction from a number of critical questions which address the groupings of resources and technologies within conglomerates of the future. Similar examples exist in Japan and Europe.

Thus, changes in the industry with which we are associated will be dynamic and far reaching for the foreseeable future. Notwithstanding the possible longer term developments, this paper concentrates on the more apparent influences and intensity of information technology as it takes root and gathers momentum both overseas and in Australia. As a microcosm of world evolution into the Information Age, there are significant and challenging opportunities for participation by Telecom Australia, which has many of the pre-requisites for successful participation.

2. GLOBAL PERSPECTIVES

Continuing with the U.S., information technology is rapidly diffusing the business world, changing both the method of conducting a business, and the way companies relate to their customers and suppliers. A fresh mind-set is developing over the power and role of information as a competitive weapon in the corporate arsenal. Successful case studies e.g. Merrill Lynch & Co., American Hospital Supply Corp., American Airlines Inc., have been mythologised by the Harvard Business School, and fuel the now critical mass of interest from companies across the broad spectrum of business. In each of the case studies, the companies have successfully applied information technology to differentiating new or existing products in a competitive marketplace.

Possibly the greatest fillip to the use of information technology in gaining a competitive edge has been the personal computer. Until the early 1980's computers were the preserve of distant data processing managers who spoke a different language than managers. Nowadays, managers can manipulate data themselves on personal computers. Even where this is not the case, executives need to know how to deploy information technology and progressively expand its business function into strategic planning and marketing. The traditional role of the DP manager is under metamorphosis, as is the focus for information management within a company. In an opinion from MIT **(Ref. 4).**

"Data processing managers will have to delight in solving the business problem, not the crossword puzzle that was programming" ...

Whilst the use of PCs and wordprocessors is fairly widespread, interconnection and access to corporate information banks, in general, still has a long way to go, but is inevitable. Thus, there is an immediate window of opportunity for communications service providers to extend their traditional roles in breaching the hiatus, and the more successful ones will be those with demonstrated in-house experience in the new market discipline.

Complementing these current developments, large scale organised efforts in Artificial Intelligence (AI) are presently in train and these should catalyse further evolution and application of more sophisticated information technology. In Europe, for instance one of the largest programs underway is ESPRIT (European Strategic Program for Research and Information Technologies) which has a budget of US$1.3b for five years. Over 100 projects are currently approved in various fields, including expert systems, software technology, office systems, robotics, and advanced microelectronics. Another 90 projects are expected to be announced during 1986. Other programs and developments of note in Europe are

- EUREKA Program (counterpart of SDI)
- ALVEY Program (UK)
- Turing Institute (AI contract research facility for commercial firms, UK)
- Research programs in West Germany, Norway and France.

In the private sector, about 200 expert systems are now in use in Europe, with capabilities ranging from the diagnosis of agricultural diseases, to assistance in oil exploration, to corporate strategic modelling. Revenues from AI software and hardware are projected to rise to

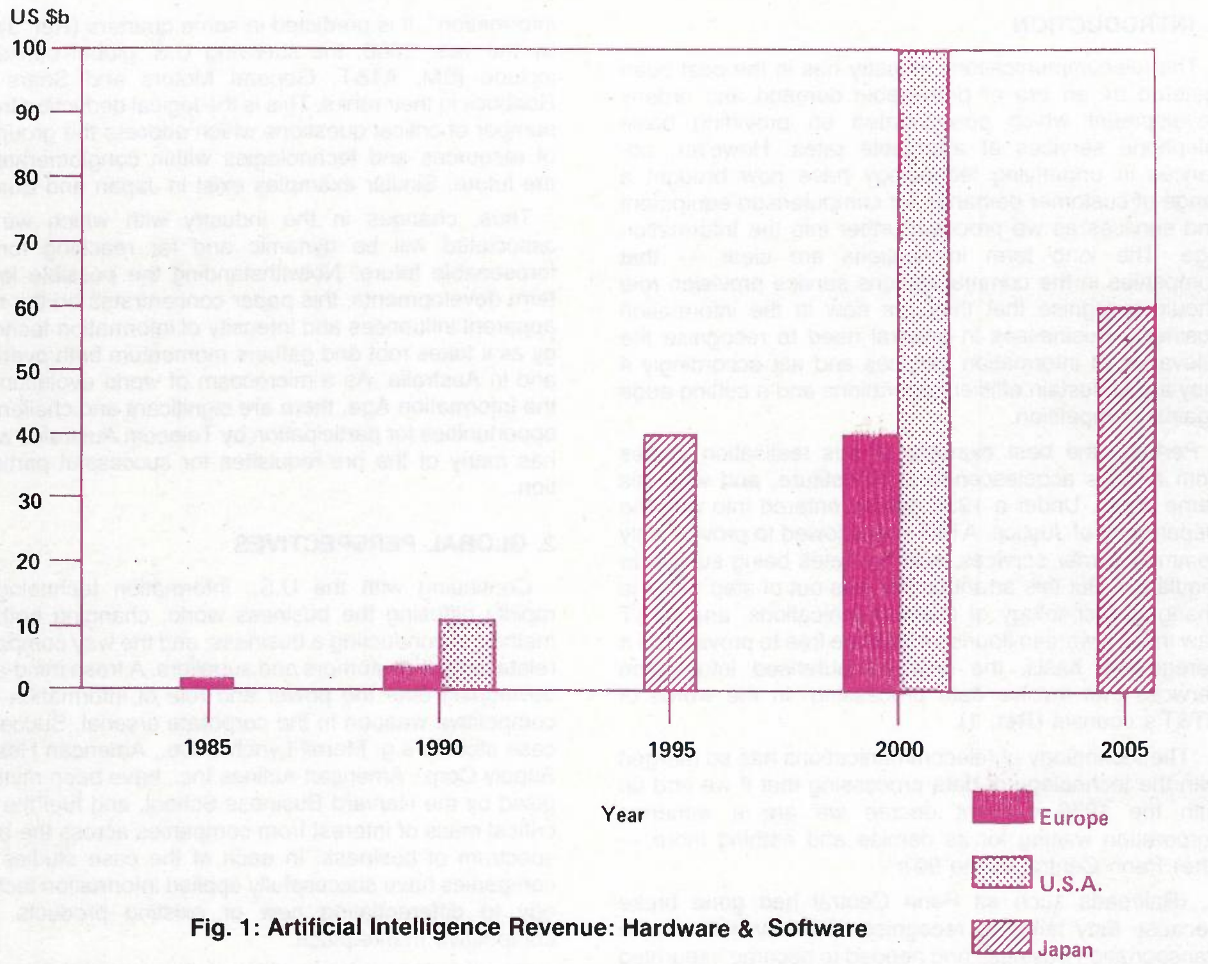
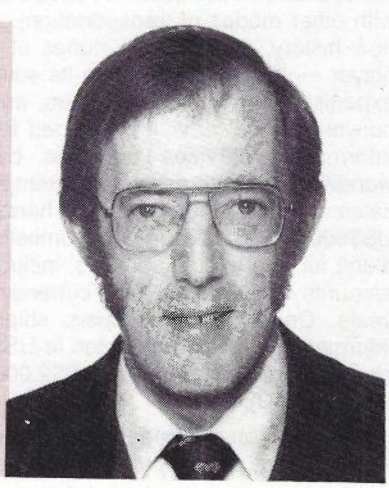


Fig. 1: Artificial Intelligence Revenue: Hardware & Software



BOB HORTON graduated from the University of Wales with a first-class honours degree in Electronic Engineering Science in 1968, and a Ph.D. in Microwave Integrated circuits in 1971.

He joined Telecom Australia in 1971 as an Engineer Class I in the Research Laboratories. The next 14 years were spent on various aspects of microwave and optical devices and systems, culminating as Section Head of the Wideband Systems Section in Transmission Systems Branch.

In 1985 he was promoted to Principal Strategy Analyst in the Business Development Directorate.

Bob is actively involved in the IREE and the brass band movement.

US$40b by the year 2000 **(Ref. 5)**. Programs are being developed elsewhere in the world, and in the U.S. AI revenue in the year 2000 is expected to be US$100b whilst in Japan revenue is estimated to be greater than US$40b. Significant programs underway in Japan include

- The TEN YEAR PROJECT (now with invited U.S. participation)
- MITI programs (some joint ventures)
- Private company research

These projected AI revenues are summarised in **Fig. 1** which illustrates the dramatic growth rate envisaged. These expectations underline the long term significance of identifying and evolving with the information industry, particularly as the voice/data distinction becomes further eroded by technology.

3. EVOLUTIONARY TRENDS AND DEVELOPMENTS IN AUSTRALIA

In Australia, business in general is coming to realise the value and benefits of information technology. The more advanced exponents are sprinkled across a wide cross-section which includes manufacturing, insurance, banking, government, mining, law and hospital industries. Whilst the initial motivation for the adoption and growing dependence on information technology varies from case to case, the fundamental reasons can be put down to a combination of productivity increases and product or strategic differentiation in a competitive market.

Before discussing statistics and some examples which encapsulate the state of development and application of information technology in Australia, it is instructive to summarise the evolutionary trend which sets the pattern of information technology acquisition and deployment.

3.1 Pattern of Evolution

The status of information technology addresses the evolving convergence of telecommunications, office automation, and data processing. The degree of integration, and motivation for applying information technology are summarised in **Fig. 2.** For instance, in the early stages of development, office automation is often aplied as a tactical response to cost control and productivity improvement in the office function. It is here that tangible and cost-centred assessments of the benefits can be measured.

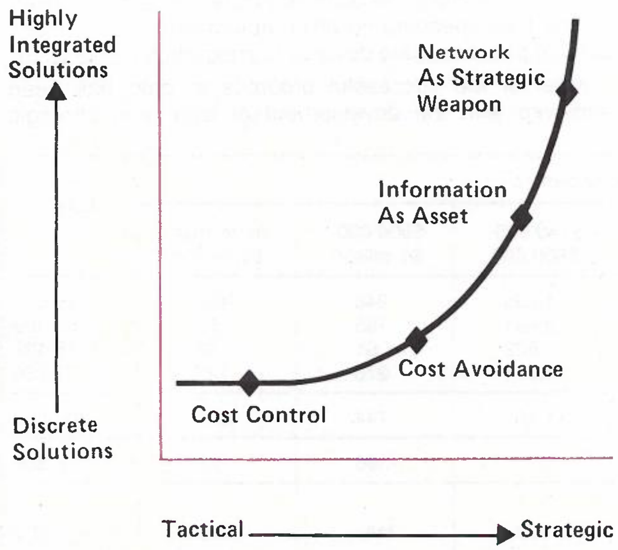


Fig. 2: Pattern of Deployment of Information Technology

However, as the degree of integration increases, and information is realised as a distributed asset within a company or industry, finally to its deployment as a strategic weapon, the benefits become less tangible and de-focussed within the organisation. At this point, benefits can only be assessed on an organisational basis, and competitive corporate performance.

With the context of Office Automation, the changed nature of developments are summarised by **Fig. 3.** This serves to illustrate the core value which communications now plays in this phase of information technology development.

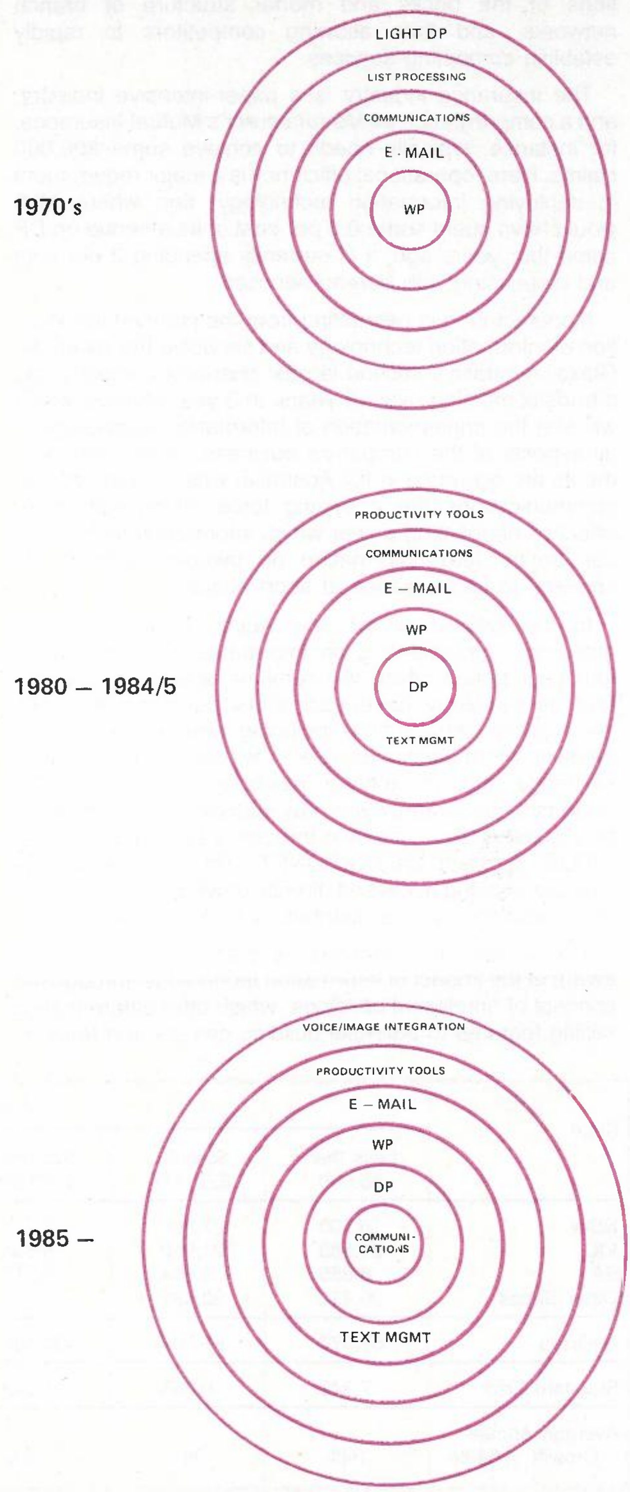


Fig. 3: Office Automation Evolution

3.2 Developments in Australia

A recent conference on Office Automation **(Ref. 6)** offered some "trail-blazing" examples which serve as an anecdotal appraisal of some of the more advanced applications in Australia at present. These are highlighted in the following paragraphs.

The Chase-AMP bank, for instance, is a good example of the role of information technology, in changing the nature of a business. Methods of wholesale and retail banking have been dramatically reconfigured by electronic transaction processing, shaking the traditional foundations of the bricks and mortar structure of branch networks, and thus allowing competitors to rapidly establish competing services.

The insurance industry is a paper-intensive industry, and a company such as Manufacturer's Mutual Insurance, for instance, typically needs to achieve some 800,000 claims. Here, operational efficiency is a major requirement in deploying information technology, and where MMI would have spent some 0.5 per cent of its revenue on DP some four years ago, it is currently spending 2 per cent and dispensing with bureau services.

Manufacturing is benefitting from the planned introduction of information technology and services. For example, Glaxo, Australia's second largest chemical company has a transitional plan over 13 years, in 3 year phases, which will see the implementation of information technology to all aspects of the company's business. Similar developments are occurring in ICI Australia, where improved site communications are a driving force, along with more effective negotiating power which information technology can confer (e.g. information on takeover activity, responses to IAC Inquiries at short notice).

In the service sector, the Austin Hospital is progressively implementing an information network over a four year period which will combine pharmacy, medical records, radiology, patient accounts, personnel, etc. with some of the ultimate aims including immediate access to medical information available in wards, better business efficiency, etc. In another example, the ABS has a dissemination strategy whereby statistical information will be electronically accessible through a hub service called INFOS, resident on CSIRONET. This service will be capable of being accessed directly or will be gatewayed to other networks and re-distributors of ABS information.

The construction industry is becoming increasingly aware of the impact of information technology, through the concept of "intelligent buildings" which offer differentiating selling features to potential building owners and tenants.

Other users might be associations, e.g. law firms, libraries, etc. which process and exchange information as a fundamental tenet of their business. Unlike the larger companies, these associations lack the same cohesive structure and organised ability to marshal information resources. They nevertheless represent a major client group.

There is much evidence of this anecdotal nature to suggest that the widespread implementation of information technology and services is now reaching critical mass in Australia. Some broader statistical information is also available. In a recent survey by Focus Research **(Ref. 6** also), it was found that the top 500 companies in Australia are presently spending an average of 3.5 per cent of turnover on their EDP budgets, ranging down to 1.3 per cent for the smaller companies. In addition, there is a trend for processing power to move from the mainframe to the mini, to the micro where this is feasible. This is also discernible from **Table 1** which catalogues the results of a survey of computer usage within Australia by the National Institute of Labour Studies **(Ref. 7)**. In a separate exercise, the Yankee Group **(Ref. 8)**, discovered significant perceptional changes within Australian companies, between 1985 and 1986, with regard to anticipated future uses of PC's within companies, broadening from wordprocessing and spreadsheet applications to greater use in electronic mail, expert systems, decision support, communications, project management, etc. (see **Fig. 4**). In the same survey, the percentage of companies which extract corporate data base information was assessed (see **Fig. 5**).

Within those companies which have progressed further with the use of information technology, there are some discerning features which can be highlighted. Firstly, there appears to be a common thread of integration and evolution with time. Initial implementations involve distributed data processing; this is next followed by widespread adoption of word processing facilities; the use of PC's by administrative and professional users next becomes a significant milestone; following this, the implementation of electronic mail distinguishes the presently more advanced users and the greatest degree of embracement of information technology to date. Obviously by this stage, connectivity and networking issues rank high on the implementation strategy agenda, as do the service offerings of Telecom Australia, and a growing coterie of private consultants. As outlined at a recent Seminar **(Ref. 9)**, the total spending on office automation now includes some 8 per cent share devoted to integration (see **Fig. 6**).

Most of the successful progress to date has been achieved with the development of long term strategic

State	Current Replacement						Total
	Less than $5,000	$5,000-$25,000	$25,000-$150,000	$150,000-$500,000	$500,000-$1 million	more than $1 million	
NSW	16,500	27,808	8,724	1,636	248	156	55,072
VIC	21,589	21,958	6,834	2,691	165	72	53,309
SA	8,855	5,454	1,217	822	61	22	16,431
Other States	20,432	32,489	17,711	6,251	270	127	77,280
Australia	67,376	87,709	34,486	11,400	744	377	202,092
Standard Error	7,349	9,355	11,533		396	28	18,886
Average Annual Growth 1984/86	34%	39%	18%	32%	31%	15%	32%

Table I: Estimate of computer numbers in Australian enterprises, December 1986

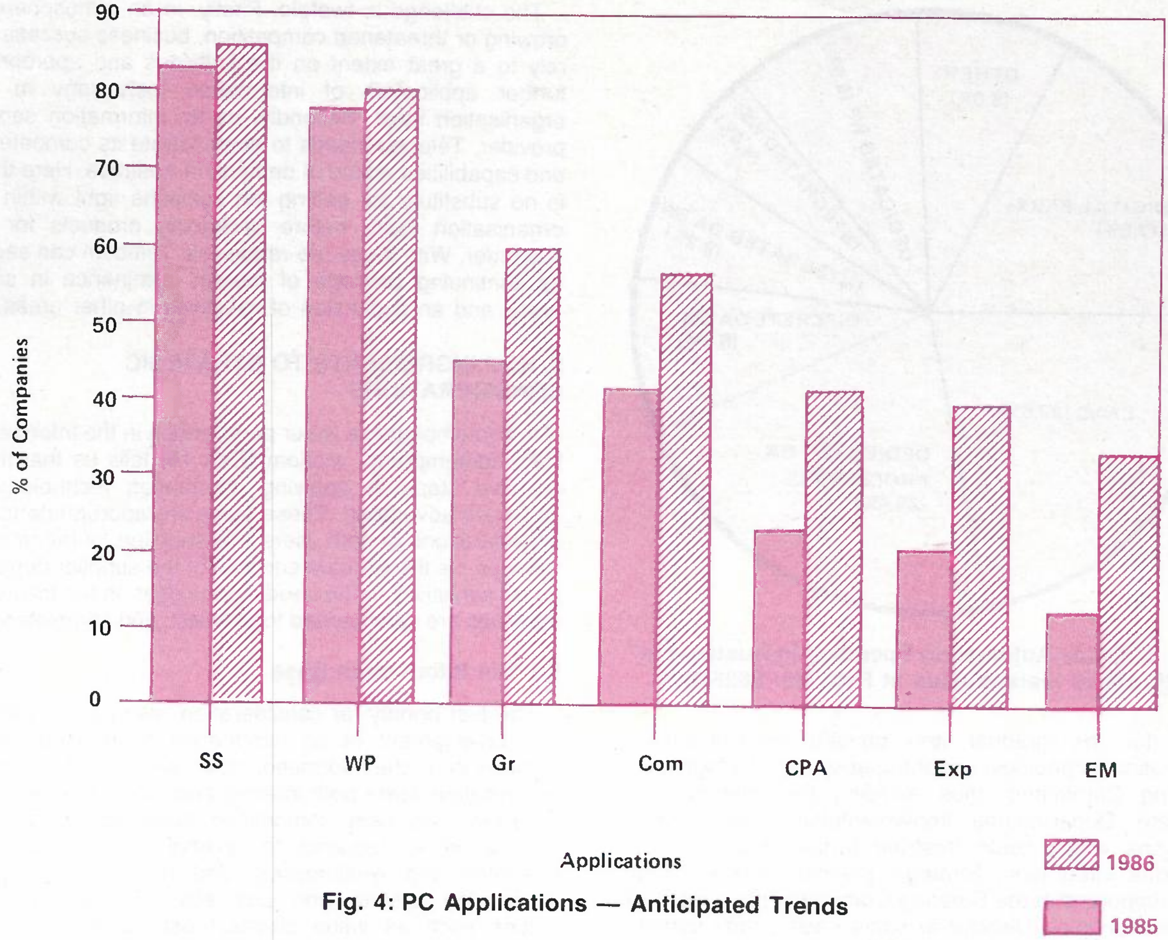


Fig. 4: PC Applications — Anticipated Trends

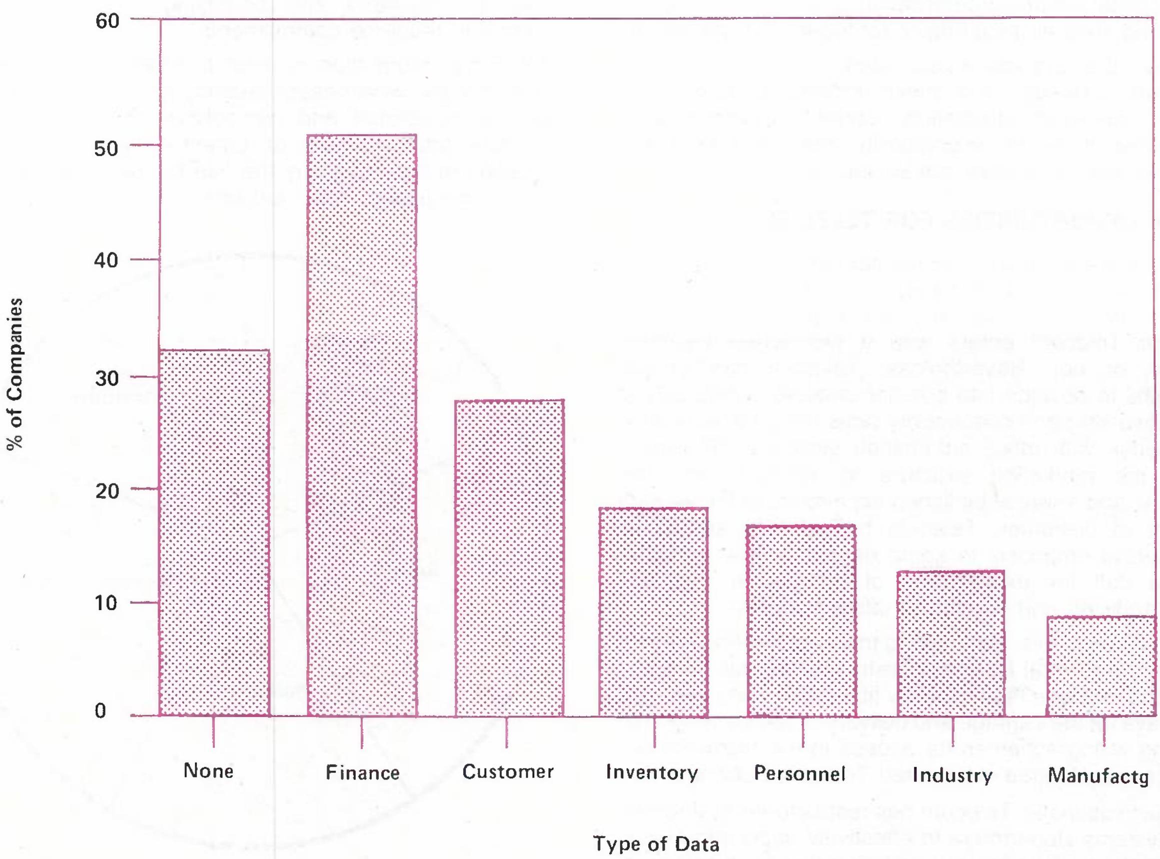


Fig. 5: Corporate Data Base — Data Extracted

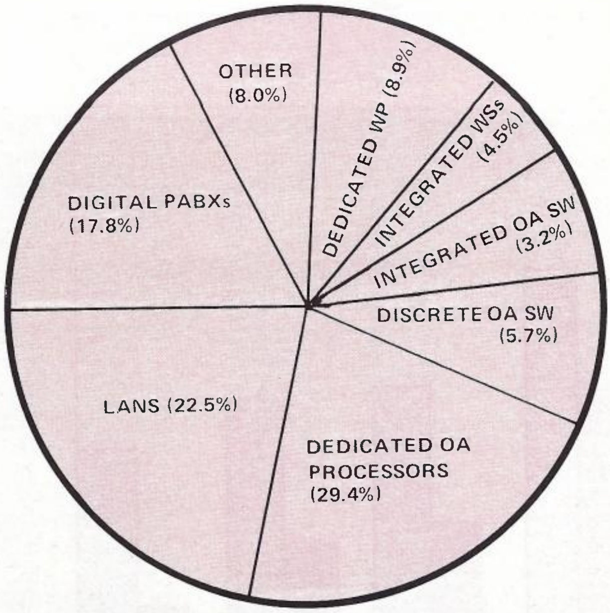


Fig. 6: Office Automation Spending in Australia in 1985. (Total market value at Feb. '85: $625M)

plans for the gradual and phased introduction of information technology, under the auspices of a high level Steering Committee, thus avoiding the difficulties of separate Departmental implementations and vendor adoptions which could frustrate further evolution and corporate integration. Strategic planning receives high level support, with the Steering Committee presided over by the Managing Director in some cases, thus demonstrating corporate commitment. Issues such as security and access control/authentication are of great importance, and another good reason for top-level involvement.

Many other considerations need to be built into the corporate strategy, and these include organisational impact, end-user education, correct implementation leadership, focus of responsibility, resolution of power conflicts, work practices, resourcing etc.

4. THE OPPORTUNITIES FOR TELECOM

Thus there is growing momentum in the adoption and use of information technology in Australia, on a widespread basis. This industry will expand and flourish whether Telecom enters with a broadened business outlook or not. Nevertheless, Telecom has unique strengths to develop into a major catalyst, particularly in the networking and connectivity skills required, extensive experience with office automation systems, DP experience, the marketing structure to interface with the industry, and a well established experience of the various sectors of customer. Telecom has already shifted its commercial emphasis to some degree in this direction, with a call for expressions of interest in the joint merchandising and support of office systems.

In addition to this, engineering trials are underway in the Melbourne Central Business District, which will demonstrate and evaluate high capacity fibre optic voice and data highways for the carriage and delivery of traffic. Integrated building wiring schemes for access to the highways will also be investigated in selected Telecom buildings.

Organisationally, Telecom has restructured its Information Systems Department to effectively apply information technology to the business and operational objectives of the Commission.

The challenge is twofold. Firstly, in an atmosphere of growing or threatened competition, business success will rely to a great extent on the judicious and appropriate further application of information technology in the organisation itself. Secondly, as an information service provider, Telecom needs to demonstrate its competence and capabilities ahead of demand in Australia. Here there is no substitute for getting the solutions right within the organisation itself, before packaging products for the customer. With these pre-requisites, Telecom can secure its continuing privilege of market dominance in some areas and an expansion of initiatives in other areas.

5. KEY INGREDIENTS TO STRATEGIC CONSIDERATIONS

In contemplating a wider participation in the information field, contemporary wisdom **(Ref. 10)** tells us that there are five steps in applying information technology to corporate advantage. These steps are appropriate to the considerations of both users and suppliers of information services, as the ultimate success of the supplier depends on his sensitivity to the needs of the user. In the following, the steps are summarised for interest, and completeness.

5.1 The Information Base

The first priority for consideration within a company is the development of an information base which maps faithfully on to the information flows which exist within the organisation. Here both internal and external information is needed to gain competitive advantage. Internally, information is required to assess an organisation's strengths and weaknesses, and given an adequate information system and architecture, analytical techniques such as value chains, cost maps, asset and investment maps etc. can then be applied in breaking down the business and identifying opportunities and optimising resource commitments.

External information is used to identify and evaluate strengths and weaknesses laterally across an industry in light of its market and competitive environment, and resulting attractiveness of potential ventures. A tool assisting in this regard is the five forces model **(Fig. 7)** which comprises new entrants, substitutes, buyers,

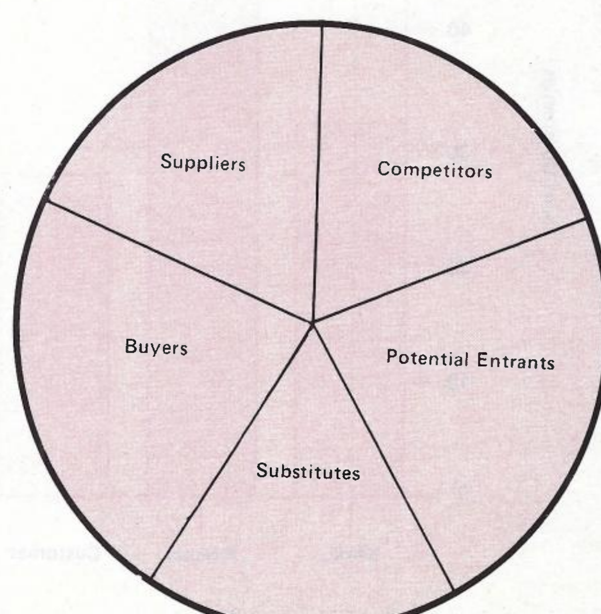


Fig. 7: Influencing Forces

suppliers and industry competitors. Each of these forces needs to be identified and analysed.

5.2 Analysis of the Information Base

Analysis of the information base is a process by which management examines each external force and internal activities with a view to exposing ways in which to alter the industry's structure to the advantage of the company. For example, through cost reductions, differentiation or substitution. In addition, the analysis may reveal opportunities for new lines of business.

5.3 Identifying the Technology Required

The next step involves selection of appropriate technology which will effectively capture the opportunities envisaged. As a supplier this may involve a range of options, or consultancy-based customisation resulting from sufficient appreciation of the previous stages as they apply to different market sectors.

5.4 Prioritisation

Analysis will throw up a number of possibilities which will have long — and short — run impacts on competitive position. Also, some alternatives will be easier to implement than others. There thus emerges a need for an orchestrated long term strategy, with an associated priority for co-ordinated implementation, which responds best to the business or other objectives of the organisation, e.g. social obligations.

5.5 Implementation Process

Effective implementation requires proper organisation, training and procedures together with careful performance indicators, which act as motivators for component projects of a strategy. Success factors and achievement targets should be posted clearly and consistently throughout the organisation to avoid misunderstandings or lack of appreciation.

6. SUMMARY

In summary, the Information Age is well and truly with us and exciting developments are ahead, as telecommunications plays a key role to the integration of components of information technology. Statistical evidence points to the fact that information technology is taking root and gathering momentum in Australia, and Telecom has recognised and is acting on the opportunities.

The challenge to entry into the broader information industry field is of significant scope. However, the potential rewards are of equal significance, with relevant strategic considerations for survival in a growingly competitive environment and as a service provider to industries which need to adopt and apply the same strategic approaches.

On the downside, as a builder and maintainer of network infrastructure the ISDN, for example, will ensure a reasonably healthy future in the "bit hauling" business, as opposed to the "information" business. Nevertheless, the ringing echo of

"a withering corporation waiting for its demise . . ."

leaves a haunting reminder from AT & T.

7. ACKNOWLEDGEMENT

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Information Transfer News

ARTECH HOUSE PUBLISHES A GUIDE TO MODERN TELEPHONE SYSTEMS

Artech House has recently published a text of broader public appeal than its usual engineering references. For anyone reponsible for maintaining, purchasing or operating a telephone system, Introduction to Telephones and Telephone Systems alleviates the process of jargon and mystique.

Written by A. Michael Noll, a professor at the Annenburg School of Communication at U.S.C., Telephone Systems clarifies the four major areas of telephones — station apparatus, transmission, switching and signalling. With insightful analyses and illustrations, the Noll text makes sense of both the technical and the policy sides of complex telephone systems and proposals.

CONTENTS: Introduction. Station Apparatus. Signalling. Transmission. Switching. Comparison of Communications Modalities and Media. Cellular Mobile Telephone Service. Data Networks. A short History of the Bell System. Perpectives.

Introduction to Telephones and Telephone Systems is available from Artech House, 685 Canton St., Norwood, Ma. 02062, USA. Book # PR203 ISBN: 0-89006-203-X. Softcover 190 pages. 1986. $35.95.

ROBOTICS PROGRESS IN ELECTRONICS INDUSTRY

The Australian electronics industry is progressively introducing robotics in selective repetitive work areas to improve productivity, quality and manufacturing efficiency.

According to a spokesman for the Australian Electronics Industry Association (AEIA), local communications companies are using robots to perform tasks so exacting that manual labour cannot do them with the degree of accuracy needed to ensure a consistent standard of quality.

First introduced to Australian manufacturing in 1975, robotics are now estimated to be used by about 600 local companies.

While the majority of these are heavy-industry type, such as those in steel-making and car manufacturing, robotics are becoming an increasingly important part of the electronics industry's push towards plant automation.

"The robot is now taking over a number of laborious and exacting tasks and consequently speeding up the manufacturing operation tremendously," the AEIA spokesman said.

"Only by maintaining the most up-to-date electronic manufacturing facilities can Australian companies expect to remain competitive on the local market and in export business," he said.

One of the robot's major uses in the telecommunications industry is in the manufacture of telephone handsets in plastics moulding shops.

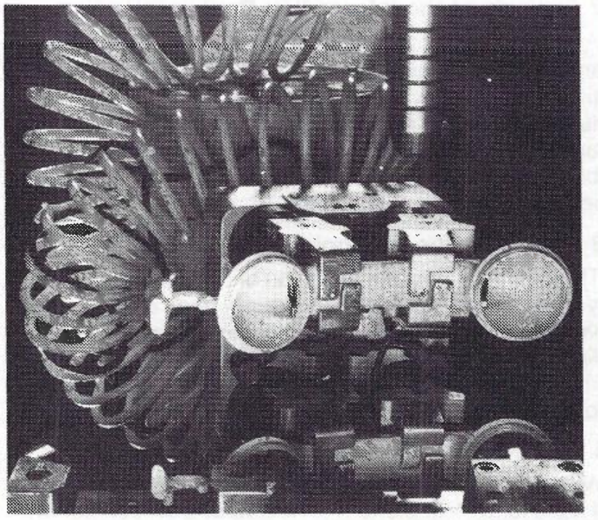
One AEIA member company, STC, is now using robotic operations for handset moulding.

At STC a robot is programmed to take metal rods out of the plastic moulds. The rods are automatically inserted and withdrawn once the mould has cooled and set.

"This is a difficult manual operation as the tools are very easily scratched," said STC's Manufacturing Director Bruce Stephens. "But once programmed correctly the robot doesn't make any mistakes."

STC has been so impressed by the robot's performance in this area that it is installing a second robotics machine to handle another aspect of its telephone manufacturing.

"With small business telephone systems the push buttons have to be individually placed on the plastic cases. Even with overhead projection techniques, this is a repetitive and time-consuming task for manual operators.



Telephone handsets being removed from a plastic moulding machine by an industrial robot at STC, Sydney.

"It is also a particularly sensitive area of quality control, because there is nothing worse than hitting a button on your telephone, thinking it will do one thing, and it does something else.

"That is why we are installing a robot with vision systems to this work. It is a case of accuracy rather than economics," Mr Hammond said.

Another AEIA member company experimenting with robotics is AWA.

At AWA's Ashfield plant in Sydney a robot has been used to punch parts for rotary dials for telephone sets. This procedure has become obsolete as telephone sets have switched progressively to push button operation, but AWA has already pinpointed other potential areas of work for robotics.

Works Manager Les Dunn said the robotics work at AWA so far has been largely experimental. "We are in a learning phase with robots, but we want to gain experience in using them. Over the next 12 months we will go much further with them."

Other areas where robots could prove viable for the company include moulding, machine loading and unloading and some assembly operations.

The Telecommunications Network and National Security

R. L. ORTON

This article was originally prepared for inclusion in the RSL 1986 Defence Paper. The theme of the RSL Defence Paper for 1986 was "Is the Home Base Secure?" and this article examines the value of a reliable telecommunications network and a viable telecommunications manufacturing industry to national security. The article also discusses the protection of the network and its ability to continue to function when it is itself under duress.

1. INTRODUCTION

It is generally accepted that a strong and vibrant telecommunications industry is important to the wellbeing of the nation. Good telecommunications are crucial in both commercial and personal activities. The telecommunications network supports all forms of modern business by providing not only telephone facilities but data transfer between computers, text services, video services, broadcasting and others on which industry and commerce are heavily dependant.

The intent of this paper is to focus on the telecommunications industry and the national network and examine the contribution made to national security and the ability of the national telecommunications network to continue to provide service when it is itself under duress.

2. TELECOMMUNICATIONS AND NATIONAL SECURITY

The Australian telecommunications network, and the operation of that network, contribute significantly to the national security. Through the telecommunications network efficient, reliable communications for both voice and non-voice is available to virtually all parts of Australia. Defence and Service organisations do operate their own communications facilities, but they do not have the ready coverage that the national telecommunictions network provides nor do they normally access people or locations outside their own organisation.

The capability of efficient communication to any area is critical to national security, particularly in a country as large and sparsely populated as Australia.

Not only is the physical presence of the telecommunications network of value to security but a number of other benefits ensue from the operation of that network, such as the provision of a skilled workforce in Australia and the existence of a viable communications manufacturing industry. Both these factors reduce our dependence on overseas organisations, thereby improving Australia's self sufficiency in these areas.

Telecom Australia enjoys the monopoly in many facets of the nation's telecommunications services. This monopoly creates certain obligations on Telecom Australia to ensure high quality service at reasonable cost. It is also incumbent upon Telecom to provide a secure network, a network that has high reliability in terms of normal plant breakdown and is secure in terms of natural disasters and malicious actions. In general, the appropriate level of security is engineered into the network but it must be realised that Telecom is operated on a business basis, which means that funds for special security measures must be allocated at the expense of revenue earning equipment. Therefore, where a possible threat is assessed as a low probability then funds are unlikely to be available. If Governments have a wish to improve security above the level normally provided then additional funds need to be made available.

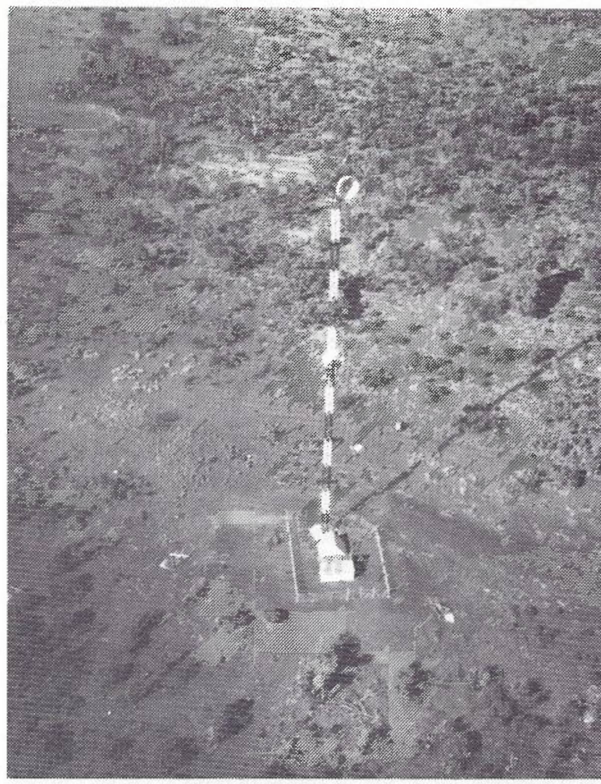


Fig. 1 Capability of Communications to any area is critical to National Security.

In this regard the Australian Government recently allowed Telecom to borrow additional funds, which were specifically to be used to improve the survivability of the network.

3. OVERVIEW OF THE NATIONAL TELECOMMUNICATIONS NETWORK

Within the framework of the total national telecommunications network Telecom operates a number of different communication networks, which are designed to meet different objectives but which share a common infrastructure. The largest is the switched telephone network, which provides voice communication facilities among approximately 6 million services, with a network of 5300 switching centres interconnected by 10 million pair-kilometres of trunk and junction circuits in pair cables, 50,000 tube-kilometres of coaxial cable and 220,000 broadband radio bearer kilometres.

In addition, there are some 42 million pair kilometres of cable circuits connecting the indidividual telephones to local exchanges, and 92,000 pole route-kilometres of construction carrying a combination of subscriber, trunk and junction circuits. The bulk of Australia's population is concentrated in the cities and regions located on or close to the eastern and south-eastern coastline, with the significant exception of Perth. The telephone traffic is similarly concentrated in these areas.

On the public switched network customers can establish data communication links in association with a normal telephone service and transmit and receive data at a range of speeds up to 4800 bits/second.

Private lines can be provided to cater for higher speed transmission up to 48,000 bits/second, operated in point-to-point or multi-drop configurations. Telecom has recently established a packed switched network to improve the efficiency of data transmission to provide faster connection and restoration times for teleprocessing applications. The packet switching netowrk known as AUSTPAC provides a framework for data communications between different equipment and offers high peak data transfer rates, low transit delays and low error rates.

The Telex Network is a separate public switched network for telegraphy. It is very much smaller than the telephone network sharing the same transmission links, but utilising its own switching centres. Although small in size, teleprinter communication assumes importance in an emergency, as it provides a record of communications with broadcast facilities. Also, it does not suffer from congestion to the same extent that the telephone network can experience during emergency conditions.

Another significant telecommunications network is the Digital Data Network (DDN) which provides premium quality synchronous digital data services for customers at speeds up to 48 Kbit/sec. The DDN has approximately 400 terminal centres around Australia with a main centre in each mainland capital city and 10 branch centres in major regional locations. A range of data services can be supported by the DDN including point to point, multipoint and netplex (i.e., multiplexing data from several low speed terminals).

Through provisions of data services on a network basis, faster service provision and restoration is achieved as well as greater flexibility. In addition to the terrestrial telecommunications network, telecommunications are now also available via the AUSSAT satellite. The first AUSSAT satellite was launched in 1985 and now offers alternative transmission facilities for both voice and non voice services. However, because of bandwidth limitations the numbers of speech circuits or blocks of data transmitted is relatively small in comparison to terrestrial broadband transmission facilities. The use of AUSSAT allows Telecom to offer 100% coverage of Australia for telecommunication services.

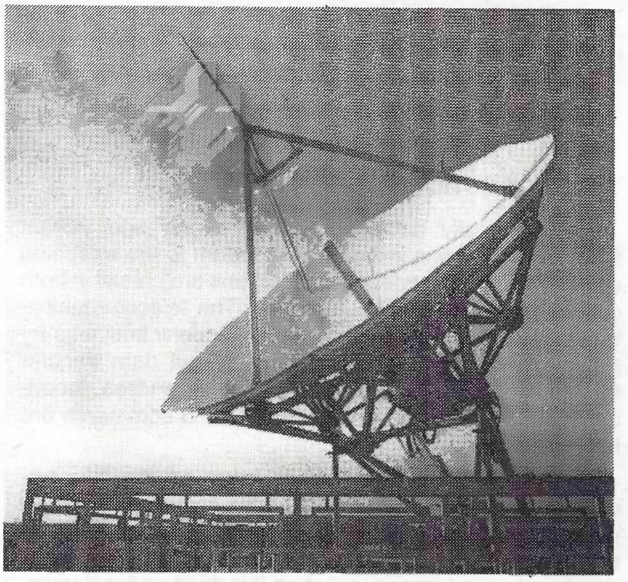
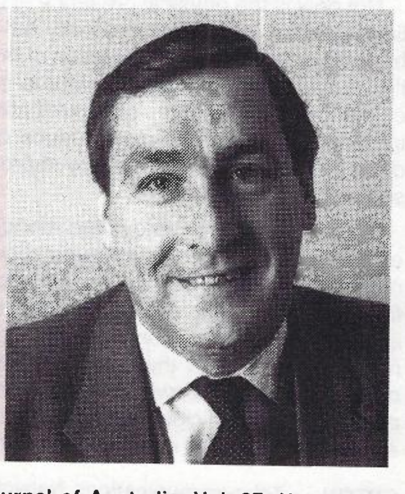


Fig. 2 Satellite Communications are now also available in addition to terrestrial networks.

For some years Telecom has been pursuing the digitalisation of the telephone network by introducing digital transmission systems and digital telephone exchanges. The digital switching and transmission capability is gradually converting the telephone network to an integrated digital network (IDN). Telecom is moving quickly to provide IDN capability right across Australia.

In Australia, as in many other countries, planning for the evolution of the telecommunications network towards an integrated services digital network (ISDN) has started. An ISDN is a network that will provide connectivity for a wide range of voice and non voice services over a telephone line. The idea of an integrated services digital network, or ISDN as it is more commonly called, has been under

BOB ORTON commenced with the PMG as a technician-in-training in Melbourne in 1958. He completed a communications Engineering Diploma at Royal Melbourne Institute of Technology in 1969 and became an Engineer in the Victorian Administration. Bob worked mainly on metroplitan exchange installation in Victoria before moving to Headquarters in 1976 where he was heavily involved in the introduction of ARE-11 into the Australian network. Since joining Headquarters Bob has worked in Switching Design, Network Performance & Operations and is currently the Superintending Engineer of Network Management Systems Branch.



discussion in international circles for at least the past ten years.

Just now there is considerable interest in ISDN arising out of agreement within the CCITT* in late 1984 of a first set of recommendations on services, access arrangements and network support functions which will see initial ISDN features being progressively incorporated into the Australian network during the latter part of this decade.

4. THE SECURITY OF NETWORK

Much has been done and is continuing to be done in the engineering and design of the telecommunications network to ensure continual and reliable service and to protect against disruption to the network for any cause. The major protection strategies employed by Telecom include:-

- Redundancy
  Key items of equipment are duplicated such that the failure of the operating unit causes changeover to the standby unit.
- Diversity
  It is usual practice to diversify major telecommunications traffic streams over different physical paths and using different transmission mediums: e.g., microwave radio and optical fibre.
- Alternate routing
  A standard feature of telephone exchange design is multiple choice routing to the selected destination.
- Service protection network
  Telecom is introducing into the network additional dedicated transmission capacity that can be utilised when a normal bearer fails.
- Network Traffic Management
  Telecom is also moving to introduce specialised network traffic management techniques which will further enhance our capacity to provide for improved traffic throughput when the network is under failure or stress conditions.

If one examines the telecommunications network within the context of the theme "is the home base secure?" it is possible to produce a list of possible threats. For the purpose of discussion these threats can be combined into 3 basic groupings.

- Natural Disaster
  Some threats are readily evident and are experienced from time to time. Natural disasters such as bushfires, cyclones and floods can cause serious disruption to the communication facilities in an area. As mentioned a significant level of security is inherent in the engineering and design of the telecommunications network.
- Technical Susceptibility
  There are also possible threats which are the result of the nature of the high technology that is used in a modern network like Australia's. Modern equipment can be susceptible to extraneous influences such as electro magnetic and electrostatic fields from such natural sources as lightning or from nuclear detonations.
- Malicious Interference
  The third area that is identifiable as a possible threat is from malicious damage or interference, either as mischief or serious terrorist activity.

In the following sections the security of the telecommunications network will be examined and the effect that the information industry particularly Telecom, has on Australian industry and in turn on our degree of self-sufficiency in providing information technology.

FOOTNOTE
* CCITT — International Telegraph and Telephone Consultative Committee.

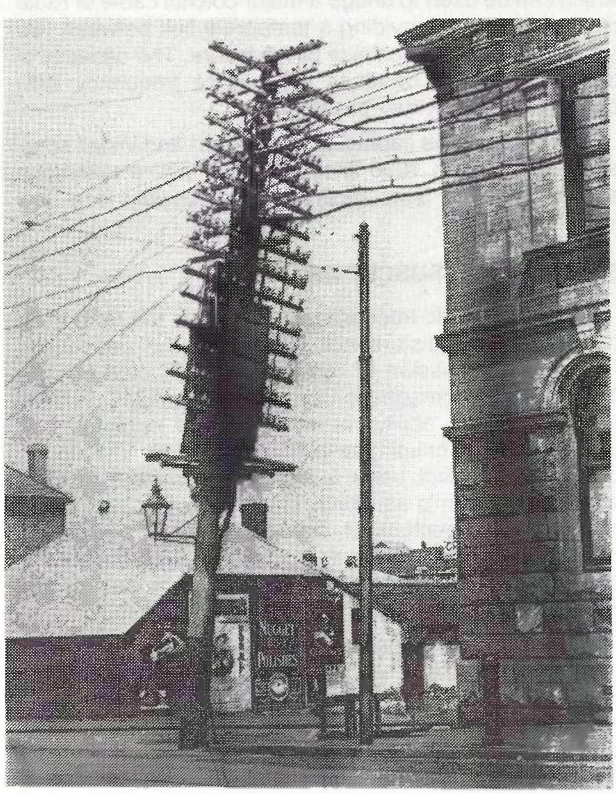


Fig. 3 The telephone network was not always as secure as it is today.

5. PROTECTION FROM NATURAL DISASTERS

In the event of a natural disaster it is important that public communications remain viable. Other organisations such as State Emergency Service and Defence organisations provide their own limited point to point communications independent of the telecommunications network, particularly in the general area of the disaster. However, they are dependent on the Telecom network for the provision of dedicated facilities to enable the mobilisation of relief and welfare measures and general co-ordination that is required in major disaster circumstances.

Thus general communications remain a vital part in co-ordinating efforts to counteract natural disasters.

The basic protection comes from the protection strategies previously mentioned in Section 4 together with the sound structural design employed for buildings and structures such as towers. In a natural disaster situation the essence is on speed of restoration of service for emergency service personnel use, welfare groups, media etc.

Telecom holds in each capital city a limited amount of special equipment which is available for use when a disaster occurs, so that restoration of at least minimal service is achieved as soon as possible.

It should also be recognised that due to Telecom's heavy capital works programs there is always a variety of modern equipment in store awaiting installation which could be utilised for emergency purposes. There is also a variety of equipment being refurbished in Telecom workshops. In addition, there is a range of spare plant, mobile power generators etc., which is available for servicing the normal operating network and may be utilised during disasters.

All the mainland States have been provided with transportable emergency broadband radio equipment which can be used to bridge a major coaxial cable or radio bearer failure by providing a temporary link between two suitable points on each side of the failure. The capacity of the equipment is rated as 1800 voice frequency (VF) channels or one video program.

Telecom has the capability to transport and install small exchanges (up to 1000 lines) to areas where telephone exchanges have been destroyed, or possibly to a new location.

6. TECHNICAL SUSCEPTIBILITY

Electromagnetic Interference, or EMI, is the term used to describe the disturbance caused by the unintended reception or emission of radiated or conducted energy. The term Electromagnetic Compatibility, or EMC, is used to describe the ability, or otherwise, of equipment to operate without causing or being affected by EMI. In the past, EMI has not been a significant problem in most areas of Telecom's activities. This was due mainly to the robust electromechanical nature of most equipment. However, with the rapidly increasing introduction of solid-state, particularly digital, equipment into the network, EMI is emerging as a problem to be dealt with.

As mentioned, a characteristic of modern communications systems is that they may be vulnerable to interruption from electromagnetic sources. One of the more dramatic sources could be the electromagnetic pulses (EMP) produced by a nuclear explosion in the atmosphere.

A nuclear explosion at a height of 400 km above the earth would generate sufficient electromagnetic pulses to cover over half of Australia. These EMPs could be harmful to unprotected communications equipment.

EMP transients tend to be short duration and usually cover a wide frequency range, typically 100 KHz to 100 MHz. Some limited action is being taken to protect equipment against this type of interference. This includes improved component designs and fitting of radio frequency bypass capacitors to heavy duty power transformers.

Fig. 4 The network is constantly being updated, extended and diversified.

Strategically important cables are protected from EMP and lightning by special practices. In this area, the introduction of optical fibre cables into the network will gradually reduce the general susceptibility of cables to damage from these sources.

7. MALICIOUS INTERFERENCE

Considerable publicity has been given recently to "hackers" interfering with computer systems either to create chaos or for criminal reasons. Modern telephone exchanges are controlled by computers and access to those computers is achieved from standard terminals similar to those used in any computer installation.

Unauthorised access (ie access from an unauthorised terminal) is only possible where access via the telephone network exists. Protection against unauthorised access is provided by a variety of techniques, individually or in combination, these include:

- Functional privilege restrictions
  This can be applied to different ports, or to different users. These can apply to both command capabilities and data access and manipulation rights.
- Passwords
  Passwords can be used to control access, however, great care is needed with their implementation if a sophisticated attack is likely. Password systems also require careful administration and strict adherence to sound operational practices to ensure, for example, that passwords are carefully chosen and are changed at suitable intervals.
- "Dial-back"
  Dial-back access control is a reliable and cheap access control technique applicable where terminals are expected to be in fixed, known locations. With such systems, access is achieved by dial-up from a terminal followed by identification (usually by password) and then link disconnection. The called computer then checks its data base for the registered telephone number of that user terminal and calls it back via the telephone network to establish the desired connection.

It is widely believed that it is not possible to design, verify, or test software that can be absolutely guaranteed to perform reliable access control functions. However, it is believed that good software can be implemented that allows an acceptable level of confidence. For this reason, systems which supplement software barriers are currently favoured for critical applications. Such systems could involve the use of dial-back systems as described above, or perhaps front-end or supplementary processors that perform access control functions.

8. AUSTRALIAN INDUSTRY AND WORLD STANDARDS

Prior to world war II, around 90% of Australian telecommunications equipment needs were imported, a situation which created extreme difficulty during the war when supply lines were significantly disrupted.

Since world war II, successive Governments, Telecom and the PMG Department before it, have followed a policy of fostering local industry to develop a local manufacturing and adaptive design capability. In more recent years, Telecom has recognised the need to promote greater Australian involvement in design and development and has taken steps to foster that involvement.

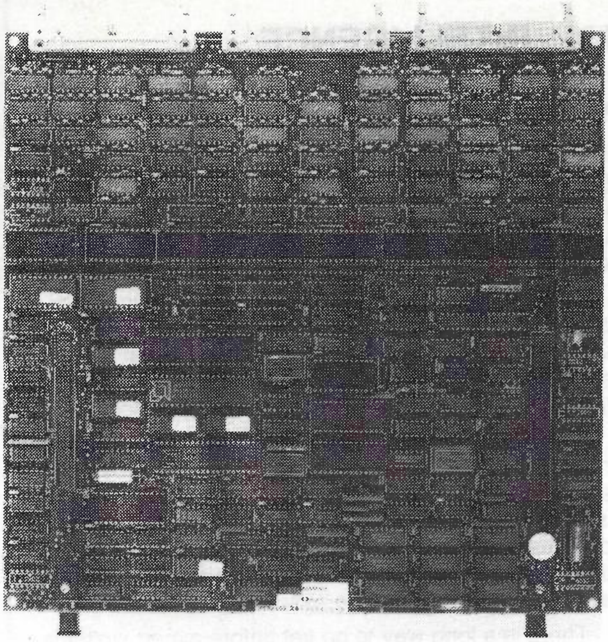


Fig. 5 Many complicated printed boards are assembled by Australian Industry.

Today, the situation is virtually the mirror image of that prior to world war II, in that around 90% of telecommunication materials and equipment required by Telecom are obtained from manufacturers in Australia. Although Telecom operates on an Open Tender basis, enabling world-wide tenders, tender schedules require that material essential to the expansion of the network is to be manufactured in Australia. This applies to around 90% of the total requirement. Equipment performance standards required by Telecom are based on the relevant international standards as set by such bodies as the CCITT (Telegraph and Telephone) and CCIR (Radio) which are under the umbrella of the ITU (International Telecommunications Union) and more recently the standards set for data communications developed by the ISO (International Standards Organisation) and adopted by the CCITT. This ensures international interworking compatibility of the Australian network.

It is a common requirement, however, for Telecommunications Administrations around the world, including Australia, to adapt the appropriate international specifications to their particular requirements for environment, compatibility domestically with interworking equipment, maintenance and operation, and safety. The above aspects of local manufacture and use of international standards contribute significantly to the security and operation of the Australian network.

One industry issue that needs to be mentioned is the absence in this country of a micro-electronic components industry. Although establishment of such an industry in Australia is desirable for the user, it is doubtful if it is a viable proposition considering the large establishment costs involved and the small captive market available. Security in this area is established by the 'long-life' standards for components required by Telecom and appropriate levels of stockholdings for critical components.

9. CONCLUSION

An effective and secure telecommunications network is essential to the security of any country. Australia is fortunate in that over the years the Australian national telecommunications network has been developed in a manner that ensures it is basically secure from serious interruption.

This is ensured by virtue of the diversity, redundancy and back-up capacity that is available to telephone and data traffic. Even though certain points of the network could be closed down, the network is self-healing to a degree and would continue to cope.

The presence of a strong telecommunications industry in Australia also supports development of related skills within Australia which keeps Australia to the fore in communications knowledge.

There is also a strong communications manufacturing industry in Australia although we have some reliance on overseas suppliers for certain component parts.

For all these reasons the Australian telecommunications network, and the industry that supports it, are making a significant contribution to the security of the nation.

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1. Ross N., 'Communications Capabilities During Emergencies.'
2. EMP: A Nuclear Threat to Electronic Systems Aust. Electronics Engineering — June 1985.

Information Transfer News

ANALYSIS AND SYNTHESIS OF LOGIC SYSTEMS

Artech House has recently added to its coverage of materials for electrical and computer engineers with the release of **Analysis and Synthesis of Logic Systems.** Written by Daniel Mange, a PhD and professor of electrical engineering, the text offers a thorough treatment of the field.

Analysis and Synthesis of Logic Systems is a comprehensive introductory text presenting both the abstract theory of binary algebra and the design methods of actual integrated circuits. Stressing the fundamental theories, **Logic Systems** discusses all aspects of synchronous sequential systems with emphasis on flip-flops and counters. Block diagrams stress the relationship between the practical and theoretical and chronograms provide graphical representations of timing and cause-effect relationships among signals in a circuit.

CONTENTS: Introduction. Modes of Representation of Combinational Systems. Synthesis and Analysis of Combinational Systems. Analysis and Modes of Representation of Flip-flops. Analysis and Synthesis of Counters. Analysis of Synchronous Sequential Systems. Synthesis of Synchronous Sequential Systems. Asynchronous Models of Logic Systems. Appendix. Solutions. Bibliography. Select Bibliography. Glossary. Index.

Analysis and Synthesis of Logic Systems is available directly from Artech House, 685 Canton St., Norwood, MA 02062, USA.

PROGRESS IN ARTIFICIAL INTELLIGENCE

During the 1950s and 60s considerable research was devoted in Britain and elsewhere to the possibility of using computers to perform tasks normally thought to require human intelligence. Playing cards, chess or draughts, performing simple intelligence tests, and solving crossword puzzles and symbolic logic problems: all were tried.

It was thought at the time that intelligent behaviour could be some way be represented by a kind of mathematical notation. Once discovered, this could be applied to solve any problem.

Sadly, trying to get a computer to simulate even a few complex thought processes and activities taken for granted by humans, such as seeing, hearing, reading, speaking and understanding natural language and different dialects, was found to be much more difficult than had at first been imagined. As a result the creation of artificial intelligence (A1) suffered a rude awakening and a severe setback.

Expert Systems

Following the early disappointments, research was directed to less ambitious projects, some of which were based on an heuristic approach, or solving the problem by trial and error. This was — in a limited way — very successful, especially when applied to performing specialist tasks requiring human expertise. In fact, the first expert system was designed to assist organic chemists in interpreting data derived from a mass spectrometer. This was quickly followed by similar specialised systems for aiding the diagnosis of infections, pulmonary diseases and internal medical disorders, and for the analysis of geological specimens.

Commercially oriented systems then began to appear, probably the best known being that developed by the Digital Equipment Corporation for specifying and configuring computer systems to meet the specific requirements of different customers.

All expert systems are based upon three basic components. The first is the so called knowledge base, which contains both heuristic and factual information in the form of assertions and rules of undefined complexity. The second component is an inference engine, which makes use of information contained in the knowledge base and uses it to satisfy a user's query.

Yes Or No

The third component is the man-machine-interface (MMI) which transfers queries and responses from the user to the inference engine and also seeks from the user additional information demanded by the inference engine.

Some computer systems allow the user to communicate with the machine in a limited form of natural language but most simply pose questions that require a "yes or no" response or perhaps request a selection to be made from a specified number of choices.

The MMI also explains to the user what is actually happening in the expert system and what it is trying to achieve. This is a very important feature since if a user is going to make a major decision based on the advice of a man-made system, he will need reassuring that the reasoning undertaken by that system is sensible and not based upon false assumptions.

There is a long way to go yet before expert systems reach maturity but the signs so far are encouraging. A research unit known as the Artificial Intelligence Applications Institute (AIAI) at Edinburgh University in Scotland, for example, was officially opened in June 1986 and already claims to be the world's second largest university department devoted to artificial intelligence.

This institute sees its role as feeding British industry with the latest ideas on artificial intelligence and related information technology ranging over the country's entire academic scene. This role is also encouraged by the Department of Trade and Industry, the Science and Engineering Research Council, and the Alvey Directorate which provides financial backing for research and development in critical instrument technologies.

These organisations also support KRSTL (pronounced "crystal"), an acronym derived from Knowledge Representation Systems Trials Laboratory. This is a £1500 million investment in some of the world's most advanced AI tools, where potential users spend three months or so at AIAI, learning how AI can be applied usefully to management techniques and to planning in particular.

Released by
British Consulate, Sydney.

An Introduction to Coherent Optical Communication Systems

J.L. ADAMS,
R.W. AYRE,
G. NICHOLSON
T.D. STEPHENS.

Coherent optical fibre systems offer great promise as a technology for high-capacity and long distance telecommunications links, and are likely to enter the Australian network early in the next decade. This paper provides an introduction to this emerging technology, including a survey of some recent experimental systems. The transmission performance and component requirements of these systems are outlined, with emphasis on the areas requiring further development before such systems find commercial application.

1. INTRODUCTION

Optical fibre systems have evolved from a laboratory curiosity in the early 1970s to become an established, commercially viable transmission technology for the telecommunications network. Telecom Australia is now installing multimode optical fibre systems in its urban junction networks on a routine basis. The first trunk systems using single mode optical fibre are now being installed, and Telecom will have an extensive network of optical cables linking its major centres by the end of the decade. These systems have become possible by virtue of the low loss and large bandwidth available in present optical fibres.

Whilst these systems offer transmission capacities and repeater spacings unimagined a decade ago, to communications engineers they use relatively unsophisticated transmission techniques. The transmitter optical source generates an optical signal with a very broad spectrum, not unlike a noise signal, and the data stream on-off keys the power level of this signal. The receiver detects changes in the level of received power to recover the transmitted data signal. These systems are described as Intensity-Modulation/Direct-Detection or IM/DD systems.

The next generation of optical transmission systems will begin to exploit the enormous potential capacity offered by the high optical carrier frequencies. These systems will involve the use of narrow spectral width optical sources, and the modulation of the optical carrier in amplitude, frequency, or phase. At the receiver, the detection process will involve mixing the received signal with a signal from another narrow-linewidth optical source acting as a local optical oscillator, and the receiver will respond only to a narrow range of frequencies about the local oscillator frequency. Because these systems employ an optical source and a local oscillator with narrow linewidths, much narrower than the spectrum of the data signal, they are called coherent systems. The receivers in these systems are similar in concept to superheterodyne radio receivers, except that the carrier frequency is many orders of magnitude higher.

The history of optical communication system developments to date has seen major advances in materials and manufacturing technology, so that silica optical fibres with successively lower losses and greater bandwidths have been produced. The limit in this trend has been reached with the achievement of fibre losses below 0.2 dB/km in volume production. Over the years, lower losses have often been associated with operation at longer wavelengths, and have prompted the development of reliable optical sources and detectors in new materials to exploit those low losses.

In contrast, the development of coherent optical systems is a trend in a new direction. It represents a major change in the technology of the communication system itself. Coherent detection techniques offer substantially higher receiver sensitivities than can be achieved in IM/DD systems, by between 10 and 20 dB. In addition, coherent systems occupy very narrow bandwidths, and employ comparatively narrow-band receivers. This means that many signals can be carried in the low-loss "window" of an optical fibre and that optical amplifiers can be used to replace some of the repeaters in a long system.

As will be seen, coherent optical systems are substantially more complex than present IM/DD optical systems. However, they enable existing single-mode optical fibre links to be substantially upgraded in capacity, and allow new links to be planned with extremely long repeater spacings. They promise to be a major factor in the development of telecommunication networks in the next decade.

2. OVERVIEW OF SYSTEM OPERATION

The key components of a coherent optical fibre system are identified for the two basic system configurations, with heterodyne or homodyne detection in **Figs. 1 and 2.**

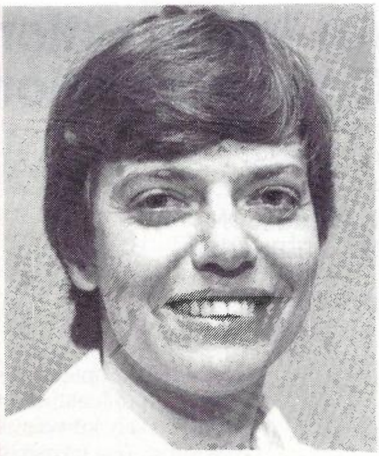
In a coherent optical fibre system the optical field from the laser is modulated by varying the amplitude, frequency or phase of the optical signal. The options for a digital modulation system are

— amplitude shift keying (ASK)
— frequency shift keying (FSK)
— phase shift keying (PSK)

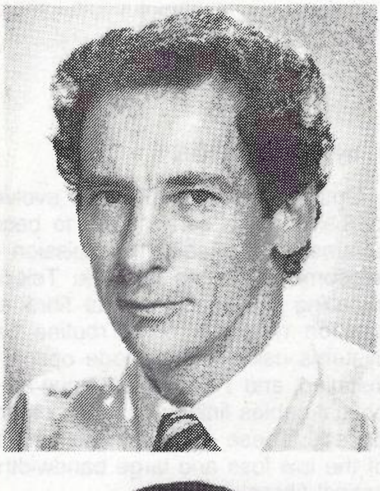
These modulation approaches can be contrasted with that for conventional IM/DD optical fibre systems in which the intensity or power is modulated.

A single mode optical fibre can be used as the transmission medium, operating for example in the 1300 or 1550 nm wavelength regions, where the fibre attenuation is low. Multimode optical fibres are unsuitable because random coupling and interference effects between the propagating modes cause amplitude fluctuations in the detected signal.

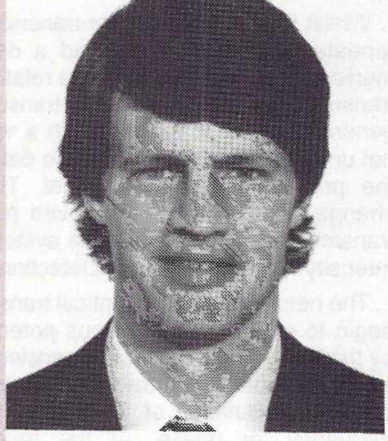
JENNIFER ADAMS received the B.Sc. (Honours) and Ph.D. degrees in Physics from the University of Tasmania in 1977 and 1981 respectively. In 1981 she joined the Telecom Australia Research Laboratories where she is currently Senior Scientist in the Optical Systems Section of the Transmission Systems Branch. Since joining the Research Laboratories she has been concerned with various problems associated with optical fibre transmission systems and digital radio systems. She is presently working on the development of external cavity semiconductor laser diode sources for use in coherent optical fibre communication systems.



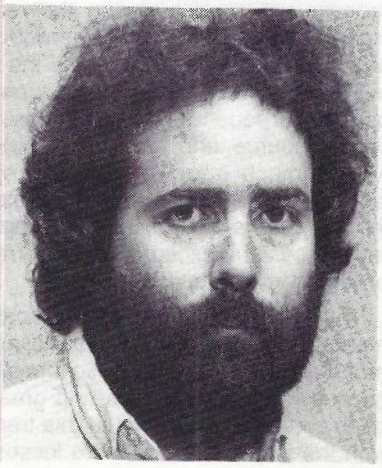
ROBERT W.A. AYRE received the B.S degree in Electronics from the George Washington University, Washington DC, in 1967 and the B.E. and M.E.Sc degrees from Monash University, Melbourne, in 1970 and 1972 respectively. In 1972 he joined the Reseach Laboratories of Telecom Australia, initiallly working on video signal processing techniques and transmission systems. Since 1977 he has been working on optical transmission systems and optical fibre measurement techniques. He is currently Head, Optical Systems Section, Telecom Australia Research Laboratories, Melbourne, Australia.



TOM STEPHENS received the B.E. (Honours) and M.Eng.Sc. degrees from Monash University, Melbourne, Australia, in 1977 and 1980. In 1980 he joined the Transmission Systems Branch of the Telecom Australia Research Laboratories and is currently a Principal Engineer in the Optical Systems Section. Since joining the Research Laboratories he has been involved in prediction, measurement and specification of the performance of optical fibre systems and is presently involved in the development of several experimental coherent optical fibre communication systems.



GRANT NICHOLSON received the B.E. (Honours) and M.Eng.Sc. degrees from the University of Tasmania, Australia, in 1976 and 1978 respectively. Since 1978 he has been with the Transmission Systems Branch of the Telecom Australia Research Laboratories, initially working in the Line and Data Systems Section. Since 1981 he has been with the Optical Systems Section, where he is presently Principal Engineer. His major activities have included optical wideband distribution networks, the characterisation of optical fibres and, more recently, the transmission performance of optical fibre systems.



The key aspect of a coherent system is in the receiver, where the incoming signal is combined optically with a constant optical signal from a local oscillator laser. The two optical fields (from the transmit and local lasers), when detected by the photodiode, undergo a mixing process producing an electrical current output which depends on the difference frequency between the optical fields.

In a heterodyne system **(Fig. 1)** the centre frequencies of the transmit and local lasers are slightly different, and the intermediate frequency (IF) output is typically several hundred MHz. This is stabilised by a frequency control loop. It is worthwhile contrasting this IF with the original frequencies of the lasers, which are about 200,000 GHz. The contrast in frequencies indicates the extreme demands on the relative frequency stability of the lasers.

can tolerate small errors in the IF. Thus the level of local laser frequency control required in a heterodyne system is much easier to achieve. A further attraction of a heterodyne receiver, with regard to ease of implementation, is that non-synchronous techniques for demodulating the electrical IF signal can be employed.

A subject of intensive investigation for coherent systems is the production of suitable optical sources. As discussed further in this paper, the optical source (preferably based on a laser diode), must be both extremely stable in frequency and have a narrow linewidth.

Because coherent systems employ receivers that respond to a narrow range of optical frequencies, they can be used with optical amplifiers. An optical amplifier is a modified laser diode that can amplify an optical signal

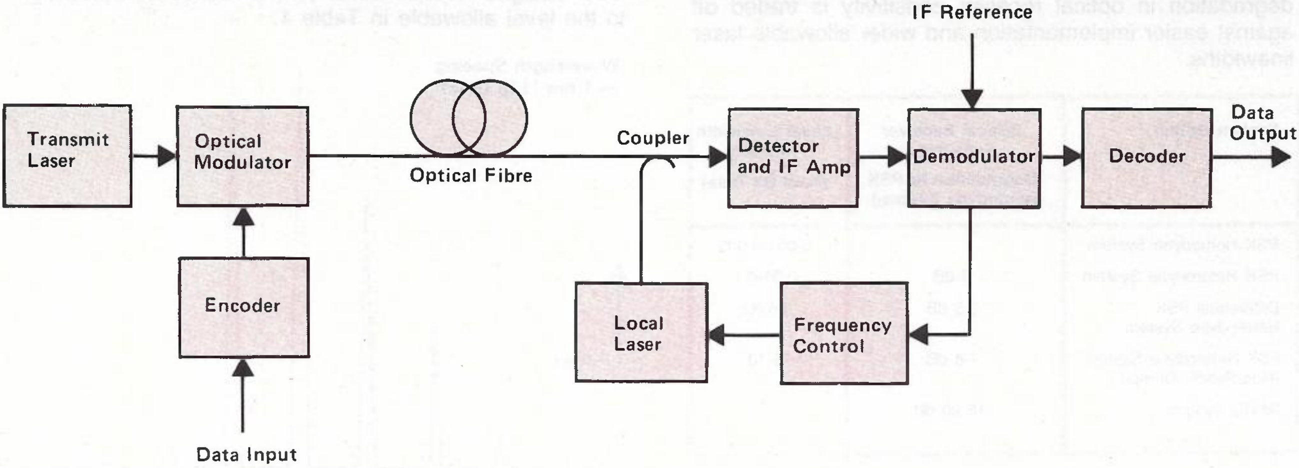


Fig. 1 Heterodyne Optical Fibre System

The IF signal in the heterodyne receiver is demodulated to recover the transmitted data signal. The electrical part of the heterodyne receiver is similar to that of a radio receiver, although in the optical case the IF may only be three or four times the bit rate. In a homodyne receiver **(Fig. 2)**, the transmit and local lasers are stabilised so as to have the same frequency and phase, and the transmitted data signal is recovered directly at baseband.

The homodyne system receiver in **Fig. 2,** while appearing relatively simple, is in practice more difficult to implement than a heterodyne system receiver. In a homodyne receiver, the local laser signal must match the received signal in frequency and phase, i.e. it must be phase locked. By comparison, a heterodyne receiver does not require phase locking, and in many implementations

through laser action. Their use is especially attractive on links where several optical carriers are combined in an FDM arrangement on a single fibre, because the optical amplifier can amplify several optical carriers simultaneously. This could eliminate the need to demultiplex the optical carriers and separately regenerate each optical carrier at most of the repeater stations in a long link.

Coherent optical fibre systems are still at a very early stage of development, with experimental systems having been only operated for short periods of time (minutes-hours) in a number of research laboratories. Many problems are presently encountered in implementing these experimental systems, although the long-term future for coherent systems is promising. The following sections will describe in more detail the performance and component requirements.

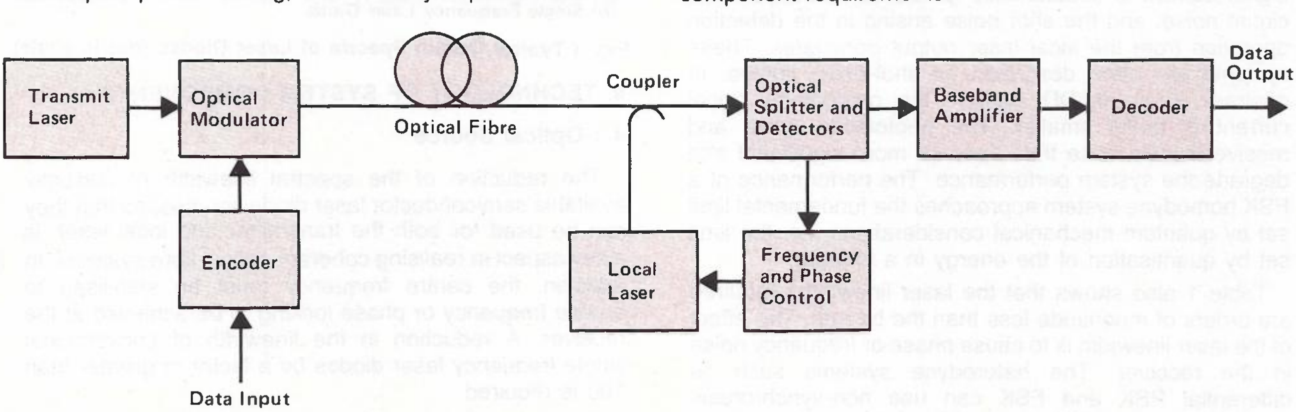


Fig. 2 Homodyne Optical Fibre System

3. SYSTEM PERFORMANCE

A frequently used measure of transmission performance for digital modulation techniques is the optical receiver sensitivity. The optical receiver sensitivity is the minimum optical power required at the receiver, (from the transmission fibre), for a given probability of error, say 10^{-9}. **Table 1** compares the predicted transmission performance for some of the more attractive coherent system options and compares these with conventional optical fibre systems using intensity modulation and direct detection.

The coherent system option with the best receiver sensitivity is a PSK homodyne system, although this is the most demanding in terms of narrow laser linewidths and difficulty in implementing the receiver. Generally in moving down through the system options in Table 1, the degradation in optical receiver sensitivity is traded off against easier implementation and wider allowable laser linewidths.

System Option	Optical Receiver Sensitivity (Degradation to PSK Homodyne System)	Laser Linewidth Allowed (% of Bit Rate)
PSK Homodyne System		0.001-0.003
PSK Heterodyne System	3 dB	0.01-0.1
Differential PSK Heterodyne System	3.5 dB	0.4-0.5
FSK Heterodyne System (Non-Synch. Demod.)	7-8 dB	5-10
IM/DD System	-15-20 dB	

Table 1. Comparison of Transmission Performance for Selected Modulation Techniques

The major point to note is that coherent systems offer potentially 10-20 dB improvement in receiver sensitivity compared with IM/DD systems. Such an improvement in the optical receiver sensitivity could be translated into some 30-60 km increase in repeater span, assuming a cabled fibre attenuation of 0.3 dB/km at 1550 nm. It is interesting to examine the reason for this better performance. In a coherent system, the local laser power is substantially greater than the incoming received power. Because the incoming signal is "multiplied" with the local laser output in the photodiode detection operation, the resultant photodiode current is much larger than is the case if the low-power received signal is directly detected as in an IM/DD system. In an ideal coherent system the signal current is substantially greater than the receiver circuit noise, and the shot noise arising in the detection operation from the local laser output dominates. These systems are often described as shot-noise limited. In contrast, in an IM/DD system, the photodiode signal current is much smaller. The photodiode noise and receiver circuit noise thus become more significant and degrade the system performance. The performance of a PSK homodyne system approaches the fundamental limit set by quantum mechanical considerations (i.e. the limit set by quantisation of the energy in a photon).

Table 1 also shows that the laser linewidths required are orders of magnitude less than the bit rate. The effect of the laser linewidth is to cause phase or frequency noise in the receiver. The heterodyne systems such as differential PSK and FSK can use non-synchronous demodulation methods, i.e. an IF carrier is not required. These systems are easier to implement, and for a bit rate of say 140 Mbit/s, the laser linewidths allowed are in the order of 0.1-10 MHz. However, current commercial laser diodes do not satisfy this requirement.

Laser diodes used in optical fibre systems presently installed oscillate in a number of modes allowed by the laser cavity, giving rise to output at several wavelengths or frequencies, for example as illustrated in **Fig. 3(a).** A laser for use in coherent systems must have a single mode and hence a single wavelength output, as in **Fig. 3(b)**; this is commonly referred to as a single frequency laser diode. Strictly speaking it is not single frequency, but contains a narrow range of frequencies. The laser output is then conveniently characterised by the linewidth and centre frequency. Unfortunately, the basic laser diode structure, even if it can be operated "single frequency", has a linewidth of the order of 100 MHz. This means special laser designs must be developed to reduce this linewidth to the level allowable in Table 1.

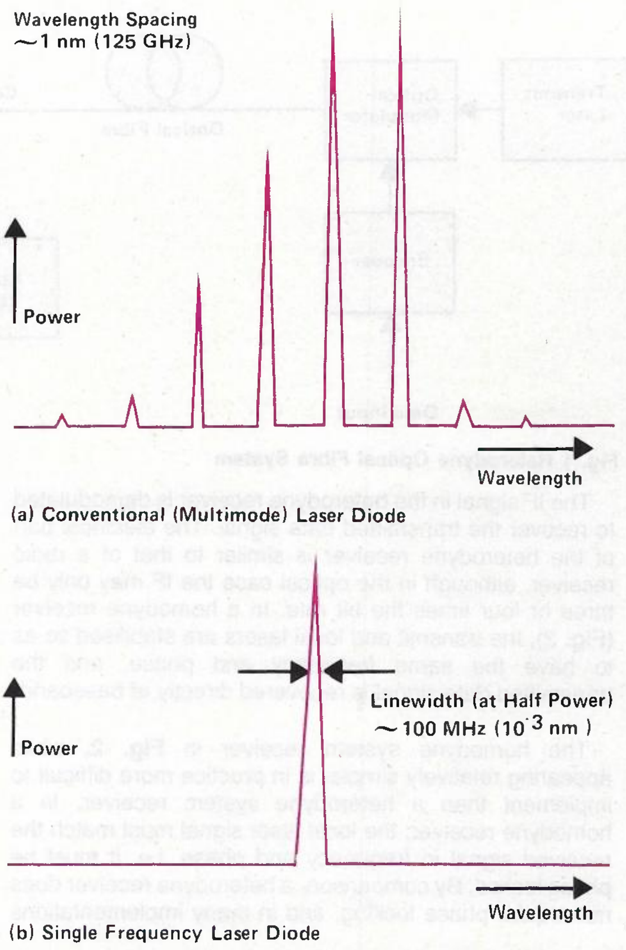


Fig. 3 Typical Output Spectra of Laser Diodes (not to scale)

4. TECHNOLOGY OF SYSTEM COMPONENTS

4.1 Optical Source

The reduction of the spectral linewidth of currently available semiconductor laser diode sources, so that they can be used for both the transmitter and local laser, is a key aspect in realising coherent optical fibre systems. In addition, the centre frequency must be stabilised to enable frequency or phase locking to be achieved at the receiver. A reduction in the linewidth of conventional single frequency laser diodes by a factor of greater than 100 is required.

Several techniques for reducing the linewidth have been investigated, with the most promising options being the use of laser diodes with an external cavity or a frequency selective element in the laser diode chip. Examples of these structures are given in **Fig. 4.** The external cavity configuration relies on a small fraction of the optical output of the laser diode being reflected back into the cavity from an external reflector surface. The reflecting surface may be either a mirror or diffraction grating, or the cavity may be created by a short length of fibre. External cavities of the order of 200 mm in length have been used to achieve very narrow linewidths. The long length of the external cavity forces the laser to oscillate over a narrower frequency range.

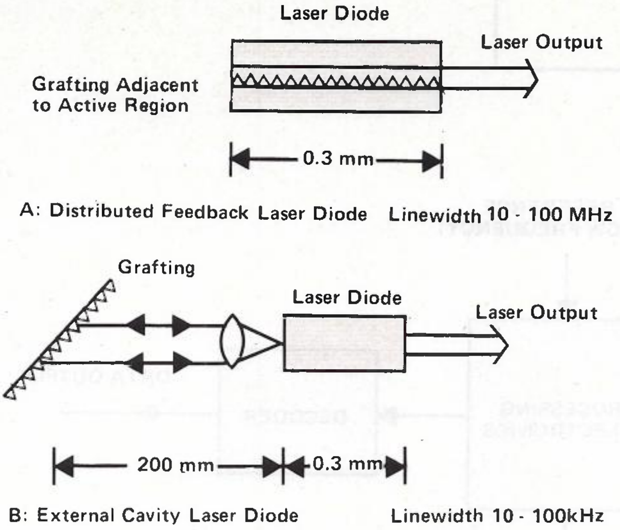


Fig. 4 Characteristics of Narrow Linewidth Sources

One example of a laser with a frequency selective element is a distributed feedback (DFB) laser. A grating is formed along the laser cavity to give wavelength selection and narrow linewidths. Typical DFB lasers are suitable for heterodyne FSK systems, but to satisfy the stringent linewidth requirements of, for example, PSK systems, they too must be used in an external cavity configuration.

To obtain the required frequency stability, it is necessary to stabilise the temperature of the laser diode, as a 0.001°C change in laser diode temperature results in a 20 MHz shift in the laser diode centre frequency. This can be achieved using thermo-electric coolers in a feedback configuration.

There are problems with the mechanical stability of external cavity configurations, due for example to temperature changes and acoustic vibrations. The long term solution may be to integrate the laser diode and external cavity with the modulator into a single optical component.

4.2 Optical Modulators

Direct frequency modulation of the transmitter laser diode can be achieved by varying the laser diode drive current. Changes in the drive current cause the refractive index of the laser diode active region to change, and hence shift the frequency of operation. However, this is usually associated with an unwanted amplitude modulation.

Phase modulation can be achieved using an external optical phase modulator composed of an electro-optic material such as lithium niobate ($LiNbO_3$) or gallium arsenide (GaAs). In these devices, an electrical signal is applied to the electro-optic material, which causes a change in the material refractive index. This in turn causes the propagation time of an optical beam through the material to change, and results in a phase change in the output signal. Optical phase modulators are waveguide devices, typically 20 mm in length. They typically achieve the desired phase shift of 180° for an applied voltage of 10v, and have an insertion loss of a few dB. Research is continuing to improve their performance at high modulation speeds and to lower the insertion loss. An alternative means proposed to produce phase modulators is to use electro-optically active, optical fibre configurations. This arrangement has the advantage of inherently lower coupling loss to the input and output fibres. The same electro-optic effect can also be used to produce amplitude modulation.

4.3 Optical Receiver

The complexity of the optical receiver in a coherent system depends on two factors; whether heterodyne or homodyne detection is employed, and the type of demodulation, for example synchronous or non-synchronous.

The received signal is, as explained previously, mixed with a local laser signal at the photodiode. In order for the system to operate with greatest efficiency, the state of polarisation of the transmitted signal and the local laser signal must be aligned. In conventional single mode fibres, the optical signal propagates in two polarisations. Manufacturing defects and changes in ambient conditions give rise to a time varying coupling of power between the two polarisations, and therefore the state of polarisation of the signal at the receiver is random. Techniques to overcome this problem include the use of polarisation diversity receivers (responding to both polarisations), and polarisation compensators that can continuously adjust the state of polarisation of the local laser to match that of the received signal. Polarisation maintaining fibres could also be used but at present these have significantly higher transmission losses when compared with conventional single mode fibre.

In addition to the simple receivers shown in Figs. 1 and 2, there are other novel receiver configurations that can be used to enable the ideal of shot noise limited performance to be approached. One possibility is the use of a balanced receiver, analagous to a balanced mixer in a radio communications system. The local laser is combined with the received signal in a two port coupler as shown in **Fig. 5.** In this type of receiver the effect of noise from the local laser on receiver performance is significantly reduced. In another novel receiver configuration, illustrated in **Fig. 6,** the local laser and the received signal are combined in a three port coupler. The three outputs are each separately demodulated and combined to recover the original baseband signal. This type of receiver can be operated with an IF that is much lower than the modulation signal bandwidth, thereby achieving pseudo-homodyne operation, as compared with conventional heterodyne receivers where the IF is typically 3 to 4 times greater than the bit rate.

4.4 Integrated Optics

The future commercial viability of coherent systems will rely on the ability, in both the transmitter and receiver, to integrate many of the functions that are now performed separately. This will bring about improvements in the reliability of these systems, reduce the physical size of the major system components and consequently their temperature and mechanical stability problems, and also reduce the cost of the components.

For example, the transmitter module could contain in

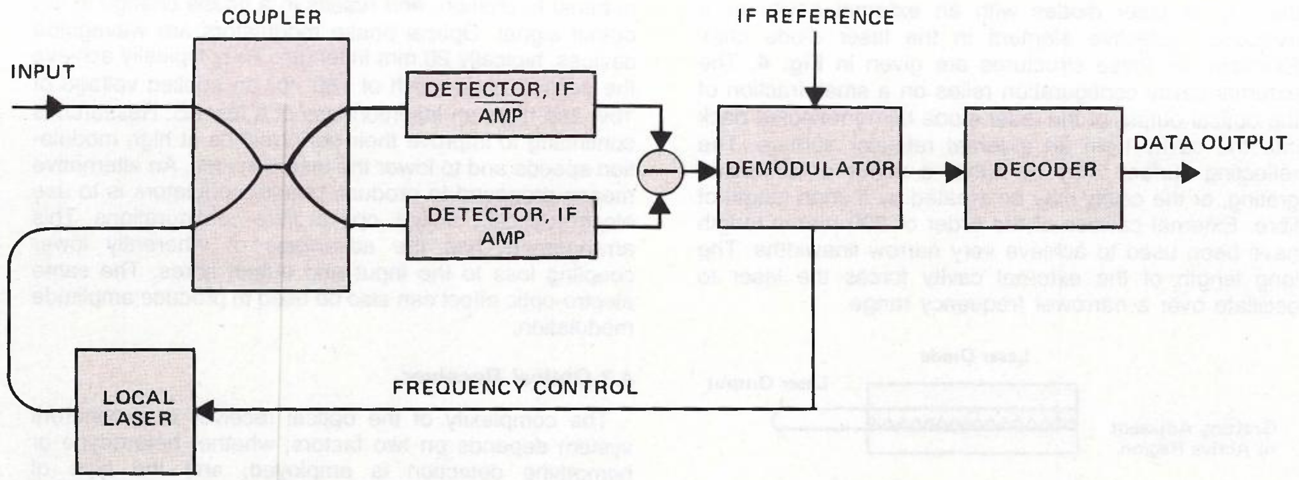


Fig. 5 Balanced Heterodyne Receiver

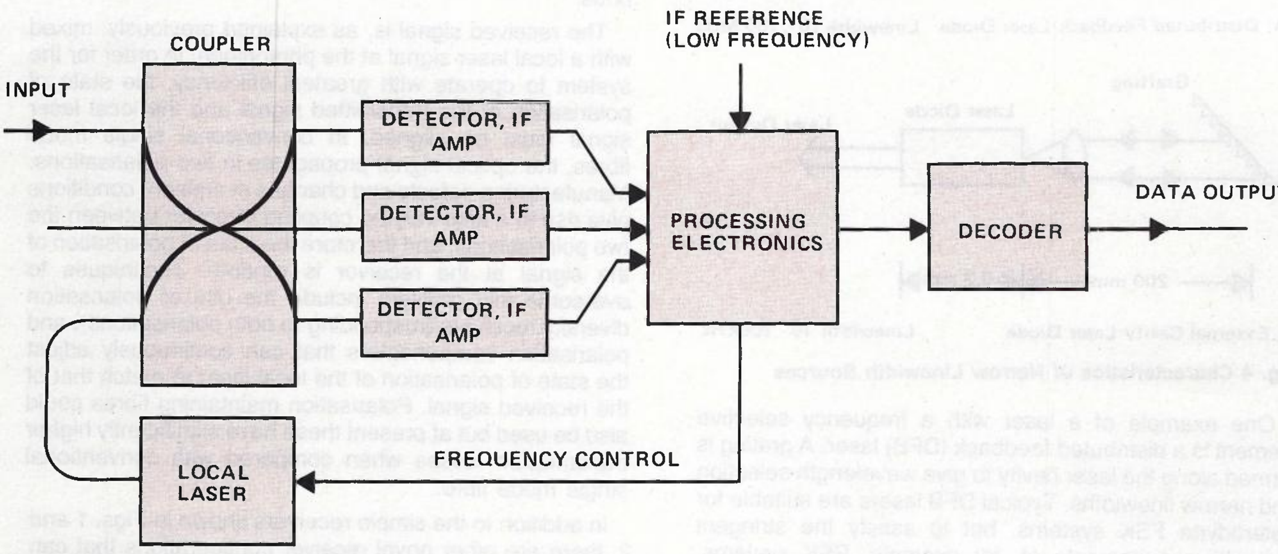


Fig. 6 Pseudo-Homodyne Receiver

one integrated unit the laser diode, external diffraction grating and modulator. A receiver could contain an optical hybrid to combine the local laser and transmitted signals, polarisation compensation, photodiodes, local laser and associated external diffraction grating. An example of a receiver module containing some of these elements is given in **Fig. 7**. However, there are a number of technological advances that must be made before these integrated devices become widespread. The major problem at present is the incompatibility between the substrate material used in different components, e.g. $LiNbO_3$ for polarisation control and InP for the photodiode. Hybrid devices combining different materials and technologies are likely to be the first such modules to be used in coherent optical systems.

5. SYSTEM RESULTS

The first experimental coherent systems were reported late in 1981 and in 1982; these could be described as simulation experiments in that they employed a single laser to provide both transmit and local laser signals. The first two-laser experimental systems incorporating local laser control by phase-locked loop were reported in 1983, employing Helium-Neon (He-Ne) gas lasers, but beginning to demonstrate the higher sensitivity of coherent system receivers compared with IM/DD receivers. Laser modules incorporating semiconductor laser diodes with carefully implemented temperature control and external feedback to reduce linewidth were reported from 1983 onward, and are now the most commonly used laser in such systems.

Table 2 lists the features of some of the most recent record-setting coherent optical communication system experiments. All are laboratory systems; although some involve installed fibre cable, no field-trial systems have yet been reported.

The receiver sensitivities now being reported for coherent systems are substantially better than those for IM/DD systems at the same bit rate. This is not yet reflected in substantially greater transmission distances for coherent systems, as the table indicates. This is because many of the record-setting IM/DD experiments have used new, very-high-power laser diode sources. It is expected that similar power levels will be available from stabilised sources suitable for coherent systems in the near future, and that coherent optical systems will then demonstrate the greatly increased transmission distances that their higher receiver sensitivities permit.

Two contenders are emerging as candidates for the first production coherent optical transmission system available to telecommunications administrations. These are particular versions of heterodyne FSK and PSK systems. FSK systems using non-synchronous detection schemes are very tolerant to high laser linewidth, and can be

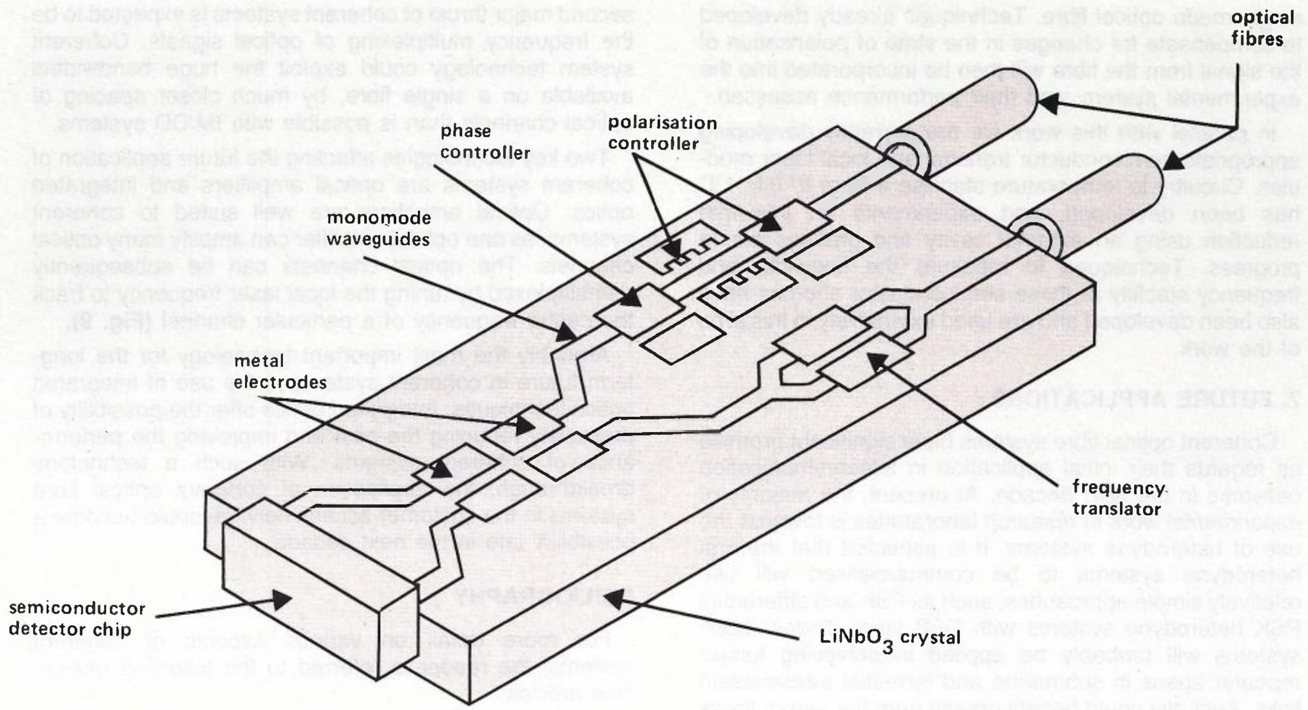


Fig. 7 LiNbO$_3$ Integrated Optic Coherent Receiver Device (After Booth ECOC'85)

implemented with the DFB laser diodes now becoming available. These systems, although simple, do not offer a substantial improvement over IM/DD systems. However, they could be very attractive in systems using frequency multiplexed optical carriers. Differential PSK heterodyne systems are also attractive, in that they offer receiver sensitivities very close to the optimum (PSK homodyne), yet are reasonably tolerant in terms of the laser linewidth they require. These systems are also comparatively simple to implement, and thus are a promising candidate for commercial application.

6. TELECOM AUSTRALIA RESEARCH LABORATORIES STUDIES

At the Research Laboratories of Telecom Australia a programme of work is being undertaken to enable coherent systems to be evaluated for possible future network applications. The work can be classified under the broad categories of analytical work and laboratory work on the components used in coherent systems. The analytical work is primarily aimed at determining the performance expected from these systems, once the technology of the individual components matures. It also provides a framework around which experiments can be performed to verify, where practicable, the theoretical predictions. The laboratory programme of work is based around the implementation of experimental coherent systems, to enable the development of expertise in the practical aspects encountered in applying this new technology.

An operating experimental heterodyne system has been built using visible He-Ne gas lasers operating at 633 nm for the transmit and local lasers. These are useful for early experiments, and will be replaced by semiconductor laser sources when their linewidths are reduced significantly. The laser signal is modulated externally and transmission at 633 nm is through air rather than through a single mode optical fibre. A photograph of the system, which presently operates using differential PSK at 140 Mbit/s, is shown in **Fig. 8.**

This system is being progressively upgraded, so as to test other modulation techniques and receiver configurations. The operating wavelength is being changed to enable experiments to be performed over conventional

TABLE 2

PERFORMANCE OF EXPERIMENTAL COHERENT OPTICAL TRANSMISSION SYSTEMS

Year	Organisation	System	Wavelength nm	Data Rate Mbit/s	Path Length km	Sensitivity Measured dBm	Sensitivity Theory dBm	Features
1983	Brit. Telecom Research Labs	DPSK Heterodyne	1523	140	109	-59	-63	First long-distance two-laser experimental system
1985	AT&T Bell Laboratories	DPSK Heterodyne	1500	1000	150	-44	-56	Highest data rate
1985	TNL-NTT	FSK Heterodyne	1530	400	251	-49	-53	Longest system span length
COMPARABLE IM/DD EXPERIMENTAL SYSTEMS								
1985	NEC		1500	1200	171	-40		High power source: 20 mW
1985	NEC		1500	565	204	-44		High power source: 20 mW

single mode optical fibre. Techniques already developed to compensate for changes in the state of polarisation of the signal from the fibre will then be incorporated into the experimental system, and their performance assessed.

In parallel with this work we are currently developing appropriate semiconductor transmit and local laser modules. Circuitry to temperature stabilise a laser to 0.001°C has been developed, and experiments on linewidth reduction using an external cavity and gratings are in progress. Techniques to measure the linewidth and frequency stability of these semiconductor sources have also been developed and are used extensively in this area of the work.

7. FUTURE APPLICATIONS

Coherent optical fibre systems have significant promise as regards their initial application in telecommunication networks in the next decade. At present, the majority of experimental work in research laboratories is towards the use of heterodyne systems. It is expected that the first heterodyne systems to be commercialised will use relatively simple approaches, such as FSK and differential PSK heterodyne systems with DFB laser diodes. Such systems will probably be applied in achieving longer repeater spans in submarine and terrestial transmission links. Australia could benefit greatly from the use of these systems with our large distances between major population centres. A likely date for the first application of a heterodyne optical fibre system is the early 1990s.

As the technology develops, the emphasis is expected to concentrate more on homodyne than heterodyne systems. The baseband operation of a homodyne receiver is better suited to systems transmitting multi-Gbit/s signals (as the need for an IF stage at very high frequencies with associated higher noise is avoided). A second major thrust of coherent systems is expected to be the frequency multiplexing of optical signals. Coherent system technology could exploit the huge bandwidths available on a single fibre, by much closer spacing of optical channels than is possible with IM/DD systems.

Two key technologies affecting the future application of coherent systems are optical amplifiers and integrated optics. Optical amplifiers are well suited to coherent systems, as one optical amplifier can amplify many optical channels. The optical channels can be subsequently demultiplexed by tuning the local laser frequency to track the centre frequency of a particular channel **(Fig. 9).**

Arguably the most important technology for the long-term future in coherent systems is the use of integrated optics techniques. Integrated optics offer the possibility of drastically reducing the cost and improving the performance of coherent systems. With such a technology breakthrough, the application of coherent optical fibre systems in the customer access network could become a possibility late in the next decade.

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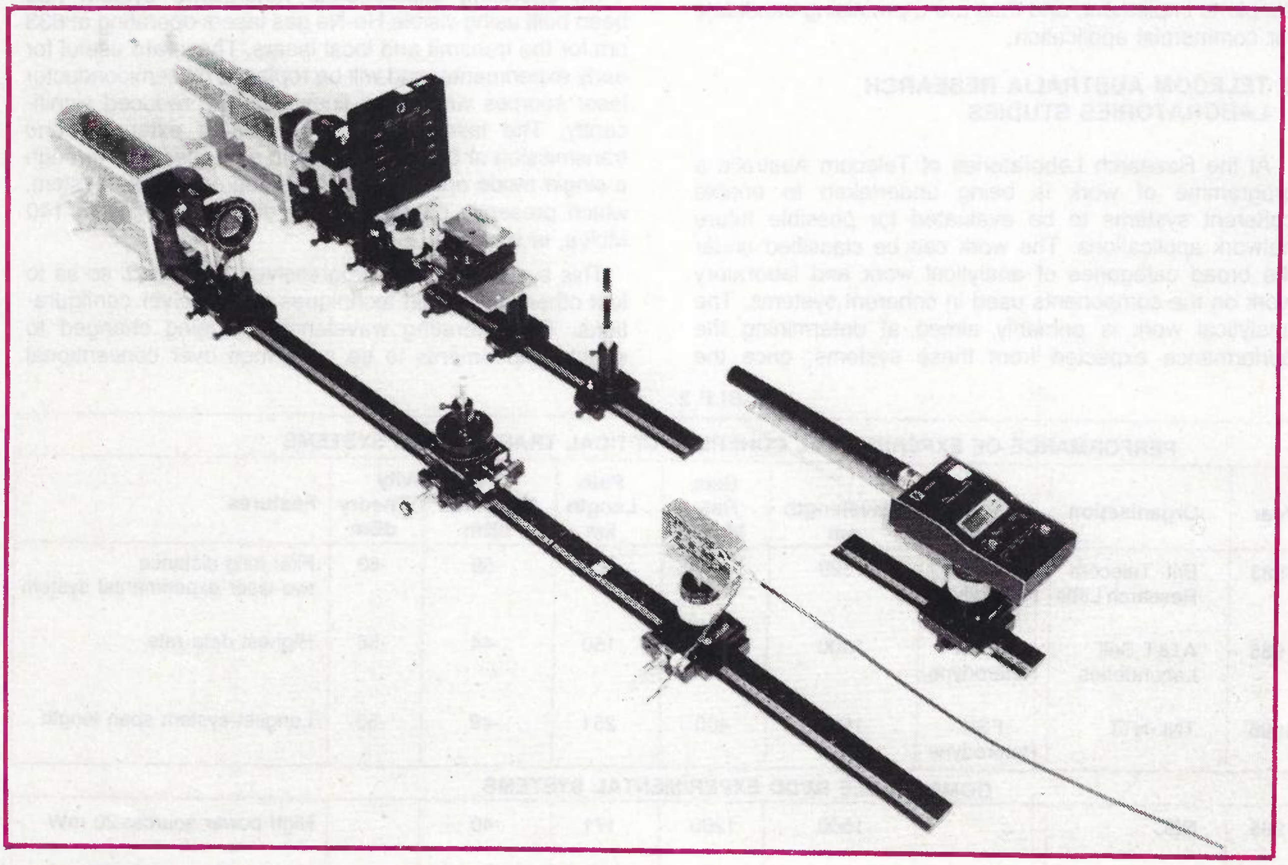

Fig. 8 A DPSK Heterodyne System using 633nm He-He Lasers

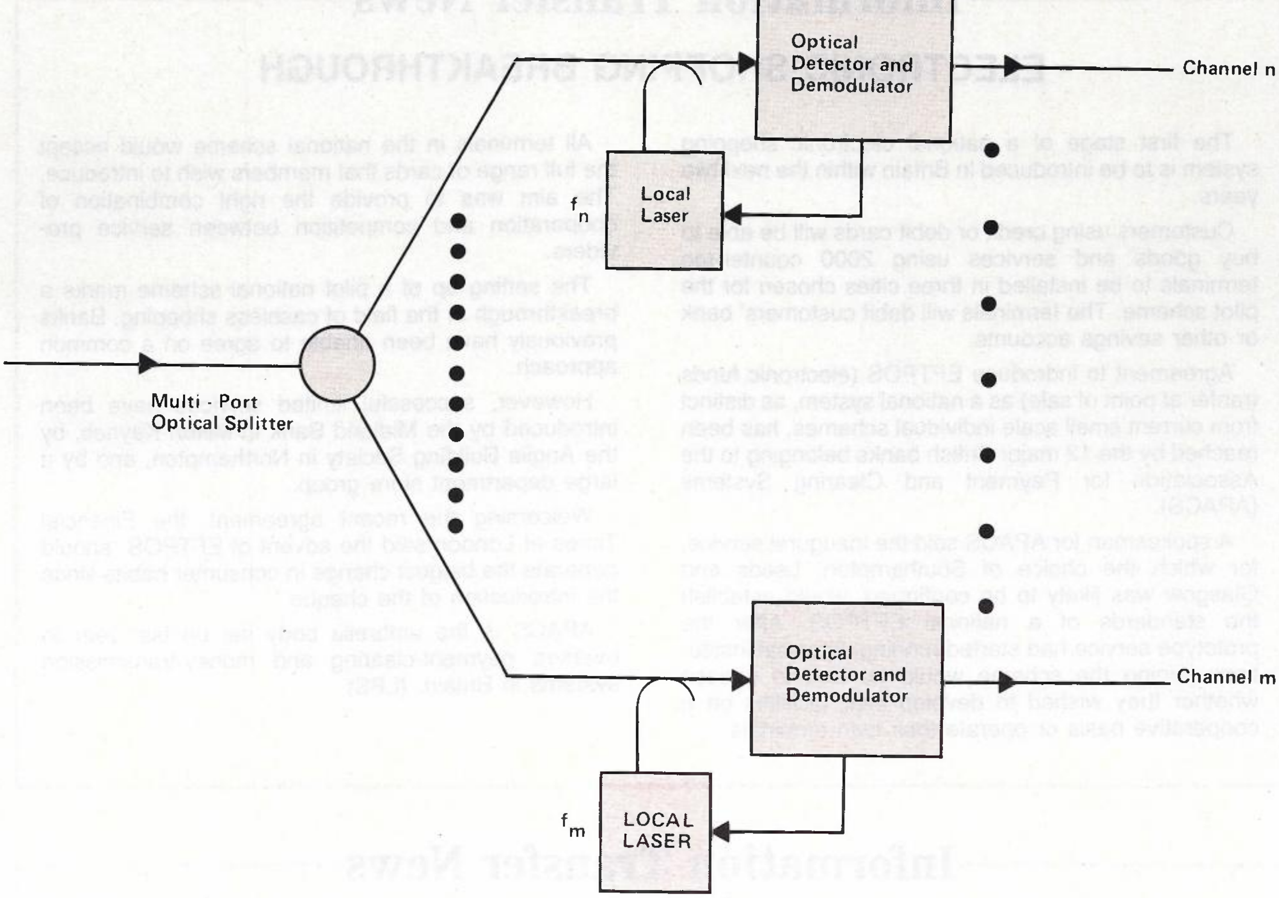

Fig. 9 Customer Terminal Architecture in Coherent System Receiver for Demultiplexing Optical Channels

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GLOSSARY OF TERMS

COHERENT OPTICAL SYSTEM — transmission system using coherent (narrow linewidth) optical sources at the transmitter and receiver, the optical signals from which are "multiplied" together in the photodetection operation at the receiver to produce an electrical output representing the difference frequency signal.

DIFFRACTION GRATING — device with micron-spaced lines etched on its surface, the effect of which is to reflect light at different angles depending on the optical wavelength.

ELECTRO-OPTIC EFFECT — is the effect occurring in certain crystals in which the refractive index seen by incident light changes when an electrical voltage is applied across the crystal.

HETERODYNE SYSTEM — coherent optical system in which the electrical signal from the photodiode is centred about a non-zero frequency (intermediate frequency).

HOMODYNE SYSTEM — coherent optical system in which the electrical signal from the photodiode is at baseband.

INTEGRATED OPTICS — technology in which a number of optical components are realised in a single miniature package, perhaps on a single electro-optic material substrate.

LASER LINEWIDTH — interval in optical frequency between the points at which the laser power is half of its maximum value (concept usually applied to lasers with long time-coherence of their output).

NON-SYNCHRONOUS DEMODULATION — refers in a heterodyne system to demodulation of the data signal without using an electrical carrier at the intermediate frequency.

OPTICAL AMPLIFIER — device which amplifies optical signals using the process of stimulated emission (as in lasers).

OPTICAL RECEIVER SENSITIVITY — minimum incoming optical power at the receiver to achieve a specified error probability.

POLARISATION — that property of a radiated electromagnetic wave describing the time-varying direction and amplitude of the electric field vector.

SINGLE FREQUENCY LASER DIODE — laser diode in which the optical output is essentially at a single frequency (or wavelength), with a narrow linewidth about this frequency.

SYNCHRONOUS DEMODULATION — refers in a heterodyne system to demodulation of the data signal using an electrical carrier at the intermediate frequency.

Information Transfer News

ELECTRONIC SHOPPING BREAKTHROUGH

The first stage of a national electronic shopping system is to be introduced in Britain within the next two years.

Customers using credit or debit cards will be able to buy goods and services using 2000 counter-top terminals to be installed in three cities chosen for the pilot scheme. The terminals will debit customers' bank or other savings accounts.

Agreement to indroduce EFTPOS (electronic funds tranfer at point of sale) as a national system, as distinct from current small scale individual schemes, has been reached by the 12 major British banks belonging to the Association for Payment and Clearing Systems (APACS).

A spokesman for APACS said the inaugural service, for which the choice of Southampton, Leeds and Glasgow was likely to be confirmed, would establish the standards of a national EFTPOS. After the prototype service had started running, financial institutions joining the scheme would be free to choose whether they wished to develop their facilities on a cooperative basis or operate their own terminals.

All terminals in the national scheme would accept the full range of cards that members wish to introduce. The aim was to provide the right combination of cooperation and competition between service providers.

The setting up of a pilot national scheme marks a breakthrough in the field of cashless shopping. Banks previously have been unable to agree on a common approach.

However, successful limited services have been introduced by the Midland Bank in Milton Keynes, by the Anglia Building Society in Northampton, and by a large department store group.

Welcoming the recent agreement, the Financial Times of London said the advent of EFTPOS "should generate the biggest change in consumer habits since the introduction of the cheque."

APACS is the umbrella body set up last year to oversee payment-clearing and money-transmission systems in Britain. (LPS)

Information Transfer News

THE COMBINED COMMUNICATIONS ELECTRONICS BOARD PRINCIPAL'S SEVENTEENTH MEETING

The Combined Communications Electronics Board (CCEB) is the supreme forward-looking Allied military communications electronics body. Its work, which is continuing in nature, embraces the full scope of communications electronics subjects including engineering standard, policy, doctrine and procedures.

The CCEB consists of the military heads of the defence CE organisations of Australia, Canada, New Zealand, United Kingdom and the United States. Brigadier Peter Evans is the Director General Join Communications Electronics and the Australian Principal for the CCEB.

The Terms of Reference of the CCEB have recently been amended to reflect an increased role in Command, Control and Communications (C3). The Terms of Reference also provide for annual meetings to be held in the country of the Chairman in office at the time. The office of the Chairman changes and hence the meeting venue changes in the order: US, Australia, Canada, United Kingdom and New Zealand. As the US hosted the meeting in Washington D.C. last year, this year's meeting will be conducted in Australia. The seventeenth meeting of the CCEB Principals is to be held in Melbourne during the period 22-26 June, 1987.

The majority of the work involved in the CCEB is done by correspondence in between the Principal's meetings. This then enables the Principal's meeting to be held in such a restricted period. Most of the work undertaken at these meetings is finalising and accepting concepts, policy and agreements initiated at the previous meeting and developed by correspondence in between the meetings. These issues must be agreed to or discussed at this meeting and the Australian delegation will ensure Australian interests are protected, particularly with respect to military communications interoperability.

The Design of a 64 KBIT/S Digital Cross Connect Switch

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J. van WOERKOM, Amalgamated Wireless Australasia Ltd.

This paper describes the design of a 64 kbit/s Digital Cross Connect (DCC) Switch by the Networking and Business Communication Division of Amalgamated Wireless (Australasia) Ltd. under contract to Telecom Australia (Research Laboratories). The DCC provides semi-permanent cross connections between nominated 64 kbit/s channels contained in Primary PCM (2.048 Mbit/s) systems. The DCC interfaces both Channel Associated Signalling (CAS) and non-CAS PCM systems. For CAS systems, the signalling information in Timeslot-16 is switched transparently; whereas for non-CAS systems, Timeslot-16 can be used as an extra voice/data or signalling channel. The development is described in terms of the functions, facilities and design approaches used to develop prototype equipment. The switch will be used by Telecom Australia in experimental trials of ISDN network interworking.

1 Introduction

PCM systems are fast becoming the predominant transmission technique in providing transmission channels for Australian telecommunications networks. The function of a Digital Cross Connect (DCC) switch is to provide semi-permanent channel interconnections at 64kbit/s which is the basic channel rate in primary PCM. The Digital Cross Connect project has had two contractual phases. Initially, a Digital Cross Connect study was performed by Amalgamated Wireless (Australasia) Ltd. under contract to Telecom Australia. The initial work involved design, feasibility and costing studies for a Digital Cross Connect Switch. Based on that study a further contract was let to AWA for the development of a prototype dual module digital cross connect switch.

The major objective of the R&D contract was to undertake detailed hardware and software design, and subsequently to fabricate and test a prototype dual module DCC. The prototype DCC Switch was delivered to the Telecom Australia Research Laboratories in April 1986 where it is currently undergoing proving tests.

The Digital Cross Connect is a wholly Australian designed and manufactured product, with industrial property jointly shared by Telecom Australia and AWA. The DCC has potential to be used in various applications associated with services which utilise the 64 kbit/s channels of Primary PCM systems.

This paper describes the design and system implementation of the DCC.

2 Digital Cross Connect (DCC) Switch Overview

A DCC switch consists of a number of DCC Switch Modules. Each Module contains its own processor and is able to perform processing/control functions for the cross-connection of channels in any of the Primary PCM lines connected to it. The switch is capable of performing both timeslot interchange and space division switching functions. Although the prototype DCC switch was specified to be relatively small, its modular design is capable of economic incremental increase to larger switch configurations.

The main design aims were as follows:

1. to perform semi-permanent cross-connections of 64 kbit/s data streams contained within a Primary PCM (2.048 Mbit/s) systems.
2. to have minimum effect on the data streams being cross connected, i.e. minimum switching delay and transparent switching of voice/data and signalling information.
3. to provide system fault tolerance such that any single fault cannot affect more than 30 voice/data channels (i.e. a single primary PCM system).
4. to design modular switching equipment so that individual parts, both hardware and software, can be improved/modified with minimum impact on other parts. This is especially important during the prototype stage.
5. to design for simplicity to manufacture, install and operate, including the facility to remove, replace and expand parts of the system without affecting existing traffic.

Fig. 1 shows the fundamental outline of the prototype DCC switch. The basic blocks are described below. Section 4 of this paper elaborates on their operation and implementation.

System Control Processor (SCP)

This unit controls the overall operation of the DCC, interfaces to the operator via the Local Terminal, and handles DCC alarm processing. It also stores the DCC data base, such as the cross-connection status and the DCC configuration. This information is stored in a non-volatile memory medium.

Clock Generator Module (CGM)

This Module provides a reference clock for all modules within the DCC and may be synchronised from external reference sources. It has its own processor which monitors and controls the operation of the Module.

Switch Module (SM)

The main function of the Module is to perform the switching of channels. In addition, it interfaces to external PCM lines and other Switch Modules. It receives its reference clock information from the CGM. The modularity of the Switch module as a building block of larger capacity switches is based on a distributed processing technique where each Switch Module contains its own processor.

Local Terminal (LT)

The Local Terminal provides the man-machine (i.e. operator-DCC) interface which is a Visual Display Unit (VDU) and a printer (PTR). It also provides a control interface to test equipment via an IEEE-448 type bus.

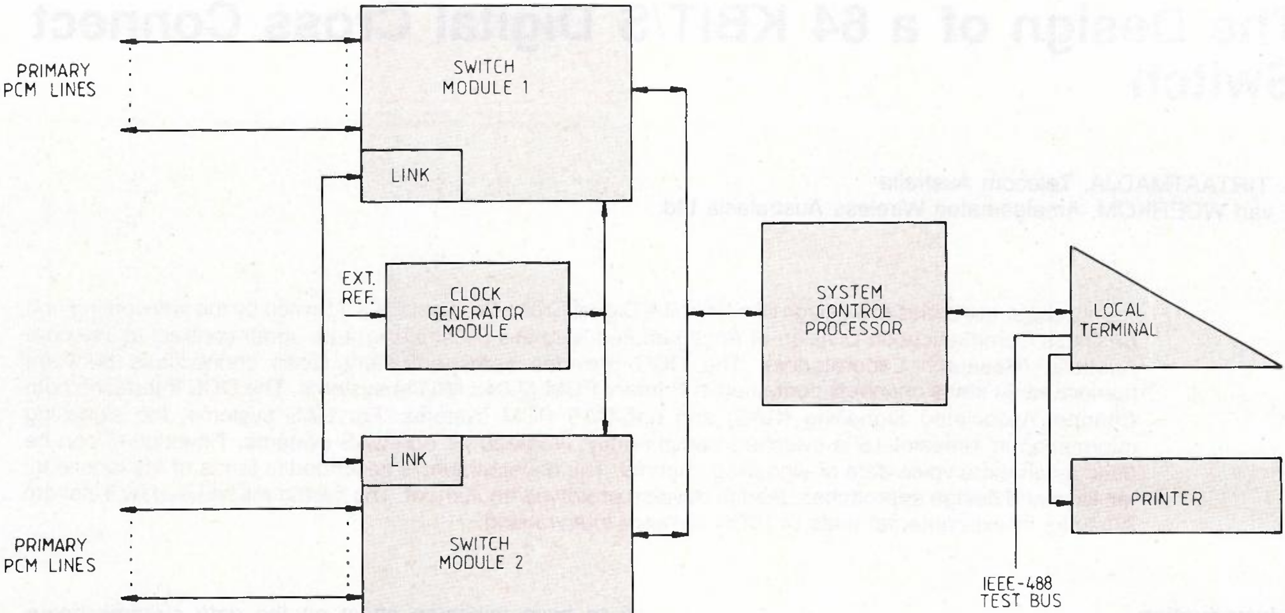

Fig. 1. Digital Cross Connect Outline

Power Supply

The power requirement of the DCC is derived from the normal 48V DC telephone exchange battery supply.

3 DCC Facilities

The major facilities and functions of the DCC are described below.

Switch modules each capable of performing timeslot interchange between any 64 kbit/s channels connected to it in Primary PCM (2.048 Mbit/s) format. Two or more modules can be interconnected via Link circuit(s) to allow cross-connection of channels in different Switch Modules. There is full availability of access from one channel to any other channel both within a Module and between Modules in a multi-module DCC switch. Access from one channel

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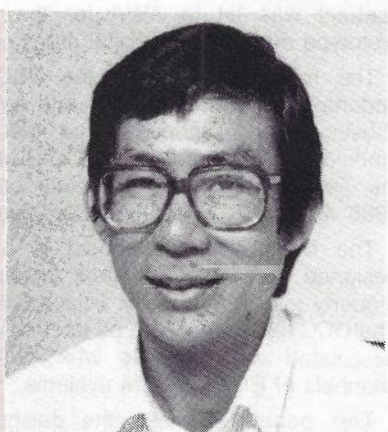
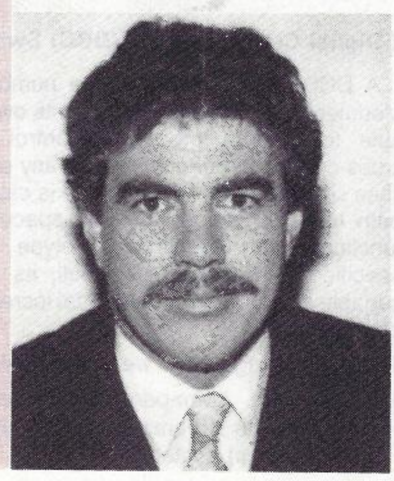


JOE van WOERKOM graduated from the University of New South Wales with a B.Sc. in physics in 1976 followed by a B.E.(Elec) in 1978. He then joined E.S. Rubin Co. Pty. Ltd. as a design engineer involved in the design and development of custom telephone switching equipment most notably Automatic Call Distributors. In 1981 he joined Amalgamated Wireless Australasia Ltd. Networking and Communications Division (then known as the Telephone Switching Group) where he was responsible for the design and implementation of various hardware and software enhancements for second generation SPC PABXs. In 1983 be became involved in the Digital Cross Connect project being promoted in 1985 to Project Manager. His main involvement in the Digital Cross Connect has been the system design and the detailed design of the microprocessor and switching subsystems. Mr van Woerkom is currently involved in the development of the DCC to a marketable product and in further research into applications and techniques of semi-permanent cross connections.



to any other channel within a Module is non-blocking. Blocking between Modules depends on the traffic carrying capacity of the Link Circuits.

A PCM system is classified upon installation as being a Channel Associated Signalling (CAS) or a non-CAS system to allow the DCC Switch to take appropriate action with the signalling bits contained in time-slot 16. The DCC provides transparency for all four signalling bits in each direction in a CAS system. In a Common Channel Signalling (CCS) System, timeslot 16 (Channel "S") can be used to provide a channel of 64 kbit/s for CCS. Each channel has a category designation to differentiate between the types of channels (e.g. junction or priority line). Generally, only channels of the same category can be interconnected.

All commands, status requests/indications, alarm status, etc. are entered via either a local terminal or a remote terminal connected to the DCC. It is envisaged that a number of DCCs will be controlled from a single centralised point using a single intelligent terminal. DCC command categories are as follows:

1. Read Commands: interrogate the interconnection status of the DCC switch, e.g. interconnection status of a particular channel, or all channels in a system, or all channels in a module, or channels of a particular category.
2. Write Commands: connect or release a pair of channels of the same category.
3. Load Commands: interconnect a number of channels from a preassembled data record.
4. Reset Commands: set all channels in a Module to the unconnected state.
5. Status Commands: determine the status of the complete DCC switch including status of MPUs, power supplies, clocks, and individual PCM system alarms.
6. Test Commands: monitor both directions of data transfer of a nominated cross-connection; split an established interconnection so that both channels can be tested independently.

Major security measures required in the operation of a DCC are:

- Independent operation of switching devices, such that once a cross-connection between channels is established, it continues even if the module processors and data link interconnecting them fail.
- Duplication of critical elements such as power supplies, system clocks and the switch planes, with automatic change over upon failure.
- Non volatile memory to store cross connection and category information.
- Low error rates (less than 1 in a million) for data link between processors.

In addition, the DCC detects various alarm conditions e.g. PCM system alarms, processor and power supply failures, equipment failure/changeover and removal, and high error rate of the data link. All alarm statistics are collected for subsequent analysis.

4 DCC Implementation

The prototype DCC is implemented using commercially available integrated circuit devices rather than custom devices. The latter is the more desirable approach for a production model. The prototype is not designed to meet all environmental conditions which might be encountered in a telephone exchange such as the temperature and humidity range, and electromagnetic interference emission and susceptibility requirements. These aspects are normally engineered into the product when it is known that the equipment is to operate in the network.

The DCC is modular in design based on Switch Modules that can each accommodate up to sixteen Primary PCM lines. Each module is self-contained with its own intelligence for module control and its own power supply capable of supplying all module power requirements.

4.1 Design Approach

In order to economically meet the design aims with minimum design risk it was decided to use a top down design methodology followed by a reduction process in which all system elements were examined for commonality. System elements were then redefined to produce a minimum number of individual element types. For example the three functionally different processors are implemented using the same single board processor with different firmware to suit different applications.

At the completion of the reduction process, hardware and software design proceeded independently and in parallel until integrated at a later stage. The system design was segmented into many individual tasks which were assigned to particular personnel who were then totally responsible for the design right through to acceptance testing stage. Frequent design reviews were held at strategic times, e.g. completion of design specification documents. These design reviews involved project personnel and personnel outside the project design team.

At the outset it was apparent that various circuit designs would be suitable for custom integration to reduce component count, increase reliability and ensure system design propriety. However, due to the high cost of custom design and the desire to prove the design before being committed to silicon, it was decided not to proceed with custom integration. Instead, the circuits were designed in a manner which would allow custom integration at a later stage.

System availability and fault tolerance were key design aims of this project. As previously stated the DCC was to confine the effect of any single fault to a maximum of 30 PCM channels. Fault tolerance was achieved by employing redundancy and distributed checking of all PCM related signal flows within the system. Different levels of redundancy were employed as appropriate, e.g. clock generator units are triplicated, switch planes and internal transmission busses are duplicated, whilst DC/DC converters have an 'n+1' redundancy.

The system was also designed to be able to continue functioning, i.e. to maintain existing cross connections, when the processors cease functioning. This was achieved by performing all switching of voice/data and signalling in hardware. Software is employed only during cross connection set-up and clear-down.

4.2 Hardware

Fig. 2 shows the block diagram of the prototype DCC which is basically a distributed processing system with four physical module types:

- The System Control processor (SCP) provides the overall control of the operation of the DCC, supervises communications between all the DCC modules and maintains a centralised data store.
- The Switch Module(s) perform the switching function and provides switching alarm information.

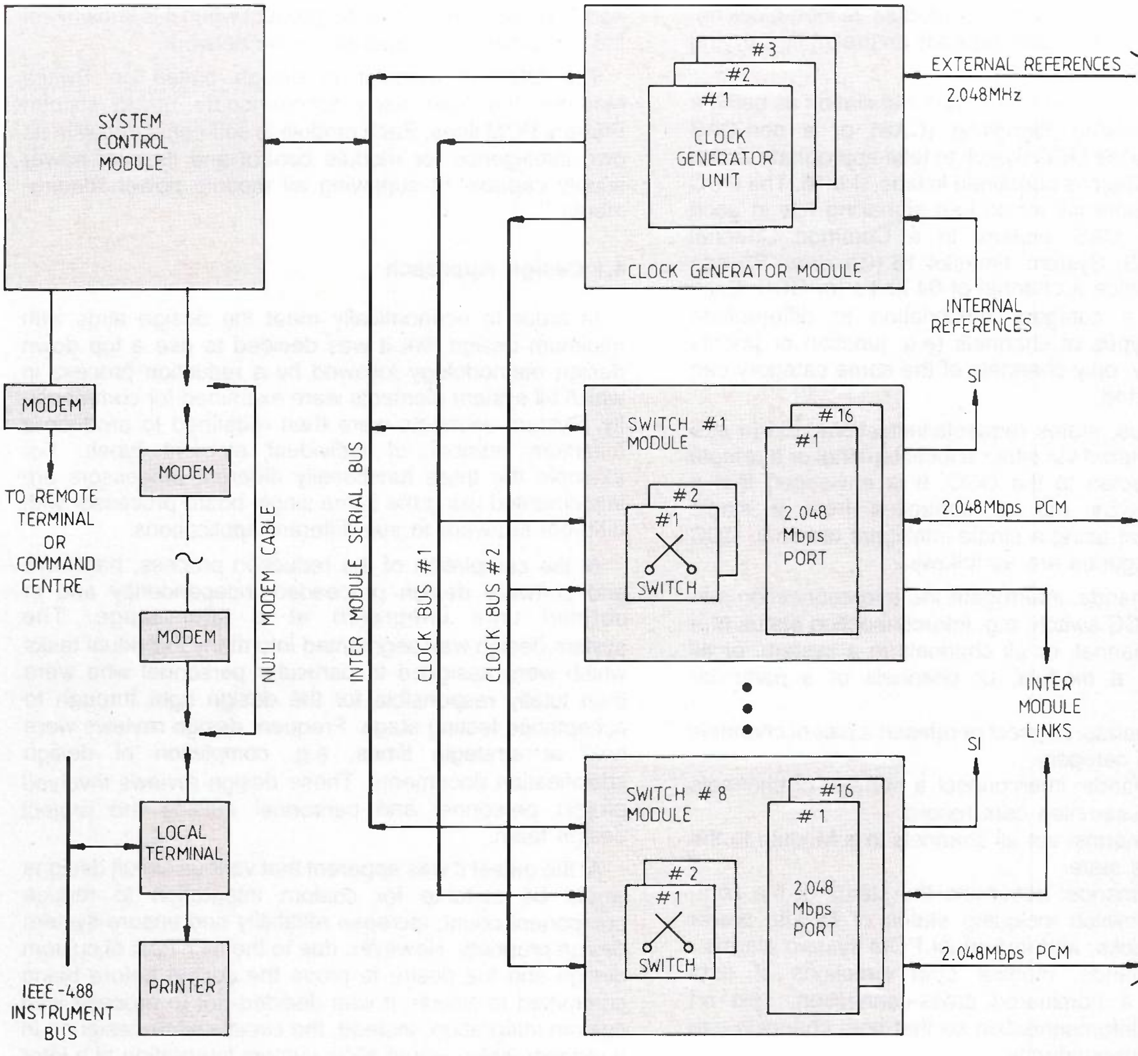


Fig. 2. Prototype DCC Block Diagram

- The Local Terminal provides the operator interface to the DCC.
- The Clock Generator Module provides synchronisation for the system.

The Modules are interconnected by an Inter Module Serial Bus which comprises four signals, viz. data and clock in both directions. These signals are transmitted on differential drivers and receivers to RS422 standards. A master/slave mode operates where the SCP is the master, controlling transmission to/from other modules. Cross-connection and status interrogation commands to other DCC Modules are issued by the SCP via the Inter-Module Serial Bus.

4.2.1. The System Control Processor (SCP)

The SCP is the communication centre of the DCC and is responsible for the control, co-ordination, and supervision of cross-connections. It provides the interface between the Local Terminal and the Switch Modules. Its other major function is to continually monitor the operation and performance of the DCC and forward alarm conditions to the Local Terminal. The SCP consists of four functional blocks interconnected by an internal bus as shown in **Fig. 3.** The functional blocks are described below.

- The Processor board has a serial data link to other DCC modules, and incorporates a Motorola MC6809 microprocessor, with up to 32 Kbytes of ROM, 8 Kbytes of RAM and a watchdog timer. The processor board is the same as all other processor boards in the DCC. The board also contains interface circuitry and software to control the operation of the Inter-Module Serial Bus.
- The Serial I/O board provides synchronous serial V.24/V.28 (RS232C) ports for the connection of the Local and Remote Terminal. Operator commands issued through either terminal are processed by the SCP before being passed on to the appropriate DCC module(s) for action.
- The Alarm board accepts alarm states from every module of the DCC and displays them on an alarm panel. Alarms include Faults, Power supply, Processor and Clock failure, card failed or removed, software error and Data Link high error rate. This board also provides the means for presetting "permanent cross connections' of selected channels. The channels to be interconnected are selected through three banks of miniature switches which define the module, the PCM line in the module and the particular channel within the PCM line.
- A Battery Backed RAM (BBRAM)/Real Time Clock (RTC) board is used by the SCP to store all non-volatile information such as the cross connection status of every PCM channel in the DCC. Also provided is a real time clock for general use within the DCC. Both the RAM and the RTC operate from a battery backed-up power supply.

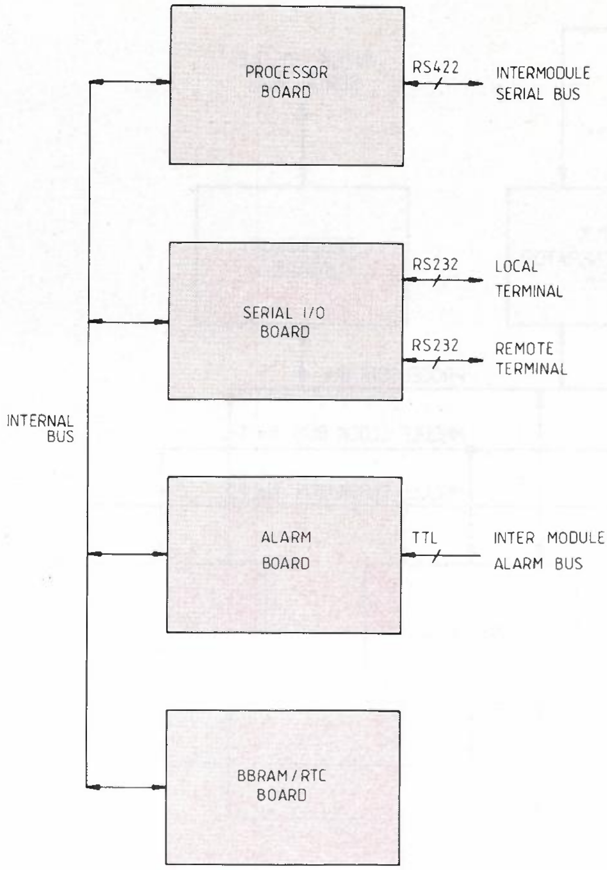


Fig. 3. System Control Processor Organisation

4.2.2 The Clock Generator Module (CGM)

This Module serves as the reference source for all the clock signals used in the DCC. It was designed to give a high degree of frequency stability as well as high reliability and survivability in the case of faults. It has a triplicated structure with majority voting among three clocks. It can synchronise to any one of six incoming 2 Mbit/s links, selecting the link with the highest rank. The CGM comprises three oscillator boards, each controlled by a processor board, and two reference buffer boards which receive synchronisation timing information.

4.2.3 The Switch Module

A Switch Module comprises a Common Control Unit and a number of PCM Line and intermodule link boards interconnected via a number of internal busses as shown in **Fig. 4.** A switch Module can have up to sixteen Primary PCM (2.048 Mbit/s) lines. Any channel from any PCM line can be connected to any other channel in any PCM line (i.e. full availability and non-blocking within a single Switch Module). To ensure that the PCM signalling bits associated with the particular channel are connected to the correct destination (for Channel Associated Signalling (CAS) systems), the signalling bits accompany the speech/data bit streams throughout the interconnection process. These signalling bits are combined with internal parity checking bits to form an additional bit stream. Internally, therefore, a second bit stream containing signalling and parity information is simultaneously switched as well as the speech/data bit stream.

Intermodule link circuits can be used in place of PCM line interfaces, in order to switch between modules. A link circuit connects two switch modules to each other. This facilitates connection between any channel in any PCM line in one module to any other channel in any other PCM line in the other module, assuming that spare capacity exists in the link (i.e. full availability with blocking between modules). Again, the signalling bits for CAS systems will be appropriately switched.

Maximum one way switching delays for speech/data are:
single module : 255 microseconds
inter module : 384 microseconds

Maximum one way delays for signalling bits (for CAS systems) are:
single module : 2450 microseconds
inter module : 2580 microseconds

It should be noted that while signalling delays will vary from one connection to another, the delay for an individual connection is constant and will not contribute to distortion of pulsed signalling schemes such as decadic or T6 interexchange signalling.

The Common Control Unit consists of the following boards:

- A Switch Module Processor based on the same single board microprocessor as designed for the SCP and CGM.
- PCM Switches containing the switch hardware. For security each Switch Module has duplicated PCM Switch planes, one being the active switch whilst the other is in a "hot standby" mode. Parity checking of all switched bit streams is a necessary requirement in a production version of the DCC. On the prototype only certain parity checking is performed for test purposes.
  Two bit streams are switched at the same time: the actual speech/data bit stream and the PCM signalling (for CAS system) plus parity bit stream.
- Clock Buffer/Generators supplying all PCM clocks within a Switch Module. For reliability, two boards are provided per Switch Module. In this case the Switch Module Processor determines which clock buffer/generator is to be used.

The PCM Line card is the interface between a Primary PCM line and the DCC Switch. It provides:

- the necessary buffering between the external and the internal PCM time references.
- the multiplexing and demultiplexing function between the 2.048 Mbit/s and the 64 kbit/s channels.
- the injection of appropriate frame and multiframe signalling to the external PCM system.
- the generation of the signalling and parity bit stream used internally within the DCC.

The Intermodule Link card provides the means of interfacing multiple switch modules such that any 64kbit/s channel within one Switch Module can be interconnected to any channel within another Switch Module. A link circuit consists of 30 channels of 64 kbit/s each, in a 2.048 Mbit/s format.

4.2.4 The Local Terminal

The Local Terminal provides the facility for the operator to control the operation of the DCC. It communicates directly with the System Control Processor (SCP) via an RS232 line. The local terminal is an AWA microcomputer with its operating system, memories and mass storage facilities. In addition to the Visual Display Unit and Keyboard, a printer and an IEEE-488 (GPIB) bus controller are connected to the Local Terminal.

4.3 Software

The DCC software is divided into four funcitonal areas which correspond to the hardware modules viz. SCP, CGM, Switch Module and Local Terminal. Each software

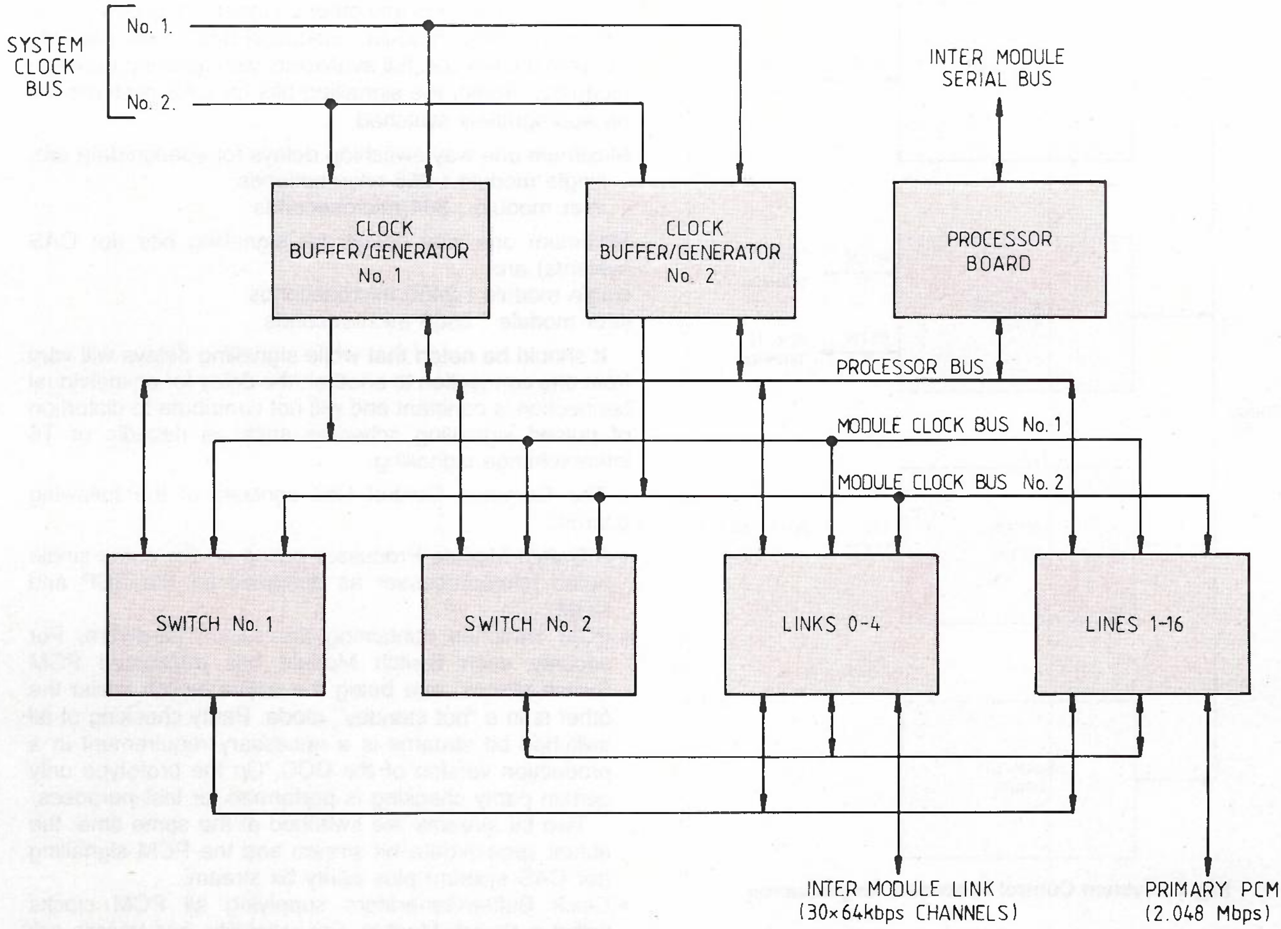


Fig. 4. Switch Module Block Diagram

module functions independently of the other three. Failure of one module is designed not to affect the others. Furthermore, the system is designed to be able to recover on correction of a fault condition. Some common software building blocks are used in a number of different modules, e.g. the Executive and communication programs in the SCP, CGM and Switch Modules.

All communication between modules is initiated either by the Local Terminal in response to an operator command or by the SCP. The software structure of the DCC is shown in **Fig. 5.** Each module contains its own communication routine for communication to other modules.

4.3.1 The System Control Processor (SCP)

The SCP software comprises the following routines (see Fig. 5):

- A Communication routine which facilitates communication between SCP routines and corresponding routines in other modules, e.g. the SCP switching routine and the Switch Module switching routine.
- An Executive routine which supervises and coordinates program execution within the Module, including message flow control and routine exit and restart procedures.
- A Switching routine which translates valid user connection/disconnection commands from the Local Terminal to particular actions to be performed by particular Switch Module(s). It also provides the DCC status display at the local terminal when requested by the operator.
- An Alarms routine which maintains a log of alarms and generates alarm messages to be displayed at the Local Terminal and printed at the printer. All alarms are time-stamped.
- An Audit routine which regularly interrogates the status of the Switch Modules and the Clock Generator Module. It generates a 24 hour total alarm record to be displayed at the Local Terminal or to be printed.

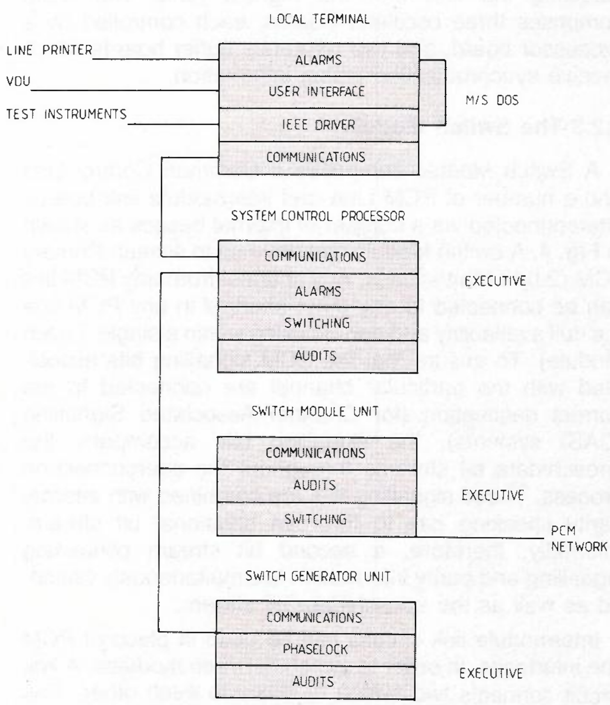


Fig. 5. DCC Software Structure

4.3.2 The Clock Generation Module (CGM)

This software Module consists of an Executive routine which coordinates the activation of the following other routines:

- A Communications routine which facilitates communication between CGM and SCP routines.
- A Phase Lock routine which ensures that the DCC clock is properly synchronised to the external reference source. It also detect failure and reports this to the Alarms routine.
- An Alarms routine which receives all module alarm messages which are then sent to the SCP.
- An Audit routine which continually monitors the operational status of the CGM, including majority logic and reference source operation.

4.3.3 The Switch Module

The Switch Module Executive routine, in a similar fashion to the SCP and CGM Executive, coordinates the activity of the other routines. It communicates to the SCP via the Communication routine. The remaining routines of the module are as follows:

- A Switching routine to control the switch hardware and perform the connection and disconnection of specific channels in response to commands from the SCP.
- An Audit routine to regularly determine the current status of the switch hardware, and send this information together with any module alarms to the SCP.

4.3.4 The Local Terminal

The Local Terminal programs are run under MS-DOS. After system initialisation, control is passed to the User Interface routine which will then respond to operator commands. The Local Terminal software consists of the following routines:

- A User Interface routine to provide the interface between the operator and the Local Terminal.
- A Communication Driver to handle the communication protocol between the Local Terminal and the SCP.
- An Alarms routine to display alarm messages coming from the SCP, irrespective of the state of the Local Terminal. The same alarm messages are sent to the printer as they occur.
- An IEEE-488 driver which transforms data/command into the form required by the IEEE-488 standard.

5 Conclusions

The Digital Cross Connect project has resulted in the development of a prototype switch currently under evaluation. The system architecture is based on modular and distributed intelligence system principles. This approach ensures that enhancement and additional facilities in the future can be incorporated economically. In particular the system allows economic expansion of capacity. This feature is an important supplement to low first-in costs. Other features of the DCC include:

- remote control capability allowing a network of DCCs to be controlled from a single terminal.
- transparent switching of speech/data and signalling information for Channel Associated Signalling (CAS) or non-CAS systems.
- the facility to individually test any 64 kbit/s channel.
- a potentially high level of system availability and reliability due to the use of parallel redundancy techniques and extensive monitoring and testing of system operations.

System tests so far have indicated the technical viability of the design approach. Further stages of development will depend upon the economics of production models and comparisons with similar products to meet perceived network requirements. The product has potential to facilitate more economical management of primary PCM systems in a network including:

- replacement of back to back PCM multiplexers and manual cross connection of individual channels
- packing PCM lines for long haul transmission
- speedy provision of new PCM lines
- automatic rerouting of PCM lines due to bearer failure
- dynamic allocation of PCM channels according to time of day or traffic density
- concentration of various traffic types, e.g. AUSTPAC, ISDN or Dedicated Data Network traffic.

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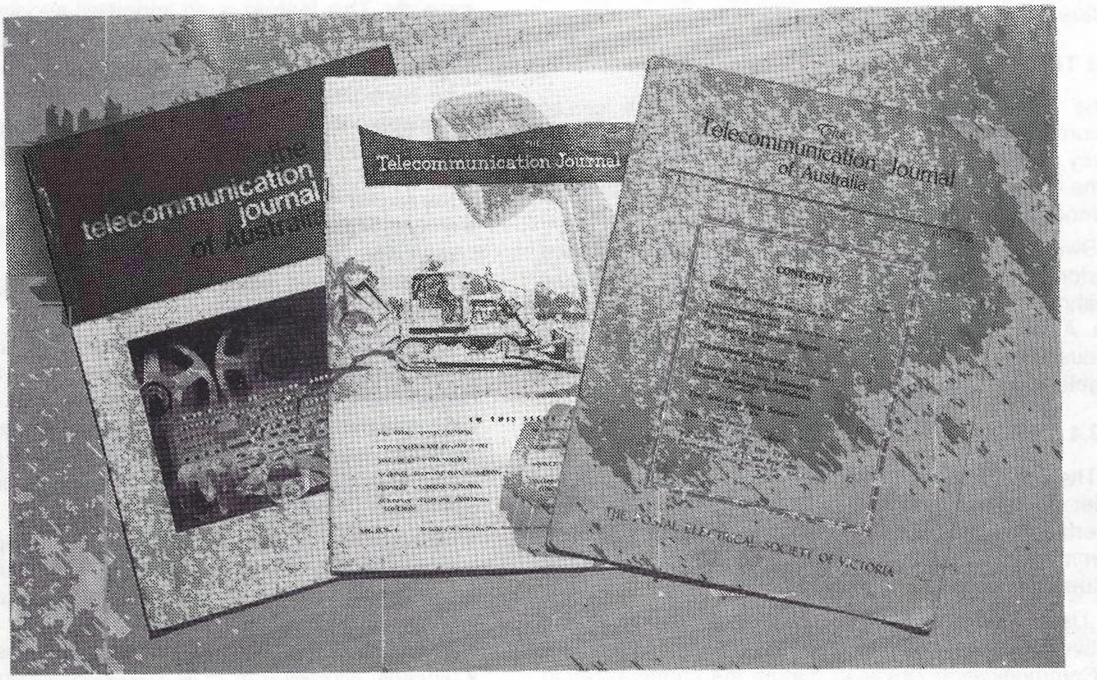

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Telecommunications and Economic Development

JEAN-CLAUDE DELORME

In May, 1986, Jean-Claude Delorme, President and Chief Executive Officer of Teleglobe Canada, addressed business and government representatives from Argentina and Chile, in his capacity as Chairman of the Advisory board of the Centre for Telecommunications Development.

In his presentation, Mr Delorme identified telecommunications as one of the key factors of economic development. He discussed the level of priority given to communications in the development process and the impact of the expanding world market for telecommunications.

"Development is a gradual process shaped by many other priorities. The various stages of economic and social development must be co-ordinated with growth in the telecommunications sector. On the other hand, the absence of an adequate telecommunications infrastructure may impede or delay the development of a country whose economy has been stimulated by investments in other priority sectors," stated Mr Delorme. He concluded by defining the role that the Centre for Telecommunications Development will play for developing as well as for industrialized countries.

INTRODUCTION

Beyond doubt we are all in agreement that particularly in the past two decades the world, at large, has experienced an incredible technological revolution in the field of telecommunications, and is still continuing to do so. The question to be posed is whether the impact of this change has been universal.

From its establishment in 1865 to the early 1970s, the emphasis of the ITU has been on administrative and technical matters. Traditionally, the ITU has been concerned with regulating and co-ordinating the existing telecommunications services of the various countries. However, the changing political and economic environment of the 1970s has prompted the Plenipotentiary Conferences of 1973 and 1982 to address the issue of developing countries. Today a major pre-occupation of the ITU is the development of telecommunications services for those countries which are currently lacking them.

The Plenipotentiary Conference of 1982 adopted Resolution No. 20 which called for the establishment of the International Commission for Worldwide Telecommunications Development, more commonly known as the Maitland Commission. In summary, the mandate of the Commission was to examine existing and possible future relationships between countries in the field of telecommunications and to make recommendations for stimulating telecommunications development in the developing countries.

As part of the recommendations made by the Commission, it was strongly suggested that a Centre for Telecommunications Development, which concentrated on assistance to developing countries, be created in 1985 by the Administrative Council of the ITU. The Centre for Telecommunications Development, in essence is intended to facilitate the achievement of a comprehensive worldwide network of telecommunications.

THE DEVELOPMENT OF TELECOMMUNICATIONS IN THE WORLD

Since World War Two, the number of telephone sets has increased by more than 800%, growing from 41 million in 1945 to 400 million around 1980. According to the Maitland Commission, it has grown another 50% since 1980, to 600 million in 1984.

At present, 84% of the world's population has to manage with only 15% of all the telephones in the world. To be even more specific:

— 66% of the world's population have no access to telephone services;
— 75% of the world's population live in countries where there are less than 10 telephones per 100 inhabitants;
— 50% of the world's population live in countries where there is less then 1 telephone per 100 inhabitants;
— by comparison, Tokyo alone has more telephones than the whole of the African continent with its total population of 500 million people;
— and Japan has more telephones (64 million in 1983) than all the developing countries of Asia, Africa and South America.

Confronted with such a reality, what has been the reaction of international development organizations?:

— the United Nations Development Program has channeled only 4% of its funds to telecommunications projects;
— only 2% of total United Nations agencies funds go to telecommunications;
— from 1969 to 1973, the World Bank directed only 5.4% of its total loans to telecommunications development and this percentage dropped to 1.7% for the period 1979-1981;
— the Inter-American Development Bank has allocated in the past only 1.4% of its loan funds to telecommunications projects.

This is the "balance sheet" of three decades of telecommunications development in the world.

NEEDS OF DEVELOPING COUNTRIES

We all know of course that food, housing, health, education and transport constitute the priority list of any developing country. Man's priorities and needs differ in accordance with economic, social and cultural stages of development. And these priorities are set by the emerging nations themselves.

But at the same time, we all agree that the gap between the industrialized countries and the developing ones must be bridged just as we all agree that we must address the problems arising from the differences in the level of development of telecommunications systems throughout the world.

This means that the development of telecommunications should be considered among the national investment priorities of developing countries. However, development requires co-operation, and co-operation requires planning.

I am not saying that economic development of the upgrading of telecommunications systems is a goal that will not be achieved during our lifetime. On the contary, I firmly believe in a rational, systematic, planned and co-ordinated development effort. I strongly believe in productive development, that is, development based on the introduction of technology that answers the specific social, cultural and economic needs of a nation.

HOW ARE THOSE NEEDS BEING MET

The UNDP, financed by voluntary contributions pledged annually by governments, funds technical co-operation and pre-investment support for economic and social development. It is the beneficiary governments which determine the priority sectors and projects for UNDP support.

The 1984 World Bank Annual Report clearly indicates the progress accomplished by the Latin American countries during the last 30 years. I quote:

"Despite the severity of the current financial crisis in Latin America, the underlying strength of these economies endure. Considerable progress was achieved in the countries of the region during the three decades that followed World War II. Economic growth was rapid and followed an upward trend. Output in 1980 was five times higher than in 1950, and per capita output rose threefold. While population has doubled since 1950, the rate of population growth has declined significantly in recent years. This trend has had favorable implications for future social expenditures and for job creation. Improvements in human welfare have been substantial. Life expectancy has risen from fifty-one to sixty-four years. Child mortality has declined from twenty-three per thousand to less than six per thousand. The literacy rate has increased from 57 percent to 80 percent. The region is also one that is richly endowed with natural resources, many of which still remain untapped." (The World Bank Annual Report 1984).

Yet despite this general advancement, little has been done in the area of telecommunications. According to the same Report, countries in Latin America and the Carribbean borrowed a total of US$3,027.5 million in 1984 from the World Bank, which was distributed as follows:

— Agriculture:	US$856.9M - 28.3%
— Energy (Power):	843.0M - 27.8%
— Transportation:	501.1M - 16.5%
— Small Enterprises:	352.0M - 11.6%
— Urban Development:	191.2M - 6.3%
— Education:	68.0M - 2.2%
— Health, Nutrition:	57.5M - 1.8%
— Telecommunications:	30.0M - 0.9%
— Water Supply, Sewage:	28.6M - 0.9%

This indicates that in 1984 less than 1% of the sums borrowed from the World Bank (i.e. US$30 million) has been allocated for the development of telecommunications in the Latin American and Carribbean region. This does not mean however that other sums from loans, other sources and investments made by telecommunications carriers from their own revenues, were not actually added to this $30 million figure. Figures for the previous years covering loans from the World Bank for the telecommunications field convey similar results:

— From 1975 to 1979, the annual average of loans allocated to telecommunications has been 1.5% or US $26.9MILLION;
— 1980: 1.6% or US$44 million
— 1981; 0
— 1982: 1.3% or US$40 million
— 1983: 0
— and as we have seen, 1984: 0.9% or US$30 million.

Given the limited financial capability of developing countries, their needs for public health, education, food, water supply and transportation will hardly allow concomitant investments in telecommunications.

Though substantial variations exist in the stages of economic development among the developing countries, and among the various regions within each country, some countries have a large "modern sector." The growth of the "modern sector" must be encouraged by a development policy in which telecommunications, rather than simply being a means of linking government and corporate offices, takes on the role of a "change agent" in modernization.

Correlation Between Telecommunications Development and the Economic Development of a Country.

Like all other components of a country's infrastructure, its communication facilities are closely linked to the gross national product (GNP). According to Dr. Joseph Pelton of Intelsat, "there is a more than 80 per cent correlation between telephones per capita and GNP per capita. In highly developed industrialized countries with a high GNP, telephone density is in some cases far in excess of 500 sets per 1000 people, whereas in countries with a low GNP there is often less than 10 sets for every 1000 members of the population.

Telecommunications services therefore play an essential role in the economic development of a nation. This is especially true for developing countries, and particularly those in geographically isolated regions of the world. The development of a telecommunications network affects economic development in a number of ways. For example, it enables industry to locate near its sources of raw materials and consequently brings industrial growth to rural areas; it facilitates contacts between producers and consumers, allowing corporations to expand and branch out into other regions of a country; finally, it increases domestic trade while also contributing to the creation of assets and the establishment of a financial infrastructure, including regional banking centres. Of course, the health and social service sectors are also closely tied to telecommunications, but it is this correlation between telecommunications and development, as demonstrated in the examples just given.

The tertiary sector is generally the most important user of telecommunications services. This sector includes, among other things, industries related to services, commerce, finance and transportation. In India, for example, the needs for telecommunications services among those industries are distributed as follows:

Commerce:	67% of utilization
Banking-Insurance:	14
Education-Research:	9
Transportation:	8
Others:	2

This example demonstrates the importance of good telecommunications services in a country's trade. This relation applies as well for the developing countries as for the industrialized ones, where a close link has been observed between the growth of trade and that of telecommunications services, such as telephone and telex.

Having established a relation between telecommunications development and the economic development of a country, I wish to examine this question more closely.

Firstly, there is a two-way cause-and-effect relationship, in that a country's economic growth brings about a greater demand for telecommunications services. The more industrialized the country, the more pronounced is this phenomenon. Here again, it is important to distinguish between the implementation of new telecommunications systems and the increasing demands on existing ones. In industrialized nations, where basic telecommunications networks (telephone, telex) have been established for a number of years, economic growth usually stimulates demand for telecommunications services, which is reflected in a greater use of existing networks. In developing countries, however, economic growth would rather call for an expansion of the telecommunications network capacity and, consequently for appropriate investments to be made when needed. The economic fallouts of these investments bring the industries more efficient telecommunications services, enhance their productivity and therefore contribute to the economic growth of the country. For example, if an increase in network capacity is expressed in terms of additional installed telephones, a 1% increase in telephone density (the number of telephones installed per 1000 inhabitants) would have a more significant impact on economic growth in a developing country than in an industrialized country.

	Initial Density	Increase in Density	New Density	Contribution to Counry's GNP
Industrialized country	80%	1%	81%	0.01%
Developing country	20%	1%	21%	0.09%

As we can see from this table, when the density of a telecommunications network increases by one percent in an industrialized country, there is a corresponding 0.01% rise in the GNP. However, the same 1% increase in a developing country would result in a 0.09% rise in the GNP.

Such an effect can be explained by the concept of marginal utility which states in this case that the greater the density of installed telephones, the smaller the economic impact of adding new phones. Inversely, the lower the telephone density, the greater the economic impact of expanding the telephone network.

However, the correlation between telecommunications and economic growth depends on a basic level of economic development. This is especially true for the business sector. In other words, the greater the industrial infrastructure, the greater the multiplier effect in absolute terms.

It is interesting to note that installation of telecommunications services in the business sector, namely telephone sets, seems to have a greater economic impact in the industrialized countries. In developing countries, the installation of residential telephones seems to have a greater impact on the economy.

While there is a definite link between a country's telecommunications development and its economic development, we should avoid taking this line of reasoning too far by concluding that a modern telecommunications infrastructure alone will put the economy of a developing country on a par with the economies of major industrial nations. Development is a gradual process shaped by many other priorities. The various stages of economic and social development must be co-ordinated with growth in the telecomunications sector. On the other hand, the absence of an adequate telecommunications infrastructure may impede or delay the development of a country whose economy has been stimulated by investments in other priority sectors. Consequently, when development is progressive and co-ordinated, the corrrelation will have maximum repercussions in both directions and the development of the telecommunications infrastructure can bring lasting benefits to a country.

Therefore, it seems reasonable to conclude that an adequate telecommunications infrastructure is vital to the growth of an economy which, in turn, contributes to the development of telecommunications networks and the penetration of telecommunications systems.

Global market development

We should keep this correlation in mind, when we read that:

- over the last decade, the major telecommunications equipment-producing countries have witnessed more rapid growth in their exports and imports of their telecommunications products than in the growth of their domestic markets;
- the current world market in telecommunications which was about US$45 billion in 1984, should reach US$60 billion in 1987, and US$90 billion in 1990;
- from 1983 to 1990, the world market for information products and services (which includes telephone, computer, and semiconductor industries) is expected to more than double from about US$400 billion to over US$932 billion . . . an annual growth rate of 12 percent;
- the share of global investment in the personal communications sector of the less developed and newly industrialized nations has grown from 20% in 1970, to 25% in 1980, and will grow to 30% in 1990; that 30% of all telephones required throughout the world in the year 2000 will be installed in Asia alone; and that the flow of goods and information in world trade, which accounted for 23% of the global GNP in 1980, is expected to rise to 30% by 1990;
- the Maitland Commission estimates that some US$8 billion, from all sources, have been invested in new equipment for public telecommunications in the developing countries in 1983 and that US$12 billion are needed every year to upgrade and extend these networks;
- the Latin American market for the development of telecommunications equipment is estimated at US$3 billion per year.

Telecommunications in Latin America: a changing marketplace

As I have said before, telecommunications is a tool of economic and social development. There is a close interrelation between economic activity and telecommunications services. With increasing industrialization, the various sectors of an economy become more dependent on each other. With increased interdependence, an increasing amount of information must be exchanged in real time among participants. Telecommunications constitutes a vital link to tie the sectors into an economic unit.

Telecommunications in Latin America is a multibillion dollar market, and forces are at work to expand it.

For example, in Peru, emphasis is being placed on telecommunications as a means of establishing national economic integration. As new areas of agriculture and manufacturing concerns are being encouraged to locate in less developed areas of the country, Peru has called for a 5-year plan to improve the telecommunications sector as part of the effort to promote this economic, social and cultural integration of the country. Expenditures for this telecommunications plan is expected to exceed US$800 million over the 5-year period.

Other countries such as Brazil, Mexico and Ecuador are also establishing telecommunications programs with the aim of rural development and economic integration. Not only are major projects being undertaken, but the most sophisticated, state of the art technology is also being sought. Sooner or later, all countries will be converting their national networks from analog to digital technology. Satellite systems are already overcoming the obstacle of extensive and harsh terrain. High technology has been found to be the most cost-effective solution.

In Latin America, the need for improved telecommunications is widely recognized. As the table below shows, there is room for expansion in telecommunications accessibility. The telephone densities, that is the number of telephones per 1000 people, of countries in Latin America underline that need for expansion. It is interesting to note that a density of 200 telephones per 1000 people is considered as the takeoff point of telecommunications development in a country.

GROSS NATIONAL PRODUCT per capita and TELEPHONE DENSITY

	US$(1983)	Telephones per 1000 people (1982)
Bolivia:	510	26
Peru:	1040	30
Paraguay:	1410	20
Ecuador:	1420	39
Colombia:	1430	68
Chile:	1870	52
Brazil:	1880	72
Argentina:	2070	111
Uruguay:	2490	100
Venezuela:	3840	62
by comparison:		
United States:	800 telephones per 1000 people	
Canada:	705	
Australia:	554	
France:	528	
United Kingdom:	524	
Japan:	490	
Italy:	387	

(Sources: — Rapport sur le développement dans le monde 1985, Banque Mondiale
— The World's Telephones, AT&T, 1982.

From this perspective, how can we envisage the role of the Centre for Telecommunications Development?

The development of Third World countries, particularly with regard to their telecommunications services, remains a relevant issue in 1986, even though the international community has addressed it and endeavoured in various ways to find adequate solutions in the four decades following World War II.

Despite these efforts and the huge sums of money channeled by the industrialized nations into the development of emerging countries, the needs of these countries continue to be tremendous. Undeniably, significant progress has been made. However, it is equally undeniable that in spite of these endeavours, a wide gap between the least-developed countries and the industrialized countries still persists.

In our field of telecommunications, the efforts of the industrialized countries during the past few years have been considerable. Nevertheless, the figures I quoted earlier demonstrate clearly that telecommunications development has always been low on the list of priorities, and that the amounts budgeted for this development represent a mere fraction of international aid budgets.

Given the magnitude of these diverse needs, the international community faces a serious dilemma. In the case of the least-developed nations, it is natural, not to say imperative, to first alleviate famine and misery. For these very reasons, how can one deny the importance of promoting agricultural development, health services, and educational programs when the needs are so painfully clear?

Nevertheless, we must realize that not all developing countries are in equally precarious situations. Indeed, through their own efforts along with assistance from the industrialized countries, many of them have been able to meet their most basic needs while at the same time building industrial and economic infrastructures which will surely enable them to place the necessary emphasis on telecommunications development from now on. Similarly, these countries have also succeeded in investing much larger sums of money in transportation and energy, two more key components of a nation's economic and industrial infrastructure.

The International Telecommunication Union has been advocating this position for over 15 years. Very explicit resolutions were adopted along these lines at the ITU Plenipotentiary Conferences at Torremolinos in 1973 and at Nairobi in 1982. These resolutions illustrate the persistence, and even impatience, with which the representatives of ITU Member Countries expressed their determination to find ways of accelerating telecommunications development. Suffice it to say that the preamble of Resolution No. 20 adopted at the Plenipotentiary Conference of the ITU held in 1982 in Nairobi recognizes "the fundamental importance of communications infrastructures as an essential element in the economic and social development of all countries." Moreover, this declaration is based on a resolution of the United Nations General Assembly which, to stress its belief in the principle just mentioned, proclaimed 1983 as World Communications Year. The General Assembly thereby hoped to stimulate the development of telecommunications infrastructures as well as provide an opportunity for all countries to undertake an in-depth study and analysis of their communications development policies.

Aware that words must be put into action, the 1982 Plenipotentiary Conference of the ITU aimed to adopt practical measures, one in particular being the creation of a commission to study the general problem of telcommunications development. Thus began the Independent Commission for World Wide Telecommunications Development, better known as the Maitland Commission, after the name of its chairman.

The Commission's work, begun in late 1982, was completed in early 1985, when its report was presented to the ITU General Secretary. This report, with the particularly revealing title of "The Missing Link", provides a relatively succinct overview of the situation. Fortunately the Commission adopted a pragmatic outlook from the start, and purposely avoided duplicating previously completed work, which included numerous studies on the topic. Indeed, the Commission attempted to "draw conclusions from the existing situation and recommend remedies."

From the viewpoint of the Centre for Telecommunications Development — and I am very honored to be chairman of its Advisory Board — the Maitland Commission report is an important milestone on the road toward what I hope will be accelerated telecommunications development. Though the Commission made many recommendations, its main conclusions can be summarized in the following two important points:

(A) That the concerned parties "re-examine the importance they accord telecommunications and provide sufficient resources for its growth"; this recommendation is addressed not only to the administrators of aid programs but also to the beneficiaries of these programs. In most cases, the responsibility falls on these beneficiaries to distribute the allocated amounts and, consequently, to determine the share for telecommunications.

(B) Secondly, the Maitland Commission recommended that a centre for telecommunications development be established by the ITU Administrative Council. The Commission based this recommendation directly on its conviction that the scope and the extent of the telecommunications assistance programs must be greatly increased, and the corresponding administrative procedures must be rationalized to make the necessary improvements.

As of July, 1985, that is, less than six months after publication of the Maitland Commission report, the ITU Administrative Council ratified the recommendation and created the Centre for Telecommunications Development. The Council has already held two meetings — one in November 1985 and one in April 1986; the next meeting is slated for the beginning of June. Hopefully the Council will be able to name the executive director at that time so that the Centre can take up its activities during the next few months.

The formation of the Centre indeed constitutes an important step forward, but this does not mean that all existing problems will be solved easily or automatically. Although the objective pursued by the international community is clear and undisputed, the means for achieving it are more difficult to define and put into application.

The Centre for Telecommunications Development is a new organization or, if you will, a new cog in the extensive international machinery available to organizations providing assistance for telecommunications development. Of course, its ultimate effectiveness will be judged by the results it produces. We should, however, bear in mind that the Centre alone will not be able to solve all problems in spite of our high expectations. We can only hope that it will make an effective contribution to the efforts of existing organizations by working closely with them, and especially with the International Telecommunication Union.

In my opinion, the Centre will, through its own efforts and by co-operating with existing organizations, have accomplished its mission and attained its goals if it succeeds in contributing significantly to the achievement of three major objectives;

— First, to convince developing countries as well as bilateral or multiateral aid agencies of the importance of giving telecommunications a higher priority in the overall social and economic development of Third World countries;

— Second, to help reduce significantly the gap between developing and industrialized countries in the area of telecommunications;

— Third and last, to help developing countries gradually become more self-reliant, not only from the standpoint of operating their telecommunications services, but also, and above all, from the standpoint of managing these services.

These objectives will be achieved gradually and to the extent that necessary financial resources are available. However, it should again be stressed that the Centre cannot take sole responsibility for achieving these objectives. Such a responsibility must be shared by all members of the international community, and this will require the combined efforts of all concerned, including governments of industrialized nations, international organizations, contributors and beneficiaries.

There are numerous ways to achieve these results and I have no doubt that the Centre and its partners will clarify them or even improve on existing methods. I would suggest that the following three-point strategy be kept in mind while seeking the most appropriate methods to achieve the objectives just mentioned:

(A) First, the Centre and its partners should always endeavour to optimize the financial resources at their disposal. Obviously, there are never adequate financial resources to meet all needs, if only because of the many priorities outside of telecommunications, as I alluded to earlier. From my own standpoint, optimizing financial resources means much more than simply paying a reasonable price for equipment and services. In the context which concerns us here, optimization also means that there is no duplication of effort, that prices correspond to the real usefulness of equipment and services, and finally that such equipment and services in turn correspond to real needs as well as priorities which have been previously established in a rational manner.

(B) The second point stems from the first and deals with meeting needs. As I have just indicated, aid programs must attempt to satisfy real priority needs. Consequently, these should not be defined unilaterally by the industrialized countries, but rather should be determined with the full knowledge and co-operation of the authorities in the countries receiving aid. The concepts, technologies and systems develped in the industrialized nations cannot simply be transplanted into the developing countries without first being adapted to the real needs of such countries. I am certainly not the first person to make such an observation and, indeed, there are numerous examples of investments, including some major projects, which did not generate an appropriate return. It is therefore important to bring together the beneficiaries as well as the contributors or suppliers of equipment and services. And it is also necessary to continue helping the beneficiaries to define their own requirements and substantiate their requests for assistance in line with their own telecommunications priorities.

(C) This brings me to assistance for training programs, the third point in the strategy which should guide the activities of the Centre and its partners if the developing countries are to achieve self-reliance. As I mentioned previously, numerous high-quality training programs already exist. However, they have usually emphasized what I would call "short-term" and "utility-oriented" training. By this I mean programs such as those aimed at operators and technicians responsible for operating and maintaining various equipment. Far be it from me to imply that these training courses are unnecessary. Nevertheless, if the developing nations are to become self-reliant, we must develop more long-term objectives and concentrate our efforts on more general training courses in the fields of management, planning, organization, marketing and, of course financial management. Some excellent courses are already available: they should be continued and broadened in scope.

Before concluding, I thought it might be useful to briefly review the mandate given to the Advisory Board with respect to the Centre's activities. According to the terms of Resolution 929 of the ITU's Administrative Council, the Advisory Board's purpose is to "provide . . . necessary directions to the Centre for its functioning; and to ensure that it is responsive to the needs and views of its potential contributors and beneficiaries."

It was also resolved that the Centre would have its own budget but that funding would be based exclusively on contributions made in cash or in kind. In addition, the Centre's activities are to complement those of the ITU's Technical Co-operation Department and, for this reason, the resolution stresses the importance of effectively co-ordinating the activities of both bodies to avoid duplicating work and to avoid inefficient use of resources which are necessarily limited under the circumstances.

The Centre for Telecommunications Development will be neither a bank nor a consulting firm competing with the private sector. For the most part, therefore, it will focus on the overall planning phase which must precede investments or other activities of a strictly commercial nature. The Centre could play a very useful role in this context by acting as an intermediary between the beneficiary countries and the various bilateral or multilateral aid agencies, as well as with suppliers of services and equipment. Thus the Centre should be in a position to provide objective and valuable advice concerning policies on telecommunications development as well as on the actual development of telecommunications.

In conclusion, I hope to have made a useful contribution to this seminar and, especially, to have provided you with a better understanding of the role of the Centre for Telecommunications Development, this newcomer on the international scene. Its future is certainly promising but of course its achievements are yet to come. I would simply ask for your confidence: give the Centre time to prove itself. Moreover, I can assure you of the determination and sincerity of the Members of the Advisory Board who are prepared to do everything in their power to ensure that the Centre achieves its assigned objectives. To this end, the Centre must be willing to explore new avenues and continue to count on the co-operation of existing organizations. It must also seek innovative solutions to develop programs which correspond both to the interests of the beneficiaries and the objectives of those who can make a tangible contribution to their telecommunications development. However, none of this will be possible if the Centre lacks adequate financial resources. In other words, the Centre's ability to carry out its promises is directly related to the extent of its resources. Up to this point, requests for financial contributions have been favorably received but only modest amounts have been collected. For my part, I sincerely hope that it will soon be possible to adopt a more systematic approach in mobilizing the necessary financial resources, not only from those countries represented on the Advisory Board, but also from the international community as a whole.

On the other hand, if the Centre as well as the developing countries themselves are successful in appropriating a greater share of the financial assistance available under existing progams, the resources available for telecommunications development will increase significantly. From this standpoint, the developing countries themselves have a key role to play because it is often their governments which determine the priorities for the financial assistance received for development.

Other organizations such as the national and international agencies in charge of administering bilateral or multilateral aid programs to developing countries also share some of this responsibility. Here again the Centre could play a useful role by supporting the representations made to these agencies, so that these same agencies recognise the need to place higher priority on telecommunications development. The amounts freed in this way would not appear on the Centre's budget since they would simply result from a shift in the priorities affecting the allocation of money already available under existing programs.

Suffice it to say that the purpose of the Centre for Telecommunications Development is twofold: it must serve Third World countries with regard to their aid programs as well as the industrialized nations, including their governments and industries. Furthermore, the multilateral aid agencies can and must play a leading role in achieving the objectives assigned to the Centre for Telecommunications Development. The expectations for the Centre are high, and some impatience is already evident. However, "where there's a will, there's a way." If we truly want to achieve our goal and are willing to maintain the required level of determination it will be possible to turn our words into deeds.

The New Teletraffic Engineering*

PETER GERRAND, B.E. (Hons.), M. Eng.Sc.

The new role of teletraffic engineering is discussed. Who are the customers and what are their requirements? What is the nature of the process by which the necessary expertise can be developed and applied? What are the consequences of not using this expertise?

The essential contributions of teletraffic engineering to system and network design, dimensioning and operation are shown to be vital to underpin the commercial success of network administrations and switching systems suppliers. Teletraffic expertise is needed to be able to offer network products with competitive performance advantages, to credibly guarantee performance in advance of wide-scale implementation, to provide commercial flexibility in trading off costs against performance, and to provide commercial reliability in providing the network performance that the customer has paid for.

The greatest current challenge to teletraffic engineers is to develop and apply their expertise to future multi-service networks carrying a proliferation of different services, with distinct end-to-end performance criteria. The now critical role of teletraffic researchers is to rapidly develop the necessary methodologies and computer aids that will permit their expertise to be applied in a cost-effective way. This will not happen in time in Australia unless the best available research talent in Australian Universities and Institutions of Technology is roused, co-ordinated, guided and adequately funded.

1. INTRODUCTION

Ten years after the only International Teletraffic Congress to have been held in Australia, and on the occasion of the first Australian Teletraffic Research Seminar, it is appropriate to review the role of the teletraffic engineer and of the teletraffic engineering discipline. Indeed, given the chill winds of our national economic climate, and the need to review all our work practices in order to improve our commercial effectiveness and business efficiency, it is essential to pose some very basic, indeed threatening, questions, such as:

What **is** the role of teletraffic engineering today? **Who needs it?** Can we do without it, or perform it in a much more effective way? If it **is** considered essential are there better ways of generating the necessary expertise, and applying it?

I hope in this paper to give good answers to these questions. While my primary focus is on the role of teletraffic engineers within a network administration, I believe many of the conclusions are also valid for teletraffic engineering within the context of telecommunication manufacturing, consultancy and academic research.

2. WHO IS THE CUSTOMER?

To clear the air, I propose a simple definition of teletraffic engineering:

Teletraffic engineering is the application of mathematics to the economic design, dimensioning and operation of telecommunication systems and networks, in order to satisfy service performance objectives.

This definition is deliberately oriented to the end-results of teletraffic engineering, as seen by the users of these outputs. If you ask a teletraffic engineer to define teletraffic engineering, (and I have), he or she is likely to define it also in terms of traffic modelling, measurement and forecasting, together with performance analysis of systems and networks; but I see these activities as being essentially a means towards certain ends, the ends of design (for development and manufacture), dimensioning (for planning and installation), and operation (for network management) that are most meaningful to the teletraffic engineer's customers.

Trusting that you agree in broad terms with my very simple definition, it is then necessary to ask: if that is what teletraffic engineering is, then who are the teletraffic engineer's customers, and what are their current and likely future requirements?

The terms **design, dimensioning** and **operation** that appear in the definition normally imply three distinct phases in the development and application of telecommunication systems and networks. The well-equipped teletraffic engineer should be capable of applying his or her mathematical skills to each of these phases; but the customer, the user of the teletraffic engineer's services, will be a different kind of person in each of these phases and will have different kinds of requirements for assistance. I will now elaborate on these points.

3. CONTRIBUTIONS TO SYSTEM DESIGN

3.1 In the manufacturer's organisation

Ideally, the design team for any complex telecommunications system will include a teletraffic engineer, or at least a person with considerable applied mathematical skills, in order to analyse the performance of the system under different hypothetical traffic loads — but the world is not an ideal place, and most of our telecommunications systems are still designed with much more art than science. Therefore it remains typical within manufacturing organisations that the teletraffic engineer is called in as a consultant to the system design team, after the basic system design has been fleshed out, in order to ascertain, by simulation and analytical techniques, the traffic capacity limits of the system design and its likely behaviour under overload conditions.

In the design phase, and within the system developer's organisation, the **customer** of the teletraffic engineers'

★ **FOOTNOTE:** This paper was presented at the First Australian Teletraffic Research Seminar on 25 November, 1986, at Telecom Australia's Research Laboratories, in Melbourne.

services is therefore typically the head of the system design team. The particular requirements of the teletraffic engineers, beyond their mathematical knowledge and skills, is their ability to rapidly and accurately model the behaviour of those parts of the system design that are likely to affect traffic performance. Often the system design is not well documented, or at least not in a functional way to suit the teletraffic engineers' task, and frequent dialogue with the system designers becomes essential in order to carry out the modelling task.

Therefore a prime requirement of the teletraffic engineer is the ability to formulate a suitably accurate model of the ultimate system behaviour, from a starting point of verbal advice and usually inadequately documented system design decisions. Someone who requires the system designer to pre-digest the problem into mathematical terms will be of very little use to this customer. It is therefore essential that the teletraffic engineer be knowledgable in the design of modern telecommunication systems, and to be readily able to absorb and interpret the constantly evolving jargons of computer science, hardware technologies and new telecommunications services. A really good teletraffic engineer can in fact make significant contributions to the system design.

The role of the teletraffic engineer in the design phase is clearly essential for the system's manufacturer or supplier, in order to supply credible estimates of system performance to potential purchasers.

3.2 In the network administration

Teletraffic engineers in network administrations get involved in the system design phase after the systems are operational, when they are asked to independently evaluate the feasibility of introducing new services or features (such as common channel signalling, or ISDN access) into an operational system. In our experience it is next to impossible to provide the timely predictions, required by our planners, of the effect on processor capacity of computer-controlled switching systems, precisely because of the lack of direct communication with the system designers (based on the other side of the world) that is essential for gaining the relevant information necessary to model the effect of changes to the system design.

As network administrations like Telecom Australia inevitably become more heavily involved in joint or in-house development of telecommunication systems, in order to reduce the lead times taken to introduce new services as well as to work with local manufacturers to improve the national export performance, then the involvement of the administration's teletraffic engineers with the system design phase must increase.

In the meantime, teletraffic engineers in a network administration such as ours are heavily involved in the design phase of **networks:** for example, the design of new, non-hierarchical routing rules for the circuit-switched telephone network and ISDN, and the design of network management flow control algorithms for many existing and future networks. In this case the customers are the network planners and network managers respectively. These customers' requirements are separately examined in Sections 5 and 6.

4. CONTRIBUTIONS TO SYSTEM DIMENSIONING

"Dimensioning" refers of course to assigning the right quantities of all resources within a system or network's architecture, in order to economically satisfy given network performance objectives at given traffic loads. These resources not only include transmission elements such as inlets and outlets, but also common control elements such as processors, processor memory modules, signalling devices, tone senders and operator positions. Dimensioning is the traditional task of the teletraffic engineer.

The ultimate customer in this case is the purchaser of the system — which for example might be a PABX or network of PABXs, an Automatic Call Distributor, a dedicated packet-switched network or an in-building Local Area Network.

For a complex system — such as the total communications system for a corporate HQ — communications consultants will be used to carry out the role of the teletraffic engineer in dimensioning the system. For smaller systems — and for some larger systems — the need to reduce costs provides motivation for reducing the involvement of teletraffic engineers to the role of producing simple tools, in the form of dimensioning tables (or software that will generate the tables), that can be used by the salesperson or installation officer to tailor the system to meet the client's perceived needs.

The new role of the teletraffic engineer is not only the traditional role of the private consultant in assisting clients to tailor the dimensioning of complex, multi-service communication systems and private networks to meet their needs. The new role of teletraffic engineering is to

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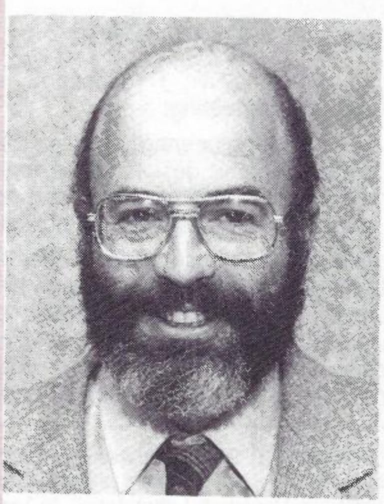
Mr Gerrand actively contributed to teletraffic research in the 1970s, both at Telecom's Research Laboratories and also at ITT's lead house for teletraffic studies in Madrid. His major contributions lay in developing new methods for modelling, analysing and monitoring processor performance in computer-controlled switching systems. In the late 1970's he led the development of a Processor Monitoring Instrument that has been used to monitor performance and debug software in Telecom's large 10C trunk exchanges and NEC mobile radio switches. He was the author or co-author of three papers presented at the 8th and 9th International Teletraffic Congresses.

He is better known for his contributions to the design of the CCITT's Specification and Description Language, SDL, and for his initiating studies of No. 7 signalling in this country. He is a graduate of Melbourne and Monash Universities, and was RMIT's first Honorary Industrial Fellow, in 1982 and 1983.



reduce the costs of such consultancy by producing versatile, self-sufficient, user-friendly software programs and manuals that a salesperson or installation officer can readily use. This requirement means that the new teletraffic engineer must be proficient in programming skills and aware of user-friendly software system design techniques, as well as relevant areas of teletraffic mathematical theory.

Do we really need the teletraffic engineer's contributions to system dimensioning? One simple, tangible answer is given by the following statistic. A software program RAND that is used to dimension Automatic Call Distributors (ACDs) and associated PABXs, written by Dr. Richard Harris of Telecom Australia's Research Laboratories, and available throughout Telecom Australia via its internal computer network, has been used over 1200 times in the past five years by Telecom's Commercial Services Departments. The frequency of usage of other associated programs is given in **Table 1.** The availability of such useful, automated dimensioning tools from teletraffic engineers provides an organisation like ours with a considerable competitive edge in the field of customer premises equipment sales and services.

TABLE 1 — Usage Statistics for Customer Equipment Dimensioning Programs

(Implemented by Telecom Australia's teletraffic researcher, Dr R.J. Harris, on Telecom's internal computing network TACONET).

PROGRAM	FUNCTION	NO. OF ACCESSES	DATE IMPLEMENTED
RAND	Analyses combined ACDs & PABXs	1289	
CAPACD	Dimensions ACDs	442	Oct. '81
DIRASS	Dimensions Directory	89	June '81
	Assistance ACDs	782	Oct. '81
CAOFD	Converts Carried Traffic to Offered Traffic		Oct. '84

A second positive answer is to point to the obvious increase over the past few years in the numbers of private telecommunication consultants in the OECD countries. A significant part of their work consists of teletraffic engineering — forecasting and evaluating their clients' traffic requirements, and dimensioning communication systems and networks to suit them. The demand for teletraffic engineering expertise "out there in the market place" is on the increase.

5. CONTRIBUTIONS TO NETWORK DESIGN AND DIMENSIONING

5.1 The new requirements

I would like to contrast a stereotype of the traditional tasks of teletraffic engineering with the real demands on modern teletraffic engineering to contribute to network design and dimensioning.

In both cases the principal customer is the **network planner.**

In the stereotype the traditional teletraffic engineer was solely concerned with forecasting traffic demand based upon population growth, and then producing minimum cost dimensions for the transmission links and switching matrices in single-service networks, whose internal design rules and tariffing policies were assumed to be quite fixed, in accordance with single, universal Grade of Service criteria. The outputs of the traffic engineer were stereotypically formulae, tables or graphs, to be used by the network planner [1]. I shall leave aside the question of whether all teletraffic engineers of the older generation fell within that stereotype; obviously many did not. But the stereotype is sadly still alive in the minds of some senior managers in the industry; it is reinforced by the educational material on teletraffic engineering found in contemporary text books; and it tends to undermine the role and under-rate the usefulness and versatility of the modern teletraffic engineer.

The modern teletraffic engineer, to satisfy the needs of the network planner, must be able

(a) to help develop new standards for **network performance,** encompassing all those performance attributes that market research shows are important to the network users. We currently focus on network availability, reliability and robustness (fault-tolerance), in addition to the traditional concept of trafficability (Grade of Service), but further performance attributes may emerge which will impact on future network design. Each of these performance standards may need to be differentiated for each new service as it emerges; and as many of these services will use the same network resources, this will involve designing and dimensioning versatile networks that can provide **distinct end-to-end performance** to different groups of paying customers.

(b) to develop and apply **new forecasting techniques,** appropriate to extrapolation from a minimum or nil historical base of measured traffic.

(c) to develop or select satisfactory, simple **models of multiservice traffic** as a starting point for network design (and network management).

(d) to **design and evaluate new, non-hierarchical routing rules** for circuit-switched traffic in current and future networks, in order to provide improved network performance at fixed network cost.

(e) to provide **user-friendly tactical planning aids** — e.g., desk-top computer tools that will enable the network planner to make short-term adjustments to the existing network in order to either introduce new services or satisfy unanticipated changes in customer demands.

Above all, the network planner needs desk-top computer tools that will enable him or her to rapidly generate **"what-if" scenarios** — the effect on network performance of speculative changes in network design, traffic demand or even the network performance standards themselves. The ability to include simple macroeconomic models that can translate speculative changes in tariffs to likely changes in traffic demand would also be of obvious value.

5.2 The additional challenge

There are at least two complicating factors that make the modern teletraffic engineer's role very difficult and challenging.

The first is the **diversification of future telecommunication services. Fig. 1** gives the author's predictions of the broad evolution of new telecommunication services in Australia over the next 14 years — with no implied commitment by Telecom Australia for introducing those services in the nominated timescales! It is noteworthy that, starting in 1988, the early "narrowband" ISDN is likely to provide common access to most services requiring no more than 64 kbit/s, and the later Broadband ISDN will probably incorporate all services requiring up to 200 Mbit/s (or even higher bandwidths). Radio networks will progressively extend the narrowband services in the

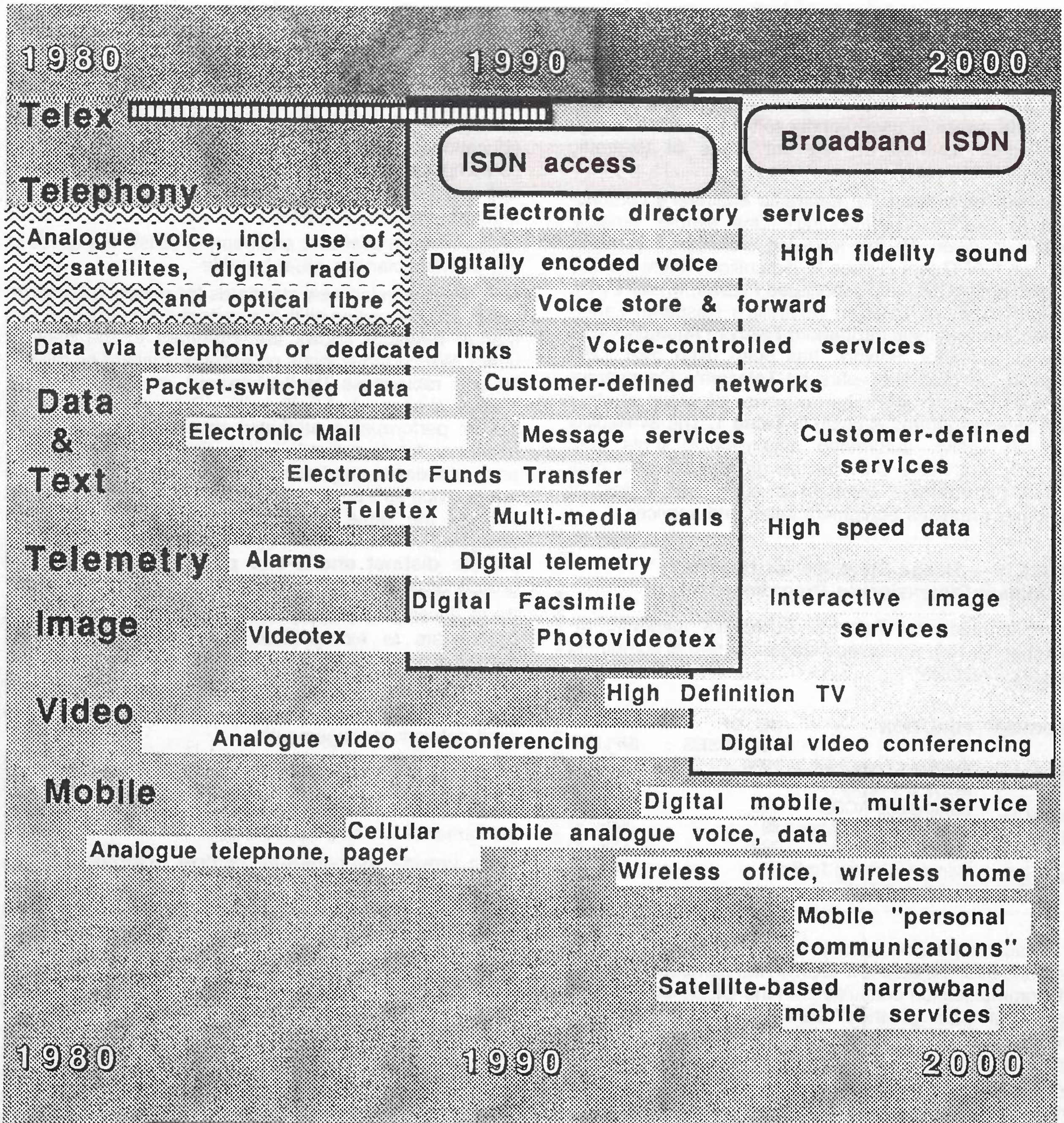


Fig.1 - Expected Evolution of Major Telecommunication Services

PG 1

Telecom Australia Research Laboratories

ISDN to more and more mobile customers; perhaps broadband services will be extended to some mobile customers by the end of the century. From a teletraffic engineer's perspective, the use of common network resources (such as optical fibre and VLSI chips) to support several different services makes very good economic sense but, when the individual services have quite different traffic characteristics and performance standards, it can complicate the mathematics wonderfully!

A second complicating factor is that of a massive **increase in network interworking,** motivated by the need to extend new services as soon as possible to customers connected to existing networks. Several networks, whose internal protocols, reliability and traffic characteristics are very different from other networks, must be interworked to permit the commercial viabilities of new services: mobile radio networks to the stationary network; Local Area Networks to not only PABXs, but also to Packet Switched Networks and to ISDN interfaces; the ISDNs to all the existing public switched networks; transaction-oriented data base management systems (that support Value Added Services) to common channel signalling or X.25-based networks; and so on. **Fig. 2** is intended to sketch out some of the main interworking necessities. Again, this requirement will add to the complexity of the mathematical models used by the teletraffic engineers and may well increase the attractiveness of network flow models from operations research over queueing theory solutions.

5.3 Commercial Consequences

What if the expertise of the teletraffic engineer is not provided? (and it is almost certain that some of these problems will not be solved in time to help the planners). Then the network administration will have to resort initially to good ad-hoc solutions, perhaps being able to confidently engineer the network reliability and availability that customers seek, but flying in the dark as far as network trafficability is concerned. Increased emphasis will be placed on **network traffic management,** in order to make the most of the existing resources in the network to improve traffic flow, and to restrict the impact of focussed traffic overloads on other parts of the network. This tactic will, however, not allow the planners to guarantee particular network performance for new services **in advance of their wide-scale implementation;** which could be a strategic difficulty when competing with private network operators making more attractive claims.

The motivation, therefore, for the use of the new teletraffic engineering in network design and dimensioning is to gain a firm, mathematical basis for relating network performance as perceived by the customer to network design and network costs, thus permitting **commercial flexibility** in trading off costs against performance, and **commercial reliability** in providing the network performance that the customer has paid for.

The cost savings through applying modern network optimisation techniques are quite significant: for example, a detailed field trial application of a modern algorithm to dimensioning the Melbourne metropolitan network for 1990 has demonstrated a cost saving of the order of 10 per cent in comparison with applying the traditional teletraffic algorithm — a saving of over $2m in equipment costs, [2]. The theoretical cost savings for this and other network applications, for which benchmark comparisons were possible, are shown in **Table 2.**

Table 2: Theoretical cost savings using a Modern Network Optimisation Algorithm compared to the Traditional Algorithm [2,3].

Network	Savings compared with traditional methods
Melbourne metropolitan network	10.8 per cent
Adelaide metropolitan network	6.5 per cent
Tasmanian trunk network	21.9 per cent

6. CONTRIBUTIONS TO NETWORK OPERATIONS

The preceding Section has pointed to the increasing use of real-time network management to partially compensate for the network planner's increasing inability to accurately predict traffic demand for new and existing services, as well as the inevitable natural disasters and equipment faults. What is the role of the teletraffic engineer in assisting the network manager as a major customer?

The modern teletraffic engineer can contribute by applying expertise and computer aids to:

(a) the creation and evaluation of **new routing and flow control algorithms,** to improve the performance of the network at minimum additional cost;

(b) the creation and evaluation of new strategies for **dynamic re-allocation of network resources** at all levels of network architecture, to improve network performance;

(c) the evaluation of **end-to-end reliability, availability, robustness and trafficability** of important sectors of the current network, by advanced measurement and analytical techniques, in order to confirm or improve current performance;

(d) the development of **efficient traffic measurement and estimation techniques,** in order to minimise the amount of data collection necessary before corrective traffic control techniques can reliably be employed, particularly to limit the impact of focussed network overloads.

(e) the development of the **best traffic overload control strategies** for the network, to cope with both network equipment failures and excessive offered traffic.

The diversification of future services and the need for extensive network interworking will again complicate the mathematical and measurement techniques needed to support this major customer.

An additional challenge will be the need to define, model, monitor and control **virtual network management facilities** provided to business customers to enable them to exercise a large degree of operational control over Closed User Group virtual networks that will compete for physical resources with other Closed User Group virtual networks within the domain of the future public networks.

Can teletraffic engineering expertise be safely ignored in modern network management? Can real-time changes to the network be made by a human network controller simply using commonsense, with an improvement to network performance comparable to that provided by the best computer aids?

Obviously, in some cases of network failure, there will be no choice other than to redirect traffic via the only remaining possible routes. But when it comes to multiple choices of how to vary link capacities in order to improve network performance, the "commonsense choices" can in fact be quite detrimental. For example, in any modern switched network with alternative routing, adding extra capacity to particular routes in order to improve end-to-end Grade of Service can in fact **reduce** the overall Grade of Service of the network (when the effect of the addition is to favour multiple-link calls over single-link calls).

It is noteworthy that today's network managers are conscious of the need to employ the best available teletraffic engineering expertise in order to assist them carrying out their function of optimising the performance of the network. An improvement of merely 0.5 per cent — half of one per cent! — in the quantity of long-distance telephone traffic that can be carried in the national network can pay for this organisation's entire overheads in network traffic management staff.

7. THE ROLE OF THE TELETRAFFIC RESEARCHER

The role of the modern teletraffic engineer is going to be crucial to the commercial success of network administra-

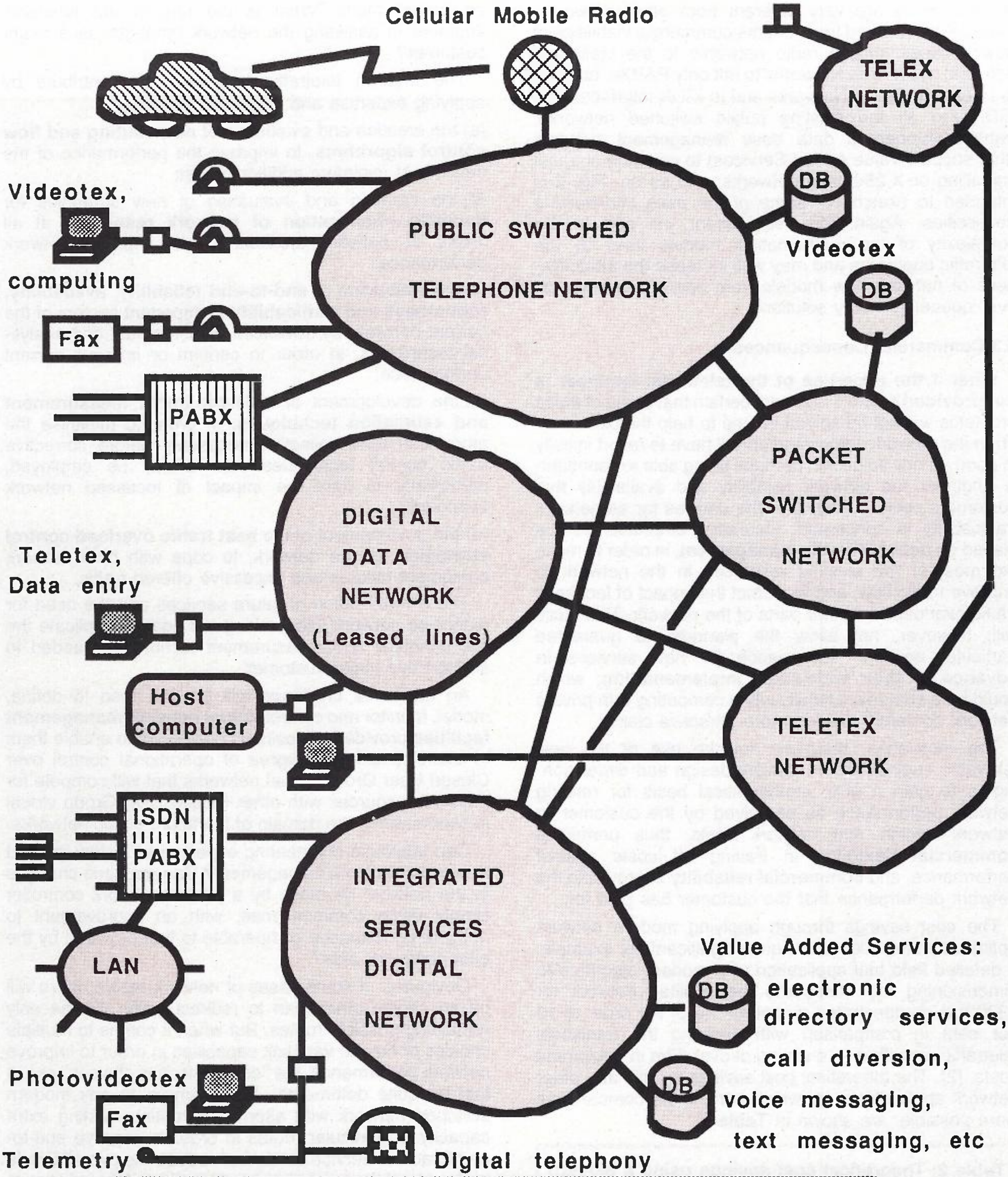


Fig.2 - Internetworking Scenario for 1990 (highly simplified)

tions and the suppliers of telecommunications switching systems and private networks — **provided** that teletraffic engineers can really meet the high expectations placed on them.

Because of the increasing complexity of new telecommunications services, architectures and technologies, the levels of **expertise** needed by teletraffic engineering will have to be higher than ever before. This expertise can only be built up and sustained by the provision of relevant new methodologies, computer aids and training courses. **Herein lies the vital role of teletraffic researchers.**

How can we in Australia ensure that the necessary methodologies are generated in this country, and the necessary know-how is transferred into our telecommunications industry? For if this does not happen that expertise and know-how will have to be imported in the form of expensive consultants and expensive software packages (that in many cases will require even more expensive adaptation).

To answer this question it is vital to look at the nature of the life-cycle of research activity.

8. DEVELOPMENT OF EXPERTISE — THE TYPICAL RESEARCH LIFE-CYCLE

Fig. 3 suggests that at least four phases of a five-phase life-cycle must be passed through before radically new concepts can be fully exploited. Research is a high-risk process: each successive phase is normally only funded and activated if the outputs from the previous phase are dramatically positive.

Phase 1 consists of **basic research** into entirely new concepts and techniques, without any clear foreknowledge of the best application areas. The purpose of basic research is to identify opportunities for applied research, leading to development of successful products. The outputs of this activity may include patent applications, but they more commonly consist of bold technology forecasts, such as "Artificial Intelligence techniques will solve most network management problems in the next ten years — but you won't get any useful products for at least three."

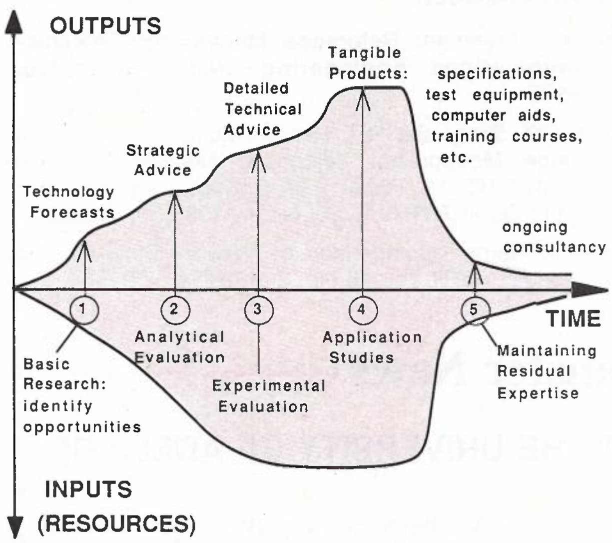


FIG.3 - LIFE-CYCLE OF RESEARCH ACTIVITY

Phase 2 consists of the first phase of applied research: **analytical evaluation** of the new concepts, in application to simple but plausible models of the potential network or system applications. In the case of teletraffic research, outline design studies need to be carried out in order to produce results that will be meaningful to the applied researcher's customers: the practising teletraffic engineers (and their clients). The typical outputs of this phase take the form of urgent strategic advice, such as "This new design technique will enable you to improve traffic throughput by at least 20 per cent, compared to current techniques — at virtually no extra cost!" The analytical evaluation needs to provide enough evidence for these claims to be examined and taken seriously, and the original concepts should now have evolved into a plausible methodology.

Phase 3 consists of **experimental evaluation:** an attempt at applying the new methodology to a real application, in order to get an appreciation of the costs and potential weaknesses of the methodology, as well as gaining a more realistic appreciation of its strengths. In teletraffic engineering this activity might typically take the form of a detailed simulation or field trial application study, with the active collaboration of the client groups (e.g., the network planners) in providing realistic data for the study. In the course of this activity an early version of a computer aid, embodying the new methodology, may well be trialled. The detailed results of this study will be used by the researcher's clients to decide whether it is worth funding the development (or purchase) of a final product embodying the new methodology. The other major output from this research phase is a greatly enhanced capability to provide detailed technical advice to the researchers' customers.

The fourth phase consists of fully-fledged **application studies,** initiated at the request of the customer, with the objective of producing tangible products such as computer aids, specifications for tender, tender evaluations, prototype test equipment, prototype control systems, and training courses. (This phase often corresponds to the D in R & D).

The fifth and final phase consists of **maintaining residual expertise** in the topic in order to provide ongoing consultancy, for as long as the demand lasts for such "technology transfer." At this stage the youthful researcher would be wise to either follow the phase 4 "product" out into the commercial application areas, change research projects, or get promoted into management!

9. IS THERE A BETTER WAY OF GENERATING THE NECESSARY EXPERTISE?

The four-stage "up-cycle" in **Fig. 3** reflects the engineering profession's cautiousness in not introducing complex new products without a series of trials. This cautiousness is OK provided the concatenation of research phases over many years does not lead to a complete loss of commercial opportunities. We are often dangerously near that situation; it has typically taken fifteen years or more in this country to proceed from first published results of new ideas in teletraffic theory to being able to commercially utilise and exploit these breakthroughs in methodology.

There must be a better way of harnessing the talents of mathematicians and telecommunications engineers in our Universities and Institutions of Technology in order to gain the expertise, the methodologies and the computer aids we need to design, dimension and operate our future telecommunications networks. I have no doubt about the existence of the necessary talent in Australian academia — as is evidenced by many papers presented at this Research Seminar. There is a general enthusiasm amongst Australian academics in the relevant disciplines to be given the broader picture of the future in telecommunications, and to be given guidance as to what particular problems in applied research need their urgent attention. They will also require adequate funding to carry out their research.

The solution appears to be two-fold:

(a) **to establish better communication between all types of teletraffic engineers and their customers,** in order that a greater awareness of user needs will stimulate the development of relevant expertise. This Seminar has been designed to improve the interface between the basic and applied researchers in the Universities, and the applied researchers and teletraffic engineers in Telecom Australia. In addition, the opening morning session of this seminar has been designed to improve the interface between **all** teletraffic engineers present and their customers amongst commercial planners, network planners and network managers.

(b) **to provide greater funding of teletraffic research in its applied phases.** I believe this is absolutely essential; but it will only work if a "critical mass" of in-depth research expertise is rapidly developed in at least one Australian University, if the funded research work is well directed towards achievable, valuable goals, and if suitable mechanisms are set up to ensure excellent communication between the academic researchers and the users of their products amongst the funding organisations.

Here at Telecom Australia's Research Laboratories we are endeavouring to develop an above-critical mass of in-house advanced teletraffic research expertise, devoted largely to those application studies that require an intimate knowledge of Telecom's network operations, systems design and commercial objectives, and therefore cannot easily be devolved outside the organisation. We are however actively implementing a policy of contracting out to University-based researchers as much teletraffic research work as we reasonably can, within the limitations of our budgets, and subject to the need to adequately resource the supervision of these contracts.

We are proud of the excellent international reputation of Australian teletraffic research, and we are determined to keep regenerating that expertise, inside and outside Telecom Australia, so that it is available to meet the challenges of the new teletraffic engineering in this country.

10. CONCLUSIONS

This paper has covered a lot of ground: firstly it examined the modern role of teletraffic engineering, to see if it is really essential to telecommunications commercial success. The tough answer is yes, it is — provided it can deliver.

Secondly, the paper focused on the critical role of the teletraffic researcher whose expertise, particularly when made available cost-effectively to customers in the form of user-friendly computer aids, will be absolutely essential for the new teletraffic engineering. If this expertise and those computer aids are not developed in time in this country, then of course they will be imported and, in many cases, heavily adapted at our further expense.

Thirdly, this paper examined the nature of the research process by which the necessary expertise needs to be developed and applied to future networks and systems. The best way to accelerate the expertise-building process will be to fund more activity in the early phases of applied research, particularly so as to draw on the available talent amongst Australian academic researchers. It must be done in such a way that the research work is well steered towards usable products, and this must involve excellent communication with the ultimate users of the teletraffic products and expertise.

11. REFERENCES

[1] R.L. Freeman, **Reference Manual for Telecommunications Engineering,** Wiley-Interscience, 1985.

[2] L.T.M. Berry and R.J. Harris, "Modular Design of a Large Metropolitan Telephone Network: a Case Study," ITC-11, Paper 2.3A-5, Kyoto, August 1985; reprinted in **ATR** Vol. 20, No. 1, 1986, pp. 41-49.

[3] R.J. Harris, "Comparison of Network Dimensioning Models," **ATR** Vol. 18 No. 2, 1984, pp. 59-64.

Information Transfer News

TELETRAFFIC RESEARCH CENTRE AT THE UNIVERSITY OF ADELAIDE

A major research contract has been signed between Telecom Australia and the University of Adelaide to establish a Teletraffic Research Centre at the University. The contract will fund the creation of a "centre of excellence" in this field of research, and will run for 5 years. The work at the Centre is intended to complement teletraffic engineering research work already done at Telecom's Research Laboratories, to build up expertise in the teletraffic engineering methodologies needed to design future multi-service telecommunications networks. The new centre is headed by Dr L.T.M. Berry of the University's Applied Mathematics Department and will be staffed by three post-doctoral Research Associates, two Senior Lecturers (part-time), and a Secretary. The Teletraffic Research Centre was officially launched on 19 March, 1987, by Telecom's Director, Research (Mr H.S. Wragge), the acting Vice-Chancellor (Professor K. Marjoribanks), and members of the Centre's Advisory Board: Professors R. Potts and R.E. Bogner, Dr Berry, Dr C.W. Pratt (Chairman) and Mr P.H. Gerrand.

The Telecommunication Journal of Australia

Abstracts: Vol. 37, No. 1

OPTICAL CABLE SYSTEMS FOR THE MELBOURNE DIGITAL NETWORK: J. K. RICHARDSON, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 3.

The Melbourne Digital Network is being established progressively to achieve digital integration of both switching and transmission in a co-ordinated manner. The transmission paths will be increasingly realised by optical systems which will enable a more rapid response to customer needs and enhance the security of the network.

NEW TARIFF PULSE GENERATOR: A. WALTER and R. JOHNSTON, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 9.

A new Tariff Pulse Generator is to replace the present interim tariff Pulse Generation equipment in all electro-mechanical STD charging centre exchanges. This equipment generates pulses at pre determined rates required for charging of STD calls. The system hardware and software is described and the design considerations and maintenance features are outlined. The new equipment is a flexible, reliable and cost effective replacement embodying the latest hardware and software design practices and maintenance aids.

QUALITY ASSURANCE PLAN FOR EXTERNAL PLANT: E. H. CHUI, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 15.

Significant improvements in the fault performance of Telecom Australia's external plant network will result from the operation of the Quality Assurance Plan for External Plant. This paper describes the development, procedures, application and recent operational results of the QA Plan.

The structuring of the QA Plan to gather specific cause information, and future directions to be taken in further development of the plan to improve the process of building quality into the external plant network are also discussed.

THE STRATEGIC ROLE OF INFORMATION: R. HORTON, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 23.

This paper attempts to summarise the influence and importance of information technology, as it applies to an individual company within an industry, and as it applies to a communications service provider. Relevant statistics appropriate to Australia are highlighted, as are some of the tools available for successful corporate survival in a world where information technology is rapidly changing methods of doing business, and relationships with customers and competitors.

THE TELECOMMUNICATIONS NETWORK AND NATIONAL SECURITY: R. L. ORTON, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 31.

This article was originally prepared for inclusion in the RSL 1986 Defence Paper. The theme of the RSL Defence Paper for 1986 was "Is the Home Base Secure?" and this article examines the value of a reliable telecommunicaions network and a viable telecommunications manufacturing industry to national security. The article also discusses the protection of the network and its ability to continue to function when it is itself under duress.

AN INTRODUCTION TO COHERENT OPTICAL COMMUNICATION SYSTEMS: J. L. ADAMS, R. W. AYRE, G. NICHOLSON and T. D. STEPHENS, Telecom, Journal of Aust., Vol. 37, No. 1, 1987, Page 37.

Coherent optical fibre systems offer great promise as a technology for high-capacity and long distance telecommunications links, and are likely to enter the Australian network early in the next decade. This paper provides an introduction to this emerging technology, including a survey of some recent experimental systems. The transmission performance and component requirements of these systems are outlined, with emphasis on the areas requiring further development before such systems find commercial application.

THE DESIGN OF A 64 KBIT/S DIGITAL CROSS CONNECT SWITCH: E. TIRTAATMADJA and J. VAN WOERKOM, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 47.

This paper describes the design of a 54 kbit/s Digital Cross Connect (DCC) Switch by the Networking and Business Communication Division of Amalgamated Wireless (Australasia) Ltd. under contract to Telecom Australia (Research Laboratories). The DCC provides semi-permanent cross connections between nominated 64 kbit/s channels contained in Primary PCM (2.048 Mbit/s) systems. The DCC interfaces both Channel Associated Signalling (CAS) and non-CAS PCM systems. For CAS systems, the signalling information in Timeslot-16 is switched transparently; whereas for non-CAS systems, Timeslot-16 can be used as an extra voice/data or signalling channel. The development is desicribed in terms of the functions, facilities and design approaches used to develop prototype equipment. The switch will be used by Telecom Australia in experimental trials of ISDN network interworking.

TELECOMMUNICATIONS AND ECONOMIC DEVELOPMENT: J. DELORME, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 55.

In May, 1986, Jean-Claude Delorme, President and Chief Executive of Teleglobe Canada, addressed business and government representatives from Argentina and Chile, in his capacity as Chairman of the Advisory board of the Centre for Telecommunications Development.

In his presentation, Mr Delorme identified telecommunications as one of the key factors of economic development. He discussed the level of priority given to communications in the development process and the impact of the expanding world market for telecommunications.

"Development is a gradual process shaped by many other priorities. The various stages of economic and social development must be co-ordinated with growth in the telecommunications sector. On the other hand, the absence of the adequate telecommunications infrastructure may impede or delay the development of a country whose economy has been stimulated by investments in other priority sectors," stated Mr Delorme. He concluded by defining the role that the Centre for Telecommunications Development will play for developing as well as for industrialised countries.

THE NEW TELETRAFFIC ENGINEERING: P. GERRAND, Telecom. Journal of Aust., Vol. 37, No. 1, 1987, Page 61.

The new role of teletraffic engineering is discussed. Who are the customers and what are their requirements? What is the nature of the process by which the necessary expertise can be developed and applied? What are the consequences of not using this expertise?

The essential contributions of teletraffic engineering to system and network design, dimensioning and operation are shown to be vital to underpin the commercial success of network administrations and switching systems suppliers. Teletraffic expertise is needed to be able to offer network products with competitive performance advantages, to credibly guarantee performance in advance of wide-scale implementation, to provide commercial flexibility in trading off costs against performance, and to provide commercial reliability in providing the network performance that the customer has paid for.

The greatest current challenge to teletraffic engineers is to develop and apply their expertise to future multi-service networks carrying a proliferation of different services, with distinct end-to-end performance criteria. The now critical role of teletraffic researchers is to rapidly develop the necessary methodologies and computer aids that will permit their expertise to be applied in a cost-effective way. This will not happen in time in Australia unless the best available research talent in Australian Universities and Institutions of Technology is roused, co-ordinated, guided and adequately funded.

Telecommunication Journal of Australia

GUIDE FOR AUTHORS

Readers are encouraged to contribute to the Journal. The following guide outlines the major points most authors would need to know in order to publish a quality article in the Journal. A more comprehensive guide is available from the Editor-in-Chief.

Type of article

Articles should deal with interesting recent developments in matters relating to the management, planning, design, installation, operation and marketing of telecommunications generally. In particular, the Journal should record those special contributions made by individuals to the Australian telecommunications industry. Overseas contributions are also encouraged.

Length of Articles

As a broad guide, articles should consist of about 4000 words. This is about 14 pages of double spaced typing on A4 size sheets. Short articles and brief technical notes are also welcome.

Subdividing the Article

Three major types of headings are used:

- **MAJOR HEADING** — BOLD CAPITALS
- **Secondary Heading** — Bold Capitals and Lower Case
- Tertiary Heading — Small Capitals and Lower Case

Abstract

An abstract of 75 words at the most must be provided when an article is proposed. It should state the scope of the article and its main features.

The Text

The text should be in an impersonal, semi-formal manner. Consistency in spelling, headings, symbols, capitalisation etc. is essential. Some examples of common abbreviations and units are as follows:

kbits/s, Mbits/s, mW, MHz, Fig.

References

References should be numbered consecutively and listed at the end of the paper. The preferred format is:

1. Smith, R. & Jones, A., "Marketing Videotex," Journal of Marketing in Australia, Vol. 20, No. 3, June 1985, pp 36-40.

Illustrations

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Tables, Diagrams and Graphs

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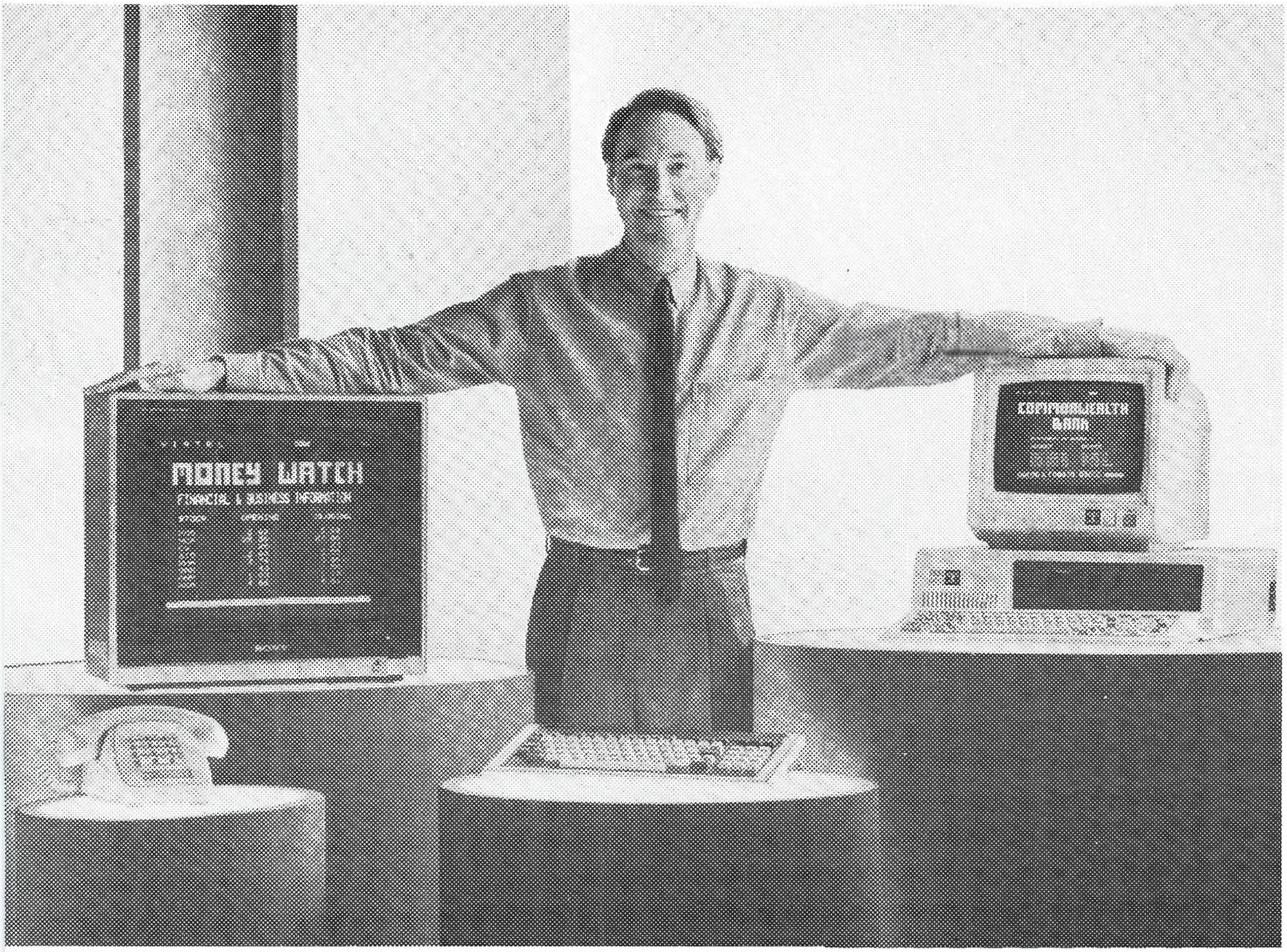

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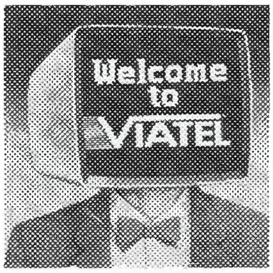

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