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Interactive Drafting Systems

M. van der ZWAN, D. PHIZACKLEA, Dip. E.E. and G. RENTMEESTER, C. of T. (Electronics).

Interactive drafting systems (IDS) are playing an increasingly important role in the provision of a drafting service compatible with the advanced manufacturing and design technologies available today and in the future. This article initially gives an overview of a typical system configuration, similar to that adopted for the first IDS installation in Telecom Australia. Finally, the article attempts to highlight some future developments and applications of interactive drafting system software and hardware.

The past 20 years have seen some rapid development in the use of computers and their evolvement from mere "information handling devices" to practical tools, performing specific tasks. With the increasing application of the computer as a tool in the engineering field, it is only to be expected that its use be extended to drafting.

Computer technology as applied to Drafting concerns computer graphics in the form of generative graphics, and systems employing this technology are called Interactive Drafting Systems, or less appropriately, Computer Aided Drafting (Design), Automated Drafting or Computer Graphics.

WHAT IS INTERACTIVE DRAFTING?

Although Interactive Drafting Systems have been in existence since the late 1960's, it is the development of the systems in the last 5 years that have made them a viable and economical proposition in a multi-disciplinary drafting environment and the use of IDS is growing rapidly.

Interactive drafting involves a person interacting with a computer-based system to generate drawings and associated documents. Where human beings are innovative, imaginative and possess intuitive powers, they are also error-prone. A computer has none of these virtues or vices. It follows procedures of a purely analytical nature which allows it to perform routine and repetitive tasks with great accuracy and speed.

With the aid of a computer, drafting techniques are being successfully applied to present engineering data in a more immediate manner, accelerating design and manufacturing processes. The visual display units (VDUs) and graphic input device shown in **Fig. 1** typify an interactive drafting system work station. The draftsman interacts with the system inputting graphic commands and data via the pen stylus and tablet, in response to the system prompts or display on the message or graphic VDU's.

IDS CONFIGURATION

An IDS may be configured in a number of different ways dependent on the output required. A basic system comprises a processor, mass storage medium and input/output (I/O) terminals. The processor is typically a mini-computer characterised by memory, arithmetic and logic unit, control unit and I/O units. The mass storage mediums are standard magnetic tape and a magnetic disc with a typical capacity of 80-300M bytes. The I/O devices provide for the variety of configurations and consist of VDUs, digitizers, tablets, plotters, paper tape punch/reader and line printer. A typical configuration is shown in **Fig. 2**.

Input Devices

IDS graphic input devices are designed to match the machine to the IDS user, providing a logical method of graphic entry. For most graphic applications an alpha-numeric keyboard is inadequate or inefficient. One method of data entry utilises a digitizer; there are two types, co-ordinatograph or free-floating cursor. Both are incremental position encoding devices but use different encoding techniques. The co-ordinatograph uses gantry mounted timing belts or glass scale encoders, whereas the free-floating cursor digitizer, shown in **Fig. 3**, utilises a cursor attached by a flexible cable to sense the cursor position through a grid of wires embedded in the table surface.

Neither type provides instant feedback unless used in conjunction with a VDU; although a timing belt co-ordinatograph can, using pens mounted on the gantry, have a plot-back facility.

The cursor is used to point to locations on the digitizer surface and, under the control of keys located on the cursor, maps the selected set of digitizer surface co-ordinates into a drawing file. Mapping may represent the co-ordinate position of a simple point or a complex shape or symbol. Shapes or symbols that are used repeatedly

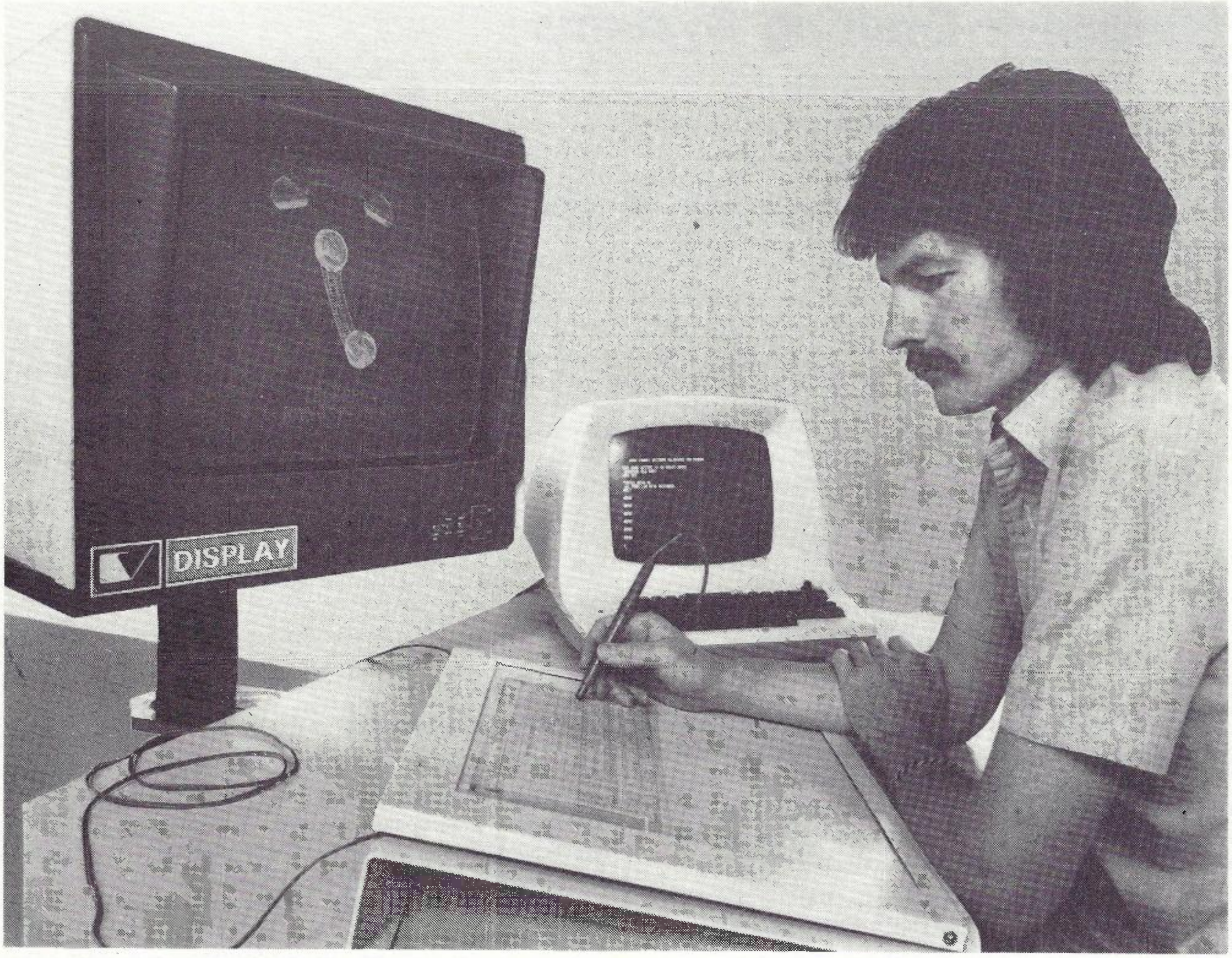


Fig. 1 Interactive Drafting Work Station.

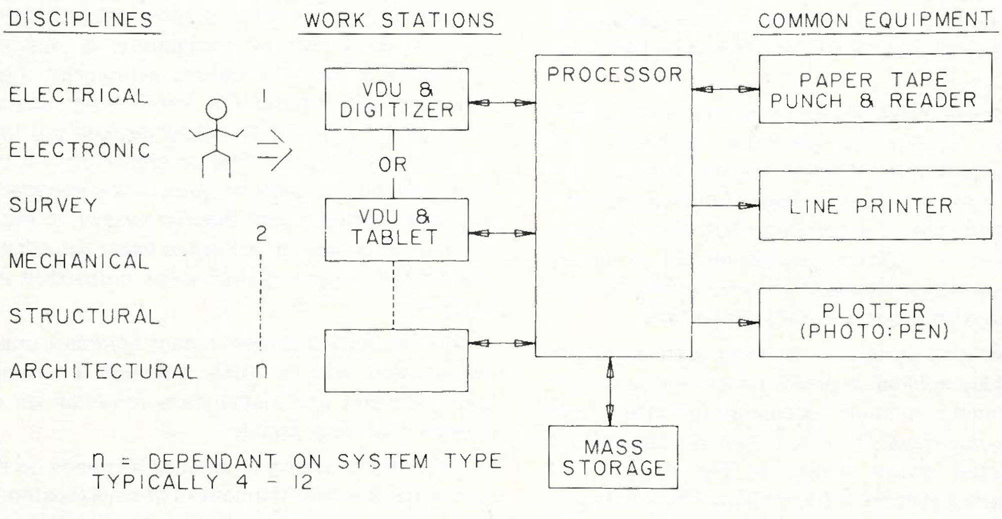


Fig. 2 Basic IDS Configuration.

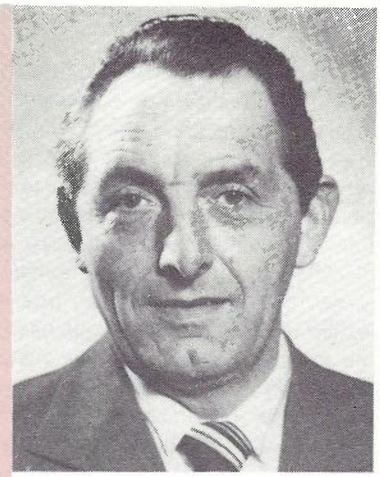
can be stored in the system and recalled when required.

The type of digitizer selected is based on the required output accuracy and ease of operation. The free-floating cursor digitizer is easier to operate but, through the method of encoding, is less accurate than the co-ordinatograph.

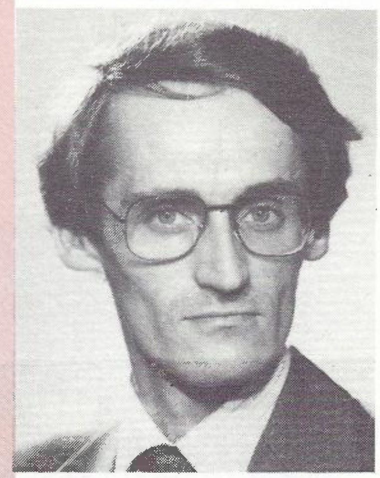
An alternative digitizing device is the tablet (see Fig. 1), which is used in conjunction with a VDU, the size is considerably less than that of a co-ordinatograph and it also has less accuracy. The tablet uses position encoding and, typically, a pen stylus to sense position, generate commands and position the screen cursor. The similarity between tablet and stylus, and, paper and pencil make them a particularly natural graphic input device. Positional encoding may be achieved by acoustical, voltage gradient or embedded wire signal sensing, the latter being the type shown in Fig. 1.

Output Devices

Graphic displays may be divided into two classes, line drawing and continuous tone images. The two use different techniques for displaying an image; the former uses a random scan and the latter a raster scan technique.



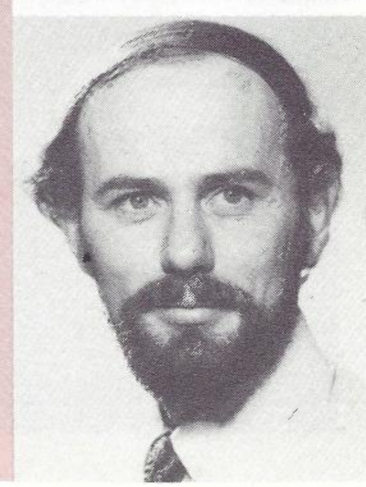
MAARTEN van der ZWAN joined Telecom in 1956 as a Draftsman in the Victorian Drafting Section. He received his drafting training with the Netherlands Postal and Telecommunications Services. In 1967 he moved to Headquarters Drafting, where he is at present acting Controller, Drafting Policy & Development. He has made extensive studies of Interactive Drafting Systems resulting in the installation of the Computervision IDS in Headquarters.



DARREL PHIZACKLEA joined Telecom Headquarters Drafting Section in 1970. After qualifying as a Draftsman in 1974, he worked as part of a Drafting sub-group; outposted to the Research Department; primarily in the field of switching and signalling techniques.

He studied part-time during 1975-1979 and graduated with a Diploma of Electronic Engineering in 1979.

Since 1979 he has worked as Assistant Controller in the Drafting Policy and Development Section, General Works Branch, Headquarters.



GERRY RENTMEESTER joined Telecom Headquarters in 1972. Since joining Telecom he has completed a Certificate of Technology in Electronics and was employed in a Drafting sub-group, outposted to the Research Department, using the GERBER IDS2. In 1978 he moved to the office of the Controller of Drafting Policy and Development where he assisted in the preparation of a schedule and the evaluation of tenders for an Interactive Drafting System. He was subsequently appointed Supervising Draftsman in charge of the Interactive Drafting System. Gerry is currently completing a B.Sc. in Computer Science.

Storage and vector refresh displays use the random scan technique i.e. the image in the form of vectors, will be displayed in the order that it was created.

A graphics storage display can display and retain an image for an appreciable time without image regeneration, but must blank and regenerate the entire image if an image is edited (modified) if the result of the editing is to be displayed.

The vector refresh display stores the information for display in a digital memory rather than a dielectric storage grid. The image is refreshed (redisplayed) at a frequency sufficient to display the optimum number of vectors constrained by the need to avoid display flicker. The continual refreshing of the display provides a fully dynamic display, displaying images (vectors) as they were created.

The raster scan display differs in fundamental aspects from random displays. A display file for a random scan display is concerned principally with information about lines and characters to be drawn; the empty areas of the screen are ignored. The raster scan display however, controls the intensity of each dot or raster of dots that covers the entire screen. A raster scan image is generated by plotting point-by-point the intensity value of each dot, the screen being scanned in an interlace pattern to reduce flickering (the same technique used for television). Hence, the display is fully dynamic, raster generated and can assign different levels of intensity to dots. One of the advantages of such a display is the ability to create images with shading, rather like a coarse grained photograph as distinct from geometrical figures.

A "Hardcopy" of images or digital information can be obtained by a wet ink plotter, electro-static plotter, photo-plotter or scan line copier. The wet ink flatbed, drum or semi-drum (see **Fig. 4**) plotters are used to generate drawings suitable for reproduction or quality drawings for checking. A scan line copier provides, relatively quickly, a lower quality paper copy of an image which is displayed on a VDU; an electro-static plotter also produces a lower quality output. Photoplotters are used when a precision photo image is required, typically for positive film masters for printed circuits and map overlays.

SYSTEM INTERCONNECTION

A simplified block diagram of an interactive drafting system is shown in **Fig 5.** The configuration for a work station can vary, as previously stated and the example shown is representative of only one of these configurations.

The information required by the system for the generation of drawings is basically X-Y co-ordinate information and/or pre-programmed commands. Some of the basic information can be processed by the work station without data transfer to the CPU, for example the cursor display or cursor position location.

Instructions given to the system, for example, to draw a line using the menu, tablet, pen and visual display; although given by depressions of the pen on the tablet; are translated as a parallel 10 bit word. The data is loaded into the beam position counter, converted from digital to

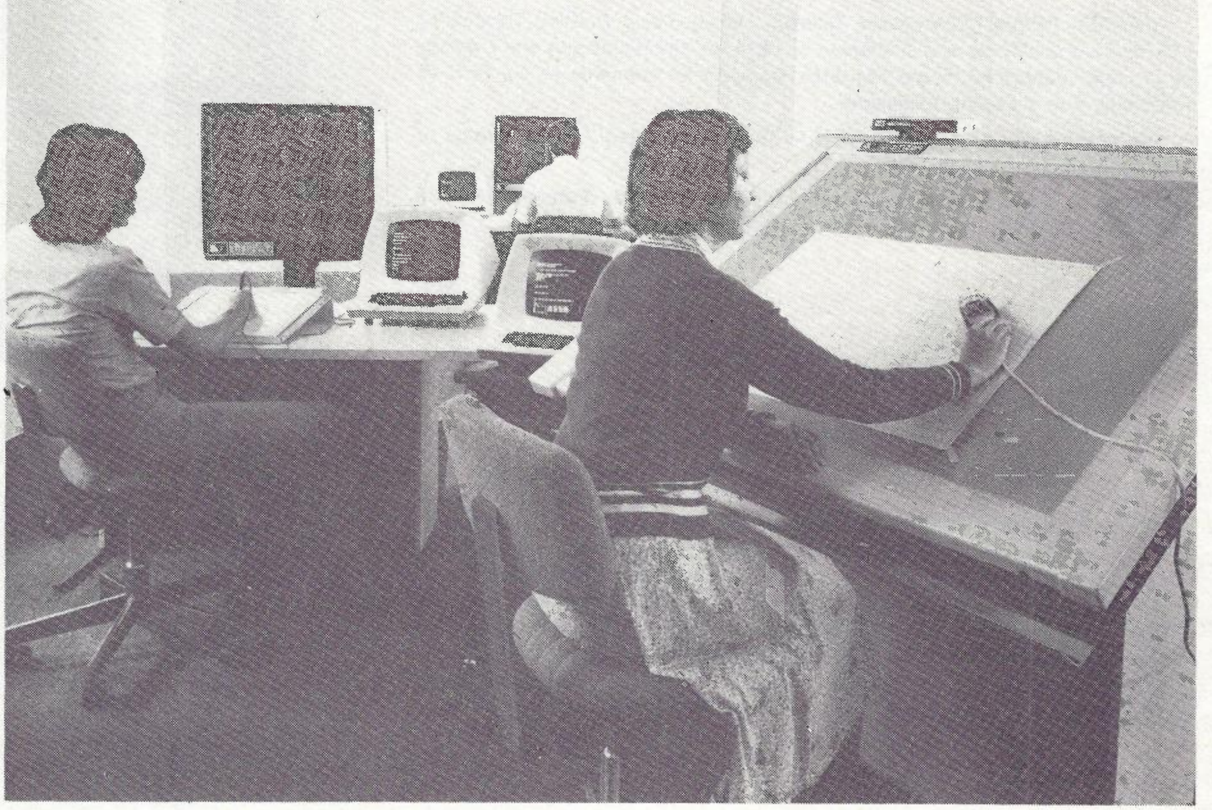


Fig. 3 Tablet and Free Floating Cursor Digitizer.

analogue and then sent to the graphics display deflection electronics for positioning of the beam.

Outgoing information requiring processing by the CPU is translated into a sequence of three 18 bit words. The first word is a control word and the second and third words are X and Y co-ordinate information. When the data does not contain co-ordinate information the second and third words are ignored by the work station input/output system. The first bit of the word to be transmitted starts the receive clock which shifts the data into a 16 bit shift register. The data is shifted until a leading zero is detected in the leading zero flip-flop. When the shift register is loaded and the trailing flip-flop is triggered the three word receiver buffer is then loaded and its counter incremented. When the buffer is loaded, an interrupt is generated, signalling the CPU software to transfer the data to core memory. The CPU reads the three words in the receiver buffer by issuing three instructions to the controller. Once the transfer is completed another interrupt is generated to clear the controller allowing it to accept new data. Similarly, information is transferred from the CPU, all transfers are under control of the controller interface.

SYSTEM INTERACTION

A simplistic model for an interactive drafting system is shown in **Fig. 6.**

The man-machine dialogue used to achieve an effective interaction between user and system is realised by the command language. Typically a command would consist of a verb, noun and modifier sequence of words e.g. DELETE, LINE, MOD, which with the location indicated by the display cursor or grid co-ordinates, deletes the defined line. The command language is generally limited and consequently does not require the user to commit to memory a large number of instructions.

When a user generates a command it is served by an interrupt routine, which in organising communication between CPU and peripheral, places the command in an attention queue. The advantage of using an interrupt instead of say polling, allows more effective use of the CPU.

The storage of commands in an attention queue protects the CPU from having to immediately process a command when it may not be ready for it. A task scheduler examines the attention queue and through a

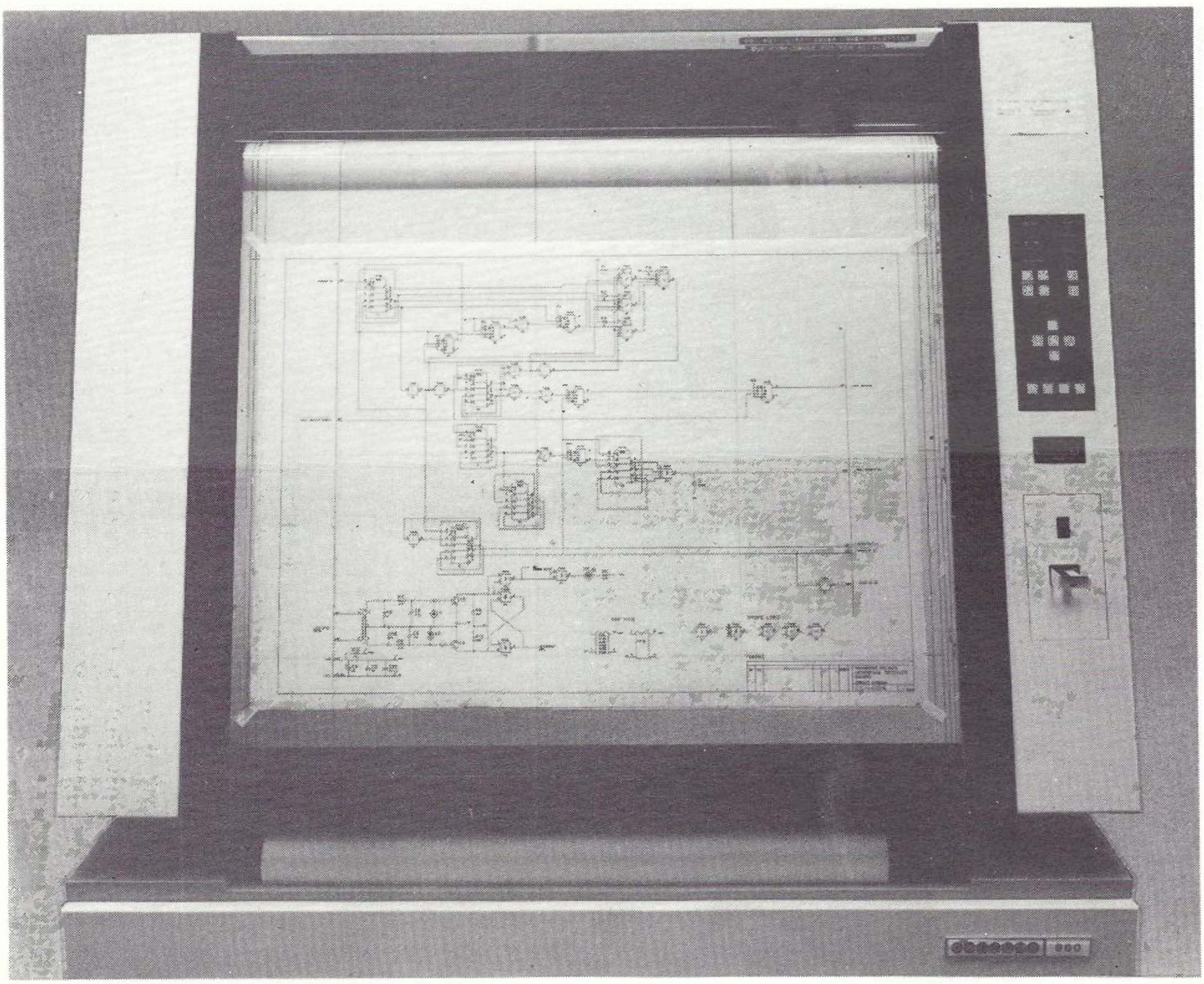


Fig. 4 Semi-drum Wet Ink Plotter.

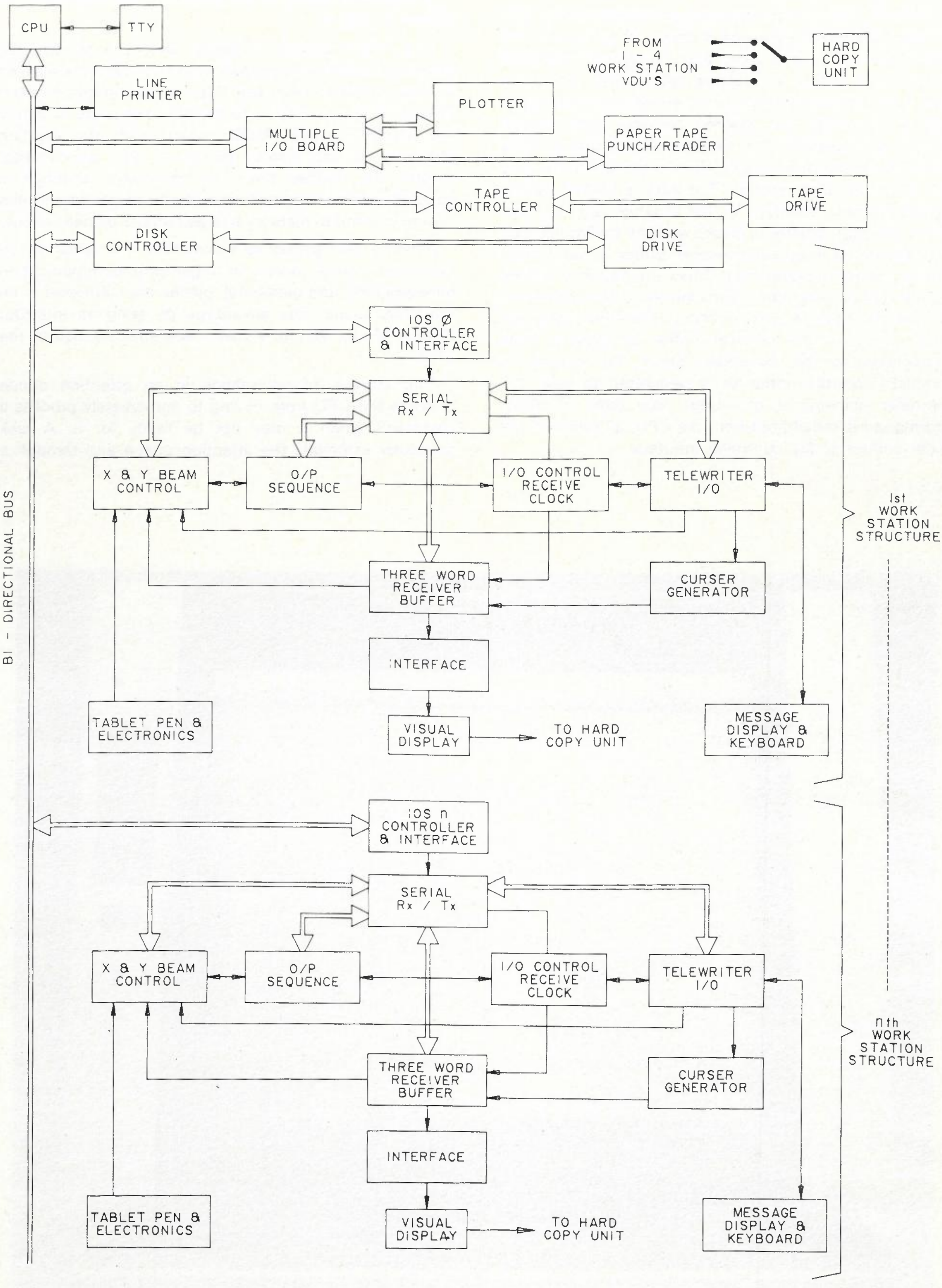


Fig. 5 IDS — Block Diagram.

predetermined priority allocation removes the entry from the queue, interprets this entry and determines which process to invoke in response.

Assuming the command is verified syntactically correct by the interpreter and hence error routines are not generated, the appropriate high level language program is copied from disk, under control of the operating system (O/S) and loaded into core memory. Each work station is allocated a fixed core memory space for program loading and after the command is processed remains in core until overwritten. The results of the process are written into the regenerate and common files under control of the file manager. The regenerate file contains information necessary for graphic generation whilst the common file contains all information relating to a drawing.

APPLICATION SOFTWARE

Drafting software is generally available as either basic software with enhancements to be extendable into selected disciplines, or as separate packages dedicated to particular disciplines.

In a multi-discipline system; such as the one shown in this article; work stations can work simultaneously and independently in any of the drafting disciplines. A user may change discipline at any time independent of any other user.

The drafting disciplines described below are typical of the types readily available, they use basic geometric entities enhanced with software for specific applications.

Mechanical and Structural Drafting

The mechanical and structural package provides a two or three dimensional work surface, to which geometric entities such as points, lines, arcs, fillets, circles, conics and B-splines may be applied. Combinations of these basic elements can be defined as sub-figures stored on file and readily recalled for use as they exist or as elements in an array. Other elements that are available are text, notes, labels and dimensioning. It is possible to insert, mirror, rotate, project and translate any of the geometric entities or their combinations. The combination of construction and edit commands give the user the graphics tools necessary to create rapidly and accurately engineering drawings.

Each entity may be placed on separate "layers" within a drawing, providing the user with a means of storing different classes of data within one drawing file, and extracting any subset via the appropriate layer list.

Construction capabilities including tangent, perpendicular, parallel, intersection, horizontal, vertical, angle specification and both cartesian and polar co-ordinate input are available, simplifying geometric construction problems.

Software dimensioning can provide automatically specific distances, generate projection lines, dimension lines and arrow heads and locate the dimension for the user. Linear, angular, radius and diameter dimensions may all be handled automatically.

To optimise the command language, and available to

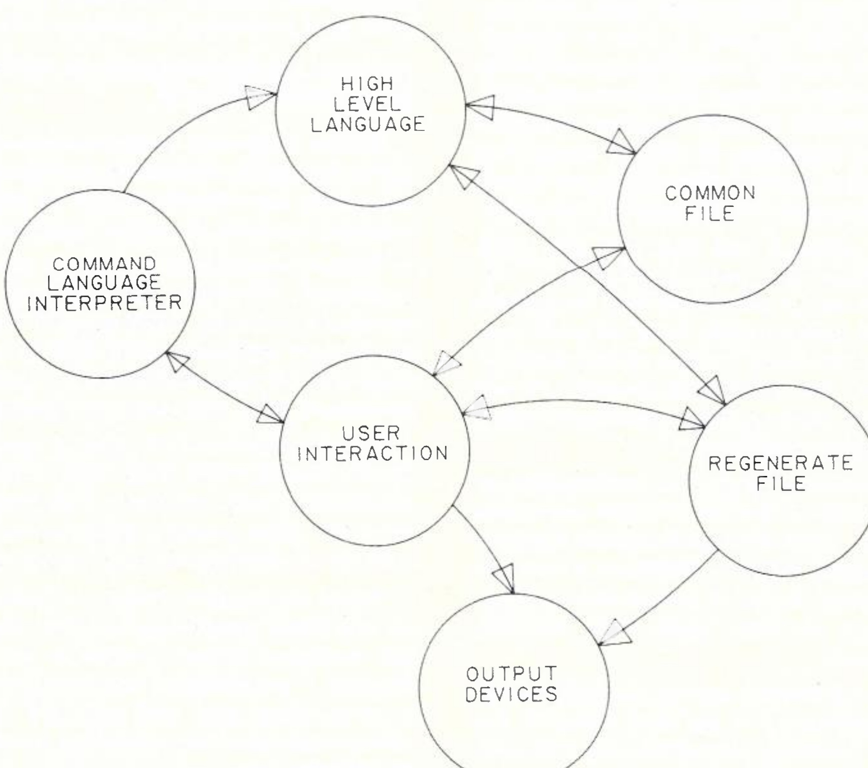


Fig. 6 Model of IDS.

all disciplines, is the ability to assign an entity or a combination of entities to a tablet menu square facilitating rapid drawing construction. Apart from these basic mechanical drafting facilities the system has the ability to perform complex functions quickly, accurately and simply, relative to manual techniques; for example, three dimensional complex shape surface construction and mass properties calculations.

Cartographic and Survey Drafting

The mapping software provides the facility to input geographic data through explicit co-ordinate input in Australian Map Grid (AMG) or longitude-latitude co-ordinates. As in the mechanical and structural drafting software, the full range of basic geometric entities are available plus facilities suited to cartography. The provision of complex line shapes may be entered simply by digitizing the centre line and specifying the required line font. Line font parameters are separately definable and end symbols may be specified. Sections of a line string may be blanked to allow text or symbols to be inserted without losing the logical connectivity of the network.

Line strings may be automatically smoothed by interpolating additional points or alternatively high density input containing redundant information can be filtered to reduce storage requirements.

Fonted text, used to distinguish the many types of data shown on maps, can be specified by the user. Character height, width and the angle at which it is drawn are definable. Characters may be skewed to give italic effects and both upper and lower case characters are available.

Rectification, is a program for adjusting the geometric information in a database based upon updated values of a number of points whose position has been more accurately determined. For example a map is digitized introducing positional errors; a number of control points whose true co-ordinates are known through conventional geodetic survey techniques are then selected. A control layer is then created consisting of vectors whose first point is a point identified on the digitized map and whose second point has the correct co-ordinates for that point.

The rectification program will use this data in a mathematical algorithm that corrects each X, Y co-ordinate value on the map in accordance with its position relative to the various control points. A roll-off factor may be defined to reduce the effect of each control point on points distant from it. The rectification program is a key element in the process of converting a collection of maps into a unified geographic database.

Sectioning and panelling allows the cartographer to prepare new maps from a number of maps previously stored in data format. Sectioning trims graphic mapping entities inside an arbitrary polygon overlaid on a map and erases all entities either inside or outside the polygon. Panelling allows two or more maps with common boundaries to be joined.

In cartography any geometric entities placed on a map are symbolic representations of the true entity. In the mapping software a full description of the map and what it represents can be entered by the user. For example, a telephone cable, although represented by a line on a drawing, has physical attributes such as type, material, size and diameter. Therefore in mapping, both the topology as well as the topography of a map can be fully described.

Electrical and Electronic Drafting

As in the previous two disciplines basic geometric entities are also used in electrical/electronic schematic preparation. Symbols are used extensively in circuit schematics and therefore are significant when an IDS is used for schematic preparation. Symbols may comprise basic geometric entities or a group of primitive symbols which represent unique symbols in themselves. The symbols may be assigned to the table menu, parts library, or both for quick recall and positioning.

There are many possible advantages to be derived from a fully described circuit schematic and hence complete data base. Parts lists can be automatically generated, interconnections checked, automatic symbol annotation, back annotation e.g. updating the pins of logic elements in a schematic with the assigned pin numbers extracted from the printed circuit board drawing; are but a few of the various enhancements possible.

Automatic printed circuit board layout commencing with the manual placement of components and physical board characteristics merged with an annotated circuit schematic can be utilised to produce an interconnected printed circuit board.

Design rule checks are available to check track to track and track to pad clearances, net list comparisons and open/short circuit checks can be automatically performed in background mode, while interactive work continues on the graphics terminals.

Auxiliary manufacturing information such as photoplotter artwork, numerical control drill tape and other post processing information can be generated.

FUTURE DEVELOPMENTS IN INTERACTIVE DRAFTING SYSTEMS

Current IDSs have been developed in response to industry demand for interactive drafting systems to perform more tasks more quickly and to do tasks that cannot be achieved manually, to reduce manufacturing lead times.

Memory capacity and electronic circuit densities have significantly increased over the past decade and will continue to increase, enabling users to store and execute increasingly sophisticated programs in less time at a lower cost per user. In addition, the speed and capacity of peripherals have also been significantly improved.

The developments for general computer technology can be utilised in IDS technology; for example improved disk access times and lower cost mass storage devices will allow faster program execution and storage of large volumes of drawings on-line instead of off-line.

Future display technologies in the form of plasma panels and liquid crystal displays may develop, eliminating the analogue element necessary for CRT technology, although it is considered that standard CRT's will remain a competitive and cost effective technology for a considerable time. Because of the continuing reduction in digital logic costs, raster-scan display CRTs will probably be the dominant display technology of the 1980's.

As raster-scan systems become more popular, colour displays will develop and will be followed by colour hard-copy units. Plotters have the capacity now to transfer displays to colour output. Interaction techniques for communicating with the display can also be expected to become more sophisticated. Also, it is expected that wet ink plotters will be replaced by high quality electrostatic plotters.

Although in principle it is possible to implement a distributed IDS now, it is restricted by the limitation of the high speed communication line. As a consequence it is anticipated that cost effective intelligent terminals will be developed that will have today's technology computer power. All systems could then be networked together, giving access to a common data base, and enhance standardisation and increase CPU capability.

The trend in software will be towards a simpler non-technical, non-programmer language, well-defined application packages providing an output or solution suitable for immediate postprocessing.

Finally, on the latter point, an IDS can provide perhaps two basic functions, currently that of a design/recording computerised engineering data function and ultimately, part of an integrated manufacturing system of automatic production and machine tool processes.

In Brief

SOUTH AUSTRALIAN DIVISION'S FIRST SEMINAR

Under the joint auspices of the Telecommunication Society's South Australian Division and Telecom Australia, a seminar on "Quality of Service" was held on 11 November 1980, from 4 p.m. to 9 p.m., at the Australian Mineral Foundation complex at Glenside.

The seminar was attended by 300 paying participants, mainly members, who heard four principal speakers focus on three specific aims:

- What does "Quality of Service" mean in Telecom,
- To what extent are we giving quality service,
- And how are we going about it.

In his keynote address, Mr Jim Smith, Deputy Chief General Manager, put 'quality' and 'quantity' into perspective as seen by Telecom's business and residential customers. The text of this address is produced later in this issue of the Journal.

Mr Rod Cunningham, Manager PABX for SA, dealt with the quality of service Telecom provides from a customer's viewpoint. The emphasis of recognising customer requirements was highlighted by the Vernon Commission of Inquiry and has been reflected subsequently in the Telecommunications Act, the Corporate Plan and Telecom's organisational changes since 1975. Mr Cunningham stressed the importance of setting performance targets which relate to customer needs and quantitatively discussed target levels and how we are meeting them in South Australia and the Northern Territory. The ability to cope with customer demands in a rapidly changing social environment was viewed in the context of 'product managers', particularly for those Telecom products requiring tight management if service obligations are to be met. Mr Cunningham raised the need for a significant effort to determine customers' and the public attitude towards Telecom's image. As our staff are the principal interface with customers and the public he considered that the central challenge was to place more emphasis on staff selection and development where direct contact with customers is a significant part of the duties of a position.

Mr Ken Bartsch, Assistant Superintending Engineer, Network Performance, in SA, spoke about the quality of telecommunications network in relation to customer calls made over the network. Mr Bartsch briefly outlined the economic and technical role of the switched telephone network and discussed the various performance criteria and the extent to which these were being achieved in South Australia and the Northern Territory. The ways of measuring performance were described as were the means by which corrective action is taken to adjust network situations to prescribed standards. In concluding, Mr Bartsch pointed towards the future direction in the evolution of performance standards and performance measuring techniques; these are both very dependent on technological change and perceptive staff management.

Mr Peter Price, Commercial Manager for TAA in SA and NT, centred his address on the personal qualities of people as distinct from their managerial or technical qualities. He spoke of the need to develop these personal qualities in an environment characterised by competitive technology and demanding customers, which had a depersonalising effect on staff. Mr Price discussed his views on the style of management needed to develop personnel balanced with respect to their technical and social attributes. He dealt with the fundamental question of human relationships and illustrated this with the TACT course (Transactional Analysis Customer Treatment) which TAA has adapted from use by American Airlines. Mr Price summed up his approach to quality service by stating that "... people are the completing factor in any organisation.".

To round off the program, Mr Murray Coleman, Telecom's State Manager for SA, joined the four speakers for an informative panel session under the guidance of Mr Ken Allison, the Division's Chairman.

This was the Division's first experience in a function of this size and the Committee considered that the outcome justified the effort and expense involved.

2048 kbit/s Transmission Over Analogue Radio Relay Systems

A. T. MICHAELIDES, BSc., B.E. (Hons), Ph.D., and G. MACKIE

Telecom's planned Digital Data Network (DDN) will require 2048 kbit/s intercapital data circuits by late 1982. Firstly, this paper outlines methods which can be used to provide these high-speed data circuits on existing trunk networks. The Data Above Voice (DAV) method of 2048 kbit/s transmission over radio systems is then discussed in some detail as DAV will be providing nearly all intercapital links in the initial stages of the DDN. The extent of the DAV network by 1982, performance objectives, operation of DAV modems, sources of errors in DAV transmission and results of field measurements are given. The conclusion, based on field measurements, is that DAV links are expected to meet, generally, the current DDN performance objectives. Performance of the very long radio routes and those with equipment approaching the end of its useful life is still in some doubt; these routes will be tested during 1981-82 when sufficient DAV modems become available.

Telecom's Digital Data Network (DDN) will be a synchronous, high performance, dedicated data communications network which will be integrated into the national telecommunications system. The DDN will provide dedicated data communications services at the data rates of 1200, 2400, 4800, 9600 bit/s 48 kbit/s. Through the use of digital hierarchical multiplexing, these data rates are combined firstly into 64 and then into 2048 kbit/s streams which are transmitted between main centres. By December 1982, the DDN will link all capital cities with 2048 kbit/s circuits (except Sydney-Brisbane and Melbourne-Hobart the main circuits of which will be 64 kbit/s on groups but their patch circuit will be 2048 kbit/s). Clearly, an essential requirement for the construction of DDN is the ability to provide readily 2048 bit/s transmission systems in Telecom's analogue network. This paper concentrates on such means of data transmission with the emphasis being on radio systems.

A brief outline is initially given on how 2048 bit/s transmission can be achieved over existing trunk networks. The provision of 2048 kbit/s links using the Data Above Voice (DAV) method over existing broadband radio routes, the operation of DAV modems and sources of transmission errors are then discussed in detail because DAV will be used almost exclusively in the first stages of the DDN. Field measurements are also given and the results are compared with the DDN performance objectives.

DIGITAL TRANSMISSION METHODS OVER EXISTING RELAY LINKS

Digital data streams have been transmitted over single voice-frequency and group-band circuits in the FDM hierarchy (at rates of up to 9600 bit/s and 64 kbit/s respectively) for many years. Higher speed data transmission, over existing analogue systems, can be achieved in two ways (Ref. 1):

- by utilizing the bandwidth of 2 or 3 supergroups in the telephony baseband. This method is known as Data In Voice (DIV).
- by using the unoccupied frequency spectrum space above or below the telephony or above the television baseband. The systems using these techniques are self-evidently called Data Above Voice (DAV) or Data Over Voice (DOV), Data Under Voice (DUV) and Data Above Video (DAVID). The terms DAV and DOV, although synonymous, are applied to transmission over radio and coaxial cable systems respectively.

In both approaches, the digital information is simultaneously transmitted with the telephony or television signals over the same link.

DAV and DIV, especially DAV, are so far the preferred means for the introduction of high speed data links into Telecom's DDN. DAVID is used to provide sound programme channels along video links. The DIV, DUV, DAVID and DOV methods for carrying high speed data in existing relay links are discussed briefly below. DAV will be discussed separately in more detail because of its planned extensive use in the network by 1982 (see **Fig. 1**) and because of first hand experience with this method arising from tests already carried out.

The bandwidth occupied by DIV is 480 or 720 kHz (2 or 3 supergroups). Hence for transmission at 2048 kbit/s one would require 4.3 or 2.8 bits/Hz respectively; this means that high efficiency multilevel modulation must be

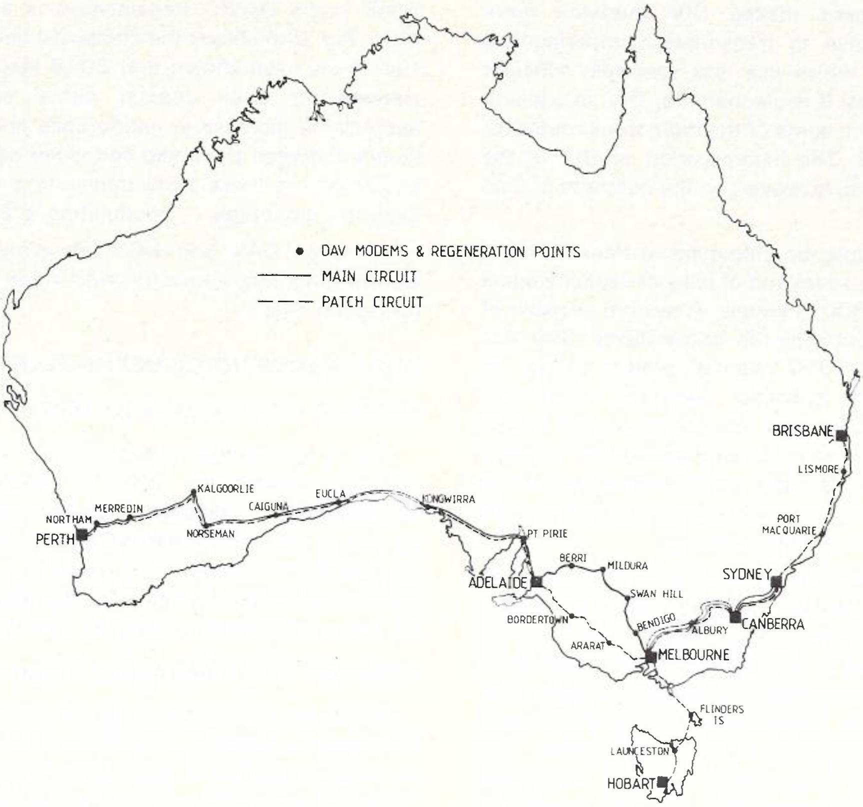
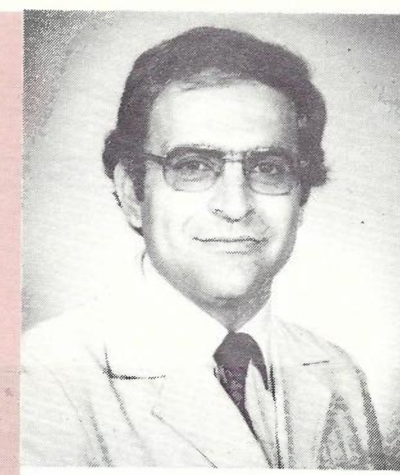
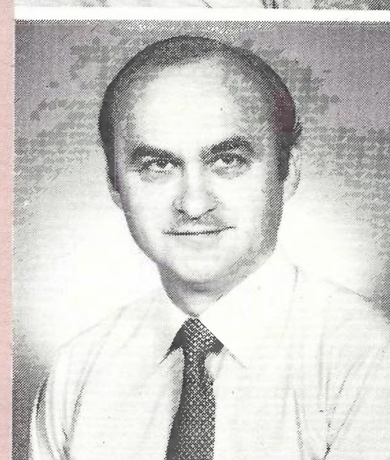


Fig. 1 — Planned DAV Radio Routes, Late 1982.



ANDREW T. MICHAELIDES joined Telecom Australia Headquarters in 1974. From 1974 to 1977 he worked with the Broadcasting Branch group dealing with the introduction of the FM Broadcasting Service. Since 1977 he has been with the Radiocommunications Construction Branch where he is now Senior Engineer in the Spectrum and Design Section. Prior to joining Telecom, he did post-graduate work in the microwave field, tutored at the University of NSW and lectured in electrical engineering at the NSW Institute of Technology. Dr Michaelides graduated from the University of NSW with B.Sc., B.E. (Hons) and Ph.D. in 1966, 1968 and 1974 respectively.



GEORGE MACKIE joined the Australian Post Office in 1961 as a Technician-in-Training and, from 1966, as a Senior Technician, worked in Radiocommunications Maintenance at Redfern and Waverley microwave terminals. For two years, from 1973, George was helping in the construction phase of communications for the Moomba-Sydney gas pipeline project. In 1976 he joined Radiocom. Construction Branch H.Q., Melbourne where, presently, as a Senior Technical Officer 2 in Trunk Systems, he is engaged in project provisioning work. Also in 1976 George completed a Certificate of Technology (Electronics) course at RMIT.

used. This requirement makes DIV modems more expensive and sensitive to transmission imperfections than other methods which use less spectrally efficient modulation techniques. It is planned that DIV, in addition to DAV, may be used in some of the main trunk routes for the DDN after 1982. The incorporation of DIV in the network would depend, however, on the outcome of field trials.

DUV can, in principle, be employed to transmit high-speed data in the sub-baseband of links of capacity equal to or greater than 1800 channels. A system capable of transmitting 2048 kbit/s in the conventional 300 kHz sub-baseband of an 1800 channel system is not, at present, commercially available. Generally, within the Australian trunk relay network the sub-baseband is well occupied by service channels and subscriber wayside channels provided via standard multiplex or direct-to-line multiplex equipment. For these reasons, it is not planned to use DUV in the Australian network.

DAVID is used specifically in the Telecom network to transmit sound programme channels rather than data services. To achieve this a sound programme multiplex equipment is used first to multiplex up to six, 30 Hz to 15 kHz programme channels into a 2048 kbit/s stream. This stream then modulates a subcarrier (eg. 7.5 MHz) using 4PSK (4-phase, phase-shift keyed) modulation. The modulated subcarrier is combined with the video and both signals frequency modulate the RF carrier for transmission in the network. The required bandwidth for 2048 kbit/s DAVID transmission is approximately 1.6 MHz. **Fig. 2(a)** shows the combined baseband spectrum. Field trials have shown that 2048 kbit/s DAVID can be transmitted over coaxial cable systems without appreciable increase in interference and deterioration in quality between the audio and video signals. The coaxial equipment in these tests transmits a video signal over cable by amplitude — modulating a 21 MHz carrier.

Although DAV and DOV use similar techniques of transmitting data above (or over) voice, DAV only will be discussed here.

DATA ABOVE VOICE IN THE TELECOM NETWORK

Extent of DAV Network by 1982.

Fig. 1 shows the extent of the 2048 kbit/s DAV network required by 1982 to meet the intercapital requirements for dedicated data services. Links already in service or planned for service shortly utilizing the DAVID method for transmission of sound programme lines are not shown in Fig. 1 because the emphasis in this paper is on the transmission of data for the DDN.

DDN and DAV Performance Objectives

These are formulated in terms of Error Free Seconds (EFS) and Availability. An EFS is a second of transmission in which no bits are in error. A system, is unavailable (an "outage") when 10 or more consecutive seconds are in error.

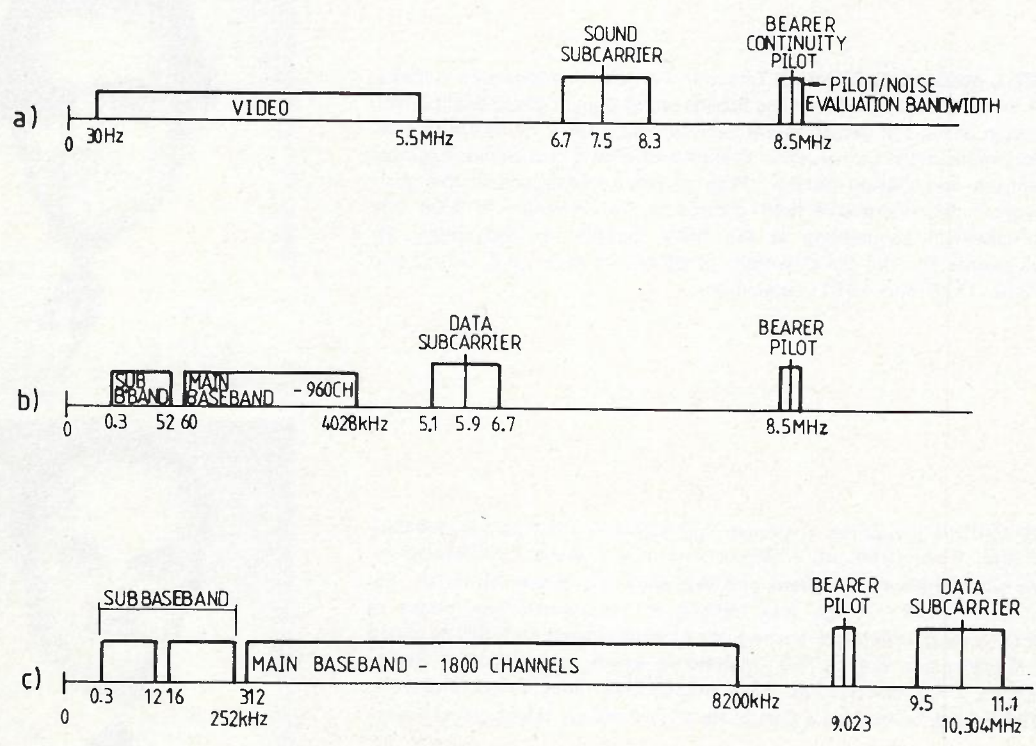


Fig. 2 — Baseband Spectra for DAV and DAVID Systems:
(a) Digital Sound on a Television Bearer.
(b) DAV on 960 channel Telephony Bearer.
(c) DAV on 1800 channel Telephony Bearer.

The performance objectives have been formulated primarily for a 2500 km route and 64 kbit/s DDN bearer. These are likely to be changed as more information becomes available after the first stages of the DDN become operational. The same objectives apply, in the interim, for 2048 kbit/s DAV systems. The 64 kbit/s DDN and interim 2048 kbit/s DAV performance objectives for a 2500 km route are:

Error performance in any month:

- long term — equal to or better than 99.5% EFS
- short term — equal to or better than 99% EFS for 90% of 15 minute intervals.

Availability performance over 12 months:

- better than 99.9% with no single outage exceeding 4 hours.

The objectives are modified proportionately for shorter routes. A proposal exists that a percentage distribution be introduced to account for different segments of the DDN route; this distribution is currently 90%, 5% and 5% for 1 long haul, 2 metropolitan and 2 local segments respectively. Also under study is the introduction of a "demultiplexing" factor (a factor relating the objectives at 64 kbit/s to higher bit rates) to relax the objectives for 2048 kbit/s systems. Measurements to determine a suitable "demultiplexing" factor so far indicate that this factor is about 10 for PCM cable systems (i.e. objectives at higher bit rate are relaxed by a factor of 10) but may be less for radio systems (Ref. 2).

OPERATION OF DATA ABOVE VOICE ON RADIO ROUTES

This section summarises the data performance of radio routes tested so far and compares them with the current objectives. It also describes in more detail the operation of DAV modems and discusses sources of error in DAV transmission over radio.

Operation of the DAV Modems

It was indicated earlier that DAV involves the transmission of digital streams by using unoccupied spectrum space above the telephony (TF) baseband. This is done by the data stream modulating a single subcarrier frequency above the TF baseband. The modulated subcarrier and TF are then combined in appropriate passive filters and the combined signal frequency-modulates the RF carrier of the radio system. Typical subcarrier frequencies which will be used in the network are 5.9 and 10.3 MHz with required bandwidths of about 1.5 MHz for 960 and 1800-channel systems respectively. **Figures 2(b) and 2(c)** show the baseband spectra in these cases.

Fig. 3 gives a schematic of a DAV modem and its connection at a radio terminal.

At the transmitter side the incoming HDB3 line code signal is converted by the TX LOGIC into a binary signal driving the SCRAMBLER. The purpose of the SCRAMBLER is to randomize the signal so that a uniform signal spectrum, regardless of the binary sequence composition, is obtained; this prevents the occurrence of interference tones within the baseband when a repetitive binary sequence is transmitted. The scrambled binary signal modulates a carrier (usually called the data subcarrier) sufficiently removed from the highest frequency of the TF baseband. This modulated subcarrier is bandlimited to within 1.5 MHz and is then added to the baseband signal in the COMBINING FILTER.

A data subcarrier frequency of 5.9 MHz will be used for 960-channel systems where the top TF baseband frequency is 4.028 MHz. A 10.3 MHz subcarrier will be used for 1800-channel bearers the upper baseband frequency of which is 8.204 MHz. A 7.5 MHz one will be employed in the case of TV bearers (i.e. in DAVID mode) to carry sound programme channels.

The modulation schemes used are differentially encoded 4PSK with the 5.9 and 7.5 MHz data subcarriers and differentially coded offset QAM (quadrature amplitude modulation) with the 10.3 MHz subcarrier. When unmodulated subcarriers for each case enter the radio bearer at the nominal levels the IF-RF deviation will be approx. 750 kHz rms for 960 and 1800-channel systems and 1.1 MHz rms for TV. This deviation is chosen as a good compromise between the desired EFS performance and the intermodulation noise falling into the TF baseband as a result of the data.

On the receive side the modulated signal is separated from the main baseband, in the SEPARATING FILTER. After demodulation, the signal is regenerated and then descrambled. The DESCRAMBLER reverses the randomizing operation of the SCRAMBLER and restores the binary signal to its original "send" form. The restored binary coded signal is subsequently converted into a HDB3 encoded signal in the RX LOGIC unit. Both the RX LOGIC and TX LOGIC units provide standard PCM interfaces according to CCITT Rec. G703.

The data modems also provide local and remote alarms. A local alarm causes a LED to light and a ground to be extended for remote supervision. A remote alarm, also called an "Alarm Indicating Signal" (AIS), consists of a continuous "1" sequence sent by the modem's supervision circuits to the remote DDN centre. The AIS may be initiated by an input signal failure at the modulator, an input level failure at the demodulator or by detection of excessive Bit Error Rate (BER). On reception at the DDN centre, the AIS is used to initiate an automatic changeover from the main to the patch circuit.

Sources of Errors in DAV

Broadband microwave bearers were first introduced in 1959. Since then the Telecom microwave network has been equipped with a wide variety of equipment, each stage of the network's development reflecting the best available technology at the time. Excluding external factors such as propagation, the characteristics of the existing radio equipment (equipped with DAV modems) will therefore have a significant effect on the performance of DAV.

The performance of DAV radio circuits is influenced mainly by the following:

- total noise in the data subcarrier bandwidth (±0.8 MHz about the subcarrier frequency).
- transient effects.

The total noise comprises:

- thermal noise and its increase due to fading.
- intermodulation noise.
- interference noise.

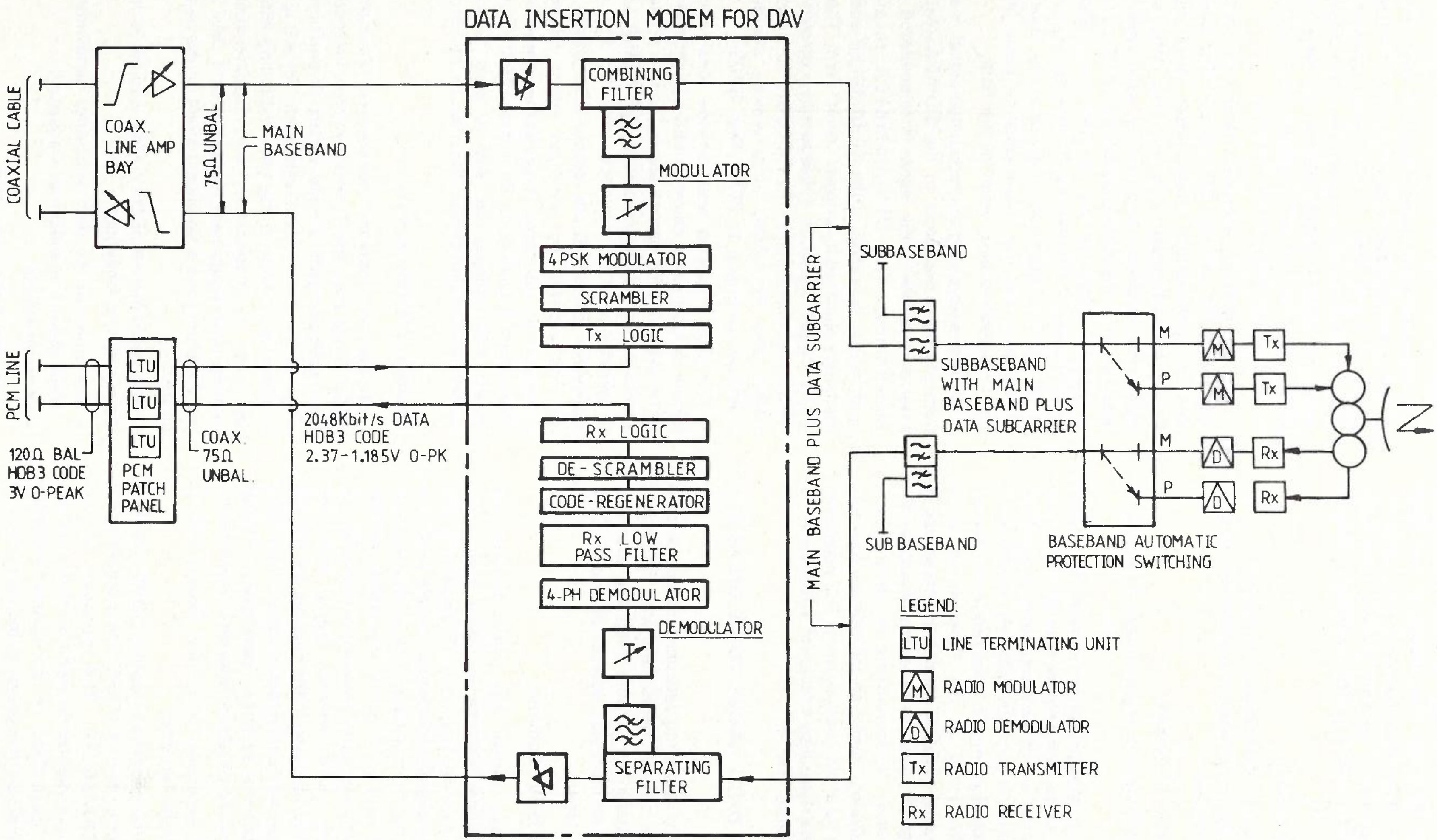


Fig. 3 — Typical Data Insertion Modem and Connection at a Radio Terminal.

The thermal noise depends on factors such as the noise figure of the receivers, the gain of the antennas and separation distance between the sites. These factors are difficult to change without redesigning the existing system and their influence on DAV is therefore very much dependent on the particular route.

The intermodulation noise arises from distortions suffered by the signals in the carrier, baseband or modem sections of the radio system. The distortions are caused by linear and non-linear amplitude and phase characteristics at the carrier section and non-linear characteristics in the baseband and modem sections. Note that the distortions in the carrier section need not be caused by equipment alone. Severe distortions can result from the propagation characteristics of the radio path; in fact, multipath fading is a most significant cause of data errors (Ref. 3) as it can cause high distortions at or near the data subcarrier.

The interference noise is contributed by other services occupying co-channel or adjacent channel radio frequencies. This is minimised to acceptable levels mainly by judicious selection of the channel frequencies, route configuration and antenna characteristics at the design stage of the system.

Transient effects are caused usually by bearer and diversity switching. Bearer switching occurs whenever the performance deteriorates below a set margin or the bearer fails completely; in both cases switching to a protection bearer becomes necessary. Most diversity switching occurs whenever the higher signal (by 4-6 dB) out of two receivers is selected for demodulation. The signal changes at the two receivers can be brought about by many reasons, the main being propagation fading. Because a higher signal is received after the diversity switching, the S/N ratio is improved. Switching diversity is widely used in the Telecom network and although satisfactory as far as telephony performance is concerned, it is not the most suitable for data transmission because short breaks of the order of 10 μs occuring during switchover, cause errors in transmission. Statistically, a bearer equipped with switching diversity will give higher data availability and hence better performance over a bearer which is not so equipped (Ref. 3). The reason for this is that without diversity a bearer would spend more time in a worse noise condition which would cause more errors than those caused by the short switching breaks. For data it is preferable to use electronic combining diversity techniques which are now becoming available and which have been shown, by laboratory and field tests, to be very effective in diminishing the occurrence of errors due to fading (Ref. 3). With combining diversity, the two separately received signals are combined in phase (no switching breaks) so that an improvement in the resultant noise performance occurs. The combining can occur at RF or at IF. The routes which will be provided with DAV modems by 1982 are equipped with switching diversity only.

DAV Measurements

Telecom performed early DAV tests on selected radio routes. These routes were Melbourne-Albury, Lismore-Sydney and Melbourne-Ararat (see Fig 1). The purpose was to confirm the suitability of DAV for data transmission and to check whether DAV will meet current performance objectives set down for the DDN.

Because the testing took place at an early stage, its network extent was limited by the number of available DAV modems. Additional, longer-period tests over longer routes will be performed during 1981-82 when the inter-capital network becomes equipped with DAV as shown in Fig. 1.

Essentially, the procedure followed in the measurements was to test the radio bearer before and after DAV modem installation and note the differences. The data performance was monitored at demodulation stations and compared with the objectives mentioned earlier for the long haul segment of the DDN.

The routes tested, salient information and results are summarised in Table 1. Measurements for the Lismore-Sydney and Ararat-Melbourne routes were taken during the summer period. This period is usually the worst for data performance because of its prevalent radio propagation variations. Over a longer period, including all seasons, the availability performance is expected to be even better; the error performance during the non-summer months is also expected to improve.

The DAV equipment used in the tests was either prototype or had a data subcarrier frequency which was different from the one which will be used eventually (eg. 7.5 MHz in test modem instead of 5.9 MHz in service modem). Therefore, some of the DAV modems which will finally be installed are likely to suffer less from intermodulation noise (because of the lower frequency of their data subcarrier) and, as a result, perform better than those used in the tests.

It is worth noting in Table 1 that the performance deteriorates drastically when no regeneration takes place at an intermediate demodulating section (see Lismore-Redfern results). Where the measured results failed to meet the objective they did so by a very small margin.

CONCLUSIONS

DAV transmission between capital centres will be used extensively in the first stages of Telecom's DDN. Further expansion of the DDN may be accommodated by DIV transmission or by digital radio bearers. From tests performed in the network so far and laboratory measurements, one can draw the following conclusions about DAV:

- it is expected that the current DDN performance objectives will be met by most radio routes but some testing will be necessary, especially on routes with existing marginal telephony performance.
- to meet the objectives, it is necessary to regenerate at major demodulating sections of marginal systems. Regeneration at these sections is also recommended for well behaved systems to safeguard satisfactory performance.
- the degradation to the analogue traffic as a result of data insertion is usually negligible. However, degradations in the upper baseband have been noted; these depend on the characteristics of the particular system used and can be alleviated by suitable engineering.
- fading, especially multipath fading, is one of the major

Measurements & Objectives / Route & Period of Tests	Error Performance				Availability		Comments
	Long Term: Percent Error-Free-Seconds (%EFS)		Short Term: Percent of 15-minute intervals with better than 99% EFS in each interval		Percent of Total time without outages***		
	Measurement	Objective	Measurement	Objective	Measurement	Objective	
Melbourne-Albury Loop back May-June 1979	99.99	99.89	-	97.84	100	99.978	The data was looped back at Albury (no regeneration). The total path length was 600 km, with 6 hops and no diversity. Short term performance was not measured because of lack, at the time, of suitable monitoring equipment. 10.3 MHz data subcarrier was used. 1800 channels capacity, system partially occupied during tests.
Lismore-Port Macquarie 27.12.79-30.3.80	99.97	99.94	99.32	98.87	99.989	99.988	One demodulating section 312 km long, being the first one in Lismore-Port Macquarie-Redfern route. 960 channels capacity. 7.5 MHz data subcarrier was used.
Lismore-Redfern with regeneration 27.12.79-13.3.80	99.76*	99.88	94.32*	97.60	99.985	99.976	Two demodulating sections, total length 665 km. Measurements were taken at Redfern, with and without regeneration at Port Macquarie. There are 13 hops in this route (6 between Port Macquarie and Redfern). 5 repeaters have RF combiners and one repeater has switching diversity. 960 channels capacity. 7.5 MHz data subcarrier.
Lismore-Redfern without regeneration at Port Macquarie 20.3.80-9.4.80	79.96**	99.88	15.61**	97.60	92.03**	99.976	
Ararat-Melbourne 21.11.80-28.1.81	99.93*	99.96	98.59*	99.22	99.996	99.992	One demodulating section of 215 km length, 4 hops and switching diversity in one hop. 7.5 MHz data subcarrier 960 channels capacity.

* Fails to meet objective by a small margin (less than 5%)
** Substantially fails to meet objective.
*** Outage = 10 or more consecutive seconds in error
\+ Worst month for error and whole period for availability performance
\+\+ For a "demultiplexing" factor of unity (worst case condition); Modified also for distance with a 0.9 factor for radio segment.

Table 1 — Comparison of DAV Measurements^{+} with DDN Performance Objectives^{++}

causes of errors in DAV transmission. Systems equipped with switching diversity may perform better statistically than non-diversity equipped systems; however, combining diversity is preferred for minimizing the occurrence of data errors.

Further tests will be done during 1981-82 when the intercapital radio routes will be fully equipped with DAV modems. The results from the Adelaide-Perth route would be of particular interest because of its known severe propagation characteristics and long length. Also of interest, in terms of performance objectives, will be measurements on over-water paths (Melbourne-Launceston) and on routes equipped with radio equipment approaching its replacement time.

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An Introduction to The Australian Digital Data Network (DDN)

T. POUSSARD, C. BEARE and Y. FALKOVITZ

The Digital Data Network (DDN) is a data communications network which is integrated into the national telecommunications system. Through this network new data communications services will be provided and marketed under the category Digital Data Service (DDS). Both point to point and multipoint synchronous dedicated services will be available, using the data rates 1200, 2400, 4800, 9600 bit/s and 48 kbit/s. These services are similar to those which have been provided over the past decade by the Datel Service, employing data modems operating over cable pairs and/or telephony transmission systems.

Dedicated data communications services are required in the general community and within Telecom in support of a wide range of teleprocessing applications. They are also required within Telecom to support other data services directly. Demand has traditionally been very high and growth rate is currently in excess of 30% per annum.

The DDN is being established to enable the rapid service provision and restoration of dedicated data communications services in a far more effective and efficient manner than is possible via the Datel Service. In addition the network is being engineered to achieve a higher standard of error performance and availability.

The major factor in the ability to construct this network is the availability of 2048 kbit/s digital transmission systems. Digital line systems as provided for PCM Systems are to be employed in the metropolitan areas, and Data Above Voice (DAV), Data on Radio (DOR) and digital radio systems on the long haul routes.

Data Networks of this type are not unique to Australia. The first digital dedicated-service public data network was introduced in Canada in 1973 (Dataroute). Since that time the United States has introduced the Dataphone Digital Service (1974) and France has introduced the Transmic Service (1978). Many other countries have introduced or planned to introduce similar networks.

NETWORK ARCHITECTURE

The DDN equipment is located in DDN centres and customers' premises.

The customers' premises house the Data Circuit-terminating Equipment (DCE) which connects the Data Terminal Equipment (DTE) to the DDN, and replaces the data modem used in a conventional Datel service. The DCEs use direct digital transmission over cable pairs to carry the data traffic to the nearest DDN centre.

DDN centres are of two types — main centres and terminal centres. The main centre is the focal point for DDN in its area and normally has associated with it a number of metropolitan and regional terminal centres. These terminal centres house multiplex and transmission equipment to gather customer traffic and route it via the main centre to other centres. The main centre also houses similar equipment and acts as a gathering point for customers in its immediate area.

In addition to its traffic concentration and transit functions, the main centre plays two other special roles. It contains the master or slave clock used for network synchronisation as well as being the control centre for network management in its area.

IMPLEMENTATION PLAN

Telecom's DDN is to be installed in stages. The Stage 1 network will accommodate approximately 180 customer ends (DCE's) in Melbourne, Canberra and Sydney. Main Centres will be established in Melbourne and Sydney with a terminal centre in Canberra and two small metropolitan terminal centres in Sydney. The inter-centre links will use 64 kbit/s transmission. The Stage 1 network will be used to evaluate the equipment and procedures to be adopted in later stages and is to be operational by September 1981.

The Stage 2 network is due to be operational as a public service by December 1982 catering for approximately 3000 customer ends and implemented as shown in **Fig. 1**. Terminal centres will be established in metropolitan areas but not in regional areas at this stage. The majority of the centre to centre links will be via duplicated 2048 kbit/s digital links using Data-Above-Voice modems on intercapital links and digital line systems on metropolitan links.

Under development are plans for further expansion of the Digital Data Network to accommodate regional and intra-urban services from around December 1983. Data on Radio (DOR) and digital radio bearer transmission will be necessary for this stage. Forecasts indicate 40,000 customer ends will be in service by mid 1986.

CUSTOMER EQUIPMENT

The Customer's premises house the Data Circuit-terminating Equipment (DCE) interfacing customer terminals (Data Terminal Equipment — DTE) with the Network proper. The Data Terminal Equipment to be used in conjunction with the Digital Data Network has been designed for inter-facing with synchronous V-series analogue modems currently used in the Datel Service. The mutliwire interface between the DTE and DCE is specified in the CCITT Rec X.21 bis.

There are four types of Data Circuit-terminating Equipment to be used with the DDN:

DCE-LS Low Speed Single Stream, transmission speeds 1200, 2400, 4800, 9600 bit/s, digital interfaces X.21 bis and X.21;

DCE-HS High Speed Single Steam, transmission speed 48 kbit/s, digital interfaces X.21 bis and X.21;

DCE-HMUX High Speed Multiplexed Stream, transmission speed 48 kbit/s, digital interface X.22;

DCE-LB Low Speed Buffered, transmission speeds 1200, 2400, 4800, 9600 bit/s, digital interface X.21 bis.

All four types are intended for use on unloaded cable pairs. They are free standing mains powered units suitable for desk top mounting or for mounting in a standard Telecom Datel modem cabinet at the customer premises.

The DCE performs three major functions:

- Provision of the appropriate signals over the multiwire interface between the DTE and DCE. The types of multiwire interfaces are specified in the CCITT recommendations as follows:

  X.21 bis. This interface is compatible with Datel V series modem interfaces (V.24 or V.35) and is used on the majority of DCE's.

  X.21 This is the new interface specification designed for data network interconnection. It uses new mechanical and electrical interconnections and has fewer interchange circuits. DCE's with this interface will be progressively introduced in DDN.

  X.22 This is a new interface that allows a multiplexed stream of data to be interchanged between a DCE and DTE. The physical interface conforms with X.21 and operates at 48 kbit/s to the user. This facility is marketed as the NETPLEX Service and allows one central DCE to accept data multiplexed from up to 20 remotely located DCE's.

- Transformation of the original information stream from the DTE into a format acceptable for the Zero order Multiplex Equipment ZDME. This transformation is done by using a technique of ENVELOPING.

  The structure of an ENVELOPE is shown in **Fig. 3**. The data stream received by the DCE from the DTE is continuously split into six-bit blocks. Before transmission of the first bit of each six-bit block toward the ZDME, a FRAME ALIGNMENT BIT "F" is transmitted. The "F" bit is followed by six DATA BITs. The last (sixth) bit of the original data block is followed by the STATUS BIT "S". The following six-bit data block is preceded by its "F" bit etc. This particular structure, when blocks of data bits are enveloped from both ends by special non-data bits, gives the name to the technique.

  The function of the FRAME ALIGNMENT BITs is to transmit a bit pattern, which allows the proper alignment of data on the receiving ends of the DCE-ZDME line. The pattern of the frame alignment bits in data streams exchanged between DCE and ZDME is as follows . . . 10101 . . . A status bit, in conjunction with data bits, conveys control information. If the status bit equals "1", the envelope transmits data information, if the status bit equals "O", the envelope transmits network control information.

  The transmission of an eight-bit ENVELOPE should take exactly the same time as the duration of the original six-bit data block. The addition of the framing and status bits results in a 33% increase in bit rate, so that bearer channel rates are:

  12800 bit/s for the 9600 bit/s data signalling rate;
  6400 bit/s for the 4800 bit/s data signalling rate;
  3200 bit/s for the 2400 bit/s data signalling rate.

  The data stream, received by the DCE from the ZDME has a similar structure and is processed by the DCE in reverse order. Individual envelopes are singled out, stripped of the framing and status bits, and the stream, containing data bits only, is sent to the DTE.

- Direct digital (baseband) transmission over the physical cable pairs between the customer and the DDN Terminal Centre.

  Due to the use of digital baseband transmission the DCE is much simpler and hence more reliable than

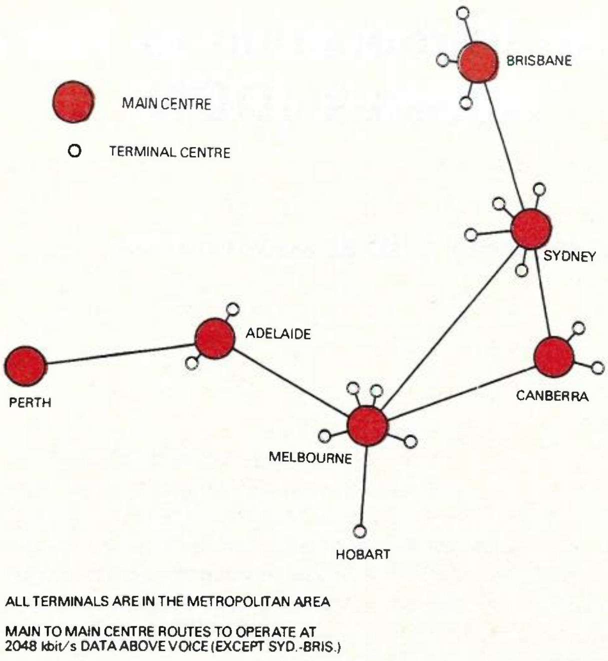


Fig. 1 — Stage 2 Implementation (Dec. 1982)

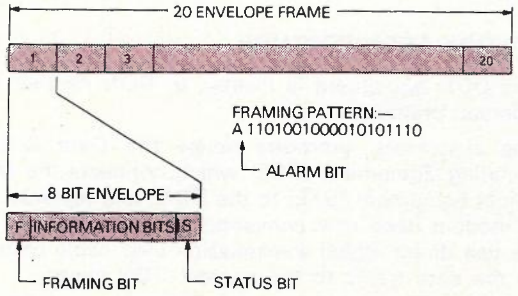
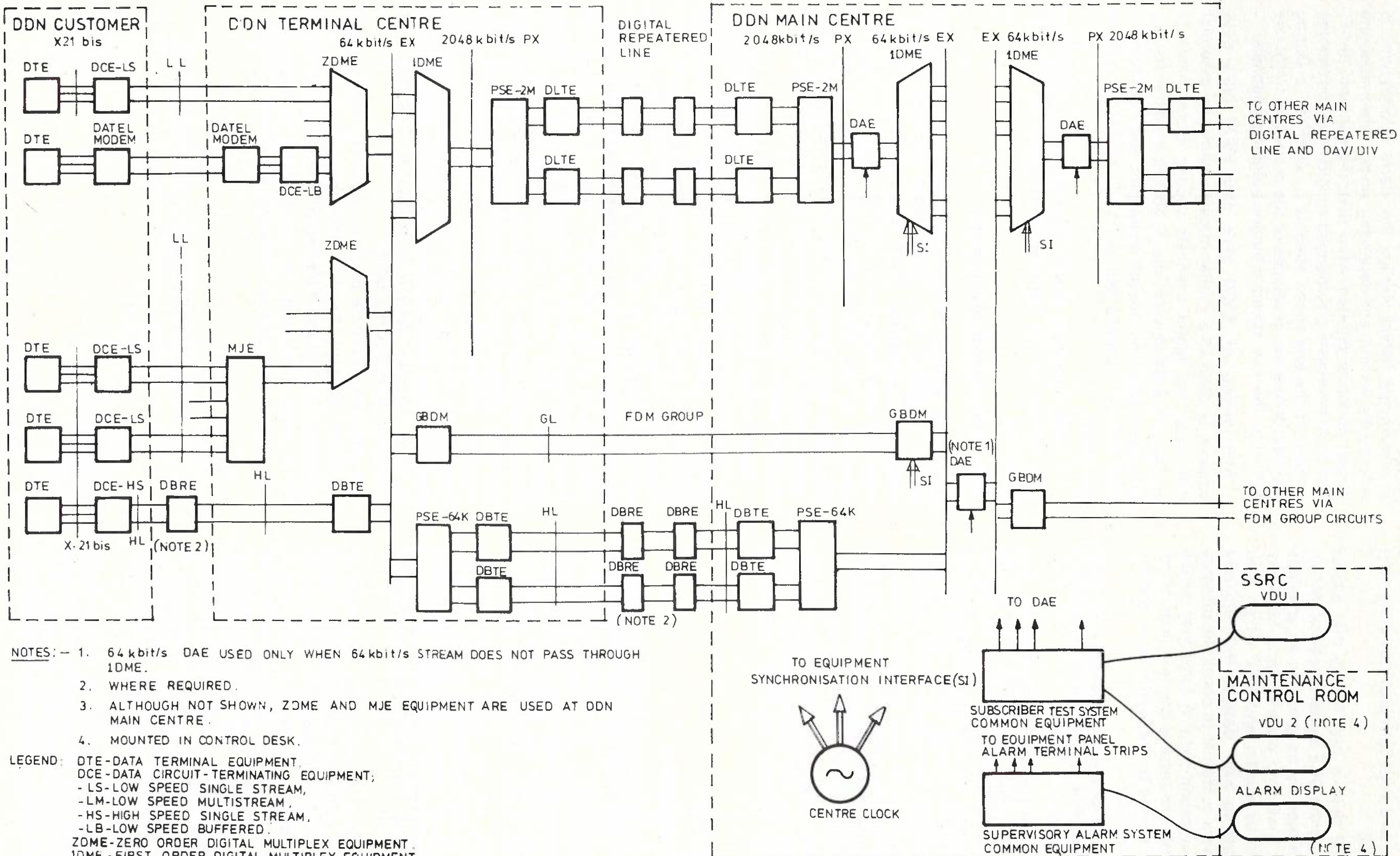


Fig. 3 — 64 kbit/s Frame Structure



NOTES: — 1. 64 kbit/s DAE USED ONLY WHEN 64 kbit/s STREAM DOES NOT PASS THROUGH 1DME.
2. WHERE REQUIRED.
3. ALTHOUGH NOT SHOWN, ZDME AND MJE EQUIPMENT ARE USED AT DDN MAIN CENTRE.
4. MOUNTED IN CONTROL DESK.

LEGEND:
DTE - DATA TERMINAL EQUIPMENT.
DCE - DATA CIRCUIT-TERMINATING EQUIPMENT;
- LS - LOW SPEED SINGLE STREAM,
- LM - LOW SPEED MULTISTREAM,
- HS - HIGH SPEED SINGLE STREAM,
- LB - LOW SPEED BUFFERED.
ZDME - ZERO ORDER DIGITAL MULTIPLEX EQUIPMENT.
1DME - FIRST ORDER DIGITAL MULTIPLEX EQUIPMENT.
MJE - MULTIPOINT JUNCTION EQUIPMENT.
DBTE - DIGITAL BASEBAND TRANSMISSION EQUIPMENT.
DBRE - DIGITAL BASEBAND REPEATER EQUIPMENT.
GBDM - GROUP BAND DATA MODEM.
PSE-64k - PROTECTION SWITCHING EQUIPMENT 64 k bit/s
PSE-2M - PROTECTION SWITCHING EQUIPMENT 2048 kbit/s
DLTE - DIGITAL LINE TERMINAL EQUIPMENT
DAE - DATA ACCESS EQUIPMENT.

INTERFACES:
LL - LOW SPEED LINE INTERFACE.
HL - HIGH SPEED LINE INTERFACE.
EX - DIGITAL EQUIPMENT INTERFACE 64 kbit/s
PX - DIGITAL EQUIPMENT INTERFACE 2048 kbit/s.
GL - GROUP BAND LINE INTERFACE

Fig. 2 — Digital Data Network — Typical Configuration.

analogue data modems. The DCE converts a binary code from the DTE into a line code, suitable for transmission over cable pairs. It also extracts its timing from the line signal, and in its turn provides the timing to the customer DTE.

DDN customers will have a test facility that allows them to perform a remote DCE digital loopback. Within the DCE this is achieved by transmitting an envelope with the status bit S=O and a particular 6-bit word, which is recognised by the far end DCE which then connects output data to input data at its multi-wire interface. This allows a customer to check the integrity of the total communication path. A local loop which connects the transmit and receive line terminals of the local DCE can be activated by the customer to test the operation of his local DCE.

Automatic equalisation for the length of cable is inbuilt into all DCEs, and therefore special line conditioning of cable pairs is not required.

The distance of transmission depends on the transmission rate and cable type (from 3km for 48 kbit/s data streams and 0.4 mm cable to 30 km for 2400 bit/s data streams and 0.9 mm cable). Current studies on transmission levels may allow these distances to be increased in the future. When customer premises are situated too far from a Terminal Centre, point-to-point Datel Service links can be used. In this case analogue modems are installed and connected to the DDN via a DCE-LB in the terminal centre.

The low speed DCEs are connected to the line through low speed line interface LL. The high speed DCE-HS are connected to the line through the high speed line interface HL.

DIGITAL MULTIPLEXING

Zero Order Digital Multiplexing

Zero Order Digital Multiplexing in DDN is the process, which combines low speed (1200 bit/s, 2400 bit/s, 4800 bit/s, 9600 bit/s) customer data streams into a multiplexed aggregate 64 kbit/s data stream. The structural characteristics of the 64 kbit/s data stream, used in DDN, are specified in the CCITT Rec. X.50, Div. 3, and its electrical characteristics in Rec. G.732, Para. 5.1.

The simplest case of the Zero Order Digital Multiplexing in DDN is the multiplexing of 20 channels, operating at 2400 bit/s (it should be remembered that due to the process of enveloping in the DCE, the rate of the data stream reaching the ZDME has increased to 3200 bit/s).

The multiplexing proper is preceded by alignment of individual tributary data streams in such a way that they can be split into individual envelopes. The alignment is done using the known pattern of the frame alignment (F) bits of each tributary data stream. The frame alignment bits in envelopes ready to be assembled into the aggregate 64 kbit/s stream, are changed: "F" bit of the first envelope is used for transmitting of the remote alarm information, and "F" bits of the remaining 19 envelopes in the order of their positioning in the 64 kbit/s frame are assigned the bits of a 19-bit framing pattern: 1101001000010101110.

The multiplexing process proper is achieved by assembling the envelopes into an aggregate multiplexed data stream in order of corresponding channels. The frame structure of the 64 kbit/s data stream is shown in **Fig. 3**.

The process of demultiplexing runs in the reverse order. The incoming 64 kbit/s data stream is aligned (using the framing pattern) in such a way that its envelopes can be directed into the corresponding outgoing tributary channels. The content of "F" bit of the first envelope (which carries the alarm information), is read by the system, and depending on the information the proper action is initiated. After that, the contents of "F" bits of all envelopes are changed according to the framing pattern of the low speed streams (. . .01010. . .). During the next frame the envelopes of the preceding frame are sent into the low speed tributary outgoing channels.

Multiplexing of 4800 bit/s and 9600 bit/s data streams is done in a similar manner, with one essential difference: the faster channels occupy more than one envelope in a 64 kbit/s frame. A 4800 bit/s data channel occupies two evenly spaced envelopes, and a 9600 bit/s data channel occupies four evenly distributed envelopes per frame.

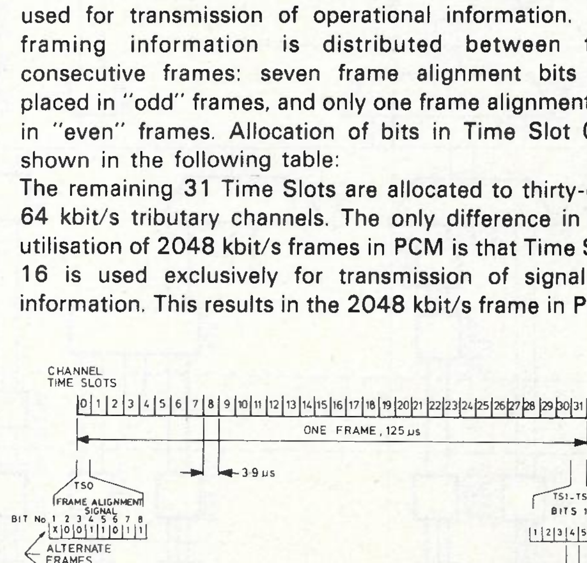
A 1200 bit/s data stream is treated as a 2400 bit/s data stream at the expense of efficiency in channel utilization.

First Order Digital Multiplexing

First Order Digital Multiplexing in DDN is the process, which combines 64 kbit/s data streams into a multiplexed aggregate 2048 kbit/s data stream. The structural characteristics of the 2048 kbit/s stream are specified in the CCITT Rec. G.732, Para. 2, and its electrical characteristics in Rec. G.703, Para. 5. All parameters of 2048 kbit/s data streams are identical to those of 2048 kbit/s PCM streams.

The structure of the 2048 kbit/s frame is shown in **Fig. 4**. The elementary building block of a 2048 kbit/s frame similar to a 64 kbit/s frame, is the eight bit envelope. In 2048 kbit/s frames, the envelopes are referred to as Time Slots (TS). The 2048 kbit/s frame consists of 32 timeslots from TSO to TS 31. The framing arrangement of the 2048 kbit/s frame is different from the framing arrangement of the 64 kbit/s frame: in the latter the frame alignment pattern is distributed through the frame, whereas in the former a frame alignment word is transmitted in the Time Slot TSO. The Time Slot 0 is also used for transmission of operational information. The framing information is distributed between two consecutive frames: seven frame alignment bits are placed in "odd" frames, and only one frame alignment bit in "even" frames. Allocation of bits in Time Slot 0 is shown in the following table:

The remaining 31 Time Slots are allocated to thirty-one 64 kbit/s tributary channels. The only difference in the utilisation of 2048 kbit/s frames in PCM is that Time Slot 16 is used exclusively for transmission of signalling information. This results in the 2048 kbit/s frame in PCM



X - UNALLOCATED DIGITS, SET TO '1' STATE WHEN NOT USED

ø - DIGIT NORMALLY '0' BUT '1' WHEN REMOTE ALARM SIGNAL IS TRANSMITTED

Fig. 4 — 2048 kbit/s Frame Structure

	Bit number 1	2	3	4 5 6 7 8
Time-slot O containing the bulk of the frame alignment signal	Reserved for international use	0	0	1 1 0 1 1
		Frame alignment signal		
Time-slot O containing one frame alignment bit	Reserved for international use	1 Frame alignment bit	Alarm indication to the remote muliplex equipment	Reserved for national use

systems accommodating 30 channels as compared with 31 channels in DDN.

DIGITAL TRANSMISSION

Digital Baseband Transmission

One of the major advantages of DDN is that it allows transmission of digital data directly on unloaded cable pairs. The advantages of digital baseband transmission are as follows:

- Compared with data modems that use digital transmission over analogue systems, the DDN transmitting devices (eg DCE) are much simpler. This is because there is more available bandwidth on unloaded cable pairs and also modulation-demodulation is not required.
- The transmitting devices, being simpler, make the equipment more reliable.
- The baseband signal can be regenerated without noise accumulation. A regenerative repeater reshapes, retimes and regenerates the signal.

Although digital transmission could be realised by directly connecting the binary digital output to the line, this is not done for two reasons. Firstly, the binary signal is not suitable for the extraction of timing, eg when continuous binary "1" is sent, and secondly, the use of the binary code would result in considerable low frequency content in the signal, which is not desirable for coupling reasons.

Differential Diphase Code

The line code chosen for the low speed transmission, eg customer rates 2400-9600 bit/s, is the differential diphase code as shown in **Fig. 5a, b.** This signal does not have significant low frequency content, and the data transitions which are present during each bit period allow data timing recovery.

The cut-off frequency of loaded telephone lines is approximately 3.5 kHz **(Fig. 5c)**. The spectrum of the baseband signals employed in the DDN is higher, and thus only unloaded cables are used in the DDN.

The interface used to connect customer DCEs with ZDME is called the Low Speed Line Interface (LL).

Differential diphase coding is also used for transmission of the 64 kbit/s signal over unloaded cable pairs. The equipment used for this purpose is called Digital Baseband Transmission Equipment (DBTE) and when long distances are required the signal is regenerated at intermediate points by Digital Baseband Repeater Equipment (DBRE). The interface between these equipments and the cable pairs is called the High speed Line interface (HL). This equipment is also used to connect 48 kbit/s DCEs (DCE-HS) to the DDN.

2048 kbit/s Digital Line Code

Transmission of 2048 kbit/s on unloaded cable pairs is a standard technique used in PCM systems. The line code used there is called High Density Bipolar — 3 zeros suppression (HDB 3) and has similar properties to the differential diphase code.

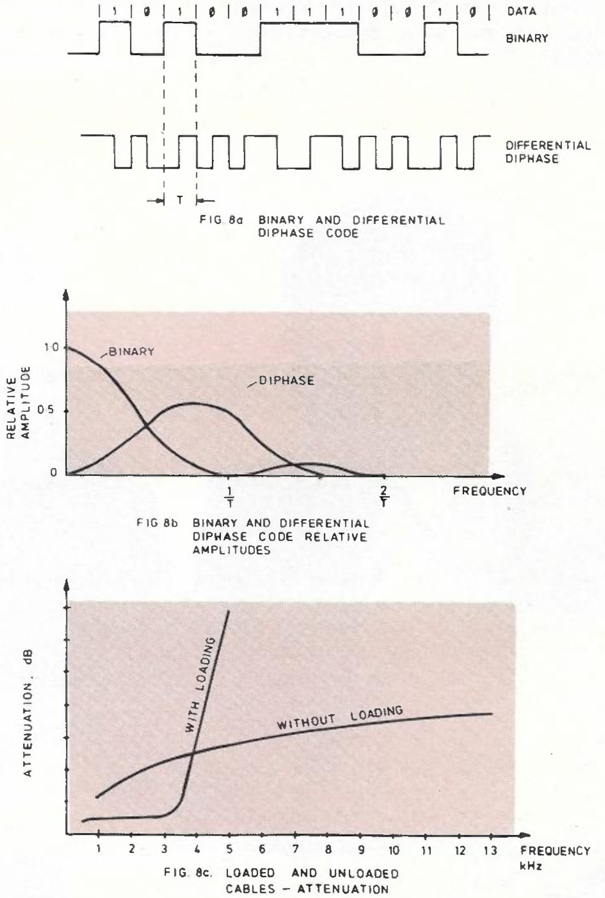


Fig. 5

DDN will use digital line systems as used for PCM transmission to transmit 2048 kbit/s between DDN centres.

Digital Interfaces

64 kbit/s Interface (EX)

The interconnection of all DDN equipment at 64 kbit/s is achieved via the 64 kbit/s interface designated EX. This interface is a 4 wire interface (one pair in each direction) and used a coding technique to convey the following information across the interface:

64 kbit/s data
64 kbit/s timing
octet timing (8kHz)

The characteristics of this signal are illustrated in **Fig. 6** and specified in CCITT Rec. G 732 Para. 5.1.

2048 kbit/s Interface (PX)

The interconnection of DDN equipment and digital line transmission equipment (as used for PCM) at 2048 kbit/s is achieved via the 2048 kbit/s interface designated PX. This interface uses a coaxial interconnecting cable and the signal characteristics are explained in the CCITT Rec. G.703, Para. 5.1.

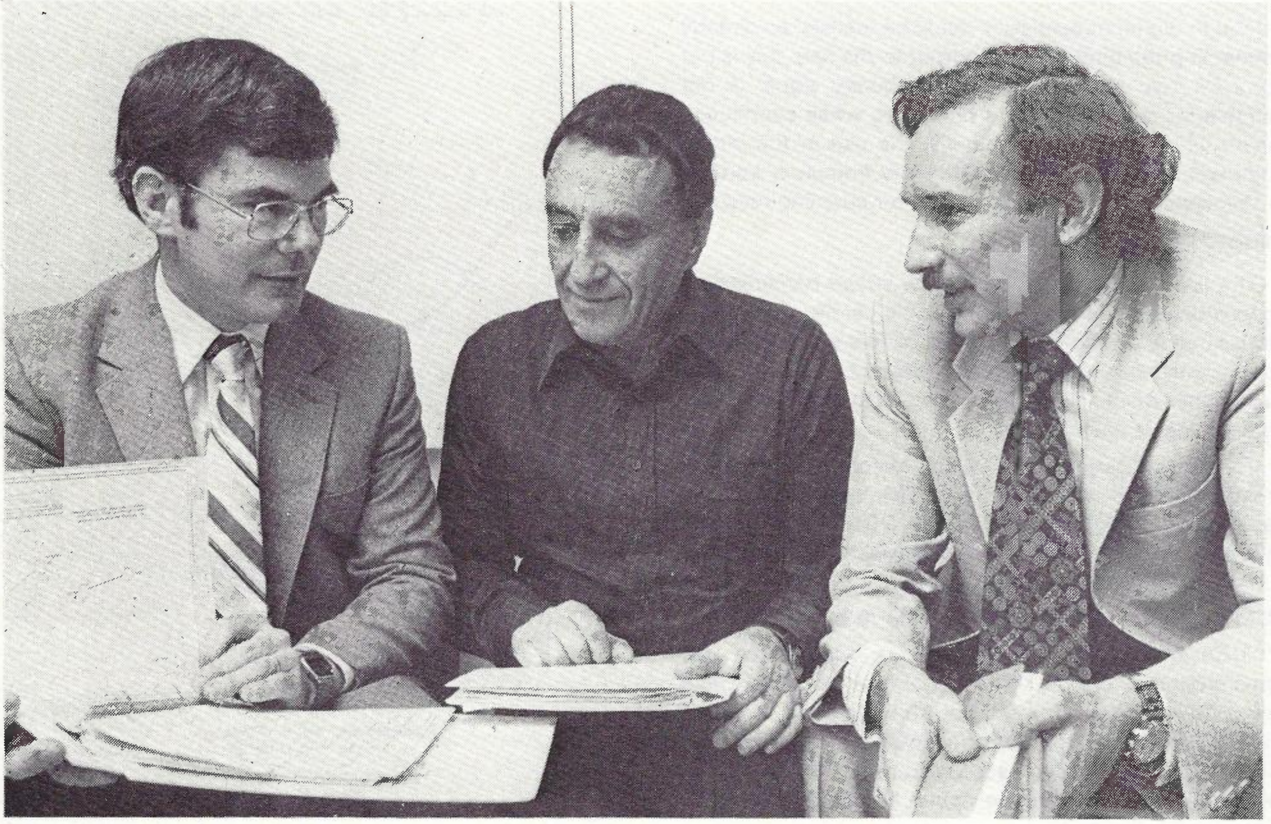
Digital Transmission Over Analogue Systems

The DDN centres will initially only be interconnected via analogue transmission systems (coaxial cables and radio links). The following main techniques may be used to carry digital data streams over these systems:

CHRIS BEARE graduated from the University of Adelaide with an Honours Degree in Engineering (1973) and Bachelor Degree in Science (1972). He spent four years as an Experimental Officer at the Defence Research Centre, Salisbury, and in 1977 completed a Ph.D. in the field of high speed data transmission while on study leave from the Department of Defence. He joined Telecom as a Class 2 Engineer in the Datel section of Customer Networks Branch in 1978 and is now a Principal Engineer in the Digital Data Network Group of the Data Services Sub-Division.

YURY FALKOVITZ came to Australia in 1974, having behind him wide experience in instrumentation engineering and industrial electronics. In 1975 he joined Latrobe University, where he worked as a professional officer (engineer). He holds a Bachelor Degree in Electrical Engineering from Moscow and a Diploma in Computer Science from Latrobe University. He joined Telecom in 1980 and is currently the Senior Engineer in charge of local distribution design in the Digital Data Network Group. He holds three patents. Mr. Falkovitz is a Member of the Institution of Engineers, Australia.

TREVOR POUSSARD has been the Product Engineering Manager of the Digital Data Network Group since its inception in February 1980. He joined Telecom in 1964 and has worked in various areas in the Headquarters and State Administrations. Before taking up his present position, he was a Principal Engineer in the Data and Telegraph Planning Branch. Apart from a Fellowship Diploma in Communications engineering (RMIT) he holds a Bachelor Degree in Commerce from Melbourne University and a Master of Science Degree from Essex University (U.K.)



- Data-In-Voice (DIV). In this technique, bandwidth normally allocated to FDM telephony traffic is used together with a DIV modem which accepts a digital stream and modulates it to fit within the allocated bandwidth. Examples of the DIV technique are:
- GBDM — transmission of 64 kbit/s of data within an FDM group (48kHz) — planned for use in Stage 1 and Stage 2.
- 2048 kbit/s DIV modems — transmission of 2048 kbit/s of data within two contiguous supergroups (bandwidth 480kHz) — under evaluation for use on coaxial cable systems.
- Data-Above-Voice (DAV). This technique utilises spare bandwidth above the telephony bandwidth on a radio bearer to transmit a digital stream via a DAV modem. In DDN this technique is used at 2048 kbit/s in Stage 1 and Stage 2.
- Data-On-Radio (DOR). This technique employs a full television bearer (5 MHz) in conjunction with an 8 or 17 Mbit/s data modem. Evaluation trials to be conducted in 1981/82.
- Data-Over-Voice (DOV). As for DAV but on a coaxial cable system. This technique has limited use in Australia.
- Data-Over-VIDeo (DAVID). As for DAV but used on a television radio bearer. Not used in DDN at this stage.

The techniques described here allow digital transmission over analogue transmission systems. In the future, as digital transmission systems (digital radio, optical fibre and high speed coaxial systems) become more widespread these will be used to directly interconnect DDN centres.

Digital Radio Transmission

Long Haul

Digital radio bearers operating at 140 Mbit/s are likely to be used on intercapital routes for expansion of DDN past Stage 2.

Short Haul

Digital radio bearers operating at 8 or 34 Mbit/s are likely to find a DDN role in the metropolitan area in support of 2048 kbit/s digital line systems.

NETWORK SYNCHRONISATION

Synchronisation of the Network will be based on a Master-Slave clock system, the overall network master clock being located in Melbourne.

Two types of clocks are provided:

Timing Unit Master clock — TUM.
Timing Unit Slave clock — TUS.

The timing information is transmitted from the master clock through the network to the slave clocks by using the 64 kbit/s and 2048 kbit/s data streams available between main centres. The timing distribution network will be of the tree type with alternative paths between the main clocks for redundancy. Each centre clock (master or slave) will supply the timing to all the equipment in the area controlled by the main centre where it is located.

The equipment located in the Main Centre, will be synchronized directly by the clock through the SI synchronisation interface, while the equipment in Terminal Centres will receive the network timing through the data streams from the main centres.

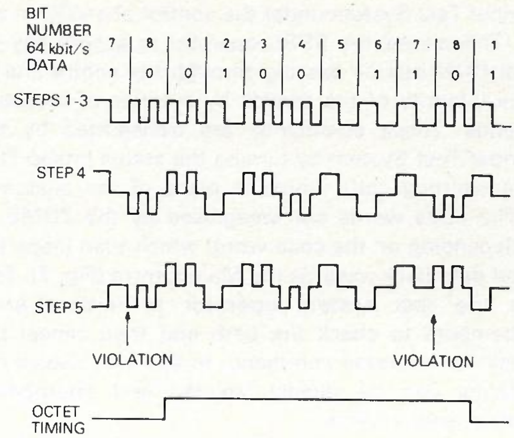


Fig. 6 — Steps in Forming 64 kbit/s Ex Signal

The master clocks have a long term stability of 8 x 10^{-8} per year and a short term stability of 8 x 10^{-10} per day. The slave clocks have a long term stability of 10^{-7} per year and a short term stability of 10^{-9} per day.

Each master of slave clock is redundant and consists of multiple oscillators, redundant protection switching logic and redundant power supplies. The expected availability is therefore very high. Nevertheless, if a complete failure should occur in the master clock or in the timing distribution network such that a slave clock cannot be locked to the network master clock, the slave clock will switch to the unlocked mode of operation. In this condition the main centre with the unlocked clock can still exchange data information with other main centres. This is possible because 1DME and GBDM are provided with elastic buffer memories so that if these equipments are used for connecting main centres, the slip rate will be contained within an acceptable value.

All the exchange equipment (except the DBTE) is provided with buffer memories to take care of the maximum jitter and delay variations envisaged for the link to which it may be connected. Therefore, the delay variations will not propagate through the network but they will be corrected link by link.

NETWORK MANAGEMENT

The focal point for management of the DDN in any area is the Main Centre. As shown in **Fig. 7**, the Main Centre consists of an equipment room and a Maintenance Control Room (MCR) in which is located supervisory and specialised test facilities. The Maintenance Control Room is responsible for all digital links connected to the Main Centre and its associated Terminal Centres. Also associated with each Main Centre is a Special Services Restoration Centre (SSRC) which co-ordinates restoration and maintenance of services at the subscriber level. DDN subscribers can contact this centre directly if they are having service difficulties.

Customer Level Management

Service restoration at the customer level relies on the DDN Subscriber Test System.

Any 64 kbit/s or 2048 kbit/s data stream connected to a DDN Main Centre passes through Data Access Equipment (DAE) which is addressable from the

Subscriber Test System under the control of a VDU in the SSRC. This allows the SSRC operator to access any individual DDN service passing through the centre and to test the integrity of the service by a series of loopback commands. These commands are transmitted by the Subscriber Test System by turning the status bits to OFF and transmitting code words in place of the customer data. The code words are recognised by the ZDME or DCE (depending on the code word) which then loops the received data back towards the Main Centre (Fig. 7). This allows the test system operator to initiate error measurements to check the path and then cancel the loopback via a release command. In this way subscriber level faults can be rapidly isolated and appropriate restoration action taken.

Network Supervision

The control desk in the Maintenance Control Room contains an alarm display which indicates the failure of any multiplexed link connected to the Main Centre. This display is part of the Supervisory Alarm System mounted in the Main Centre equipment room. By collecting and processing main centre equipment alarms, the Supervisory Alarm system is able to display, for each multiplexed link:

a local urgent alarm,
a local non urgent alarm,
a remote urgent alarm
a remote non urgent alarm.

Whereas local alarms refer to link failures at the Main Centre and remote alarms refer to link failures at the remote centre, non urgent alarms refer to failures in protected links. Most centre to centre links are provided with standby automatic protection switching to ensure that a single fault does not result in link failure. Apart from the Supervisory Alarm System, each DDN centre is connected to the exchange station alarm system to assist

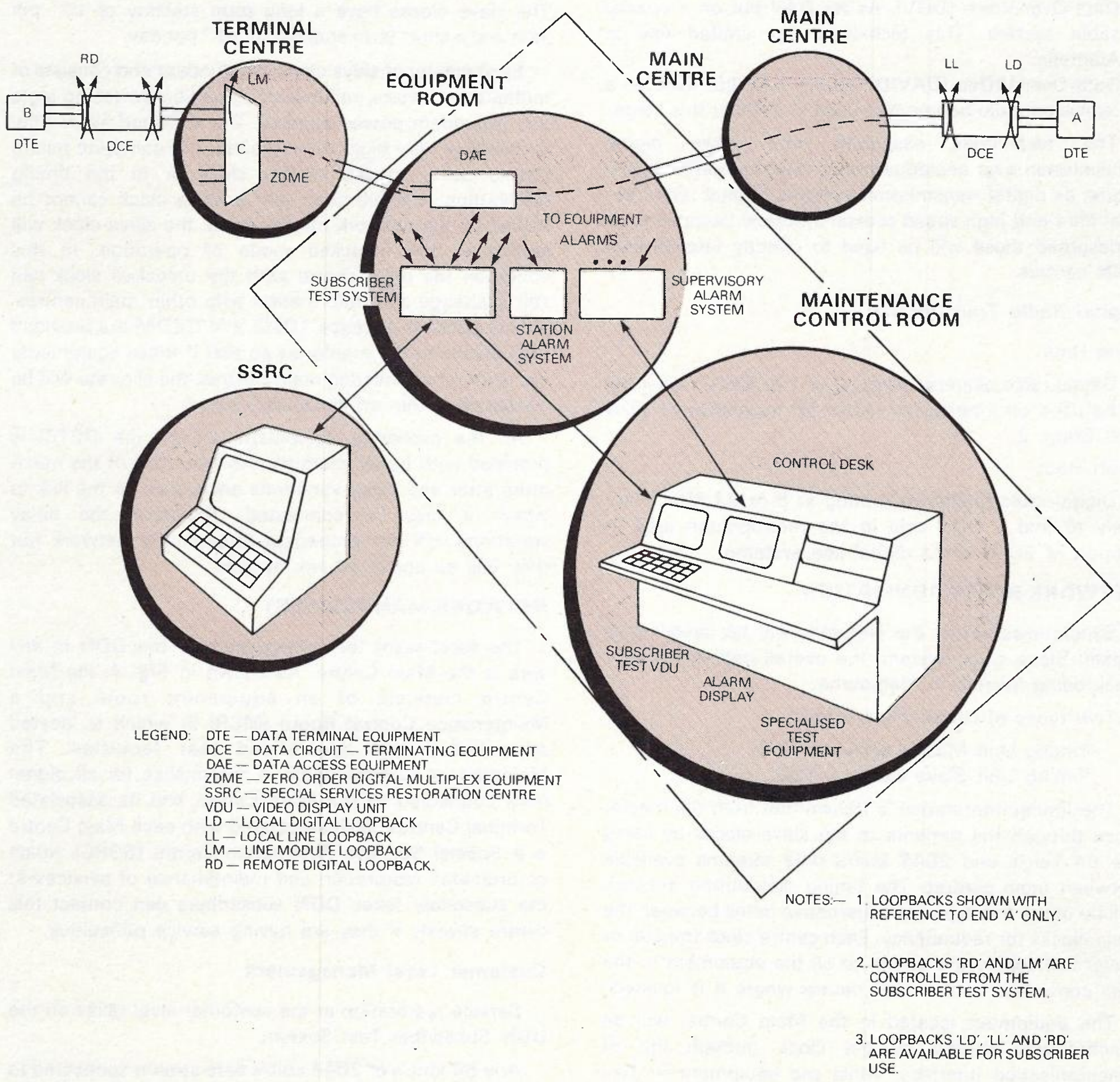


Fig. 7 — DDN Network Management

in tracing of faults. This is further aided by comprehensive front panel equipment alarm indicators.

SUMMARY

Digital transmission systems are gradually being incorporated into the national telecommunications network. The Digital Data Network takes advantage of this development to provide a more appropriate method for provision of dedicated data services. The DDN can therefore offer a data service at a lower cost of provision, with higher availability, better error performance and more rapid service connection and restoration that is currently possible by other means. These factors, together with its wide eventual coverage, allow it to be used to offer attractive dedicated services to customers as well as being the vehicle for supporting future data communication services.

In Brief

SAA UPDATES REQUIREMENTS FOR SPOOLS FOR MAGNET WINDING WIRES.

The Standards Association of Australia has issued a revision of the standard on spools for magnet winding wires to bring the Australian requirements into line with IEC Publications 264-2 and 264-3.

This edition of AS 1005 differs from the previous edition in that the section on cylindrical containers for bulk packaging (pail packs) has been deleted.

The standard now has two parts —

(a) parallel barrelled delivery spools for winding wire,
(b) taper barrelled delivery spools for magnet winding wires.

Copies of AS 1005 ($3.00) are available from the offices of the Association in the state capitals and Newcastle. Postage and handling 50 cents extra.

PERFORMANCE STANDARD FOR HOUSEHOLD BATTERY CHARGERS WILL BENEFIT CONSUMERS

The Standards Association of Australia has published a standard, AS 2401, for household battery chargers.

Chargers conforming to AS 2401 must have detailed instructions attached. This is to ensure that any potentially dangerous conditions have been drawn to the attention of the user of the charger. Convenience of operation and compliance with the output characteristics as described are also requirements of the standard.

The requirements of the standard have been laid down with the intention of ensuring optimum battery life; in particular a maximum ripple current percentage has been specified. In general, this means that the charger would have to be of the full wave type to comply. The standard specifies test procedures, and includes design, construction and performance requirements.

Copies of AS 2401 ($3.00) may be obtained from the offices of the Association in the state capitals and Newcastle. Postage and handling 50 cents extra.

Network Plan for AUSTPAC — The Australian National Packet Switching Service

M. J. HARRISON M.I.E. Aust

Telecom Australia has announced its intention to provide a national packet switching service (AUSTPAC) by the end of 1982. This paper outlines the main features of the network plan for the initial establishment of AUSTPAC and its later expansion.

BACKGROUND

The data communications market is experiencing a high rate of growth and rapid change as new applications such as electronic mail and electronic funds transfer develop. In order to provide the national switched data communications infrastructure necessary for this development of customer teleprocessing systems, as well as potential new public data services such as Teletex, Telecom Australia has announced its intention to provide a national switched data network — AUSTPAC by the end of 1982. AUSTPAC is to be implemented using packet switching technology (Ref. 1). Public tenders for the supply of packet switching equipment to establish the network closed at the end of August 1980. It is expected that an announcement of the successful tenderer will be made in mid-1981. This paper outlines the main features of the network plan for the initial establishment of AUSTPAC and its later expansion.

OBJECTIVES OF THE NETWORK PLAN

The main objectives that the network plan for AUSTPAC attempts to achieve and the constraints within which these objectives are to be realised are:

Objectives

- to provide a common national public network to cater for switched data communication users, particularly those in the developing areas of corporate data and message systems, electronic mail, electronic funds transfer etc.
- to provide high network service availability and to receive and deliver users' data with minimum loss, duplication or delay to the intended recipients.
- to provide comprehensive management (i.e. technical, administrative and accounting) control of the operation and usage of the network.

Constraints

- the network must be operational by the end of 1982
- the network architecture must provide maximum flexibility to cater for highly variable customer demand. That is, a high growth rate of subscriber terminations with widely different traffic generation characteristics
- the widest possible range of customer interface protocols must be made available, consistent with the use of appropriate international standards
- the network must provide access to other public networks such as the telephone, telex and international data networks.

CUSTOMER NETWORK INTERFACE PROTOCOLS

The AUSTPAC network will provide a nationwide packet switched data communication service based on the 'virtual circuit' concept as specified by CCITT Recommendation X25. The network will initially support 3 main categories of Data Terminal Equipment (DTE):

- Synchronous DTEs operating in the packet mode in accordance with CCITT Recommendation X25 (e.g. Computers, front-end processors, communications controllers, intelligent terminals, terminal cluster controllers, etc) and operating at data rates of 2400, 9600 and 48000 bits/s.
- Asynchronous character mode terminals which interface to the network in accordance with CCITT Recommendation X28 and communicate with X25 DTEs via the network in accordance with CCITT Recommendations X3 and X29 and operating at data rates of 110 bits/s to 1200 bits/s.
- Synchronous Block Mode DTEs operating according to industry standards such as IBM's Binary Synchronous 2780/3780 and 3270 data communications protocols at data rates of 2400, 4800 and 9600 bits/s.

CUSTOMER NETWORK ACCESS

Depending on the type and operating speed of the DTE, access to the network is to be provided via dedicated circuits using either analogue modems (i.e. Datel Service) or digital transmission using the Digital Data Network. Access via the Public Switched Telephone Network (PSTN) is to be provided initially, with access via the Telex network to be provided at a later stage.

The relationship between customer interface protocols, network access methods and the network is outlined in **Fig. 1**.

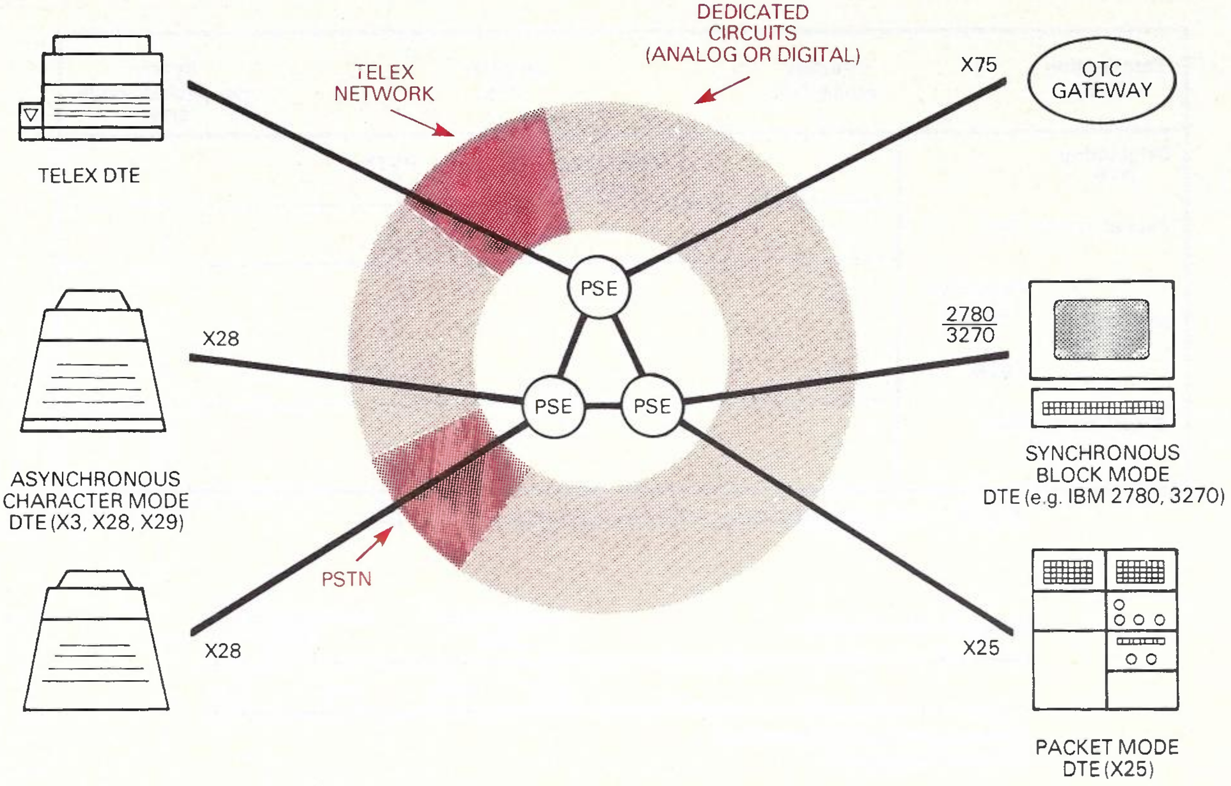
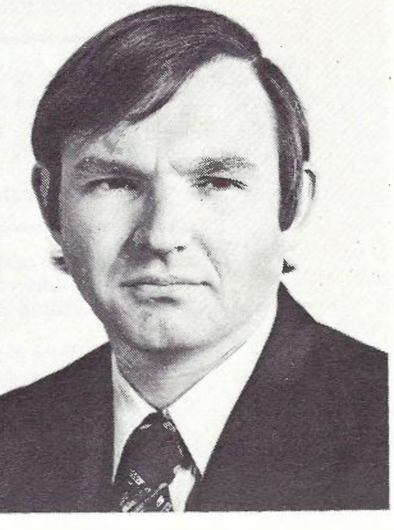


Fig. 1 — Network Interface Protocols and Access Methods.

M. JOHN HARRISON joined the PMG's Department in 1963 as a Technician-in-Training and then obtained a Trainee Engineer position in 1967 which enabled the completion of an Associateship in Communication Engineering at the Western Australian Institute of Technology in 1969. He then spent 2 years as an Engineer Class 1 in external and internal plant areas in the West Australian Administration before joining the Telegraph and Data Engineering Branch at Headquarters working on the CUDN project. In 1975 he joined the Data Planning Branch at Headquarters as an Engineer Class 4 working on the automation of the public Telegram Service, and then later as Engineer Class 5 in charge of Telex network planning. He is currently the Product Engineering Manager, Packet Switching Network Group, in the Data Services Sub-Division at Headquarters.



USER SERVICES AND CUSTOMER FACILITIES

User Services

The network will provide the following CCITT recommended user services:

- Switched Virtual Call (SVC)
- Permanent Virtual Circuit (PVC)
- Fast Select

SVC is a user service which through a call set-up and clearing procedure enables data to be transferred between two DTEs. All the user's data is delivered by the network in the same order as it was received from the originating DTE.

PVC is a user service in which a permanent association exists between two DTEs. This enables data to be transferred without any call set up or clearing procedure.

Fast Select is a user service which enables a small amount of user data, typically 128 octets (1 octet is 8 bits), to be included by the originating DTE in the call request phase, and similarly by the called DTE in the response to the call request.

Originating DTE \ Terminating DTE		Packet mode DTE	Asynch DTE: Dedicated Circuit	Asynch DTE: PSTN	Synch non-packet mode DTE
Packet mode DTE		X	X	—	X
Asynch DTE	Dedicated Circuit	X	—	—	—
Asynch DTE	PSTN	X	—	—	—
Synch non-packet mode DTE		X	—	—	X

Fig. 2 — Permissible Calls (X) and Call Restrictions (—)

Network User Facilities	Packet mode DTE SVC	Packet mode DTE PVC	Character mode DTE SVC	Character mode DTE PVC
Optional user facilities assigned for subscribed period				
One-way logical channel	X	—	—	—
Call Barring	X	—	—	—
Closed user group	X	—	X	—
Closed user group with controlled access	X	—	X	—
Multiple circuits to the same DTE	X	X	—	—
Direct call	—	—	X	—
Reverse charge acceptance	X	—	X	—
Fast select acceptance	X	—	X	—
Charging information	X	—	X	—
Optional user facilities requested by the DTE on a per call basis				
Reverse charging	X	—	X	—
Fast Select	X	—	—	—
Charging information	X	—	X	—
Optional user facilities only applicable when a Character mode DTE is communicating via the network-provided PAD facility				
Selection of PAD parameter settings	X	X	X	—
Reading values of PAD parameters	X	X	X	—
Automatic detection of data rate, code and operation characteristics	—	—	X	—

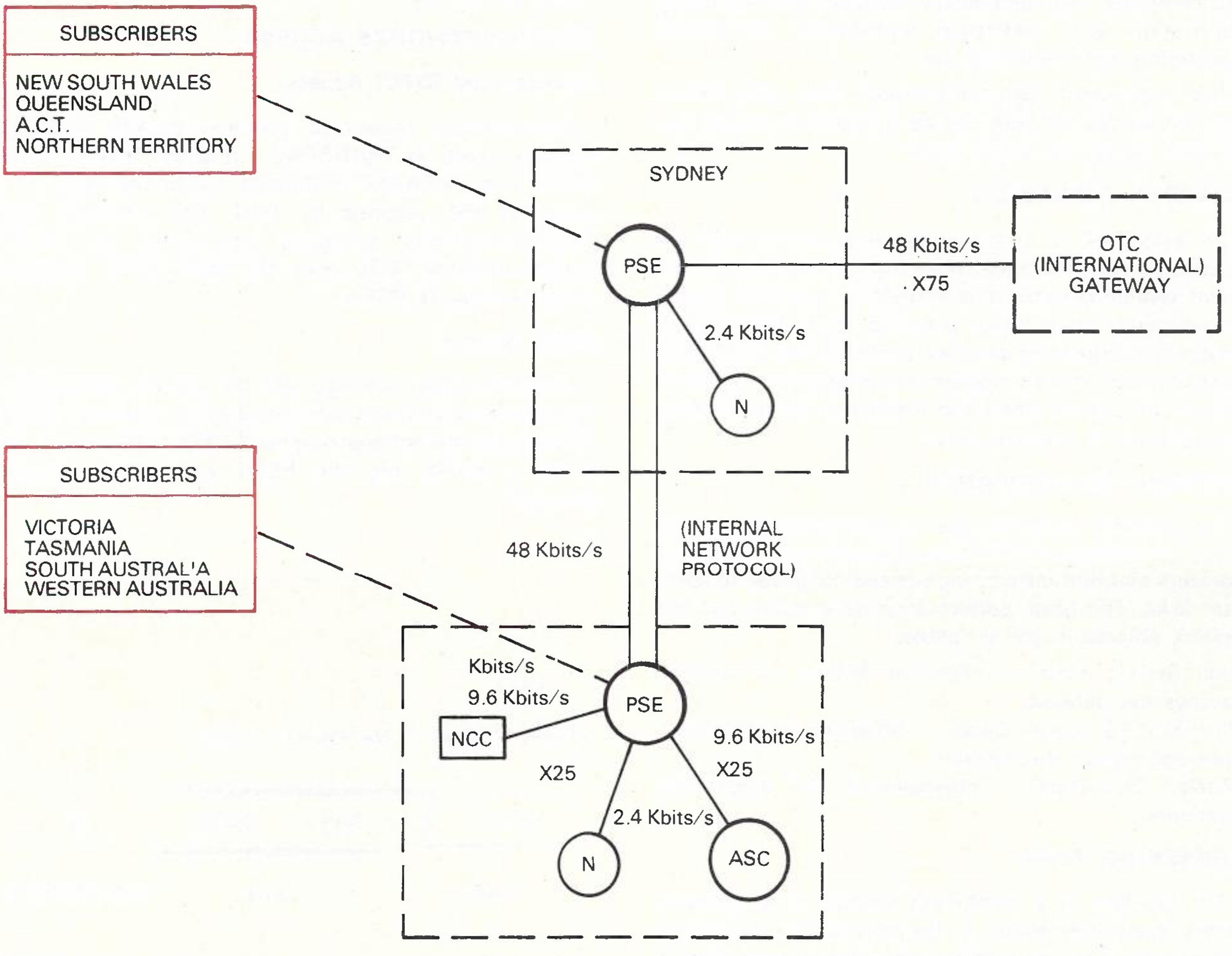
Fig. 3 — Network User Facilities

Because some methods of access from AUSTPAC to other networks (e.g. PSTN) will not be initially available not all combinations of communication between the three DTE types will be provided in the network. The permissible calling combinations that will be available in 1982 are detailed in **Fig. 2.**

Customer Facilities

There are very many optional user facilities **(Fig. 3)** available on either a per call or on a more permanent subscription basis. A description of some of the more important facilities is as follows.

- Closed User-Group — this facility enables a group of users to communicate with each other, but precludes communication with all other users of the network. Variations of this facility can be introduced through control of incoming and outgoing access to the user group.
- Multiple Circuits to the same DTE — this facility enables a DTE to have several physical connections to the network but all with the same network address. Thus the effective bandwidth and reliability of a customers connection to the network is increased.
- Reverse Charging — this facility enables the calling DTE to request, during the call establishment phase, that the call charges be debited to the called DTE. Such calls are only connected if the called DTE subscribes to the "Reverse Charging Acceptance" facility.
- One-Way Logical Channel — a packet-mode terminal may support more than one SVC or PVC at a time via a single physical link. Each SVC or PVC is associated with a logical channel of the link. The one-way logical channel facility limits the use of the channel to either incoming or outgoing calls.



PSE — PACKET SWITCHING EXCHANGE
NCC — NETWORK CONTROL CENTRE
ASC — ACCOUNTING AND STATISTICS CENTRE
N — REMOTE NCC FUNCTION

Fig. 4 — Initial Network Configuration

NETWORK CONFIGURATION

In order to achieve the in-service date of 1982 the initial network is deliberately kept to minimum dimensions. This reduces the project complexity in that fewer equipment sites are required, less specialised transmission is required to be provided and the overall project communication and co-ordination task is reduced. The basic element of the network **(Fig. 4)** is a Packet Switching Exchange (PSE) which includes Packet Assembler/Dis-assembler facilities (PAD) for interfacing the different data communication protocols. A PAD converts characters, or blocks (in the case of synchronous block mode DTE's) into packets and vice-versa.

Management and control of the network is carried out using the facilities of the Network Control Centre (NCC) computer. These facilities, such as subscriber testing and service restoration, connection of new subscribers and gathering of network utilisation and other statistical information, are exercised by terminals using a command language which is acted upon by the NCC.

All call-accounting records, generated by SVC and PVC calls, are transferred from the PSE's to the Accounting and Statistics Centre (ASC) computer. The ASC computer then periodically produces detailed billing information and statistical summaries for traffic engineering and marketing use.

The high-speed data-transmission links (48 Kbit/s) used within the network can be of either analogue (i.e. Datel) or digital (i.e. DDN) type.

NETWORK EXPANSION

As AUSTPAC is a completely new service with no established customer base, planning for expansion of the packet switching network is subject to a greater degree of uncertainty than when planning for addition to or substitution of existing services. However, the most likely expansion path is the progressive introduction of PSEs in each of the capital cities and extensive use of network concentrators in regional areas.

NETWORK PERFORMANCE

The network must be able to accommodate a wide variety of applications, from the slowest combinations of operators and terminals to high-speed computer to computer links. The basic performance parameters and the network objectives are as follows:

- Call Set-Up Time — objective 480ms on average across the network
- Packet (128 octets) Delay — objective of 180ms on average across the network
- Packet Error-Rate — objective of 10^{-8} across the network.

NUMBERING PLAN

The function of a numbering scheme is to uniquely identify every connection to the network to which it is applied, and to enable routing and charging to be carried out by the network as economically as possible. In addition it may be desirable for the numbering scheme to give subscribers some indication of the geographical location of terminals and the charge which they will have to pay for connection to them.

For subscribers' convenience, it is essential that once a numbering scheme is introduced, and numbers are allocated, subsequent number changes are kept to a minimum. Therefore, it is desirable that a numbering scheme, when introduced, have as much flexibility as possible to be able to cope with growth in the number of terminals and other changes over a very long period.

International Standard X.121

The AUSTPAC national numbering plan is to be based on CCITT Recommendation X.121. This recommendation utilises the concept of every public data network throughout the world being identified by a 4-digit Data Network Identification Code (DNIC). The first 3 digits form a Country Code, with the fourth digit identifying the individual network within a country. If there should be more than 10 data networks in a country, sufficient flexibility exists within the Country Code allocations to allow additional, consecutive, codes to be allocated.

National Plan

Each DTE with authorised access to the network will be assigned a unique Network Terminal Number (NTN). This NTN and the DNIC form the international data number which uniquely identifies the data terminal on a world-wide basis.

OTHER NETWORKS ACCESS

International (OTC) Access

International access to overseas packet switching networks such as TRANSPAC in France, Telenet in the U.S.A. and DATAPAC in Canada will be provided via a gateway PSE planned by OTC. The interface data communications protocol used will be CCITT recommendation X.75 over 48 Kbit/s, links from the national network PSE's.

PSTN Access

Asynchronous terminals will be able to call packet-mode terminals directly connected to the network via the PSTN using the national number 0192X. Calling from the packet network into the PSTN will not be initially provided.

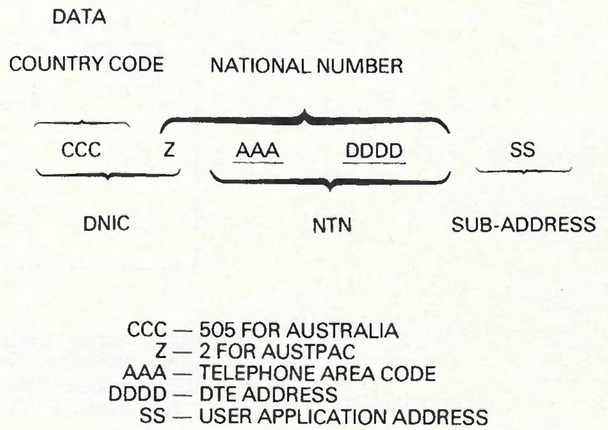


Fig. 5 — Numbering Format

Telex Access

Access via the Telex network will not be provided initially. The most likely stimulus for the provision of this facility is the introduction of the CCITT standardised Teletex service for communicating word processors.

CONCLUSION

This paper has briefly outlined the objectives and main features of the network plan for AUSTPAC — the Australian national packet switching service. A second paper, planned for the latter half of 1981, will provide details of the system selected for use in the AUSTPAC network and examine some of the more significant operational aspects, such as network and customer management.

REFERENCES

1. Edvi-Illes, A. et al, "Packet Switching for Data Communications — An Overview" Telecom Journal of Australia, Vol. 30, No. 1, 1980, page 26.

A Note to Readers

The publication of this journal is one of the many activities undertaken by the Telecommunication Society of Australia. In one form or another the Society has served the needs of members since 1874, two years before Alexander Graham Bell patented his telephone.

Each State Division arranges an annual lecture series to which members and friends are cordially invited at no charge. This year, for example, the following series of lectures will be held in Melbourne:

- Business Development.
- Integrated Service Digital Networks.
- Serving the Major Business Customers.
- Data Service Initiatives.
- Development of Videotex Services in Australia.

Lectures at country centres are also held throughout the year.

The Society has always benefitted from the interest, support and ideas of its members and readers. Over the years emphases have changed in line with members stated or perceived needs. For example the high standards of technical presentation achieved in the past by this journal are now being complemented by informed insight and comments on the significance of technological developments within the telecommunications field. The term "technical" now encompasses aspects such as organisational initiatives, market research activities and operational concepts in order to meet contemporary needs for telecommunication knowledge. This is aimed at assisting many more people and particularly those who find themselves in a multi-functional role. The older conceptions of "purely technical" or "purely clerical" are fast becoming untenable.

The Editors of this journal welcome and would freely give advice to you and your friends on the writing of articles of interest. Subject matter can best be treated in as broad a technical mode as possible. Editorial policy encourages clarity of expression, with brevity, in order to reduce the workload on authors and to enhance readability.

The Society would also encourage attempts on your part to contact other people who could benefit from membership. Many people still think traditionally in terms of single functions; and the propensity of modern employment towards multi-functional knowledge has not been recognised. Their attention could be drawn to the fact that the kind of information sponsored by the Society is in the spirit of new ideas and new ways for maintaining comprehension in the world of telecommunications. State Secretaries whose telephone numbers and addresses appear below can contact editors and give the names of the nearest agent to enrol new members. A pay deduction scheme operates for the convenience of Telecom Australia people.

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Quality of Service

Keynote Address by J. R. Smith, Deputy Chief General Manager, Telecom Australia

presented to the Telecommunication Society of Australia, Adelaide Seminar, 11th November 1980

Let me begin this address on quality by talking about quantity, which is often seen as the opposite. We've all heard people say "Give me quality not quantity".

We all know Telecom handles a huge quantity of business in a year, quantities like:

- 500,000 new telephone services;
- 5 billion local calls;
- 600 million trunk calls;

and those quantities are rising quickly.

The customer pressure to handle this quantity of business is felt by us all.

We all know too that Telecom has set quality of service objectives like:

- 90% of new services installed within 15 working days;
- 2% congestion loss on STD traffic;
- 90% of faults repaired by the day after report.

Certainly also there is considerable customer pressure not only to handle the quantity of business but also to meet or better the quality of service objectives.

Is quality inconsistent with quantity? Is quantity better than quality? These are issues the managers of Telecom have had to face because of the drive to give service, but give it efficiently, increasing the productivity of labour and of capital.

In this audience there may be many who would say that Telecom regards quantity as more important than quality and that quantity and quality have been made incompatible.

Let me test those views.

In the last year of the P.M.G. Department we connected 345,000 new telephone subscribers. Last year Telecom Australia connected over 500,000 new telephone subscribers, an increase in quantity of nearly 50% in 5 years. In that same 5 years, average waiting time for a telephone service came down by nearly half. We made considerable gains in both quantity and quality. It can be said that we are still not meeting our quality of service objective although we are close in many districts. Perhaps that indicates Telecom regards quantity as a little more important than quality.

However, on subscriber service indicators I'd be happy to have a statistical contest to demonstrate that large increases in quantity — in telephone demand and in telephone network size — have been accompanied by increases in quality of service which range from modest to large over the last 5 to 10 years. Examples are the fault clearance time, the subscribers' repair report rate, and the external plant fault rate. Unfortunately we often wear rose-coloured glasses in viewing quality in the so-called good old days.

To be fair, let me take another example — STD traffic. Over the last 5 years, the quantity of STD traffic has more than doubled. We all know that STD congestion is worse than standard because price reductions, advertising, and network growth have created traffic levels well above the forecasts for which we dimensioned the network. We are not sitting back pleased with the revenue from that extra traffic, but rather, rapidly increasing the size of our trunk construction programme to restore the standard quality of service. That trunk programme is planned to increase by 50% next year from about $65 million to $100 million.

For those wearing rose-coloured glasses, I'll be unkind enough to remind you of the so-called good old days in the 1950s, before STD, when operators worked back to back in delay, when you commonly waited for an hour or two for your trunk call in the busy hour, and were asked to limit it to three minutes. Some of you may remember operators being told not to book the call because "it would be quicker to get in the car and drive there".

It is fair to say, however, that despite congestion we have been prepared to continue to reduce prices, advertise, and increase the network. Again perhaps that indicates Telecom regards quantity as a little more important than quality.

I was most interested to read recently about American congestion standards. A.T.&T. generally engineers its trunk groups to provide 99% accessibility during the busy hour. To be explicit, this means that, on average, during the busiest hour of each day, one out of every 100 attempted calls between two points cannot be completed because there is no idle transmission channel.

By contrast, the competing specialised common carriers, which charge rates 30-40% below A.T&T.'s, design their service for up to 50% blockage during the busy hour. By A.T.&T. standards, the competitors' quality is unacceptable, but there are sufficient numbers of customers willing to use them for the sake of a lower price.

This brings me to the issue of quality and cost. Let me explore with you the suggestion that quality should be free — that it should be obtained at no cost.

Telecom Australia has adopted jelly-filled cable for its rural subscribers' distribution network. The previously used dry core small size plastic cable gave an unsatisfactory service to the customer. Water eventually finds its way into this type of cable and dramatically increases transmission loss and crosstalk, most noticeably nearer the transmission extremities of exchange areas. Jelly-filled cable avoids that problem and so reduces maintenance costs. Taken in conjunction with its longer life expectancy, the use of jelly-filled cable will give

Telecom at least a 20% rate of return on investment. It can be said that quality is free — indeed it is profitable.

Recently in this State (SA) we have been exploring the need to upgrade subscriber cable distribution areas with a high fault incidence, affecting quality of service. The initial proposal to upgrade 200 distribution areas next year gave a rate of return of about 15% on investment, slightly above the semi-government loans interest rate, so it could be said again for that case quality could be obtained for no cost. In fact for several reasons, mainly other demands for investment funds yielding higher returns, a smaller proposal involving about 100 distribution areas has been accepted and this is estimated to yield a 23% rate of return — quality is free, indeed it is profitable.

I am sure we could collectively produce a number of other examples where new technology is providing a higher quality of service for free — indeed at a profit. Major programmes like the conversion of manual exchanges to automatic, and the computerisation of directory assistance, are just two examples, on which papers crossed my desk while I was drafting this address.

In fact I would like to test the general proposition that quality should always be free. It can always be produced at no cost.

When faced with the need for quality improvement, it is natural to focus on the cost of improvement. That is one side only of the equation. I suggest that the cost of quality is the expense of doing things wrong, especially of doing things wrong in the first place. The cost of quality in the workshop is the cost of scrap and rework, the cost of quality in the maintenance depot is the cost of service after service — of not doing it right in the first place — the cost of quality in installation by Operations or Construction is the cost of further tests and inspections, maybe of re-doing the work, and of higher maintenance than usual.

Some time back I had the privilege of a session with a Mr Phil Crosby Vice President, Quality, of I.T.T. New York. As you know, I.T.T., the International Telephone and Telegraph Company, is one of the world's largest companies, a conglomerate involved in telecommunications services and telecommunications manufacturing, as well as consumer products manufacturing, hotels, and so on. Mr Phil Crosby created the concept of Zero Defects and applied it to I.T.T. Over a 10 year period the manufacturing cost of quality at I.T.T. was reduced by an amount equivalent to 5% of sales, with somewhat smaller reductions in the cost of quality in service areas.

I believe you will find amongst the real professionals in the field of quality, agreement with the view that quality should be free, is free, in fact is a profit-maker.

The careful listeners amongst you will have noted that while I have been getting the above thoughts off my chest I have avoided defining what "quality" means to me.

The conventional definition equates quality with goodness, even with excellence and perhaps luxury. The conventional definition also says that quality is intangible and immeasurable. In those definitions quality is used to signify the relative worth of things in such phrases as "good quality" and "quality of life". I don't agree with those conventional definitions.

I would like to suggest to you that quality is "conformity to requirements" and that it is measurable.

If a Rolls Royce conforms to all the requirements of a Rolls Royce then it is a quality car. If a Sigma conforms to all the requirements of a Sigma it is a quality car. If both cars conform equally to their requirements they are equal as quality cars. Obviously, the requirements for each must be specified and performance against those specific requirements measured.

It follows that quality concerns the totality of the features, characteristics, or properties of a product or service that determine its suitability for its intended task over its intended life.

Looking upon quality as "Conformity to requirements" and insisting on it being measurable ensures that we escape from fruitless subjective arguments about the quality of service in Telecom. In many areas I believe we have defined quality in the way which appeals to me, but I am too well aware that the other conventional definition is widespread in its use.

Because quality has been, is, and will be an important factor in the decision to buy, it is a fundamental prerequisite for an atmosphere of confidence between supplier and customer. I believe Telecom has established a good reputation for quality in its products and a fair to good reputation for quality in its services.

It is clear to me that quality-mindedness on our part has gained more significance in the technical areas. Complex electronic systems, often with hundreds of thousands of components, can function only when each component works reliably or the redundancy works reliably. Components in finished goods have become far more reliable. In the 1960s for example, a maximum failure rate of one in a million component hours was required for electron tubes. Today, a maximum failure rate of one in ten million component hours is being demanded of integrated circuits that contain hundreds or thousands of functions.

While it is also clear to me that quality-mindedness, in terms of the products and services we provide, has also increased, I would question whether it has gained the same level of significance as in the technical areas.

Perhaps this reflects a community attitude to quality — one that still would like to have quality but has found that generally it's elusive. However, one only has to contrast the success in recent years of discount stores versus departmental stores to appreciate that there has been a change in relativities in the community between quality and price in favour of price. For our residential customers therefore I am sure our emphasis in recent years on quantity and price and not quite so much on quality reflects the community trend. Of course if the customer can get all three he is triply pleased.

In the business community, especially larger organisations, although price is important I am not so sure that it is more important than quality. Obviously our new approach to organising our service to larger business customers in Sydney and Melbourne is a recognition that quality of service to them is not adequate, in fact is unsatisfactory to them. Similarly the emphasis we are giving to data and special services is a reflection of the same view.

I believe therefore that whilst most of our quality standards in Telecom are about right, those for our larger business customers at least in the eastern states are too low, need to be raised, and raised quickly.

Obviously in this address I have only touched on some aspects of quality — I have scarcely referred to the human side of quality improvement or its management — but I expect these will be covered by other speakers and in the panel discussion.

Thank you for making me think about quality of service and I trust that my observations will make you think also about the quality of service this enterprise of ours — Telecom Australia — gives to its customers.

Disabled People and Telecommunications

D. B. WILSON, B.A., M.A.Ps.S and C. G. KEATING, Dip. P.A.

During 1978 and 1979 Telecom conducted an investigation into the needs of telephone users who are disabled. Available statistical data and studies published by overseas telecommunications organisations did not provide adequate data that would enable a rational approach to the planning, development and production of aids for the disabled.

The study, through the use of interviews, discussion groups, postal surveys and assessment of other local and overseas research provided an analysis of functional disability, categorised by severity. It also provided estimates of the number of people in Australia for each category and the types of aids requested by each group.

A more detailed summary of the study is available in a report entitled "Disabled People and Telecommunications" released by Telecom as a contribution to the International Year of Disabled Persons.

BACKGROUND TO THE STUDY

Following the establishment within Telecom Australia of a functional area responsible for the development of facilities for handicapped and disadvantaged users, this study was commissioned to provide a data base to be used in determining priorities and the direction of development of such facilities.

The main objective of the study was to produce practical and meaningful information to assist in the planning, development, production and distribution of specialised telephone equipment. This telephone equipment would assist individuals who find it difficult or impossible to use the currently available range of telephone equipment. As part of the main objective there was the proviso that all points of view would be represented as well as all main types of disabling conditions.

METHODS USED

Although approximately 800 individuals participated in this study, the emphasis of the methods used was qualitative rather than quantitative. Quantitative estimates were derived from available sources and postal surveys.

In the absence of meaningful quantitative data on the disabled population people were selected to participate in the study on the basis of their availability and the type of disabling condition they suffered.

Interviews, group discussions and case studies were used to collect opinions of educators, administrators and health care workers as well as the disabled from within special institutions, colleges, government agencies, hostels, hospitals, disabled persons' organisations, other affinity groups and private households.

Individual interviews were most often used with individuals participating in case studies. Disabled individuals were contacted from leads supplied by agencies, hospitals or other individuals. Interviewers encouraged participants to talk on limitations imposed by their disability and how these limitations affected telephone use. After the initial discussion the individual was allowed to select equipment, where alternatives existed, from the range used in this study; instructed in its use and allowed to use it in his or her usual environment for a minimum period of two weeks (usual period of 4 weeks). At the end of the trial the individual would be asked to comment on the equipment and suggest what modifications appeared necessary. If appropriate, alternative equipment would be left for a further trial period, enabling the individual to make comparisons and state preferences.

The study placed most emphasis on the comments of individuals who have had extensive use of the equipment.

Individual interviews and discussions were also conducted with educators, administrators and health care workers. The general format of these discussions was for the participants to summarise the disabilities/limitations that the organisation was concerned with, and then, to offer suggestions on aids or appliances for telephone use and/or comment on the various items of equipment used in the study.

Group discussions, usually held with affinity groups of disabled, and arranged through various organisations and agencies, followed a similar pattern. Persons were asked to start discussions with the problems they faced in using the telephone, how these related to particular disabilities and what modifications and innovations were required. At the natural termination of this phase, the discussion leaders would display and demonstrate all the items of equipment used in the study. Discussion would then focus on the apparent relevance of the equipment to the needs of the individual group members.

Postal surveys were conducted through the various newsletters of organisations, whose membership mainly consisted of individuals afflicted by some disabling condition. Many of those organisations operated on an informal and irregular basis and it was not possible to be absolutely certain on the actual number of questionnaires distributed. In terms of number of questionnaires distributed to agencies and organisations however the response rate was quite small.

Estimates on incidence and extent of disability have been provided and are based on available published and unpublished estimates, as well as, on data collected from participants during the course of the study.

STUDY POPULATION CHARACTERISTICS AND BIASES

Over 800 disabled persons and 200 health care workers, administrators and educators participated. Participants were involved primarily due to their availability and since there is a lack of meaningful information on the disabled population, no attempts could be made to ensure that the study sample accurately represented the actual disabled population.

The decision was taken early in the study to oversample the more severely and profoundly handicapped individuals in order to ensure that their viewpoints were as well represented as the less severely handicapped.

The incidence of most disabling conditions is extremely low and in order that resources were not expended unnecessarily, organisations and institutions with concern for particular categories of disabled were overwhelmingly used.

The decision to use these groups as a base for

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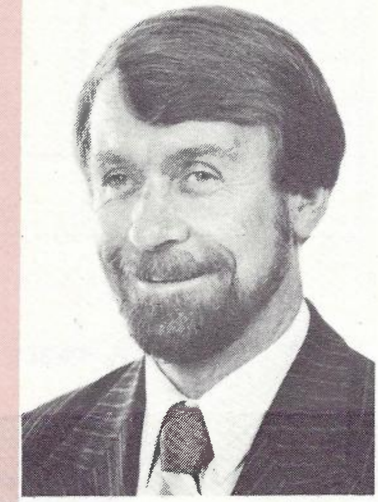
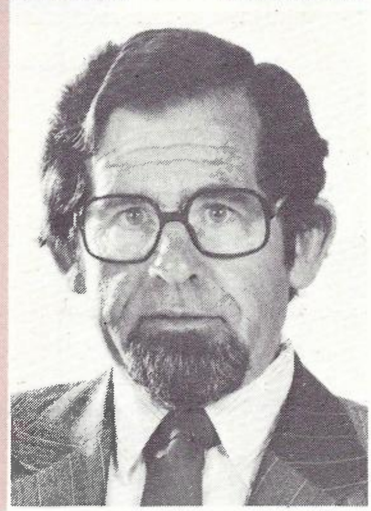


CHAS KEATING is Senior Project Consultant, Marketing Planning Branch, Telecom Australia. Chas joined Telecom in 1978 as an internal management consultant, in Organisation Development. Chas has spent most of his career in the training and development field of the Commonwealth Public Service. His specialty is in the area involved in human interactions, group processes and communications within organizations.



Disabling Condition	Group Discussions	Group Case Studies	Individual Case Studies	Postal Surveys*	Total* Partici-pating Conditions	Distribution (excluding other) (%)
Spinal Cord Injury	33	20	8	53	114	12.8
Hemiplegia & Stroke	37		1	19	57	6.4
Rheumatoid arthritis & allied conditions	67		4	246	317	35.5
Multiple Sclerosis	54		3	12	69	7.7
Cerebral Palsy	31	9	9	8	57	6.4
Partial Sightedness	31			3	34	3.8
Hearing Impair-ment	20		3	19	42	4.7
Intellectual Handicap		62			62	6.9
Paralysis	28		2	32	62	6.9
Paralysis (Other)				13	13	1.5
Muscular Dystrophy			8	12	20	2.2
Amputees				10	10	1.1
Other	12	5	3	16	36	
TOTAL PARTICIPANTS	313	96	41	370	820	

(* Figure for incidence of various conditions which exceeds the actual number of participants).

TABLE 1 — Disabled Study Sample (Numbers participating).

Group Discussions Case Studies, etc.			Postal Surveys Respondents		
Age Group	**Males**	**Females**	**Age Group**	**Males**	**Females**
0-15 years	33	14	14-20 years	2	2
16-25 years	46	30	21-40 years	39	40
26-40 years	53	29	41-60 years	45	107
41-60 years	39	67	Over 60	29	106
Over 60	28	111			
TOTAL	199	251		115	255

TOTAL NUMBER OF FEMALES: 506
TOTAL NUMBER OF MALES: 314

TABLE 2: Sex & Age Distribution of Participants.

participants introduced bias in the study since it could be presumed that the disabled of these institutions were better informed, better educated, or different in other ways to non-members.

Most group discussions or individual interviews were held between 9 a.m. and 7 p.m. on weekdays and this would have excluded many disabled persons in full time employment.

Table 1 lists total numbers of disabled participants whilst the sex and age distribution of participants is indicated in Table 2.

The overall statistics indicate a sample population different from the estimated population suffering from a chronic limiting illness (Australian Bureau of Statistics 1974).

In summary the sample population is thought to be different from the actual population of disabled in the following aspects:

- they were a better informed and more active group;
- the less common disabling conditions were over-represented;
- the members probably came from a higher economic group than the 'average' disabled;
- females are over represented;
- the over 60 age group is over represented; and
- the age distribution of the sample differed from estimates of the actual population suffering from a chronic limiting illness.

FUNCTIONAL DISABILITIES AFFECTING TELEPHONE USAGE

This study began with the premise that each physically disabled person has a unique and specific set of needs when related to aids required to communicate over the telephone network, and that a specific and unique set of aids would be required. However, during the course of the study and as a result of discussions with groups and individuals suffering some disabling condition, it became apparent that rather than a multiplicity of telephone aids being required, there are relatively few aids required to enable the vast majority of disabled to make independent use of the telephone. There is not a great deal of difference between the quadriplegic who cannot use his arms or the severe polio victim in terms of disabled functions relevant to use of the standard telephone. Similarly the paraplegic and the dwarf have common problems in using public telephones — both cannot reach the handset, dial or coin slots without assistance. Of course, the dwarf does not have a great deal of trouble in getting inside the telephone booth but the paraplegic in a wheelchair finds this impossible.

From experience and as a result of postal surveys it became obvious that persons with upper limb disabilities almost always have lower limb disabilities. The combination of speech and perceptual disorders also are quite often combined with impairment of upper and lower limbs.

In practical reality it was found that a more meaningful categorisation of physical handicaps, especially as related to abilities required to use the telephone, is to place them in the following broad categories:

- Lower limb disabilities only.
- Upper and lower limb disabilities.
  - — Upper limb disabilities.
  - — Upper and lower limb disabilities combined with speech and perceptual disorders.
- Hearing impairment.
- Speech, Intellect and sensory impairments.
- Ageing.

It was also found most useful to further classify the extent of the disability in general terms ranging from mild to profound. The definitions of terms used to classify the extent of an impairment are as follows:

- Profound — this indicates the complete loss of an ability and indicates a need for an aid that will make use of other abilities in order to perform tasks that are usually a function of the lost ability;
- Severe — this category refers to an impairment of the particular ability and indicates that the use of aids for the impaired ability or substitute abilities will result in definite improvement in performance of tasks that are generally a function of the impaired ability;
- Moderate — refers to an ability impairment that may hinder the performance of tasks usually a function of that ability and where an improvement in task performance is possible with the use of appropriate aids to the impaired ability; and
- Mild — refers to a degree of ability impairment that hinders the performance of tasks usually a function of that ability and where aids may not necessarily improve task performance.

The remainder of this article attempts to outline the difficulties and needs of the disabled as well as to give an indication of the incidence of the abovementioned categories of disabilities.

Lower Limb Disabilities

Some 75,000 Australians have impairments to lower limbs, approximately 43,000 require aids in moving from point to point, of these 43,000 approximately 34,000 have additional disabilities.

The major problem faced by persons with only lower limb disabilities in private telephone use is in moving to the telephone in a personal emergency or when attempting to answer incoming calls. In public telephone use the major problem encountered by the estimated 7,000 persons with lower limb disabilities only, in the mild to moderate range, is in gaining access to public telephone booths. For the estimated 5,000 with profound lower limb disabilities only, who are confined to a wheelchair, not only is it impossible to gain access to a telephone booth, but the coin slot, dial and handpiece cannot be reached — dwarfs have a similar problem.

For private telephone use, persons with lower limb disabilities only say they would be assisted by aids such as lightweight telephones (such as Ericofons) which have long retractable cords and sockets and plugs that are larger and easier to manipulate. Cordless telephones and answering machines that answer the phone and indicate that it will be answered by a slow moving handicapped person are other suggested aids.

For the disabled elderly person and the person confined to a wheelchair, services that check on the health and status of an individual such as offered by emergency automatic diallers will meet an important need for many disabled and elderly persons who live alone or are frequently left unattended.

Upper Limb Disabilities

Approximately 64,000 Australian people have upper limb disabilities that impair performance of functions normally performed by upper limbs; this group is not only impaired in the use of upper limbs but almost all have impairment of the lower limbs as well and approximately 34,000 benefit from the use of aids to either upper or lower limb functions. Therefore, for this group of disabled, the statements made on telephonic aids for persons with lower limb disabilities only apply equally as well. In addition, this particular group have an even greater need for lightweight push button telephones and attachments such as lightweight headsets and quite often, hands free telephones. Within this category fall most of the estimated 9,000 hemiplegic stroke victims.

Approximately 5,000 persons have severe to profound upper and lower limb disabilities and require aids to assist or replace the impaired limbs. The usual aids used by this group are devices such as wheelchairs, mouth-sticks or head pegs, handpegs or sophisticated electro-mechanical equipment. Aids required in telephone use for this group range from push button hands free telephones to remote controlled instruments like the experimental digital display dialler, currently under development and shown in **Fig. 1**.

Towards the extreme end of the continuum, in terms of severity of disability of this group, are approximately 1,500 to 2,000 persons with additional handicaps such as lack of physical co-ordination and perceptual problems as typically suffered by the cerebral palsied individual. This group needs not only remote control devices but instruments that have sufficient flexibility and adaptability to cater to their individual additional disability such as machines that make allowances for spasmodic movement or delays in responding due to perceptual problems or controls that do not depend on slight movement of a limb.

At the extreme end of the continuum is the cerebral palsied and brain damaged individual who not only requires the aids just described but a non-oral means of communication such as the telephone typewriter.

Current use of the telephone by these latter groups, in the absence of specific aids for telephone use, is restricted to times when an able-bodied person is available to answer or dial and place the handset in position.

Hearing Impairment

By far the most widespread disability faced by modern man is impaired hearing. In Australia, there are an estimated 300,000 people with a hearing impairment ranging from effects that completely inhibit the receipt of communications via sound waves to difficulties in localising sound or understanding speech in situations with background noise.

Profound hearing loss, as far as definitions used in this study are concerned, is defined as the complete absence, from pre-lingual stages of development, of the ability to respond to sound — thus profound deafness is usually associated with the inability to produce speech. The needs of this group have been investigated in a separate study on the telephone typewriter **(Fig. 2)** and indications are that devices such as the telephone typewriter offer a substantial, but not satisfactory solution to the difficulties faced by this group. More futuristic technologies such as speech synthesisers or video-phones may offer a more comprehensive solution.

Individuals within the 'severe' category estimated to be in the vicinity of 30,000 in number for Australia range from individuals who are capable of benefiting from amplified speech to those who may themselves be able to reproduce speech but amplified sound itself only serves as a signal indicating a trend of a conversation or as an alerting device. For the vast majority of the 'severe' group, aids already in existence, such as the gliding tone caller and volume control telephone provide some assistance. However, the gliding tone caller makes use of an impaired sense and it would appear logical that a signalling device that makes use of an unimpaired sense (such as visual or tactile) would better serve the desired purpose.

The 'severe' group usually all rely on hearing aids for

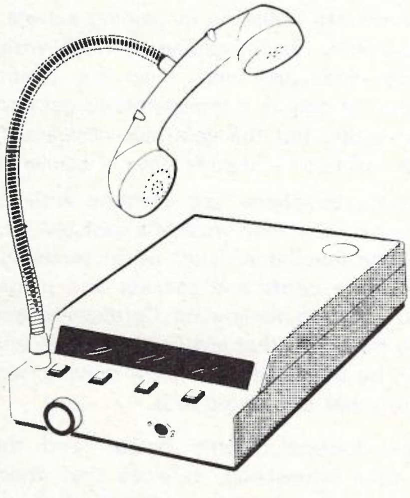


Fig. 1 Digital Display Dialler

Fig. 2 Telephone Typewriter

oral communication. Most hearing aids have an induction switch to allow receipt of sound through electromagnetic induction, enabling receipt of oral communications over the telephone free from background noise at the point of receipt of the communication. What appears to be a realistic and practical suggestion is to provide a portable induction coil for those telephone users who rely on a hearing aid.

The 'moderately' affected group of some 56,000 individuals may have similar problems to the severe group, however in the main, the amplified speech normally found on telephone receivers is adequate for conversation. The main problem of this group, and the 186,000 persons with a 'mild' hearing loss is with background noise and in hearing high pitched telephone bells. Consideration given both to sound proofing and background noise, in the design and the location of public telephone booths would provide considerable assistance in the use of public telephones by individuals with hearing impairments.

Speech, Intellect and Sensory Impairments

These impairments are quite often associated with impairments to limb function. Disabilities resulting from brain damage caused by trauma or chronic disease (such as cerebral palsy, stroke) often not only affect limb movement but also speech, vision, perception, memory intellect and physical co-ordination.

Speech

Some 34,000 Australians have impairments to speech, of which 23,000 have severe to profound speech disabilities, approximately 3,500 of these are probably full time residents in various institutions. Impairments range from the severely slurred and disjointed sounds articulated by severe cases of stroke to the complete inability to articulate meaningful sounds as is common with the deaf mute or profoundly affected cerebral palsied.

Telephonic aids to communication may include devices ranging from the telephone typewriter to speech synthesisers or videophones.

A major difficulty faced in use of the telephone by the severe to profoundly affected, if substitutes to speech such as telephone typewriters are used, is that communication over the network is restricted to communication with persons who have similar devices. Some 18,000 deaf mutes are not only disabled by lack of speech, but of hearing as well. Therefore advanced concepts such as speech synthesisers should be able not only to translate symbols into sound, but sound into symbols.

This category of disability, with its associated hearing problem, appears to be the major problem area in the design of equipment for disadvantaged telephone users. All other disabilities are able to be aided by current technology and equipment — aids such as the telephone typewriter are expensive and are only a limited aid for this group.

Approximately 11,000 persons have mild to moderate speech disorders that range from malfunctions in the perceptual processes of the cerebral palsied and stroke victims to the hoarse whisper of the laryngotomee. The former category have limited potential for assistance through aids whilst the laryngotomee is encouraged not to use aids in voice production — however, there may be a desire by a proportion to be assisted in telephone use by aids that amplify speech or achieve this effect by use of super sensitive microphones.

Intellect

Next to hearing, intellectual handicap affects the next largest portion of the population. Various estimates indicate that approximately 120,000 persons suffer mild to profound mental retardation. However, it is possible for the vast majority to use the telephone in an appropriate manner.

Problems related to telephone use for the 16,000 persons with moderate intellectual handicaps basically evolve around awareness of a need to communicate, the perception of who it is desired to communicate with and the mental processes involved in dialling a sequence of numbers.

Aids that assist this group, to some degree, are aids that replace the need to dial a sequence of numbers and aids that identify the person with whom it is desired to communicate. Aids that meet this specification may come in the form of the memory dialler used in this study.

The estimated 3,600 people with a severe mental handicap are mainly institutionalised and unable to communicate other than in a rudimentary, usually non-oral form.

Intellectual disability is quite often associated with other disabilities such as encountered by the cerebral palsied.

Sight

Impairment of vision is another of the more common disabilities, it is estimated that there are approximately 67,000 partially sighted and 24,000 legally blind persons in Australia.

Although several health care workers and academics hold the view that aids such as enlarged number rings will be of assistance to the blind and partially sighted in telephone use, no supporting evidence of the usefulness of such aids was found in this survey. Persons who had tried such devices at the prompting of health care workers found that such aids were a hinderance. Studies by British Telecom indicate that the only benefit of such aids is that of a subjective feeling of re-assurance obtained by some users.

Blind and partially sighted people in this study indicated that familiarity with equipment and the environment in which it is used were the main aids to their personal telephone use.

Physical Co-ordination and Perception

There are up to 16,000 Australians, mainly cerebral palsied, stroke victims and other brain damaged persons, who have additional handicaps of physical co-ordination and perception. Of these, approximately 6,000 are severely to profoundly affected, and therefore either institutionalised or under intensive private care. There are an estimated 1,700 over 10 years of age in the severe category who may be aided in telephone use by devices similar to the digital display dialler which compensate for perceptual difficulties and lack of physical co-ordination. However, many of this group would also have severe speech and intellect problems. Up to an additional 1200 may benefit from a combination of equipment such as the digital display dialler and a non-oral means of communication such as the telephone typewriter.

Ageing

The sector of Australian persons over the age of 65 years constitutes a significant and growing segment of the Australian population. The Australian Bureau of Statistics estimates that approximately 20% of the 1.2 million people over the age of 65 are handicapped to some degree. Within this group are the greatest concentration of people handicapped by rheumatism and arthritis, stroke, hearing impairments and defects of sight.

Features common to many disabled elderly people are a denial of handicap and a reluctance to accept aids which may focus attention on their handicap or aids which appear complicated or not related to past experience.

One of the greatest fears of elderly disabled people living alone is that of suffering a sudden severe illness and being unable to obtain assistance. It is estimated that over 50,000 persons would appreciate a telephone service, similar to ones available commercially, that enables subscribers to either obtain assistance when required (without actually having to use the telephone themselves) or have assistance despatched when the subscriber fails to respond to 'checking' calls.

For a summary of statistics on disabled people requiring aids see Table 3.

IMPLICATIONS FOR THE DEVELOPMENT OF AIDS TO TELEPHONE USE

For most disabled with impaired mobility, the telephone represents a device that is invaluable for maintaining contact with friends and relations, in many cases the use of the telephone has theraputic value. For many disabled, use of the telephone is dependent on the services of others. The aged person of frail health often regards the telephone as a lifeline that may save his or her life.

Rather than a wide variety of aids being required, the disabled population require relatively few. Aids that assist the majority of disabled are already available — features such as loudspeaking telephones, repertory dialling, cordless telephones, push button dialling cater to the needs of most severely disabled people.

Development of instruments such as the 'digital display dialler' which through a L.E.D. display shows numbers in changing sequence and requires a reaction by the operator every time an appropriate number is displayed, offer a remedy for the person with profound upper limb disabilities. Such a device requires voice activated controls and a loudspeaking telephone.

For the profoundly deaf the videophone or more futuristic concepts such as a voice synthesiser / converter appear to hold greater promise than current alternatives. The telephone typewriter, a device that transmits messages between compatible units, allows only limited communications for the profoundly deaf.

Disabilities	Severity			
	Mild	Moderate	Severe	Profound
Both Lower Limbs only	2,740 (19.6)	3,124 (22.3)	1,000 (7.1)	5,000 (35.7)
Two Upper and Two Lower Limbs only	20,000 (142.9)	14,045 (100.3)	5,075 (12.2)	2,498 (24.5)
Two Upper and Two Lower Limbs with disorders of speech, intellect and perception	5,606 (46)	2,196 (15.6)	1,708 (12.2)	3,436 (24.5)
One Upper and One Lower Limb only (non-institutionalised)	3,000 (21.4)	2,000 (14.3)	1,000 (7.1)	
One Upper and One Lower Limb with speech and perceptual difficulties (non-institutionalised)	1,350 (96)	900 (6.4)	450 (3.2)	
Hearing	186,000 (1,331)	56,300 (402)	30,100 (321)	
Hearing and Speech				17,600 (126)
Speech only		1,000 (7.1)		
Sight		67,000 (477)	24,200 (173)	
Intellect	100,800 (720)	15,600 (111.4)	3,600 (25.7)	

TABLE 3: Summary of Estimates of Disabled Requiring Aids

Number & Incidence (per 100,000) Australia 1978

Design of future terminal equipment could very well take into account the needs of disabled users, for example, push buttons with a horizontal rather than an angular inclination are easier to use for persons with mild to severe upper limb disabilities.

Public telephone booths located with consideration given to background noise levels and accessibility, incorporating features such as push button dialling and waist level coin chutes would benefit all users.

Specialised pay phones located at institutions catering for the disabled, with features such as push button off line dialling, loudspeaking telephones, volume controls, with coin chutes and benches designed for users in wheelchairs, are required.

These features would not only be of great psychological benefit to disabled users but would also lighten the burden of institutional staff.

The great burden faced by the majority of disabled is that of economic hardship. Aids enabling the use of a telephone for many disabled have a lower priority than aids necessary for day to day survival and mobility. The unanimous view of the disabled community is that they should pay no more for the right to use the telephone network than the able-bodied community. Ultimate costs will determine the availability of aids to telephone use.

CONCLUSIONS

The major conclusions reached as a result of this study were that the majority of disabled people can be assisted in independent use of the telephone with relatively few aids, all of which use current technology.

It was also found that there were, at times, differences between the needs and preferences expressed by the disabled person and those inferred by other groups.

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Telecom Policy on Microprocessor Developments for Engineering Applications

W. F. TAYLOR, A.R.M.I.T. and C. H. McCALL, A.R.M.I.T.

In 1977 there were over 40 microprocessors on the Australian market; many of these devices were being utilised by Telecom design staff to solve previously impossible design problems.

It became apparent that, unless standards were adopted for microprocessor design, Telecom could face unnecessary expense over the whole area of equipment development and support.

For some time there has been an appreciation within Telecom that the application of microprocessors to "in-house" designs requires a special approach to ensure that all the relevant economic and technical criteria are considered regarding their use. In 1977 the first general policy on this subject was issued to Telecom design staff. The policy dealt specifically with "in-house" designs and deliberately refrained from making any rules which might inhibit the activities of Telecom's suppliers. The policy of 1977 recognised that microprocessor technology and cost structures were changing very rapidly and that the policy would need to be examined again in two or three years.

To carry out the review of the policy a team of specialists from a number of disciplines and interests within Telecom was established in 1979. The review team conducted a survey of the extent and direction of ongoing microprocessor - based design work current in Telecom. This information, together with specific studies into commercial aspects of the Australian market, was used to make a number of recommendations to form the basis of a revised policy.

The general thrust of these recommendations was to confirm and expand the scope of the 1977 policy. The new policy confirms that there is a continuing need for a uniform Telecom approach to design applications using microprocessors in order to maximise the use of scarce technical resources. The specialised Microelectronic Systems Development (MSD) centres that have been established in Telecom Engineering Departments (Headquarters and States) will continue to be the focus for developing a body of experience and expertise in the use of microprocessors.

THE NEED FOR STANDARDS

In 1977, the most pressing requirement for 'in house' Telecom design work was for standards to be established. The Motorola M6800 was chosen as the preferred microprocessor component and a series of standard modules was developed in Headquarters. A contract was then arranged for purchase of the standard microprocessor based modules. The design was based on L. M. Ericsson production techniques and design principles using the ROE type printed board assembly (PBA). The principle of the design was to enable MSDs to add on local varients with the resulting design being suitable for mounting in standard available racks and shelves as used in telephone exchanges.

The ROE based modules have mounting restrictions if required to be used in other than the telephone exchange environment. On the other hand many of the commercial modules now available are acceptable for small projects with limited scope and medium life expectancy but can have physical constraints if a design has to be manufactured in large quantities and mounted in telephone exchanges. **Fig. 1** illustrates Telecom's standard microprocessor modules on ROE PBA's and the LME shelf into which they mount. **Fig. 2** illustrates Telecom developed wire wrapped PBA of the ROE type which was created as a design tool to quickly create design variants; for example for the creation of an input/output PBA.

During 1979 the review team conducted a survey of microprocessor applications work within Telecom Engineering and Research groups. This provided valuable information and insight into current work together with the costs and controls applied to this work.

The survey revealed a current expenditure, in salaries and overheads, of $3M per annum and a capital investment in Development Systems and Test Equipment of approximately $0.6M. The survey also revealed that there were an inordinately high number of projects which appeared to be of only local interest. Telecom has highly standardised equipment common to all States and it is considered that justifiable design projects should have a national application. It was apparent from the information provided that there were some projects which could only be justified as local training exercises and others which had started without adequate design development facilities and most probably would not reach completion.

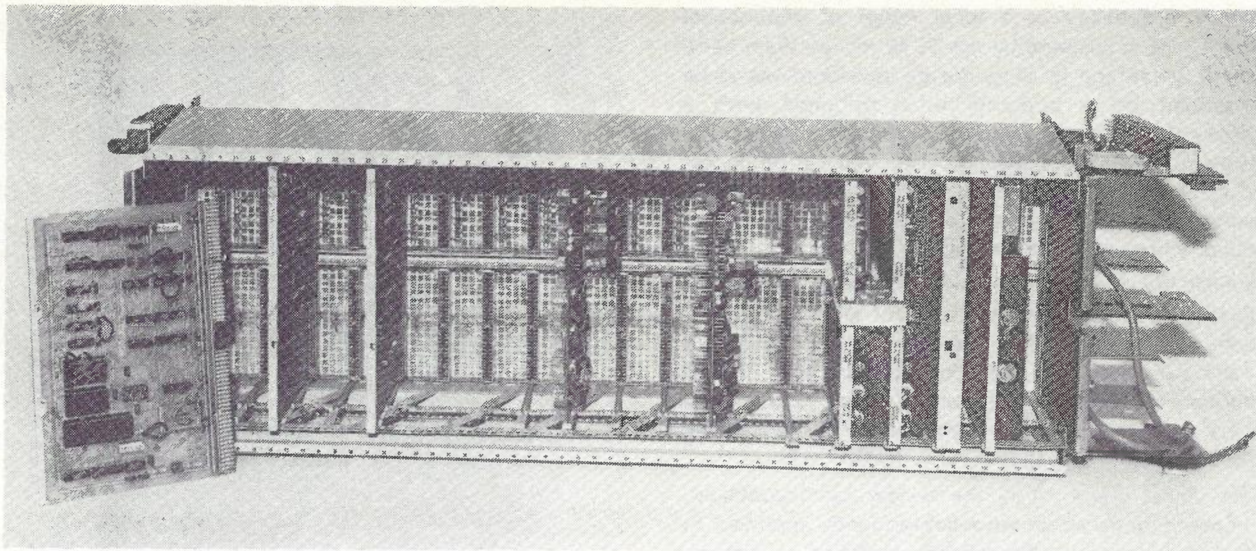

Fig. 1 LME Shelf with the PBA Incorporating the Microprocessor Extracted.

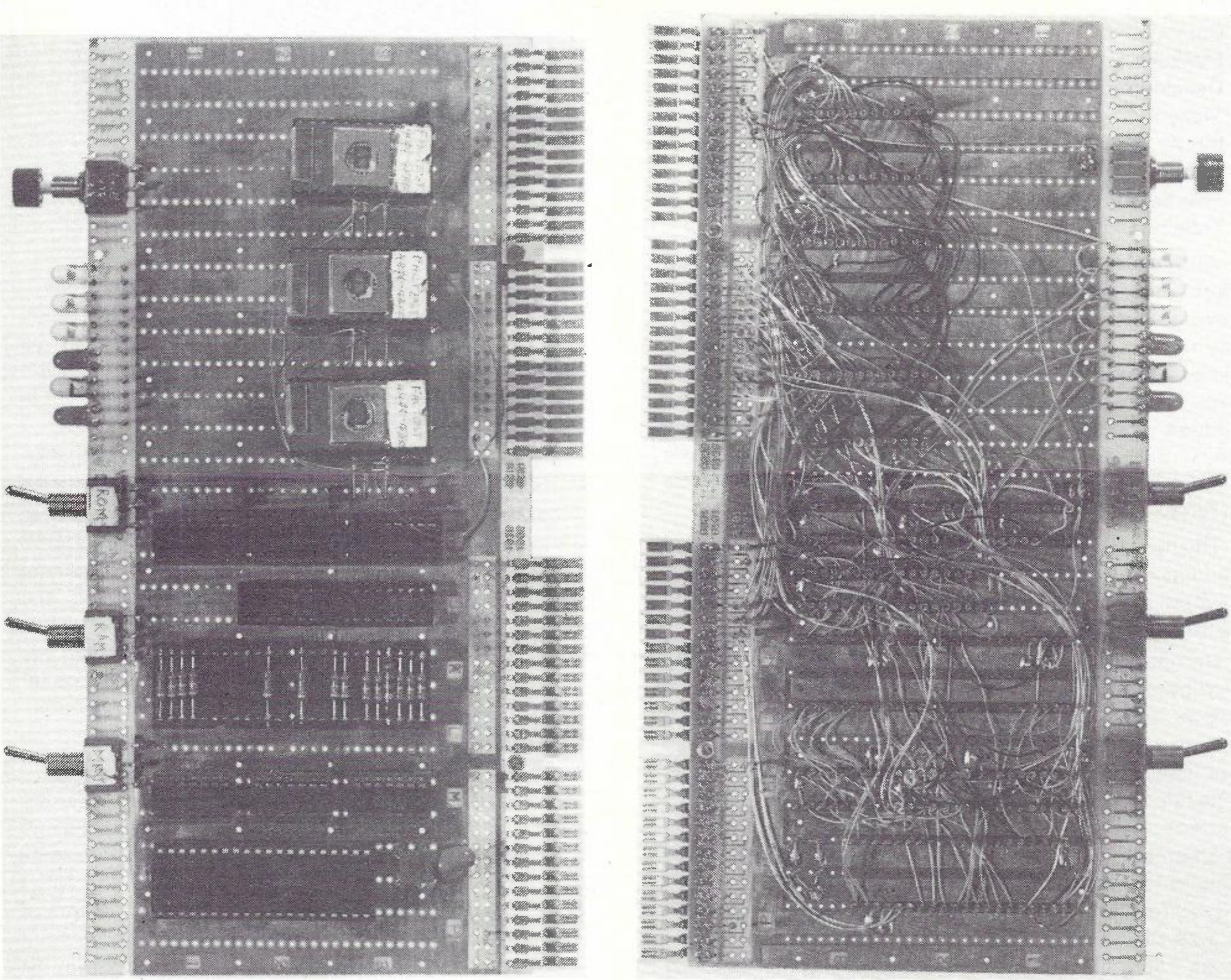

Fig 2. Wire-wrapped PBA: (a) Component side (b) Wiring side

Ready availability of a wide range of commercial modules was considered by the 1979 review team to be of prime advantage to allow design developments to be approached on a building block principle with a subsequent saving in development time and effort. It was considered that only in special cases would it be necessary to design and build modules from component level upwards. **Fig. 3** illustrates one of the commercial modules which are now available.

Availability of consultative services was considered as important in 1977. The establishment of a uniform approach within Telecom has had the effect of building up an effective core of expertise around the chosen microprocessor and development systems. The mutual support now available between the MSD laboratories made this factor less important in 1979.

The report prepared by the review team contained recommendations which were subsequently approved as policy. As well as providing specific technical guidelines, these recommendations addressed problems in design control, purchasing, support and training. The following sections give some highlights of this work.

SELECTION OF HARDWARE

A Tender Schedule entitled 'Microprocessor Integrated Circuits, Modules and Development Aids' was issued in September 1979 which sought information about the following items:

- Components
- Modules
- Development Systems
- Mass Storage
- Input / Output Devices
- Software Packages
- Test Equipment
- Training Courses

At the time of evaluating the tenders, the major design effort within Telecom was in building 'one off' devices to prove designs before proceeding to contract. This activity was reviewed and it was decided that the purchase of microprocessor chips for the purpose of building custom cards should be actively discouraged and standard modules should be obtained and used to enable the design and documentation work to be handled more quickly. The modules offered against the Schedule were therefore examined in considerable detail.

The modules selected needed to be suitable for limited production runs of say 1-10 units. The survey of Telecom microprocessor activities indicated that this would satisfy the majority of requirements.

One problem was to determine the most appropriate microprocessor base. After a study of existing in house support in MSDs in respect to laboratory equipment, staff training, and software availability the Motorola family was found to be the most favoured. The offers against the Schedule also indicated a leaning towards Motorola in respect to the number of independent offers incorporating Motorola products. Taking all factors into account it was apparent that the decision with the least cost to Telecom was to adopt the Motorola microprocessors as the Telecom family for the main stream of "in-house" designs where microprocessors have economic application. This does not necessarily mean that the Motorola family of microprocessors are the "best" microprocessors nor is it intended that other microprocessors could not be used to solve particular design problems, particularly if there were benefits to be obtained which would provide a clear economic return on the substantial support and training costs involved in adopting another microprocessor.

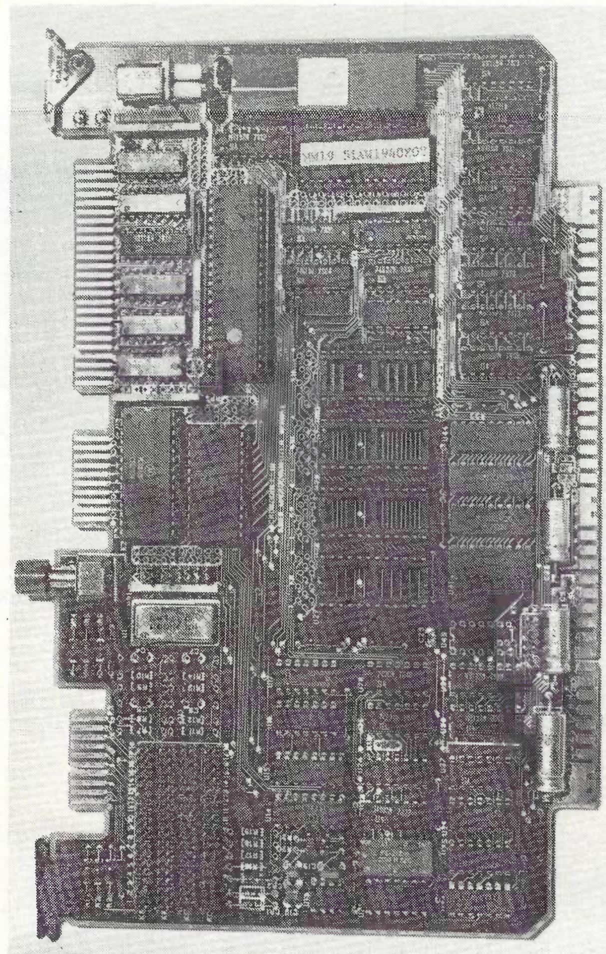

Fig. 3. Motorola PBA Incorporating their Type 6809 Microprocessor.

16-bit microprocessors were offered and considered. All provided a significant increase in performance compared to the 8-bit devices which can often surpass the power of many minicomputers. However prices were very high and the choice of modules limited. The training available was scarce and specialised. To use the increased performance effectively a high degree of skill in design and choice of options is required. Under the circumstances it was considered that the applications for 16-bit microprocessors in Telecom would be very limited. This situation could change however, and evaluation studies will be continued.

Both local and overseas manufacturers were awarded contracts to provide microprocessor system modules and the modules chosen are bus compatable. The decisions which have been made reflect the needs of the MSD groups. The dynamic nature of technology in this area of design is well recognised and in order to provide a rapid response to future needs, a continuing program of investigation of new devices, modules and development aids will be undertaken.

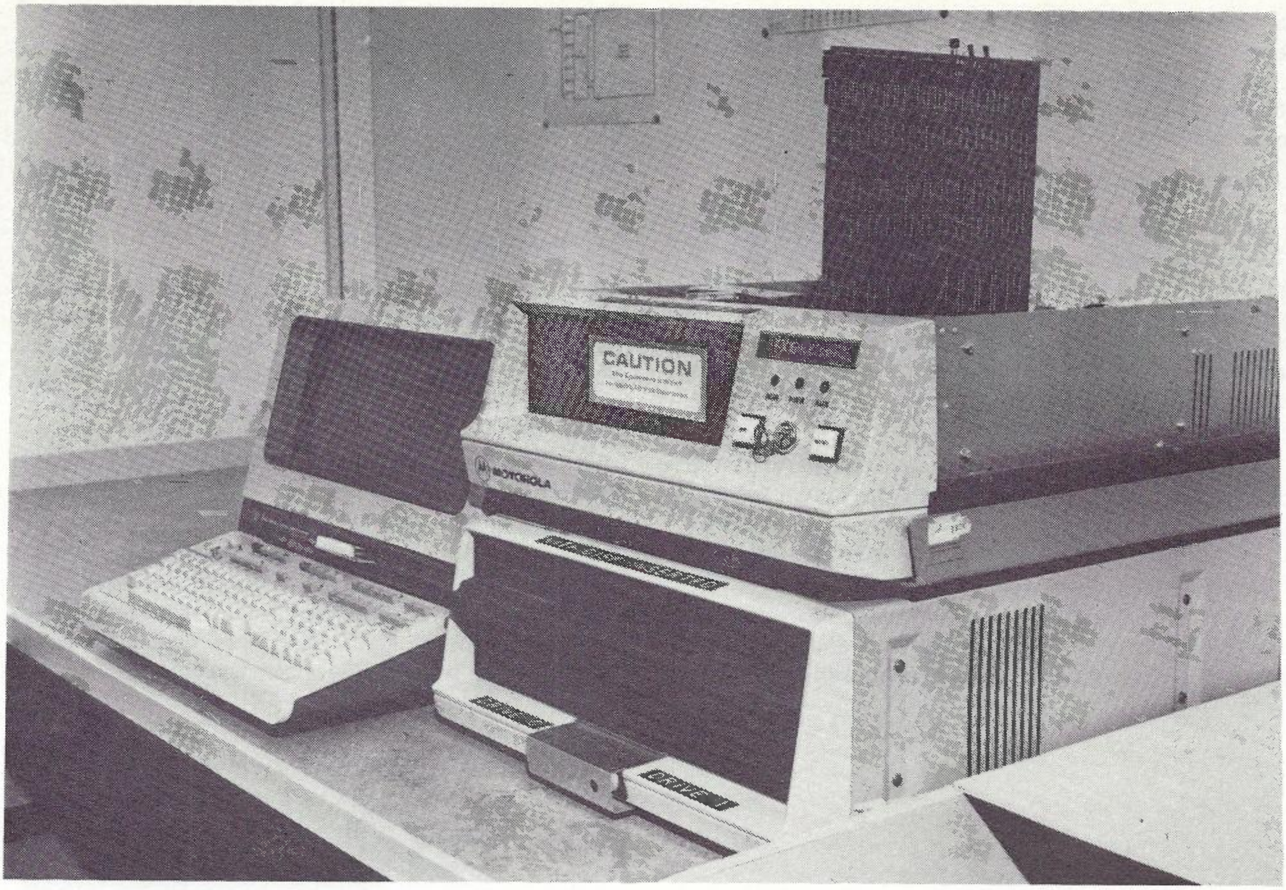

Fig. 4. Motorola EXORciser with EXOR Disc and Hewlett Packard Terminal.

SOFTWARE SUPPORT

TACONET, The Telecom Australia COmputer NETwork, uses the public switched telephone network and centralised microsystem software is provided. Thus only one suite of software is required and this can be readily updated and modifications are available immediately to all MSD users. Further advantages with the TACONET system are the power of the host system with secure file system maintenance and efficient editing and assembly compilation.

The use of high level languages on microprocessors is still in an embryonic state. Manufacturers of microprocessors who have implemented high level languages have defined their own proprietary language. Hopefully a standard for high level languages for microprocessors will appear. Of the high level languages evaluated by the review team, PASCAL had the qualities and features needed for general-purpose programming of microprocessor systems.

DEVELOPMENT SYSTEMS

Development systems can be divided into those dedicated to a particular microprocessor and the so called universal development system that is designed to cater for a number of different microprocessors. The dedicated systems are manufactured by or on behalf of the microprocessor developer. The universal systems are made by independent manufacturers.

The conclusion drawn by the review team was that the system dedicated to a particular microprocessor family was generally superior to the universal type system. Universal systems tend to lag the dedicated systems in their support of new devices and are biased towards the most popularly used microprocessor in the developer's field of interest. If a design centre was working with different manufacturer's microprocessors, the cost of dedicated systems would need to be considered against that of a universal system. The Motorola EXORciser was considered as a very suitable development system and is illustrated in **Fig. 4.**

DOCUMENTATION

Documentation must provide the needs for all phases in a development, viz:

- Design
- Manufacture
- Installation
- Operation
- Maintenance

It is the responsibility of the design group to ensure that all these areas are adequately covered.

Two problems were identified by the review team in respect to software documentation, the first was the tendency for software documentation to be late and the second was the ineffectiveness of documentation in communicating the appropriate information to the particular area concerned. These problems stem largely from a lack of guidelines and standards in this area and the new microprocessor policy calls for this situation to be corrected.

COMMERCIAL SUPPORT IN AUSTRALIA

All microprocessors and associated integrated circuit (IC) devices together with their associated development systems are manufactured overseas. The imported items are usually sold through a network of agencies throughout all States, except Tasmania. Consultation is generally available for the items concerned, however it is of declining importance to Telecom as our own expertise builds up.

Some of the principal overseas manufacturers have followed the practice of providing packaged training courses for the tertiary education institutions in the hope of developing the market by influencing the undergraduates.

Australian agency participation is predominately in the area of training and consultancy services and may cover several microprocessor types. Four Australian companies offered Australian designed modules based on the Motorola M6800 family. The policy to give preference to Australian manufactured equipment lent support to the choice of the Motorola M6800 family. Other Australian made modules for other microprocessors are believed to be available in Australia, but were not offered against the Schedule.

DESIGN SUPPORT

The successful application of a microprocessor design requires careful consideration of all phases of support from the design concept to its implementation. Consultation should be available to design staff on development systems and applications, material provisioning, software development aids, documentation, field implementation maintenance aids and training schemes.

Compared to June 1977 Telecom is now fairly independent of commercial consultative support as expertise has been developed in most States to a high level. Consultation on hardware and software is available either through the MSD groups of the Engineering Department or from the Research Directorate.

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Further work still has to be done to establish a range of common software packages. However a number of facilities are provided on TACONET and these go a long way towards satisfying the basic needs of the MSD groups. These include cross-compilers, a library of routines and other utility software programs. A manual is being prepared which will encompass instructions for TACONET access as well as user instructions for the various cross-compilers provided.

Telecom HQ Engineering Training is now offering an introductory course on microprocessors. Further courses of a more specialised and advanced nature are being developed and will follow in the near future.

PROJECT COSTING

The problem associated with inadequate project costing has been compounded with the introduction of microprocessor based projects. Two major difficulties in this respect are the general enthusiasm of staff to design with microprocessors and the failure of designers to recognise all the cost factors involved in such developments.

The boom in the use of microprocessors was largely caused by the price of 8-bit devices falling from $300-400 of a few years ago to the $10-15 range today. The low component costs encouraged designers to use microprocessors in preference to other solutions. The cycle is apparently being repeated with the development of the 16-bit microprocessor.

Software costs are very high as they are labour intensive. However costs are falling with the increasing availability of software aids, development systems and the increasing expertise of designers. Programming costs can be approximated by using the generally accepted figure of 10 lines of source code per day, fully tested and debugged. Existing projects have average requirements of between 500 and 1000 lines of source code.

It is stressed that a uniform approach to microprocessor design development within an organisation can result in economies which are often difficult to quantify but nevertheless are real. Hardware development costs can be reduced when standard modules are used for the common functions. Microprocessor based modules providing basic computer building blocks such as CPU, memory, clocks and various interface modules are readily available. This has eliminated the need to undertake project development from the component level for these standard functions.

It is considered that the minimum development support requirements for carrying out microprocessor design require an initial outlay of some $40,000. This cost is mainly to provide a minimum level of adequate support, generally referred to as "Development Aids" and without which a designer would be compelled to work in an ineffective manner. A fully mounted set of modules with power supplies for prototype work can cost between $2500 and $3500.

It was found that design staff often regard project costing as a black art to be avoided if at all possible. Designers generally will compare available hardware costs but not ascertain long term availability, reliability or maintenance aspects. Design staff tend to overlook the cost of their own efforts as well as drafting and documentation costs. An accepted general rule for assessing labour costs is to use 150% of salary to cover overheads. Consideration also needs to be given to hidden costs such as those associated with tooling for manufacture as well as the cost of training maintenance staff.

THE PRESENT SITUATION

It is quite apparent that Telecom cannot afford the luxury of a variety of microprocessor development groups working independently and based on different microprocessor systems. The high costs involved lead to the conclusion that design work should only be undertaken in laboratories adequately equipped with the designers supported with software packages from a common source.

That is broadly the position that Telecom has now reached. There are MSD groups in each State and Headquarters. Software support systems are available on TACONET and the Research Laboratories continue to provide technical support.

WHERE NEXT?

In this article reference is made to the 16-bit microprocessors. They are the obvious next generation. However when the microprocessor policy is next reviewed there will be other factors which will influence the next round of studies. The achievements and frustrations of the MSD groups will be important. Developments offered to Telecom in new communication systems which are microprocessor based will also be important. These will introduce a new range of modules potentially available to MSD groups.

There will also be new developments on offer from the semi-conductor industry such as specialised large scale integrated circuits which will be prime purpose microprocessors. There will be matrix arrays too, that can be programmed by designers to fulfill a limited microprocessor function.

Consequently there will be pressures to widen the scope of the microprocessor policy to adopt more powerful devices. On the other hand we may come to regard the microprocessor as "a sledge hammer to crack a nut," whereas the use of devices with less power may be more appropriate for many applications. These devices may be the basis for counter-pressures. We will leave this problem to the next review team.

A Discussion on Telecommunication Equipment Building Design

H. P. GUTHRIE, M.I.E. AUST.

There is evidence of significant reduction in the space requirements of new telecommunication switching systems.

This reduction provides an opportunity to review the traditional bases of many parameters of telecommunication equipment building design. In 1978-9, a joint Telecom — Department of Housing and Construction study of equipment building design developed a series of conclusions after such a review.

Innovative in the method of approach, the study examined in some depth the complete building-equipment relationship and raised several matters which provided an indication of the likely development of future equipment buildings. This discussion considers these matters in a little more detail.

The overriding theme of this discussion is that the flexibility of modern telecommunication equipment systems must be utilised to effectively and economically overcome the lack of flexibility in the building system.

Telecommunication equipment, since the early manually operated systems, has been housed in specially designed buildings. These telephone exchange buildings have been taller and stronger than most other buildings of the same general capacity.

And they have been expensive to build. Like many other special purpose buildings, telephone exchange building construction bears a significant cost penalty compared with conventional building construction with which the building trade is familiar.

Therefore, there would seem to be a need to examine the present design criteria for telephone exchange buildings and ask two fundamental questions:

- Must the telephone exchange building have these special provisions, and,
- When these provisions are necessary, how can they be provided to carry out their function economically and effectively?

Later on in this paper, a third question is raised which suggests a complete turn about in the building — equipment relationship. This question is:

- Should in future, telecommunication equipment be designed to meet the needs of the accommodation?

In the past, the traditional features of telephone exchange buildings have gone virtually unquestioned, and have been perpetuated at significant cost to the building. In consequence there has been little evidence of a system approach to the design of these buildings. Rather, the supposed equipment requirements — whether real or not — have dictated the design form of the building.

A REAPPRAISAL OF BUILDING DESIGN

In February 1978, a study was commenced in Telecom Australia to carry out a reappraisal of the fundamental criteria used in the design of telecommunication buildings, in light of the changes taking place in both the telecommunications equipment and buildings areas. This Reappraisal Study, under the guidance of a joint Telecom and Department of Housing and Construction Steering Committee, was undertaken by a Working Party drawn from both organisations.

The Working Party, at the end of the twelve month study, prepared a Report (Ref. 1) recording the method of approach used by the Working Party and setting out the conclusions and recommendations arising from the Study. Some of these recommendations were suitable to be put into practice immediately. Other recommendations required further development to determine the scope of their application and to establish the necessary machinery for their introduction.

Although the terms of reference of the Study referred to telecommunication buildings, the Study focussed mainly on telephone exchange buildings. These buildings form a major component of the building works programme, but represent a building system unique to Telecom. Many of the concepts developed by this examination, however, are transferrable to other telecommunication buildings.

NEED FOR THE STUDY

The Reappraisal Study was established because there was growing evidence that traditional telecommunication equipment building design was steadily becoming out of step with the development of new telecommunications systems.

This divergence became clearer with the proposed introduction of the AXE switching system with its radically different requirements for space, environment, operation, cabling and installation techniques.

In the past, network expansion almost invariably meant an extension of equipment building capacity. The introduction of AXE provided new concepts of operational flexibility, and actually reduced spatial needs, a situation not previously encountered by network planners.

This introduction provided the spur for a fundamental examination of the real accommodation requirements for all types of telecommunication equipment.

Attempting to develop cost-effective accommodation for AXE equipment provided a challenge at a time when there was little historical information on the needs of that equipment.

The opportunity was therefore taken to "start from scratch" and develop a fresh look at the design of accommodation for AXE equipment. It was possible to develop alternative building concepts free from the restrictions imposed by adaption of present day design. Using the introduction of AXE as a catalyst, the validity of present building design criteria was examined critically to ascertain whether the lessons learned from the design of accommodation for AXE could make savings for present buildings.

This examination brought to light several areas in the design of buildings where changes were necessary. For example, at 3660 mm, 760 mm taller than crossbar racks, the conventional MDF is the tallest piece of equipment in any terminal telephone exchange, and dictates the building height. Whilst a lower-height, increased-capacity MDF is required for low-height AXE exchanges, there are other reasons for the traditional MDF design to be altered in concert with the trend to above ground cable rooms, alternative cable entry and new termination methods.

STUDY METHODOLOGY

The Working Party utilised the collective multi-disciplinary experience of the members to develop an innovative method of examining the design of telecommunication equipment buildings. This method examined the accommodation needs from first principles and explored the range of possible alternatives.

Many of the fundamental design criteria for telephone exchanges seemed to have developed out of tradition which varied between States, and between metropolitan and country areas. Establishing the reasons for these criteria posed a serious problem in the restricted Study period.

With the aim of developing a co-ordinated approach to the design of telecommunication buildings, the Working Party set about to define the total system described by the building, its engineering services and the telecommunication equipment it houses and went on to optimise that system in terms of cost and operational effectiveness. This method utilised the expert opinion of the team members, and the experience of the areas they represented rather than attempting to establish the specific justification for particular criteria from history. This method allowed:

- A total system view to be communicated to many people who had not previously recognised the degree to which changes in their area affect the total operation.
- Traditional views to be questioned from outside the framework which preserved those views; for example, floor level tolerances which are rarely attained in practice but which still continue to be rigidly specified.

To promote the understanding of this total system concept, a discussion booklet entitled "New Concepts in Telephone Exchange Buildings" was produced.

The booklet provided a comparison between an existing crossbar building being used to accommodate AXE equipment — Endeavour Hills, Victoria — and a conceptual design incorporating the innovations developed by the Working Party. This illustrated by example the interaction between the functions installed in the building.

The booklet showed that considerable savings were possible by re-examining the traditional justification for particular accommodation requirements. In the case of Endeavour Hills, the conceptual design reduced the space requirement to 40% and the estimated cost to 32% of the original crossbar-based design **(Fig. 1)**.

This booklet was widely distributed in Telecom and the Department, and supplemented by a series of seminars conducted in each State and at Headquarters to gather comments on the Study. In each case, strong representation from Telecom Engineering and Operations Departments and local Department of Housing and Construction ensured lively discussion and worthwhile comment.

The opportunity for the users, providers and designers of telecommunication equipment buildings to join in wide-ranging discussion on the general subject of the building and the equipment it houses was obviously welcomed and illustrated that the distribution of the booklet had provided an excellent stimulus. The major items of discussion, across all States, and their percentage relative to the total number of topics raised, were:

- Reliability, including the social responsibility for the security of telephone services 26%
- MDF, cable entry and non-exchange services 20%
- Air conditioning, ventilation and AXE environment 17%
- Design considerations of telephone exchanges 15%

Not all the concepts raised by the Study were considered practical in all States, indicating that further consideration in some areas is necessary. However, the discussions, seminars and subsequent correspondence from each State was extremely useful in formulating the conclusions of the Study.

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CONCLUSIONS OF THE STUDY

A series of conclusions was developed as the outcome of the Study. The detail support for these conclusions is included in Ref. 1. These conclusions gave rise to concomitant recommendations which propose methods of developing the conclusions toward effective action. The general and over-riding conclusion reached by the Study was that all future building proposals must be justified as the most effective, economical system alternative, after an examination of the equipment accommodation requirements, possible network alternatives, likely future trends, and the cost of each function of the building.

To meet this objective, the Study reached across the spectrum of the building equipment partnership to develop these conclusions:

- With the introduction of the AXE switching system, and the network alternatives available with that system:
  - — sufficient equipment space may already exist in metropolitan exchange buildings to cater for long-term growth particularly within central areas of capital cities;
  - — the use of remote subscriber stages, for installation in existing buildings, and in transportable containers, can postpone building replacement or extension; and
  - — no further new exchange sites, or extensions to existing sites need to be purchased in metropolitan areas.
- A re-examination is necessary of the traditional view of designing equipment areas on the basis of present day technology and providing space for future growth in the same manner, in view of the greatly reduced accommodation

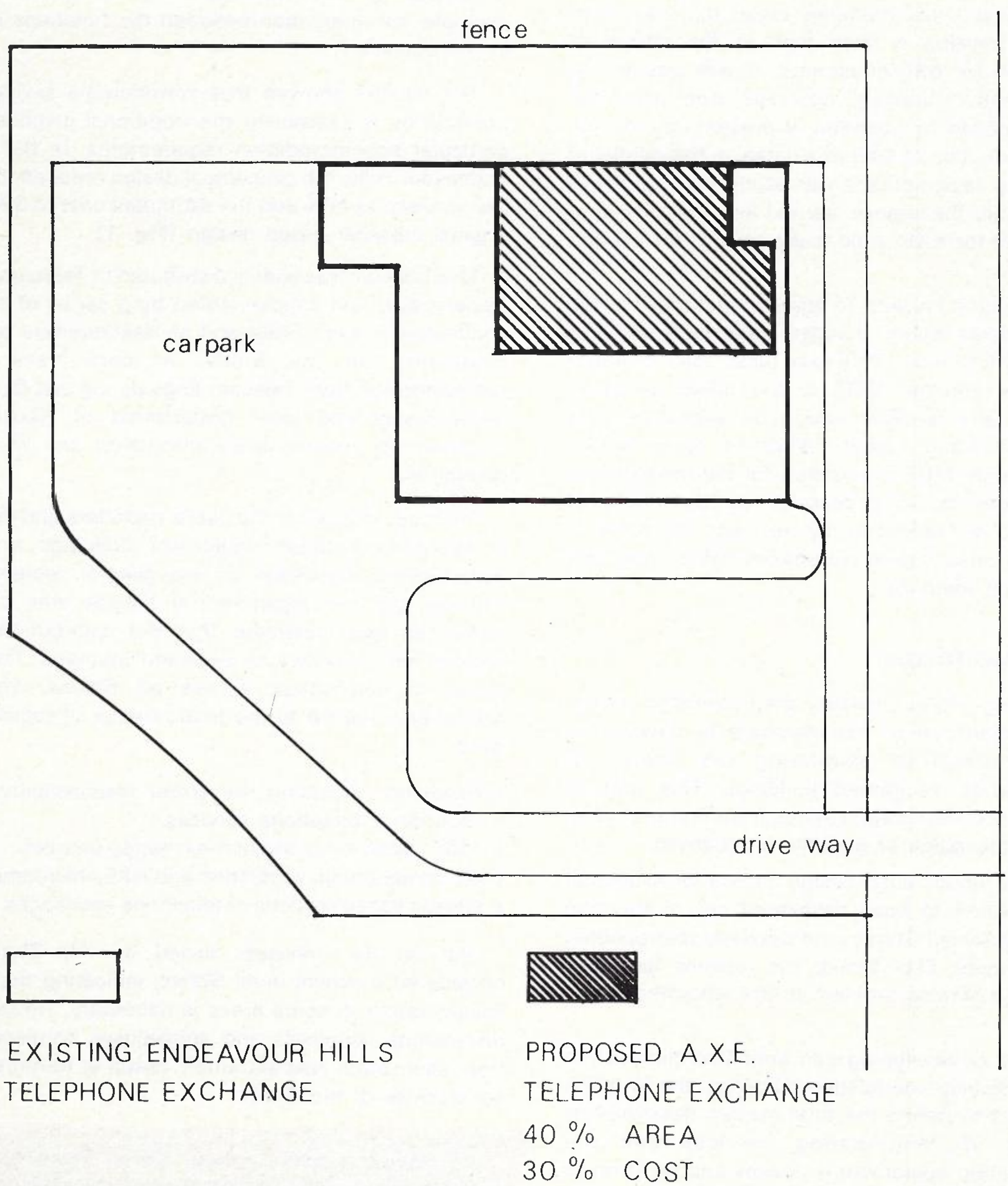

Fig. 1 — Comparison of Building Area.

requirements and increased system flexibility of the AXE system, and the indication that the future space requirements for particular functions will continue to reduce.

- A review is required of the real need for air conditioning of telecommunication equipment and of the methods used to provide that air conditioning.
- A new MDF design could offer considerabl building cost savings.
- Above ground cable rooms, and curved duct cable entries should replace the more expensive underground cable chambers.
- Future telecommunication equipment should have an operational height (rack height plus cabling space) of not more than 2700 mm. This represents a 6-shelf high, 2250 mm AXE structure, compared with a crossbar rack of 2900 mm.
- Any future telecommunication building should be suitable for either equipment or office accommodation without major alteration.
- The specification of standards of finish, floor loading limits and floor level tolerances in telecommunication equipment buildings should be reviewed, since current standards are restrictive, expensive and often unnecessary.
- Telecommunication equipment buildings should be designed with a mimimum of designated areas enclosed by walls and partitions. Any partitioning that may be required should be provided after the building is completed, and the area use specified.
- To ensure the development of optimised design, a co-operative design method should be developed to relate the design of the building to the actual network needs.
- Functional Cost Analysis should be developed and used to provide an effective management tool to control the cost of building projects.
- A clear definition of the level of overall reliability expected of the telecommunication network, and the reliability of the elements of that network is needed to allow accommodation and power supply requirements to be more rationally planned.

RESPONSE TO THE REPORT

The Report issued at the completion of the Study, from which these conclusions have been drawn, met with a mixed response. Many of the ideas, when advanced by the Study team in the early stages of the Study, had been greeted with some scepticism. However, as the Study progressed, these same ideas became conventional wisdom through constant discussion and exposure. By the time the Report was issued, several of the ideas were "old hat".

However, the Study did become a catalyst for change and a forum for discussion between the equipment designers and building designers at a level not previously attained.

This discussion exposed a shortcoming of the Study in the lack of detailed attention directed to the reuse of existing buildings for the installation of the new types of equipment. Several pointers were provided in the Report to the ways in which the recommendations could be directed toward the effective use of space in existing buildings but these did not provide sufficient practical guidance for the formulation of policy, or to assist implementation planning.

Overall, the Study provided an opportunity to stand back from the day to day pressures of providing for immediate network needs, and evaluate the effectiveness of traditional methods of meeting these needs. The potential introduction of AXE provided a convenient focus for the re-examination of the building-equipment partnership. Not that this partnership had been serving Telecom badly in the past, but there were sufficient indications that the needs were diverging. This divergence has been effectively camouflaged by the competence of the staff in the building and equipment areas to adapt their requirements to the available accommodation standards. This divergence may have been compounded by the keenness in some areas to show that challenges can be met and difficult problems solved, rather than question whether the challenge itself should ever have arisen.

WHAT OF THE FUTURE?

There were many matters raised by the Study which impact heavily on the future development of the partnership of the equipment and the accommodation for that equipment. Many of these arose from a realisation that some traditional methods and practices have a questionable justification that may have arisen from a past of different technology and cost structures. At the same time, this realisation is heightened by the knowledge that major intervention is necessary before some methods or practices can be changed, even though there may be agreement that the justification no longer applies.

The Study, because of its objective to examine the fundamental criteria affecting building system design, provides a useful stepping off point to raise some of the interesting aspects of the future of the design of accommodation for telecommunication equipment.

It must be said that these aspects of the possible development do not, in any way, represent the "present thinking" of Telecom but serve to illustrate the manner in which the building-equipment partnership has changed, and will continue to change. It must also be stated that many of these matters are presently difficult to bring toward resolution within the present structure. However, they are worthy of raising and even if then rejected, their exposure will have advanced the understanding of the building-equipment partnership much further than had these matters never been exposed at all.

What follows is a short discussion on some of the more important of these aspects of the building-equipment relationship. The selection does not indicate any particular priority.

CO-OPERATIVE DESIGN

There is a need for some ongoing mechanism which questions the reasons for particular building designs, and whether the traditional solution is acceptable. When two areas of expertise — the building engineering and the equipment engineering — come together to arrive at a solution, there has been the tendency in the past to settle for a serial solution. That is, one area — usually the telecommunication engineering — proposes a set of accommodation parameters which favour the operation of the telecommunication equipment and the building design is expected to adapt to meet those parameters.

Each area of expertise respects the quality of advice of the other, and is usually considered unqualified to question that advice. The outcome of this series development tends toward a less than effective building-equipment partnership.

Any mechanism which is developed to replace this serial development must recognise that traditional methods of operation often develop historical support — they worked satisfactorily in the past so they should work satisfactorily today. What is required is a more interactive involvement of all areas of expertise involved with the project, from the earliest stage. Mutual education, carefully defined goals and effective cost control criteria would make for more acceptable solutions or at the very least, establish that whatever building design is finally accepted represents the most cost, and operationally-effective solution

RELIABILITY

How reliable must the telephone service be? And what effect does the provision of redundant plant and standby emergancy equipment have on the final cost of the building system? There must be some agreed reliability criteria against which to balance this cost.

There is a commonly held principle within Telecom — particularly in the technical fields — that the telephone service must never fail. "What if" stories of accident, sickness and sudden tragedy abound in an emotional response to any questioning of the reliability built into the network, equipment or support services.

On the other hand, the network does fail — for a range of reasons — and the staff accept that the network does not, and cannot, meet any "failure-free" criterion. This dilemma calls for examination.

An assessment of the costs and benefits of provision of standby plant and its accommodation, for example, is rendered impractical because of this lack of definition of the service reliability.

Since the telephone service does fail occasionally there must be some definition of the level of failure, and the conditions under which this failure can be tolerated. This definition must be from the CUSTOMER'S point of view, not the network designer's.

The degree of reliability required as expected by the customer, equated to the cost of the service should be ascertained and compared with the expectation of reliability as seen by the providers of the service. The "essential services" thinking embedded in network system design appears to be the justification for overprovision and overly high safety factors.

In particular, the degree of reliability of the service under conditions of prolonged power failure (a situation where another "essential" service to the residence or business has failed) or under conditions arising from partial failure of the telephone network (failure of a junction cable, etc.) requires definition. A failure regime which describes the order in which particular network units may fail will be required.

Until these aspects are defined, it is impossible to establish the correct level of provision of standby plant and its accommodation in telecommunication equipment buildings.

Any investigation of system reliability raises the question of the design of the network hardware to cope with power failure. At present, removal of power supply usually means loss of any network intelligence. The development of non-volatile memories, that is, memories which retain their data when the power supply is removed, offers insurance against losing the important control information at times of power failure and could markedly speed up the reinstatement of the system after power failure. This direction of development in system design would represent a change from the present emphasis on developing the switching system to provide extra facilities for the customers. The customer would however, still be the beneficiary if the system cost was reduced by matching of the system reliability to user needs.

There is a further aspect of the reliability of telecommunications which illustrates the need to view the system in totality. There are many telecommunication systems which interface with the network, but do not directly affect the traffic handling capability of the network. Such systems as traffic measuring equipment and the AOM 101 maintenance control system (Ref. 4) are important parts of network management, each provided with adequate back-up provisions to safeguard data and protect the overall function of the system in the event of power failure. Traffic data during times of failure may not represent a suitable sample, whilst fault reporting methods will still be available even if the AOM is not functioning. It is difficult, therefore, to accept that either of these systems, for example, warrant the expenditure on complex standby generator plant.

Tested against the criterion of lost revenue or equipment damage, non-network systems do not, on the face of things, warrant the provision of an uninterrupted power supply. This is not to suggest that these systems should not perform to appropriate service availability requirements, but that the service reliability at times of power failure, for example, should be re-examined.

FLEXIBILITY

The telephone exchange is a special building with floor-to-floor spacings which are considerably greater than those provided in normal office buildings.

Worldwide trends away from these special telecommunications buildings stem from:

- The rising cost of special purpose buildings.
- The need to effectively utilise building space throughout the life of the building.
- The knowledge that large telecommunication equipment buildings will not be filled with equipment for many years.

The uncertainty in the future space requirements of telecommunication equipment, and the changes in network topography likely to arise from increased logic power within the switching machine, require the utmost flexibility in building space provision.

The AXE switching system using the 6-shelf row structure has a floor loading requirement of 4.5 kPa and an operational height of 2700 mm. Both of these dimensions can be satisfied in a new office type building without major structural change, since ceiling heights in these buildings are normally 2700 mm and storage and similar areas have floor loading provision of 4.5 kPa.

The development of multifunctional buildings greatly increases the versatility and flexibility of the switching network, provides ultimate equipment space that can be efficiently used as office accommodation meantime, and ensures maximum utilisation of building assets.

The development of remotely operated subscriber stages and similar switching system line concentrators introduces a degree of flexibility into the location of switching centres. These need no longer to be located in specially constructed buildings but can be located in rented space, portable containers, in fact in any area where the requirements of cable entry, security and network economics decree.

This flexibility, coupled with the economics of PCM junctions, extends to the consideration of utilising the AXE system — and most other modern processor - controlled systems — to upgrade the country network and reduce the expenditure on country equipment buildings. This concept depends on the high proportion of traffic directed to the metropolitan area from the country centre, and the economics of trunk and junction provision. A central processor with associated group selector in a metropolitan switching centre could control remote subscriber stages throughout the State, replacing existing obsolescent equipment and bringing the latest range of facilities to the country areas.

The modularity of modern equipment, and the flexibility inherent in the design of modern processor controlled equipment provides a series of options which may improve labour productivity in the installation of the equipment. For example, an exchange could be erected, installed and tested in a modular form at a construction centre associated with the contractors assembly plant. In "powered-up" condition, and under the surveillance of a small computer, the modular unit could be transported and positioned in its final location, requiring only to be "plugged-in" to complete the installation. Such installation methods would have a marked effect on the design of equipment areas and the provision of services and amenities in these buildings.

RENOVATION

The marked reduction in space requirements and system flexibility of the new generation switching equipment, particularly the AXE system, has made it possible to plan the installation of this equipment in previously un-useable areas in equipment buildings.

The consideration of renovation of existing telephone exchange buildings for the installation of new generation equipment raises interesting economic and operational questions. The introduction of any new system is often the excuse to provide showroom conditions. If the equipment space is not to be completely re-constituted, what is the middle course?

If, for example, a 10 000 line step - by - step exchange is renovated, and replaced by AXE equipment of the same number of lines, much of the area of the step-by-step building will not be re-used. The equipment room will be 25% occupied, the MDF may have been extensively modified or even replaced, and the space previously utilised for staff for a fully staffed exchange is now only partly required. The rather large building will be sound, but relatively old, and almost certainly in a prime commercial location.

The questions then arise:

- Will all the building be renovated?
- If only partial renovation is planned, what parts will be renovated?
- To what use will the rest of the building be put?
- Should the cost of renovation of the unused parts of the building be a charge on the network?

If the cost of renovation is about half the cost of new construction — and this ratio is heavily dependent on the form of the renovation — would it be cheaper to build a separate AXE exchange somewhere else? This new building would be more efficient and secure than the old building and cheaper to maintain. Against these advantages, if the rate of recovery of the obsolescent equipment is slow, the investment in renovation can be equally slow. Whilst this may release capital for other opportunities, it does not solve the problem of the cost of large areas of vacant space in an inefficient building.

These considerations will require prompt examination, since most AXE installations in the near future are planned for existing buildings. The direction of action toward renovation should not be accepted as an obvious move, without detailed questioning of the rationale. The goal is to achieve the savings which were used to justify the introduction of the new system; savings which included the promise of reduced building costs.

SPACE SAVINGS

For as long as switching equipment has been installed in telephone exchanges, adequate space for expansion has been a mandatory requirement. The space requirement of electromagnetic systems used by Telecom has always been directly related to the line capacity of the equipment. Double the lines meant double the space, in general terms.

With the advent of processor controlled switching systems, this need to reserve large areas of space for expansion has virtually disappeared.

There is still an entrenched view, however, that space must be safeguarded, cossetted and never squandered despite the quite visible trends toward increased miniaturisation. If AXE, for example, has 25% of the floor space requirement for the same number of lines of step-by-step equipment, the replacement of the latter by the former will leave a very large area of equipment room unequipped. There are few established exchange areas of 10 000 lines in 1981 that are forecast to reach 40 000 lines before the next generation of equipment becomes available.

MINIATURISATION

There is, however, another entrenched view — this time amongst system designers — that works in the opposite direction. This view is that the equipment must be made smaller and smaller per unit of switching capacity. At the risk of denying progress, there must surely be an optimum size for switching equipment which must interface with other units — cables, man-machine interfaces, etc. Miniaturisation which ignores the practica blems of operating and supporting the system is not economic in the total system sense.

The present heat output per card in AXE equipment averages 2-5 watts in the hotter areas of the equipment. This heat generation can be adequately dissipated by convected airflow through the equipment at realistic ambient air temperatures. There is some evidence (Ref. 2) that new space-conserving configuration of components may raise this figure to 10-15 watts per card. These heat outputs will require special treatment of the air in the equipment space, placing greater reliance on forced cooling and adding another item in the reliability chain. Failure of the cooling system automatically means shutdown of the switching system.

Miniaturisation of this magnitude brings problems of cooling of the actual components, and water circulation through the rack structure is presently a consideration. This suggests that the saving in equipment space may be lost in the space requirement of what will then be the absolutely mandatory environmental control equipment. Reliability of this environmental control equipment can only be guaranteed by duplication and redundancy, and the physical laws of thermodynamics, hydrodynamics and aerodynamics preclude miniaturisation of this equipment to save space.

There seems to be a need, therefore, to model any new system in service before committing the purchase, to ensure that the overall space requirement is optimised. There are quite cogent arguments for making switching systems as small as possible for particular applications. These arguments must be weighed against the practical consideration of operation in Telecom's circumstances.

It is not only in switching equipment areas that space reservation tends to become a hallowed precept. The provision of large cable chambers, **(Fig. 2)** and extended MDF areas reflects a historical approach, ignoring the effect of changing economics and changing technology. This is particularly relevant in the provision of cable entry and cable chambers in tandem exchanges where the introduction of PCM junctions and digital tandem switching would, for example, require fewer cables to be installed in the cable chamber.

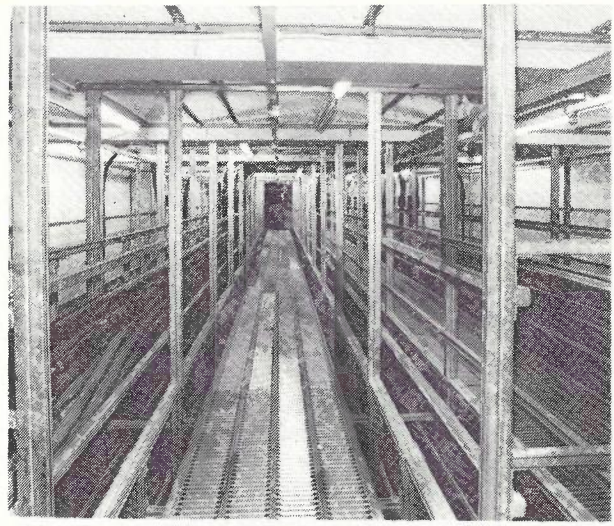

Fig. 2 — Metropolitan Exchange Cable Chamber — Excellent Finish, Extensive Racking.

ENVIRONMENTAL CONTROL

The provision of a controlled environment, specifically air conditioning, for processor controlled switching equipment represents a classical case of the perpetuation of traditional relationships, typifying the main theme of this paper.

Here we have two complex technical areas with a great deal of expertise within the organisation, but without a great deal of understanding by one of the fundamental requirements of the other. The two areas of air conditioning and telecommunication equipment design have worked together in the past to provide quite effective solutions, and there can be no criticism of the professional capabilities of each group.

When the equipment designer specifies a climate for the equipment, the air conditioning engineer provides that climate. Challenges have been met, and met professionally. Solutions have been provided, and the specified conditions met. What has been missing, however, is the question "Are these conditions necessary for the task?"

It can be argued that modern solid-state equipment is highly reliable. The components specified for telecommunication equipment are of considerably higher standard than those used in commercial electronics manufacture. It could be expected, then, that these higher tolerance components should be capable of withstanding greater ranges of temperature, humidity and air-borne dust contamination than, say, the household TV set.

Within Telecom there is wide variation between the environmental limits specified for various types of equipment. Transmission line and radio equipment has wider limits (Ref. 3) — virtually eliminating the need for air conditioning for the equipment — than those specified for switching equipment. Yet this transmission equipment carries trunk traffic where failure means considerable loss of revenue.

The removal of dust from the air in AXE exchanges is an exemplary case. The environmental specification for this equipment calls for removal of all but the smallest dust particles — all particles of size greater than 50 microns — the same specification as was laid down for electromechanical systems. In AXE exchanges only a small number of magnetic tape drives are likely to be affected by dust.

It is possible to argue that dust may build up on components, affect cooling or cause insulation breakdown and circuit failure at high humidities. Dust may be deleterious to printed circuit board contacts, if ever they are disturbed.

But where is the evidence that these problems do exist?

This situation only reinforces the view that traditional support can perpetuate unnecessary and uneconomic provisions. The experience of Telecom and L. M. Ericsson in two areas casts some doubts on the validity of the dust removal argument:

- ARK exchanges in hot, dusty areas do not have high quality filters on any fans or vents. Dust can and does enter around door seals and when doors are opened. ARK equipment is similar to ARF and operates under these conditions with a high standard of reliability.
- The graph **(Fig. 3)** shows that the majority of the dust in a telecommunication equipment building is generated by people moving about in the equipment room (Ref. 5). Filtration of the air should perhaps be replaced by restricting the entry of people.

There are some good reasons why the dust should be

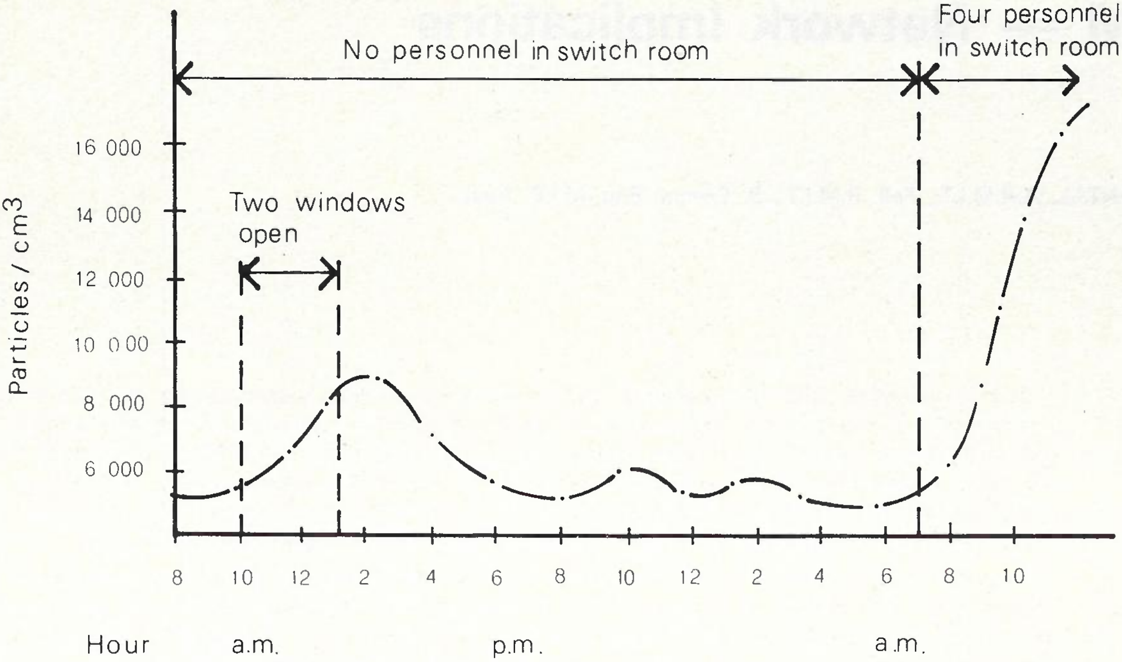

Fig. 3 — Variations in Dust Concentration in an Automatic Switchroom.

filtered from the distributed air. Clean ducts have lower resistance to air flow, so reducing energy input and improving efficiency. Modern filter materials have a low resistance to air flow, so that there may be adequate reason to provide air filtration — but not only for the equipment.

CONCLUSION

For too long, the building has been designed as the gift wrapping for new equipment. The game is now changing, and the building-equipment partnership must adapt to keep up with the pace.

The new generation of telecommunication equipment has the ability to change in form and function to a degree not possible in older forms of equipment. The building, however the technologies of building may twist and turn, is constrained by physical laws and is pricing itself out of the race.

With the assistance of new organisational mechanisms to smooth the transition, a new approach to the building-equipment partnership could contribute usefully to the streamlining of Telecom's future operations. Tradition should not be cast aside lightly, but Telecom needs to be in a position to take advantage of the opportunities for change that will present themselves.

It may perhaps be said that Australia is not the world, so who are we to influence design?

If not us, then who else — and when?

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PCM — Network Implications

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Costs associated with the provision of interexchange junction networks are significant. Capital investment in this area can be reduced or deferred by the efficient utilisation of available junction cable and duct plant through the application of primary Pulse Code Modulation (PCM) systems. PCM systems can also provide improved transmission performance and will interface readily with future digital switching systems. The use of digital switching and transmission would establish the integrated digital network (IDN) and provide for a possible evolution to the Integrated Services Digital Network — (ISDN).

This paper considers the motives for the adoption of primary PCM systems into Australian metropolitan telephone networks. Reference is made to their current application in the Melbourne metropolitan junction network and the strategies adopted in the planning of PCM systems in an analogue switched environment. The future role of PCM is also discussed, particularly in the digital switched environment.

Until recently the economic justification for the use of primary Pulse Code Modulation (PCM) systems as an alternative form of transmission in Australia's metropolitan telephone networks has been less than in some overseas countries. With the rapid cost escalation during the 1970s of cable and duct plant, which constitutes a significant cost component of the overall telecommunications plant, the economic justification for the use of primary PCM systems in metropolitan junction networks has increased.

The proliferation of primary PCM systems currently occurring in urban telephone networks in major capital cities of Australia has reduced the need for capital investment on interexchange junction cable relief projects. The ongoing implementation of PCM systems on major junction arteries is also paving the way for the introduction of integrated digital transmission and digital switching during the 1980s and beyond. With the integration of digital transmission and digital switching, further and far greater economic advantages are envisaged, particularly in relation to total network costs, for which PCM becomes the correct economic and technical choice over any distance, with or without capital deferral benefit.

This paper aims to emphasise the importance of digital transmission, particularly in the long term, where demand for multi services and sophisticated communication flexibility is on the upward trend. With the development of large scale integrated solid state technology, digital modes of communication offer the facilities demanded and at the same time provide the most economic solution compared with alternative forms of transmission.

HISTORICAL ASPECTS

Digital transmission was probably the earliest means of transmitting information other than by direct speech, and in the early 19th century the electric telegraph foreshadowed the development of the modern digital transmission techniques which are an essential part of the PCM concept.

PCM was pioneered by Reeves, a member of the ST & C Group working at that time in Paris for I.T.T. The patent was filed in 1938, 1939 and 1942 in France, Britain and USA. Bell Telephone Laboratories had demonstrated that PCM was well understood, but due to the complexity of the then valve technology, it was found uneconomic and little resulted from the subsequent work. With the emergence of high speed and cheap solid state digital electronics in the later 1950s, some 20 years after PCM's invention, it became a worthwhile proposition to pursue further development.

Historically, Europe (CEPT countries) has adopted a 30-ch PCM system format, (CCITT G.732, G.734), USA and Japan have adopted a 24-ch PCM system (CCITT G.733). America had in situ in 1965 approximately 7420 24-ch systems and at present has over one million working 24-ch systems. Japan had in 1968 over 1000 24-ch systems.

Telecom Australia has studied closely overseas development and the increasing use of PCM transmission systems to augment the number of speech circuits available in VF cables by a considerable factor, utilise ducts and cables to a greater extent and to defer expensive heavy gauge cable provision, while at the same time providing transmission improvement.

During the late 1960s and early 1970s Telecom installed several PCM 24-ch systems throughout the States for field trial use. One such trial of PCM 24 systems was on the Dandenong-Berwick route in Victoria (1968) and currently 12-24ch systems are in use on that route utilising pairs in a 200 pair junction cable.

In July 1976, Telecom Headquarters recommended that PCM systems be used in the Australian network for short haul (junction) applications where they meet technical requirements and are more economic than alternative transmission means in an analogue switched environment. Studies showed that the adoption of PCM would provide network economies now as well as form a stepping stone towards the future integration of digital switching with digital transmission.

The choice of system standard (ie 24-ch or 30-ch) was decided on completion of studies that demonstrated the importance of the PCM 30 standard in relation to the digital switch block designs of European SPC local exchanges. Another advantage in PCM 30 was the signalling flexibility, particularly in relation to 64 Kbit/s common channel signalling compared to 4 Kbit/s offered by the PCM 24 format.

Preliminary and detailed studies in the various States of Australia have determined the overall plan in relation to PCM provision in an analogue step by step and cross-bar switched environment in order to defer or diminish relief junction cable/duct expenditures. **Fig. 1** shows the cumulative total number of PCM 30 systems planned for the Melbourne 03 closed numbering telephone zone.

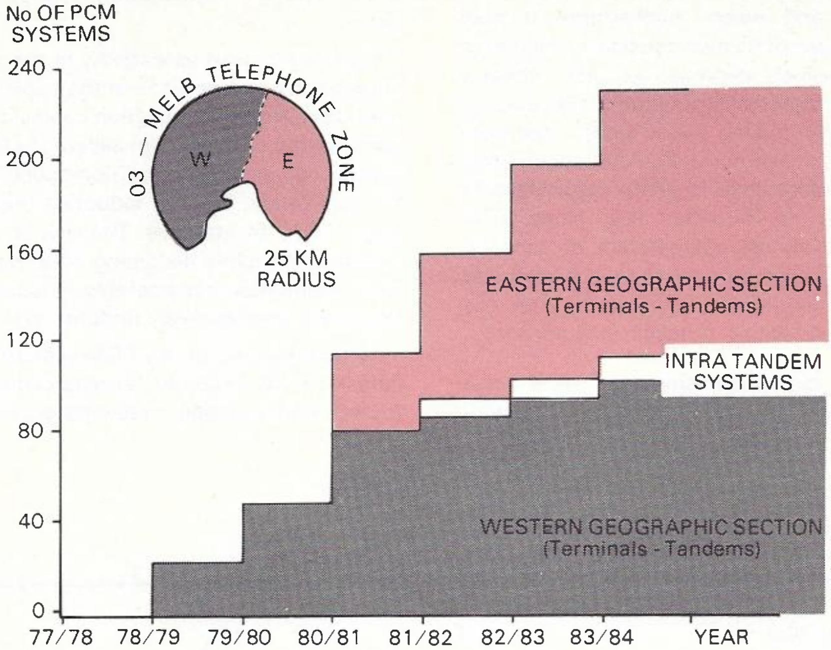

Fig. 1 — Total PCM30 Systems in Melbourne '03' Zone.

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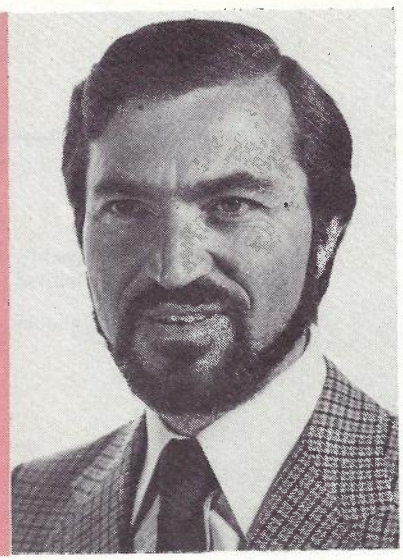


REASONS FOR PCM USAGE

Historically all types of modulation systems, whether pulse or continuous waves, have been analogue representations of the message. PCM is distinctly different in concept; the message is represented by a coded group of digital pulses.

Since the decoding equipment has only to analyse the coded group of digits rather than their amplitudes (ie it only has to detect the presence or absence of a pulse), effects of random noise are greatly reduced; this is the principal advantage of PCM. A second advantage is that PCM signals can be regenerated at intervals along the transmission path. Analogue communication systems, both radio and cable, often require the use of repeaters between terminals. A repeater can do no better than amplify both signal and noise; furthermore it may introduce additional noise of its own causing the signal to noise ratio to progressively decrease at each repeater station. With PCM the signal is regenerated in its original form at each repeater producing a new signal, free from random noise. As a result the noise does not accumulate and overall system performance is nearly equivalent to that of one repeater to repeater link alone. The transmission quality is almost independent of distance and, as a result, PCM transmission will have a profound effect on network configurations, particularly after the introduction of digital switching is taken into account.

Furthermore, once digital transmission paths have been introduced they can be used as bearers for digital signals originated by other sources than telephony, with less interference than frequently arises with analogue transmission using frequency division multiplex techniques.

DIGITAL TRANSMISSION OVER VF JUNCTION CABLES

Typical metropolitan junction networks in the Australian capital cities consist of symmetric pair cables of various copper pair counts and gauges. Up until the late 1960s, almost the only types of cable used in the junction sector were 0.64 mm PIQL and 0.90 mm PIQL cable, which represented the best method of maximising the number of circuits in a given cable diameter. Since the 1960s, PIUT cables have been adopted because of their superior transmission characteristics and lower cost.

Loading is used extensively in the junction network to improve the performance of the cable for voice frequency operation. Normally, junction cables are provided with all pairs loaded except for an allowance for pairs required for special services requiring nonloaded pairs. Typically for VF application, 88 mH inductors (loading) are provided every 1830 m intervals. The use of lumped inductance results in the cable becoming effectively a low pass filter, with attenuation considerably reduced below the cut off frequency and relatively uniform over the VF bandwidth.

A 30 channel primary PCM system consists of two 32 timeslot PCM multiplex terminals interconnected by two 2 048 Kbit/s digital transmission bearers. See **Fig 2.**

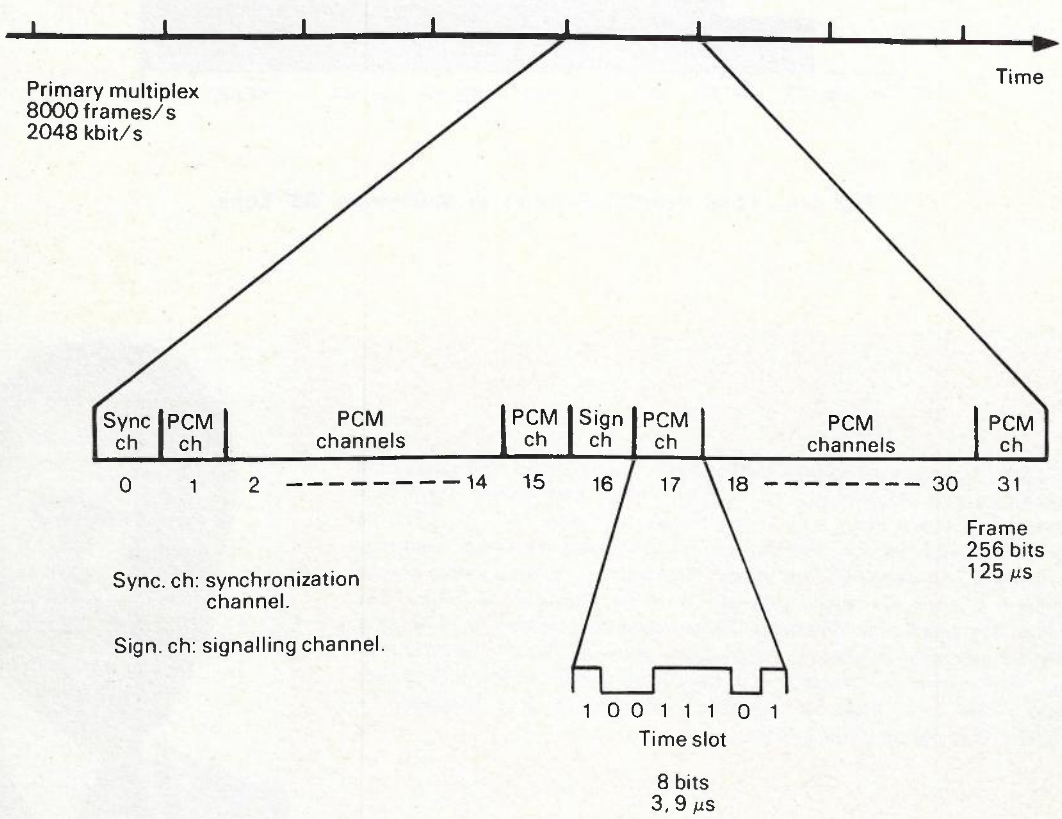


Fig. 2 — Primary PCM30 Multiplex Frame.

Each direction of transmission is multiplexed and transmitted separately; and in Telecom Australia PCM 30 application the VF multiplex interface is four wire speech with two E and M lead signalling facilities per channel. (The VF interface is therefore suitable for use with T3 or T5 type signalling relay sets). See **Fig. 3** illustrating the NEC PCM 30 terminal equipment.

In the PCM 30 multiplex equipment a frame is made up of a set of 32 channel timeslots numbered from 0 to 31. Each channel timeslot comprises eight bit timeslots and since each channel is sampled at a rate of 8 000 samples/second, the complete frame repeats every 125 μs. Hence each channel timeslot duration is $125 \div 32 = 3.9$ μs and each digit timeslot duration is $3.9 \div 8 = 0.488$ μs. The gross digit rate generated by the system is $8\,000 \times 32 \times 8 = 2\,048$ Kbit/s.

Channel timeslot 0 (TSO) contains the frame alignment signal together with alarm indication facilities and channel timeslot 16 (TS16) is devoted almost exclusively to signalling information.

Voice channels 1 to 30 are allocated to channel timeslots 1 to 15 and 17 to 31, all eight bits in each channel timeslot being used for encoding the voice samples.

The 2 048 Kbit/s unidirectional digital bearer consists of line transformers for impedance matching and power feed access, symmetric cable pair transmission media and regenerators. The function of a regenerator is to accurately reproduce a pulse train in response to receive signals. A regenerator:

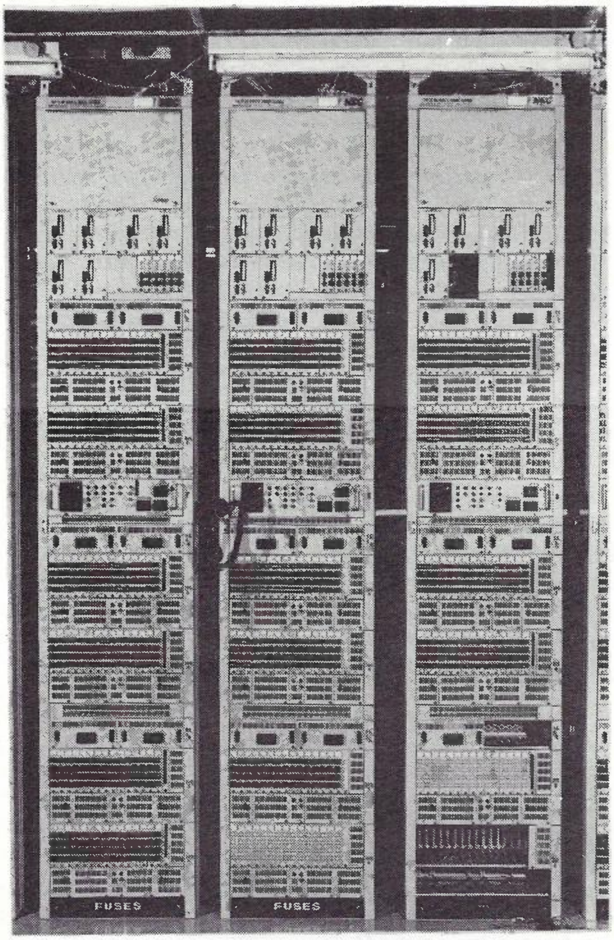
- equalises the attenuated and distorted receive pulse for application to a decision circuit,
- extracts 2 048 Kbit/s timing "clock" information from the equalised signal to provide decision and regeneration timing,
- generates an output pulse in response to pulse information at the decision circuit.

Regenerators are required at periodic intervals and are located in underground housings (see Fig. 3), intermediate exchanges and receive terminals. Underground regenerator housings are located in an appendage manhole adjacent to an existing cable joint manhole.

The current method of providing digital transmission is by means of the 2 048 Kbit/s digit rate primary level PCM 30 systems using symmetric pair junction cables normally used for voice frequency circuits, but with loading coils and building out capacitors removed from the PCM 30 bearer pairs. The terminal equipment provides power feed to the regenerators and monitors the overall performance of the digital path.

In addition to the attenuation, which is compensated by regenerators, PCM signals in voice frequency cables are degraded by three types of interference or "noise". The first is impulsive noise from such sources as d.c signalling, teleprinter connections, exchange equipment, and electric traction. The second is crosstalk from other PCM 30 systems in the same cable. The third is crosstalk from other high frequency services in the same cable. Because the probability of noise, causing errors to be generated by regenerators, increases as the amplitude of the PCM signal decreases it is necessary to limit the length of inter-regenerator sections.

The penetration of 30 channel PCM systems in existing VF cable is a function of the spacing between regenerators. A study carried out by the Research Department and Transmission Network Design Branch (HQ) indicates that for a given probability of exceeding



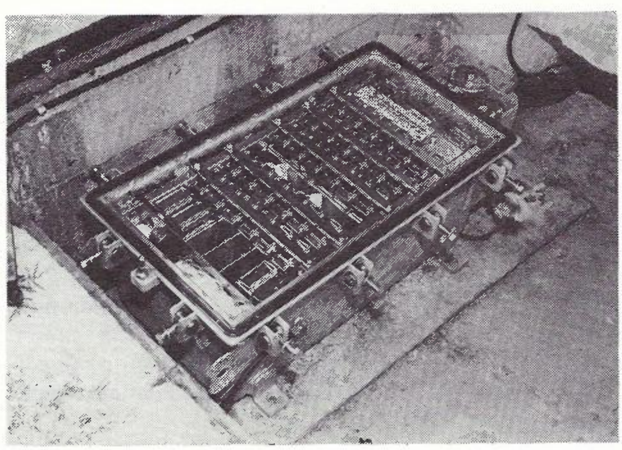


Fig. 3 — PCM30 Terminal and Underground Repeater Equipment.

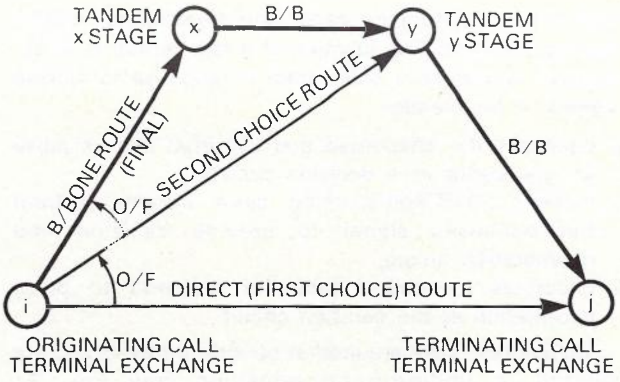


Fig. 4 — Simplified Metropolitan X-bar Switching Plan.

the PCM performance criteria (basic error rate), the required regenerator spacing reduces as the number of PCM systems in the cable increases. Utilisation of each cable will need to be planned on this basis.

Optimum route planning rules have been formulated (ie minimising line equipment costs while maintaining satisfactory system performance) which provide information relating to regenerator spacing and pair selection methodology for either PIQL or PIUT cable.

ECONOMIC CONSIDERATIONS

Analogue Switched Environment

Many telecommunications administrations and operating companies find that in the range of about 15 to 40 km the economics of PCM are most apparent, and are often accentuated when cable capacity is near exhaustion and heavy capital expenditure would be incurred in providing new cable to meet the traffic growth between local exchanges. This is particularly so when civil engineering costs would also be incurred in providing new duct routes.

Traditionally, network design involves defining the locations of the exchanges forming a telephone network, the form of the junction network linking these exchanges, and the nature of the switching facilities needed in the exchanges. The ultimate objective is to manipulate these parameters in such a way as to produce the most economical network and still provide an acceptable grade of service.

In the Australian crossbar network, an optimal solution between a fully star and fully mesh network evolved. This network dimensioning process incorporated alternate route switching principles along with crossbar "tandem" exchanges. Thus direct routes were provided to carry the bulk of the local traffic in the most economical manner, with overflow traffic being offered to the second and backbone choice routes via tandems. The collective overflow traffic from local exchanges offered to the second and backbone routes causes the circuit packet sizes on these routes to be larger than on direct routes. **Fig. 4** illustrates the crossbar alternate route switching philosophy.

Metropolitan transmission plans evolved which assigned the maximum planned losses to the various links in the alternate switching configuration. Since the second and backbone routes were generally longer and allocated lower loss limits as compared to direct routes, heavier gauge cable pairs (namely 0.90 mm) were predominantly utilised on these routes. The consequence of this was that circuits required for second and backbone traffic were more expensive. The average annual charge/circuit for various transmission loss objectives is shown in **Fig. 5.** Also shown in the figure is average annual charge/circuit for a fully equipped PCM 30 rack.

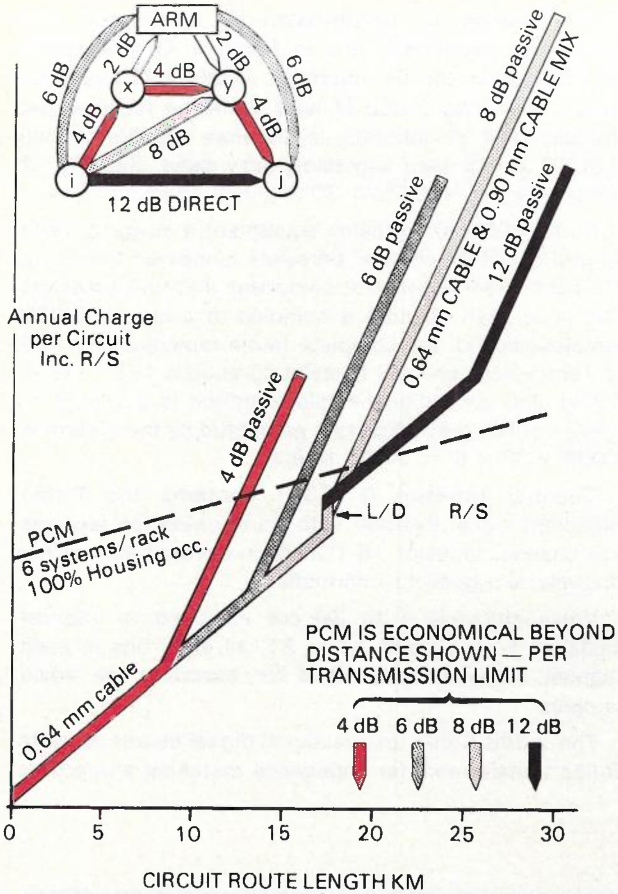


Fig. 5 — Cost Per Circuit of PCM30 Vs Pair Cable.

For Melbourne metropolitan zone, average annual charge graphs have been used to determine the potential range of PCM economics in an analogue switched environment. The range of prove-in distances, in relation to the various transmission loss limit objectives was approximately as follows:

Transmission Limit (dB)	PCM 30 prove-in distance (km)
4	13
6	16
8	19
12	21.5

Fig. 5 shows the prove-in distance on the various links in the alternate switched analogue environment. The prove-in distances were used to map out the contours beyond which PCM 30 was potentially economic. **Fig. 6** illustrates equi-distance contours from each existing crossbar tandem in the Melbourne 03 telephone zone for various transmission loss limits, beyond which PCM 30

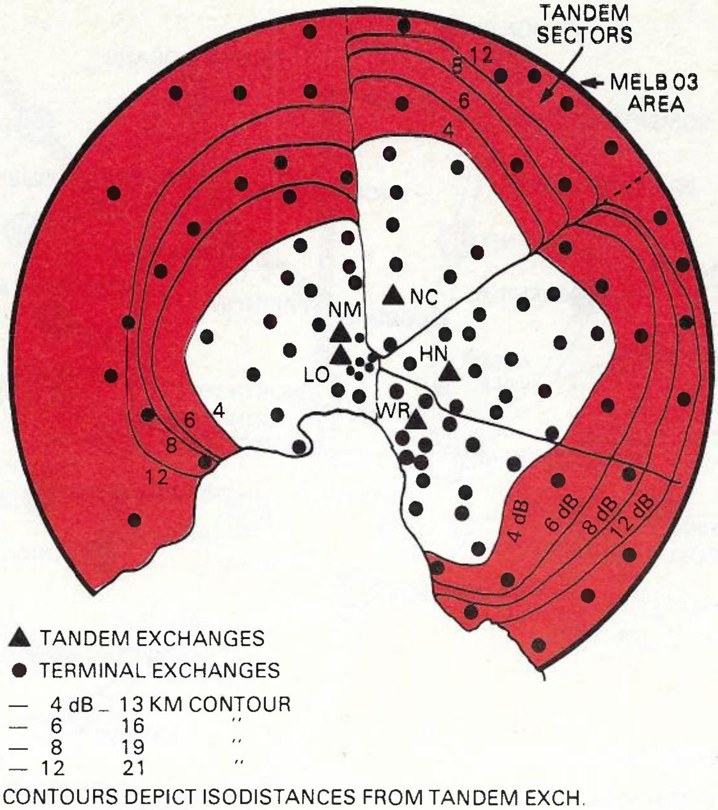


Fig. 6 — PCM30 Prove-in Contours.

application was economic. Also shown in the figure, are locations of exchanges which potentially justified PCM 30 for traffic switched via the tandems.

With the continual need for additional junction circuits required for the increasing growth of interexchange traffic and with junction cables nearing their full capacity, economic studies have shown the advantages in using bearers for PCM 30 as an alternative to the historical procedure of cable and duct provision.

In the Melbourne 03 telephone zone, junction cable routes were examined to determine their "run out" dates. To defer relief cable expenditure over an almost indefinite period, exchanges were selected from the PCM 30 economic annulus as requiring PCM installation. Existing junction circuits emanating from these exchanges, which would be economically provided on PCM 30, were progressively transferred on to PCM 30, freeing pairs for direct traffic use and future bearers for additional PCM 30 systems. Better utilisation of PCM 30 systems could also be achieved on the second and backbone routes, since these routes comprise larger circuit packets as compared to direct junction routes. Thus the progressive transfer of existing circuits on to new PCM 30 systems has averted the need for additional 0.90 mm junction cable, and in some cases, duct relief expenditure. The overall PCM 30 installation strategy plan for Melbourne 03 zone is shown in **Fig. 7** showing installation of PCM 30 in exchanges sited in the "economical annulus" depicted in Fig. 6. The planned strategy enables the deferral of junction cable and duct expenditure.

Digital Switched Environment

Until recently the common method of telephone switching was performed on an electromechanical basis. The progressive developments in the method of controlling these operations have commenced with the manual operator and advanced through the automatic step - by - step systems (introduced in 1911) to the L. M. Ericsson common control process used in crossbar exchanges (introduced in early 1960s). In 1976 a processor controlled crossbar switching exchange ARE-11 was commissioned for local metropolitan exchanges. In 1974 the first Stored Program Control (SPC) trunk exchange, using STC Metaconta 10C equipment, was brought into service in the Sydney (Pitt) exchange, followed by installations in Melbourne in 1975, Adelaide in 1976 and Bendigo 1977. At the same time worldwide tenders were called for an SPC local exchange switching system, and the L. M. Ericsson AXE system selected. The first Australian exchange using this equipment is now scheduled to commence operation in 1981.

At the time of selection, only the analogue version of AXE was operational and thus acceptable for application in Australian urban networks. It was also in 1977, in line with a Headquarters 1976 recommendation, that digital transmission through the use of primary PCM 30 became economic and was adopted and introduced on a large scale into the Australian network. More recently the AXE digital system has also become available. This now provides the opportunity for Telecom to enhance the present analogue system and thus introduce the IDN

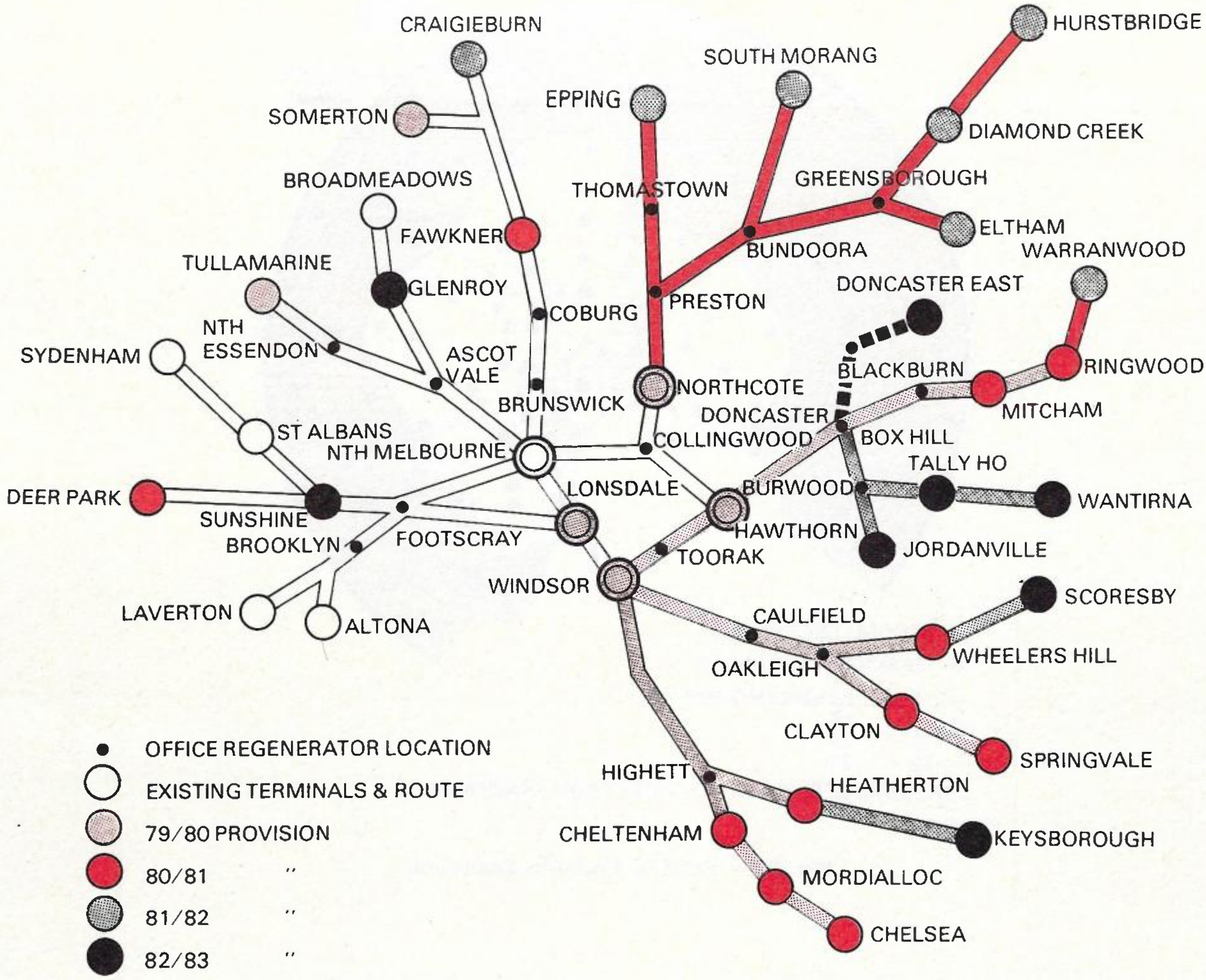


Fig. 7 — PCM30 Network Plan — Melbourne.

(Integrated Digital Network) for telephony through the integration of digital switching with PCM transmission.

Advanced telecommunications administrations, such as those in Germany, France, Sweden, United Kingdom and Japan, have now either introduced digital switching already, or are developing plans to do so. In some instances, the introduction of digital switching will be preceded by the use of an analogue SPC switching system.

The world trend now clearly evident, to extend the use of digital technology to all sections of telecommunications networks, is fuelled by the continuing rapid reduction in the cost of micro-electronics. Manufacturers are diverting resources to the development of digital rather than analogue products. As a result, the availability and prices of equipment, together with technological improvements, all favour the future application of digital systems.

Overseas telecommunications administrations have conducted various studies, indicating the economic and technical advantages in the adoption of digital switching and digital transmission networks. For example, one study conducted by the CIT - ALCATEL Network Study department in France considered an urban telephone area of 30,000 to 100,000 subscribers lines. The exchanges comprised "local" and "group" switching stages connected to other group switching stages and trunk exchanges. Traffic and switching profiles were considered to resemble realistic patterns. Analogue and digital options were considered to determine the most economic solution. Results of the model indicated that the adoption of digital switching with digital transmission offered the most economic solution. **Fig. 8** illustrates the results, both in terms of switching costs and total costs. As far as switching costs are concerned, the relative crossbar costs were shown to be nearly one and a half times as expensive as digital time switch costs for a 30,000 line exchange. In the context of total costs, the digital transmission and digital switching option represented a saving of 35% of total network cost when compared with analogue transmission and analogue switching.

Similar studies have been conducted on an extensive scale by Telecom Australia to determine how best to capitalise on the potential benefits offered by these new generation telecommunication systems. Telecom's original intention was to adopt the AXE switching system for use in analogue terminal and tandem exchanges in urban networks. However several new features are potentially available with the digital switching systems which could offer further economic benefits. The new features include:-

- Digital group switching subsystem (GSS-D)
- Remote subscriber switching subsystem (RSS)

Having selected AXE for local urban switching applications, the Commission required decisions on the type of AXE switching options which should be adopted for use in Australian urban networks, and which network structure would be best suited to the application of the selected switching option when used with PCM transmission.

The Tandem Study Task Force (TSTF) was commissioned in September 1977 to assist in the decision - making process. The TSTF consisted of representatives from Headquarters and State switching and transmission planning areas. A considerable number of other Headquarters and State people also contributed to the Study, which culminated in the production of a major report in March 1979.

TSTF conducted a study, using computerised network modelling techniques, into the effect of PCM transmission on total network cost, assuming various switching options. The switching options taken into account were:-

- Analogue / Analogue — AA network — terminal and tandem exchanges with analogue group switching stages (GSS)
- Analogue / Digital — AD network — terminal exchanges with analogue GSS and tandem exchanges with digital GSS stages
- Digital / Digital — DD network — terminal and tandem exchanges with digital GSS stages.

Fig. 9 shows one aspect of the study for the Melbourne 03 zone, taking into account traffic growth profiles and other developments between 1985 and year 2000. The results show that local network switching equipment capital costs are lowest if the DD option is considered with PCM 30 transmission, even to the point of only 12% bearer penetration for PCM use.

Other studies have shown that the cost relationship of digital switching with digital transmission versus distance dramatically varies from the cost of the analogue switched environment depicted in Fig. 5. In fact the costs follow the trend illustrated in **Fig. 10** and show that for the digital switching strategy, the use of simpler, less-costly PCM systems reduces the initial step function costs, and brings down the "break even" distance for PCM use to zero. In this case PCM provides the most economic technical solution for any distance. If all the connected lines can be digital the advantages which can be obtained include:

- cheaper terminal units — no analogue / digital conversion required. This in turn leads to substantial savings in costs as shown in Fig. 10.
- accumulated quantized distortion is avoided — if digital signalling and switching are used, the quantizing distortion which occurs at each analogue / digital interface point is eliminated.
- data switching — digital switches can switch all kinds of digital information which will allow the integrating of data and telephone switching facilities (Emergence of ISDN).

On the basis of the system and network aspects

SWITCHING COSTS:

EXCHANGE SIZE		X BAR	TIME SWITCH E.10
10 K SUBSCRIBERS		1.5	1.3
20 K	"	2.8	2.1
30 K	"	4.0	2.8

TOTAL COSTS — TRANSMISSION, SWITCHING, BUILDING POWER PLANT

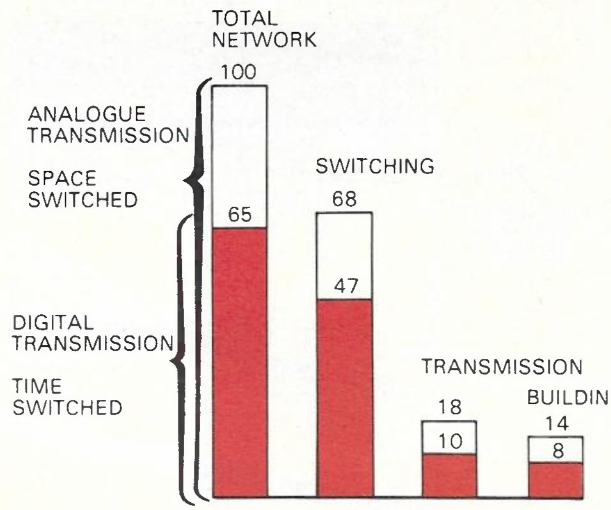


Fig. 8 — Analogue / Digital Switching and Transmission Costs.

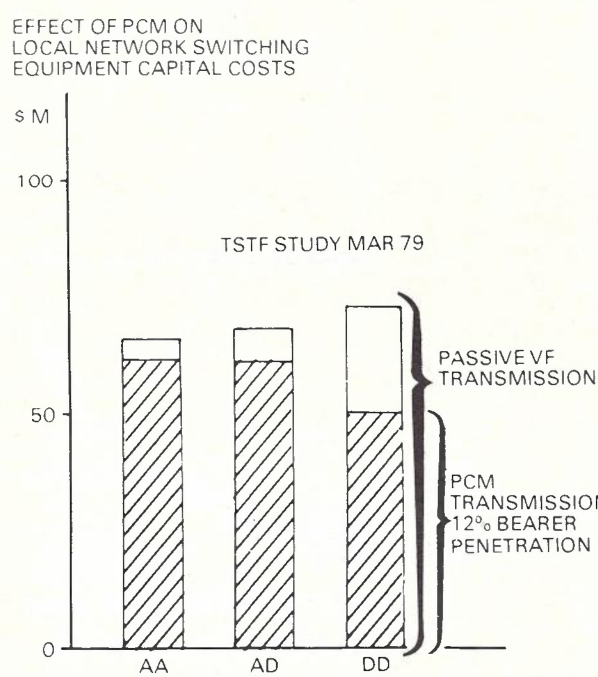


Fig. 9 — Effect of PCM30 on Local Network Costs — Melbourne 1985-2000.

considered in the Tandem Study, and overseas and future trends, the Task Force recommended a plan to develop urban telephone systems on the integrated digital network technique (IDN) including the use of —

- digital group switching in terminal exchanges (GSS)
- digital group switching in tandem exchanges incorporating STD charging facilities.
- remote subscriber stages. Further studies have now recommended digital remote subscriber stages as the likely development.

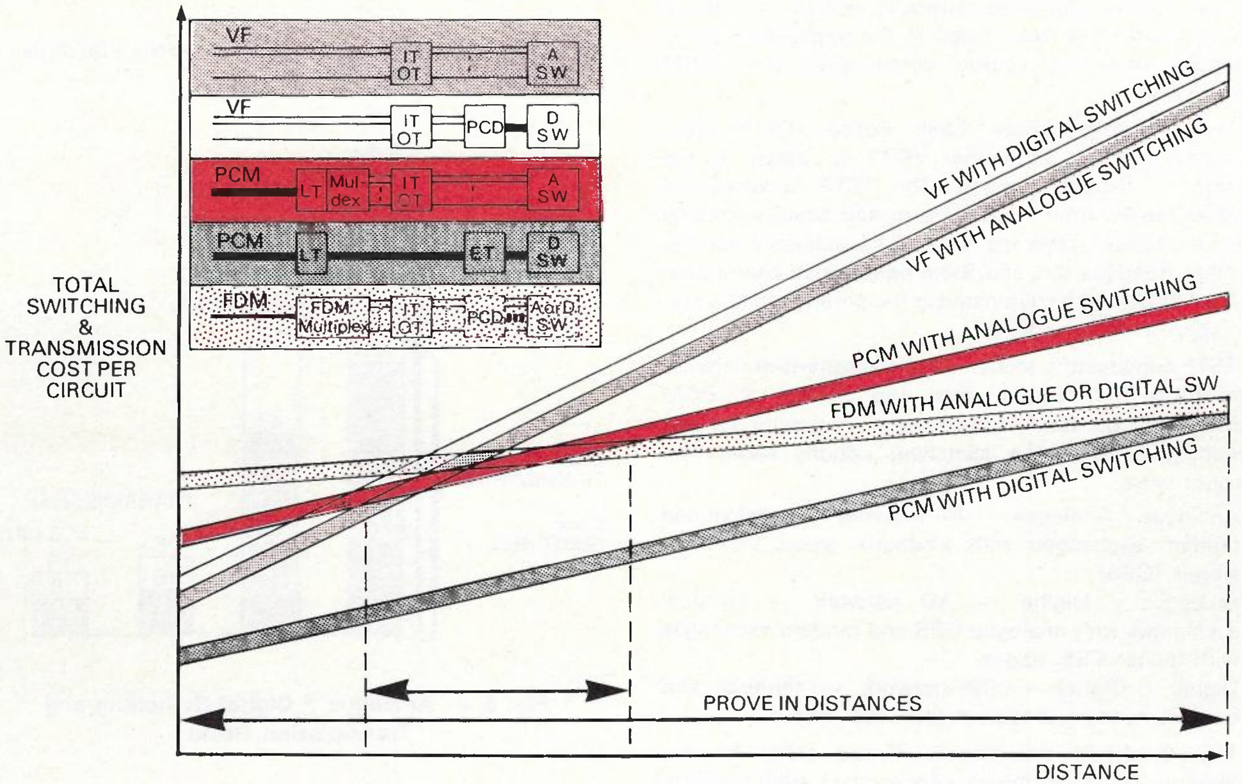


Fig. 10 — Switching and Transmission Prove-in Distances.

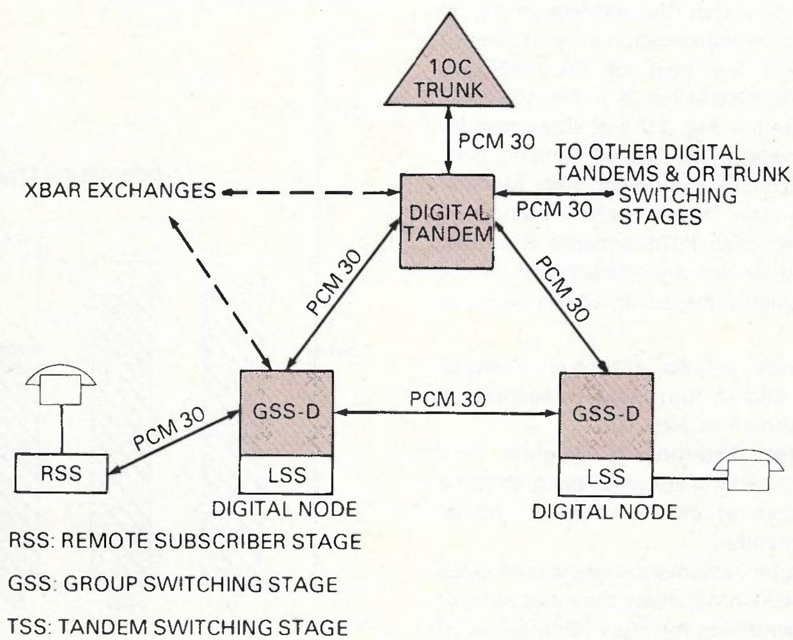


Fig. 11 — PCM30 and Digital Switching Plan.

Approval in principal to develop the urban telephone system on the basis of the IDN, including the abovementioned points, was given by the Commission in March 1980. The likely network plan for the digital switched environment, with digital transmission is shown in **Fig. 11.** The recommendations aim to commence introduction of digital switching equipment early in the 1980s. A transmission plan to interlink existing analogue crossbar and proposed digital switching equipment is being formulated with a possible structure shown in **Fig. 12.**

There will be a substantial improvement in transmission performance for circuits using the full digital transmission and switching path. Since digital switching is of a 4 wire composition, 0 dB loop losses can be established between the most distant 4W points, provided a 3 dB minimum loss in the 2W/4W points at each end is maintained for stability and echo considerations. The overall maximum loss thus expected on a fully digital link is expected to be 6 dB. For other circuits using various combinations of analogue / digital links, the losses allowed will be assigned as 12 dB maximum. Fig. 12 shows the likely typical maximum losses assigned to each link.

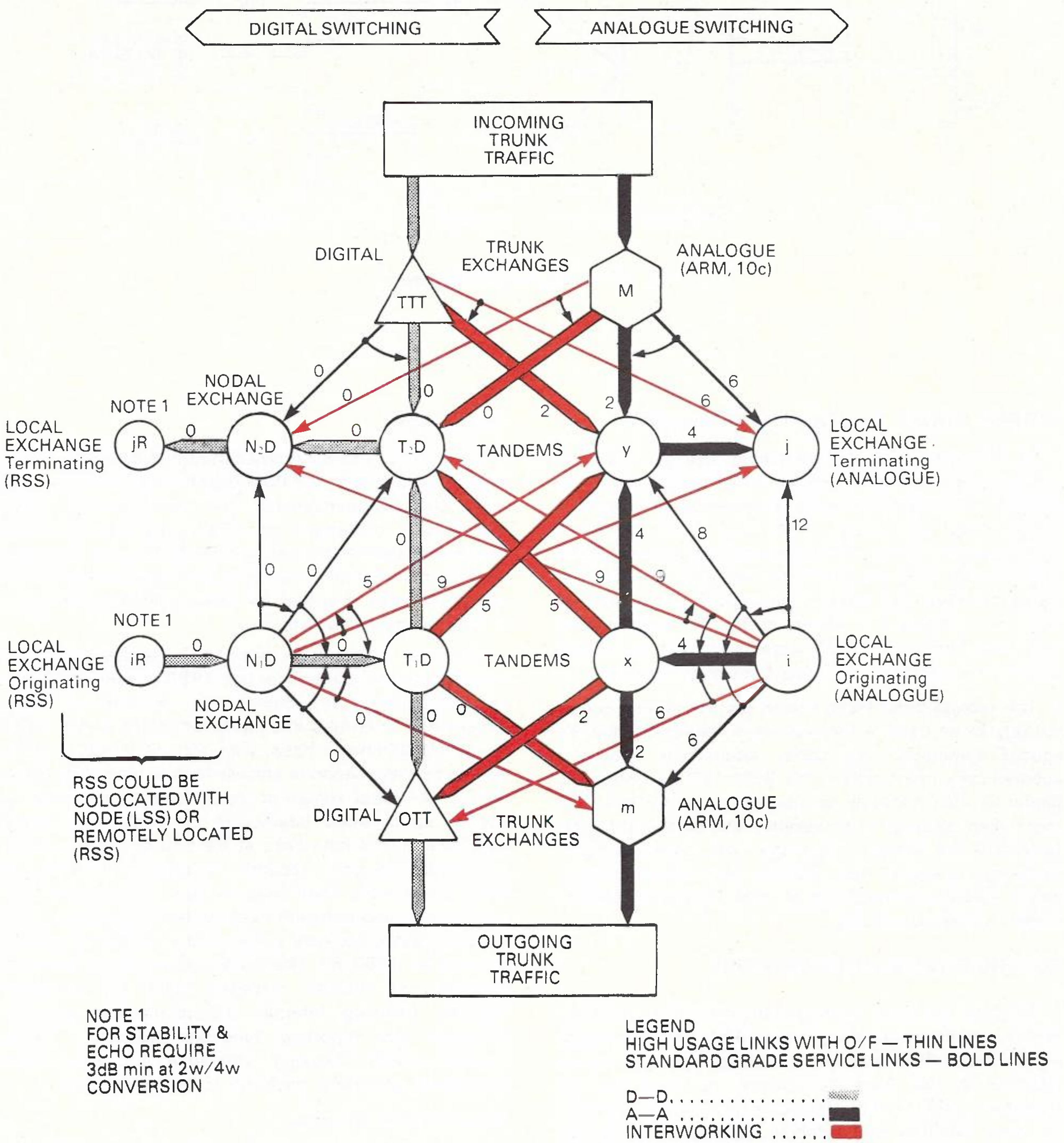


Fig. 12 — Possible Future Metropolitan Switching and Transmission Configuration.

HIGHER ORDER DIGITAL TRANSMISSION
DIGITAL HIERARCHIES

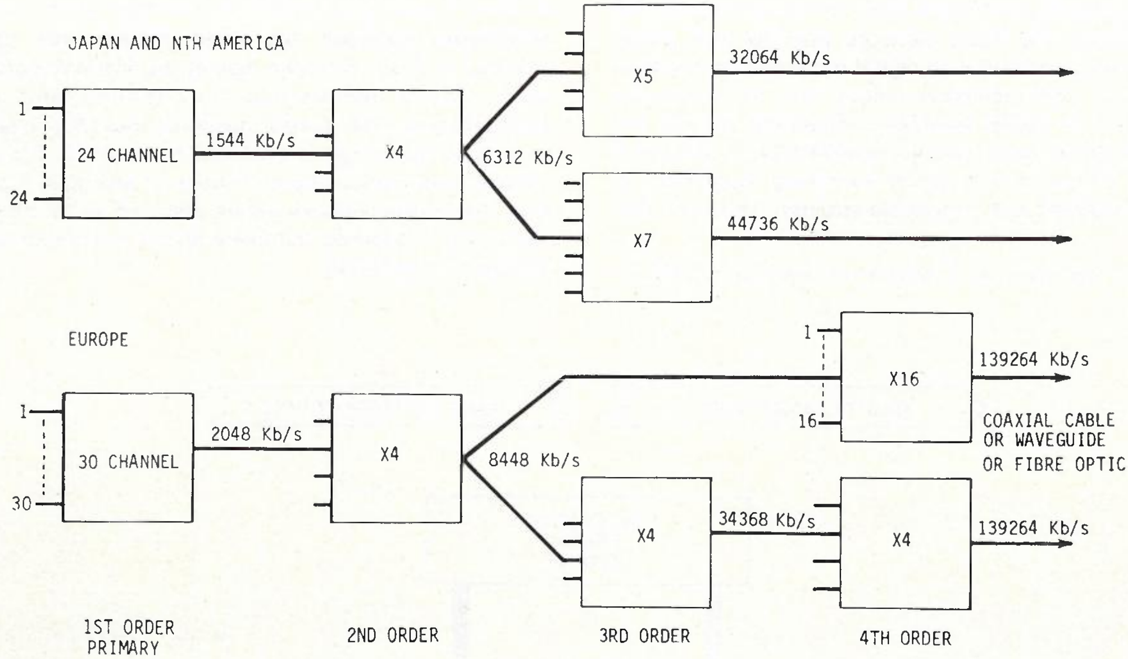


Fig. 13 — Digital Hierarchies.

HIGHER ORDER DIGITAL TRANSMISSION

In the same way that frequency division multiplex systems are arranged in 'Groups' and 'Supergroups', time division multiplex systems can likewise be arranged in a hierachical structure. The two PCM systems recommended by the CCITT generate respectively 2048 Kbits/sec for PCM 30, and 1544 Kbits/sec for PCM 24. Based on these digit rates, 2 separate digital hierarchies have been proposed as shown in **Fig. 13.** As discussed previously, primary PCM 30 systems are utilising circuits which were designed for voice frequency operation.

The second order PCM 120 (8 Mbit/s) system seems unlikely to be used in the Australian network, since the special symmetric pair cable required as bearer is economically unattractive. The PCM 120 on fibre optic bearer is also currently economically unattractive. The more likely strategy to be adopted will be the 3rd order PCM 480 (34 Mbit/s), using fibre optic cables in multi-exchange networks and 2.6/9.5 mm coaxial bearers where available. Application of PCM 1920 (140 Mbit/s) is also a likely possibility.

FUTURE POSSIBILITIES (DIGITAL)

Mention has been made already of digital switching, likely to be introduced early in the 1980s and the trend to higher order PCM systems - strategy, possibly to be adopted in the Australian scene, to cater for the telephony traffic in the interexchange network. Demand for other services and facilities, data transmission for example, requires the future networks to be more flexible and adaptive.

Digital Data

Since data is usually transmitted in a binary format, it integrates well with the PCM digital network. Various bit rates can be manipulated and combined by digital multiplexing equipment to obtain aggregate bit rates compatible with those required for PCM voice channels. There is considerable interest in the development of data equipment able to access 64 Kbit/s channel timeslots in a PCM multiplex system.

To meet competition from the proposed domestic satellite system, planned for late 1983 or early 1984, the establishment of the digital data network has been accelerated to bring it into operation by the end of 1982 on a full nationwide basis, with the initial pilot scheme linking Sydney, Canberra and Melbourne. The likely result will be the rapid spread of digital data transmission at speeds up to 4800 bits/sec in the subscribers' cable networks and of data links at 64 Kbit/sec in the multi-exchange (junction) networks occupying timeslots of PCM 30 systems. High capacity data transmission links will be provided between major cities of Australia, with eventual upgrading to a public packet switching system planned for 1982/83. The major applications of the data network will include corporate data and message systems handling internal correspondence, progress checking and reporting functions, electronic funds transfer, credit checking, clearance and debit card operations, electronic mail and resources sharing.

Integration of Services

Integrated digital network will not only facilitate telephony traffic but will also evolve towards the

Integrated Services Digital Network (ISDN). Such a network will provide flexibility in the integration of telephony, data and a host of other services such as for example telex, picturephone, conference TV, slow scan TV and broadcast programme lines.

PABX networks may emerge as a significant network element for incorporation in future integrated networks. In recent years a number of new stored program controlled (SPC) PABXs using time division and space division switching techniques have been developed, replacing large and inflexible electro-mechanical devices and offering convenience, flexibility, efficiency, control and accounting advantages.

Two features offered by some SPC PABXs are of particular interest, and will play a significant role in the evolution of integrated voice / data networks. The first is the capability for transit switching in a private PABX network over tie lines. The other is the ability to perform digital switching functions for a terminal - oriented data network. Time division switched SPC PABXs use either pulse-amplitude modulation (PAM) or pulse code modulation (PCM). With the PCM type switches, future development may make it possible to interface directly (without A/D conversion) to digital transmission lines.

Subscriber's Loop

At present PCM multiplex equipment and switching equipment are located in telephone exchange buildings. With the changing cost relationship of modern component LSI technology versus traditional metallic pair cables, distributed switching units will make inroads into the subscribers' distribution network plant. The switching will concentrate the traffic originating and terminating in these networks onto fewer pairs in the distribution network. This pair gain method will be achieved through the use of advanced Line Concentrator Units (LCU) and proposed Remote Switching Subsystems (RSS), either of which could provide traffic via PCM bearers, thus further enhancing the pair gain aspects.

Other developments taking place in the subscriber's loop are the digital subscriber carrier systems. One such version for example, is the Bell-Labs designed system called the Subscribers Loop Carrier — 96 SLC system. Instead of concentrating subscribers (by switching) at the pillar location by means of the traditional Line Concentrator Units to achieve "pair gain" benefits, the digital subscribers carrier system permits subscribers (by multiplexing) to be served by digital PCM transmission lines. The facility provides higher "pair gain" benefits than currently offered with Line Concentrator Units. Other cost benefits seen with such pair gain systems include the avoidance of complementary exchange PCM terminal equipment when digital switching is available at the local exchange.

The extension of digital operation to the customer, enabling direct access to the digital network via digital telephone, will enhance his available services. Apart from speech, the facilities offered would include Viewdata, Facsimile, Telewriter, Data, Alarms and Telemetry.

A number of international authorities have been proceeding with the development of duplex transmission on a single metallic pair. The method employs echo cancelling hybrids associated with a 2-wire line and 4-wire digital telephone set. The bit rate is most likely to be 80 Kbit/s (64 Kbit/s voice component plus normal signalling, special signalling and data capacity occupying the remaining 16 Kbit/s). Another method is to employ half-duplex transmission and time share the loop in each direction.

PLANNING FOR THE FUTURE

Planning of PCM must be viewed in a total network context particularly with the introduction of digital computer controlled exchanges. In planning the future development of urban networks, two important aspects must be kept in mind. First, changes in present equipment costs are likely to occur. For example, a significant downwards movement in prices of PCM and digital switching equipment is expected to happen in the near future. Secondly, increasing network application overseas of higher order digital systems, particularly using optical fibre cables and accumulating experience in the Research Department, is expected to confirm the technical and economic advantages of these new transmission systems.

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An End to Silence,
by Peter Taylor.

Methuen of Australia, (192 pages)

The author, born in England, came to Australia in 1970 and now lives in Sydney. The book deals with the building of the overland telegraph line from Adelaide to Darwin in 1870-72.

The author decided to write the book after a visit to Alice Springs a few years ago. Intrigued by the loneliness and the effort it must have represented to build the line in the circumstances at the time, his enquiries as an experienced publisher indicated that surprisingly, the story had been almost forgotten. In researchng the subject as well as talking to many people, he consulted over 100 publications, including reports, Telecom journals, articles, books, diaries and letters. These covered writers, journalists historians, explorers, engineers, private Parliament and Government papers.

The result, taking into account the undoubted ability of the author as a writer, is a most interesting, accurate and complete story of the whole undertaking. It includes a clear picture of social and business conditions in Australia which helped in driving the project.

In this age of telephone, television, radio and instant communication by satellite, it is difficult to remember that only a little over a century ago, the Australian colonies were isolated from the mother country and the rest of the world. At that time it could take three months or more for a letter to reach London from Australia.

Charles Todd, the main driving force and a man of vision, married in England before migrating in 1855. In responding to the traditional toast at his wedding to his bride Alice, (after whom Alice Springs was named), he said he hoped that he would be instrumental in bringing England and Australia into telegraphic communication. This was to take 17 years to accomplish.

The book relates how the South Australians, despite fierce competition from Queensland, undertook to build a line from Darwin to Adelaide and not Normanton in Queensland on the Gulf of Carpentaria, where it could be coupled to the existing Australian network. The line was to pass through some of the most inhospitable country known to man for a distance of over three thousand kilometres. Most of the land was uninhabited by white people, and indeed had only been crossed once before. One of the greatest difficulties not foreseen was the effect of the "wet" season on operations, and this finally brought on a "strike".

Interesting pen pictures of the character of the main people involved and how they reacted to the situations make absorbing reading. The reactions of the Aborigines in the various areas are dealt with. Included in these is their attack on the Barrow Creek Telegraph Station after its establishment, and the aftermath. One Aboriginal, on seeing the line for the first time said, "What plurri fool white feller put up this one-feller fence? It no stop 'em horse."

When completion of the line, messages of congratulation flashed to and fro; Adelaide and indeed all of Australia celebrated. The final irony, that the present microwave link goes through Queensland to the eastern States, and S.T.D. calls from Adelaide to Alice Springs go through Sydney, Brisbane and Tennant Creek, is covered in the last paragraphs.

The book is attractively presented and contains no less than some 70 illustrations. These include photographs taken during, before and after the construction period, photos of interesting relevant documents and maps showing the route of the line and associatied localities. Also included are some fine coloured photos showing typical repeater buildings and physical features along the route as they are today.

Altogether, the book is a most readable one written by a first rate narrator.

Reviewed by E. J. Bulte, BSc.

Communications Equipment and Systems
IEE Conference Publication No. 184

This book contains a collection of 56 papers presented to a Conference held in Birmingham, England on 16-18 April 1980. The Conference was organised by the Electronics Division of the Institution of Electrical Engineers in association with the Institute of Electrical and Electronics Engineers, Communications Society, Institute of Electrical and Electronics Engineers (United Kingdom and the Republic of Ireland Section) and Institution of Electrical and Radio Engineers with the support of the Convention of National Societies of Electrical Engineers of Western Europe (EUREL).

The authors of the papers are from a variety of sources — the British Telecommunications Administration, the telecommunications industry from various parts of the world, research institutes, and some academic institutes.

Each of the three days of the Conference took up a separate theme; each theme is divided into two parts. In the first part the theme is covered generally and the second part is devoted to the technology. Each part is introduced by an overview address. The themes are —

- Public Telecommunications
- Data and Business Communications Systems
- Civil Radio and Emergency Communications.

The papers discuss the impact of developments which are expected to play a major part in the telecommunications industry over the next decade. These are developments in satellite communication, in micro-electronics and in opto-electronics. The papers concentrate on the implications of these developments, on the scale, diversity and nature of the services which will be offered to customers, on the telecommunications industry of the world and on the relationship between telecommunication administration and the socio-political environment in which they operate.

Many important predictions are made for the decade ahead. In this respect, the book is of value to planners and designers of communications systems and facilities. It offers the opportunity to compare their own concepts and contemplations with others in the communications field who are in a position to influence world opinion. The book is a nice condensation of these thoughts.

The papers are very readable and usually of 3-4 pages in length. Their scope varies from general overviews to technical details of particular systems. The price is £18.50 outside the UK.

Reviewed by D.H. Howatson,
Operations Planning and Programming Branch,
Telecom Australia HQ.

Sixth European Conference on Optical Communication

Institution of Electrical Engineers (U.K.), Conference Publication No. 190

Over the past few years many books have been published covering various basic (theoretical, technological and practical) aspects of optical communications. The publication of the Sixth European Conference on Optical Communication is a collection of 110 technical papers presented in a four-day conference held at the University of York (U.K.) in September 1980. These papers embody a broad spectrum of subject material dealing in the state-of-the-art of this rapidly evolving technology. The papers are contributed by specialist authors from Europe, North America and Japan who are directly associated with optical communication in industries, government administrations and universities. The authors assume that readers are equipped with fundamental knowledge obtainable from textbooks.

The publication is divided into nine sections. The first is on fibre fabrication. Improvements in techniques for fabricating high quality graded-index multimode fibres by vapour-phase axial deposition and modified chemical vapour deposition methods are reported in eight papers. Three other papers deal with low-loss single-mode fibre fabrication. This is followed by a fundamental study of single polarisation fibres by H. Matsumura, T. Katsuyama and T. Suganuma. Another paper describes the identification and elimination of potential sources of diameter fluctuations when fibres are drawn from preforms, leading to very low diameter fluctuations of the order of 0.15 μm r.m.s. The section concludes with a paper on a graphite induction furnace for simultaneous drawing of five fibres from five separate preforms.

In the following section on fibre properties, five papers deal with the phenomenon of modal noise, peculiar in fibre systems when highly coherent optical sources are used with multimode fibres. G. D. Khoe et al. report on a practical solution to this problem by permanently coupling one end of a single-mode monitor fibre to a laser diode and providing a reflecting surface to the other end. Six papers deal with single-mode fibre properties. A simple optical pulse equalisation technique for minimising pulse dispersion in single-mode fibre transmission systems is described by C. Lin and H. Kogelnik. The remaining papers are concerned with various properties of multimode fibres, fibre fatigue characterisation and evaluation, and photobleaching effects in fibres.

A section on measurements includes three papers on optical time domain reflectometry (OTDR) techniques. Very good agreement between results from three different OTDR experimental set-ups are reported by B. Costa et al. Other papers in this section are on measurements of fibre refractive index profile, attenuation and dispersion.

The next two sections of the publication are on semiconductor sources, detectors and circuits. Current improvements in fabricating laser and light-emitting diodes for 0.85 μm and longer wavelength optical communication systems are included. Two papers report on detectors for longer wavelength applications. S. Sakai et al. discuss the performance of dual channel optical sources and detectors for wavelength division multiplex systems. Basic details for the implementation of a low consumption, optically powered telephone for transmission distances of up to 2 km are given in a paper by A. Brosio, M. Perino and P. Soligna.

There is a short section containing seven papers on integrated optics. The subsequent section is on coupling and thirteen papers cover source-to-fibre coupling devices, automatic fibre end-preparation, wavelength division multiplex devices, characteristics of splices, connectors, optical switches and directional couplers.

Articles in the next section are on design, manufacture and characteristics evaluation of cabled fibre. Two papers describe high density cabled fibres based on ribbon and conventional multi-core cable structures under development in France and West Germany, respectively.

The last and largest section is on systems. Papers in this section reflect the existence of a mature technology due to the rapid advances made in recent years. There are four papers on fully engineered digital system trials operating at up to140 Mbit/s and free from any significant problems in normal telecommunication environments. P. H. Kravarik reports on the success of the optical fibre systems used in the 1980 Winter Olympic Games to carry 384 telephony and 2 video channels. Five more papers are on the use of optical fibres for cable TV applications. Included here is a conceptual design by G. Mogensen of an optical fibre network for integrated distribution of TV, radio, telephone and other services. A field trial of this network is tentatively planned for 1983 in Denmark. Various other systems aspects are dealt with in the remaining papers.

In summary, this conference publication contains a wide range of unedited optical communication papers contributed by a large number of overseas authors. Different presentation styles and (fortunately not too frequent), grammatical and spelling errors are encountered. The publication however, is excellent for keeping an up-to-date knowledge in this rapidly moving technology.

Reviewed by Alex Quan, Research Laboratories, Telecom Australia.

Learning to Live with a Visual Display Terminal

M. J. TROUNSON, M.I.E. Aust; F.I.E.S. (Aust); Dip.E.E.

The introduction of new technology, in many cases, produces some degree of resistance from the end user, particularly if its operation is noticeably different from previous experience. Quite often, all the results of introducing new devices to everyday life cannot be foreseen at once, for example the road accident trauma resulting from the advent of motor transport. But with the widespread introduction of visual display terminals (VDTs) as an operator interface with computerised data processing, reactions have been often immediate and antagonistic. It is fair to say that, as with most other such advances, some mistakes have been made in the early stages of introducing VDTs through ignorance or uncertainty.

Telecom Australia is rapidly becoming a major user of VDT equipment for many of its operations and it is likely that a very large proportion of its personnel will soon need to use VDTs for some or all of their daily work.

It is not the purpose of this article to take sides, but rather to attempt to disclose the inherent difficulties in the development of this interface between man and machine. All points of involvement are considered, but particular emphasis is placed on visual aspects. Specialist committees have been formed, to examine all aspects of VDT usage and work station environment. Their charter is initially to co-ordinate the findings of previous investigators in the various fields involved, and to then develop appropriate total designs for work places where VDTs will be used.

An outline is given, of the areas in which these committees will work, and indications that, in some cases, tentative solutions are already at hand.

WORKING WITH A COMPUTER

The advance of computer facilities over the last approximately 10 years has made it possible for most of the tasks that were previously carried out with pencil and paper or by reference to a large number of books to now be done by computer. People using these facilities for the first time may well experience some problems in their daily work because working in this manner seems at first to be different from everything that they have done before. Operators faced with a visual display terminal for the first time could well be forgiven for a feeling of frustration because it would appear that this machine is actually holding a conversation with them, in fact telling them what to do, and consequently producing a good deal of pressure upon them to perform their own task with increasing rapidity.

It is as well to remember that the computer and its associated interface, in this case the visual display terminal, is nothing more than a high-speed idiot. It cannot usurp the operator's powers of decision, can only respond to specific commands given to it, and can then only repeat information which has been put there (laboriously) by the operator or other persons. However, because it carries out these tasks at very high speed and may then immediately ask for the next question, it seems to uninitiated operators that they themselves must attempt to match this speed, with a consequential feeling of inadequacy. One must always remember that the computer is the obedient servant of the operator and not the other way around. The visual display terminal comprising a display screen and a keyboard is not a monster, it is only the interface between the operator and the willing servant.

Since these types of technical aids first began to be used for hitherto routine office tasks, many investigations have been carried out in an attempt to ensure that operator efficiency was kept to an optimum value. Less attention was given initially to the comfort needs and satisfaction of the operators, although the specific purpose of introducing VDTs is to increase productivity. The result of this lack has been to generate a feeling of antagonism amongst some operators towards these electronic wizards even to the extent of causing industrial unrest. That this unrest has been justified at least in part is unquestioned. However, it now seems likely that the antagonism may well have been misdirected, in many instances. (Ref. 1)

TRADITIONAL vs. VDT TASKS

Since the introduction of VDT-based tasks there has been a good deal of criticism that these are quite different to any other tasks that operators have had to perform in the past. The reasons for this criticism are found in the basic principles of vision and ergonomics.

For instance, the normal task of reading and writing to which everyone has been trained practically since birth takes place under a well established set of rules. In most cases the work is arranged horizontally, or nearly so, for the obvious reason that books and papers tend to "stay put" in this attitude. The force of gravity dictates that a comfortable writing posture is adopted for horizontal tasks. It follows automatically, that lighting suitable for normal reading and writing is usually arranged to come from above the task and well above the performer's line of sight. The work material also is traditionally that of a dark message applied to a light background, because greater effect is gained by applying dark pigment to white paper than vice versa. This is the format to which everyone has become accustomed and therefore feels comfortable at work. It also follows, for a dark message on white background that, up to a point, the greater the illumination provided on the task, the better it will be seen.

The display section of a visual display terminal, commonly referred to as the VDU, has a self-luminous message which is brighter than the background. This is, visually, the opposite condition to a pencil and paper, or "hard copy" task. Furthermore, in order to maintain adequate contrast between the message and its background as little extraneous light as possible must be allowed to fall upon the VDU screen. It might be concluded, that viewing VDUs in complete darkness would therefore be the best answer, but experience has proved this approach unsatisfactory as most people prefer not to work under these conditions.

Where the lighting of the surroundings is arranged for traditional hard copy tasks on a horizontal surface, it follows that the VDU screen should be arranged in a near-vertical attitude. This results in the operator being compelled to carry out the seeing part of the VDU-based task with a line of sight which is almost horizontal or even slightly above the horizontal in some cases. Again this is quite different from the traditional hard copy task where the line of sight is well below the horizontal. Unlike a relative minority of people in the task force such as artists, draftsmen, and lecturers who tend to become accustomed to conducting their visual and display tasks in the vertical plane, most people find themselves somewhat dissatisfied with this arrangement.

One must therefore reconsider many aspects of the design of the work station in order to achieve a comfortable working station, and this will probably result in something different to that associated with hard copy type of work. The fact that these considerations are tedious and have many ramifications in regard to ergonomics and physical health have tended to delay satisfactory guidelines being established. Because of this many VDT work stations have initially been introduced to the workforce without sufficient consideration being given to these aspects. Where mistakes, even minor ones, have been made, these have served to harden many people's attitudes against the increased use of VDTs.

THE FUTURE OF VDTs

That this new technology will persist, seems inevitable. It is inescapable that with advancing needs to store, process and retrieve very large quantities of information, computerised technology provides the most practical answer. It is unfortunate that the very magnitude of the storage and processing tasks makes it difficult for the average person to comprehend that pencil and paper technology is already inadequate for this need. Somewhat over-enthusiastically perhaps, the concept of the "paperless office" has been widely promulgated. Human nature however seems evidently resistant to this concept and recent thinking by researchers tends to support this resistance with some good reasons. (Ref. 2)

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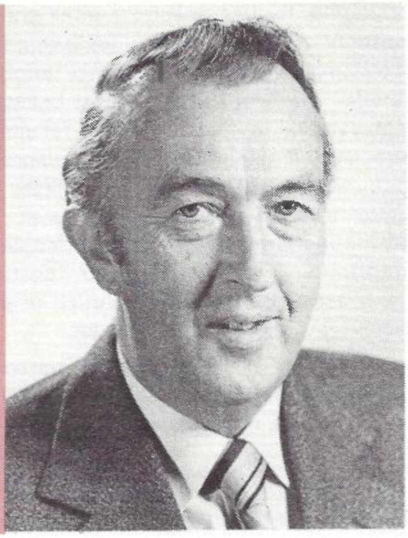
He graduated from RMIT in 1956 with diplomas in Mechanical and Electrical Engineering; he is a Member of the Institution of Engineers, Australia, and a Fellow of the I.lluminating Engineering Societies of Australia. Although nominally an Electrical Engineer he has for many years specialised in the field of lighting design and application. After spending a total of twelve years with the Melbourne City Council, Electricity Supply Dept., Bates Smart and McCutcheon, Architects; and WE Bassett and Partners, Consulting Engineers, he joined the Department of Construction in 1968.

He has served on many specialist lighting applications committees including those of Standards Association of Australia, Housing and Construction Central Office and Telecom. He is currently "on loan" to Telecom Headquarters Buildings Branch for the purpose of recommending lighting designs for VDU application.



It is realised that people have been traditionally trained to process and store their information in their own way and in their own time, for example in shorthand or pencilled notes, and this information is retrievable, once again in a person's individual way and rate. It is reasonable to be highly suspicious at first, of a machine which rapidly swallows all of the information the operator puts in, will only give it back at the touch of the right buttons and tends to give no assurance that it will not lose this information. Human beings may therefore need a great deal of convincing that this machine is here to stay, even if it can be readily forseen that design improvements will reduce or eliminate the causes for complaint.

Enthusiastic acceptance of the VDT into the work place in the near future will depend very largely on successful elimination of the frustrations which operators are experiencing at present.

READABILITY

From the operator's point of view, the key to avoiding frustration when using a VDT is good readability of the message displayed on the VDU screen.

Readability is determined by a combination of several factors, and these may be considered broadly as either operator/machine oriented, or as related to the workplace environment. The second group will be discussed later in this paper, in the section on the design of the work place. In the first group are:

- the selection of characters and format, which requires some experience of operator preference, and
- the operator's visual acuity and performance under appropriate lighting conditions.

LEGIBILITY AND FORMAT

The legibility of the display may be measured in terms of the lack of confusion that occurs in recognising individual characters in the message. In a hard copy task for example, the confusion which can occur between C and G, S and 5, 2 and Z, B and R, S and 8, is well known. With hard copy tasks this type of confusion can be minimised by ensuring well formed characters with sharp edges in high contrast with the background, such as black ink on good quality white paper.

With the VDU this solution is not quite so simple as it will require for best results a small grain size in the VDU phosphor, high resolution of focussing from the character generating system, a strong brightness difference between the "dot" signal and its background, and so on. Achievement of most of these results is demonstrably expensive, if required to a high degree. It is obviously pertinent to first consider the likely consequences of failure to perform the visual task correctly, before committing large expense. For example, failure to read a telephone account number correctly could be embarrasing, but misinterpretation of an air traffic radar display could become a disaster.

The format of characters may be somewhat less of a problem as these are necessarily stylised to a slightly greater extent than those used in normal printed copy. (Ref. 3)

If attention is not paid to all aspects of legibility, the VDU task can become rather like reading the fifth carbon copy on poor quality grey paper in poor lighting conditions.

In addition to the foregoing aspects of legibility, VDU displays may often exhibit other visual problems due to instability of the displayed image. "The VDT Manual" defines such items as 'flicker', 'jitter', and 'swim' which, if present, may substantially reduce legibility. (Ref. 3)

The cause of these disturbances stems from the selection of VDU hardware. In particular, the electronic components of the character generating system, the type and persistence of the phosphors used in the cathode ray tube, the refresh rate, and line spacing all have some influence on the amount of instability present. Until now, almost all the VDU hardware used is identical to that used for entertainment television, and it is unfortunate that sufficient studies of the visual problems associated with VDU-based work were not made before the adoption of TV technology for VDU equipment.

These stability problems are not as evident in an entertainment TV situation, as the display is seldom static, and the correct viewing distance is (or should be) at least 3 metres.

There is no doubt that the more static message of the VDU and the relatively short viewing distance involved, may require more sophisticated, and presumably, more expensive hardware to achieve the necessary freedom from instability. This is particularly so where the VDU task is a critical one as discussed earlier. (Ref. 4)

Visual Acuity and Performance

The ability to perform any visual task (i.e. to see) comes from the basic functions of the eye and brain, which are to detect and interpret brightness and form. (Ref. 5) These are subjective functions as are all other sensory functions of the human brain, and brightness detection is the only function which the eye itself can perform. The brain can only sense a visual difference in two objects if the amounts of light they provide to the eye are different in value or arrangement. In most everyday tasks these differences can be provided in several ways — for example, by the density of light emitted from these objects, by their shape, by the difference in colour, or by their movement. The eye is not capable of providing useful information in regard to the absolute measurements of light values or colour values, but nevertheless the eye is extremely sensitive where small differences exist in these parameters.

Visual acuity is broadly defined as the ability to distinguish fine detail (Ref. 9) and is essentially determined by the physical functions of the eye. In basic terms there is a limit of size, defined by the visual angle of the task subtended at the eye, below which distinction between small objects is not possible. This is determined ultimately by the spacing of cone receptors in the retina. Acuity is modified in varying degrees by other factors such as the eye's power of accommodation, (the ability to focus on near or far objects), individual slight differences in the focussing structure of eyes, and the state of an individual's adaptation to ambient lighting or visual conditions. All of these effects are further modified by the operator's age and certain visual deficiencies which may be inherent in any particular person.

Because the operator's own visual acuity plays an important part in the legibility and hence readability of the display, it is necessary to create lighting conditions in the VDT workplace, which will provide maximum benefit to any operator's acuity capabilities.

It is usually considered that lighting conditions which satisfy 95% of the operator population are acceptable, although some authorities suggest that this ratio may be too low. This latter view is supported by several researchers who have found that up to 30% of the working population may have an uncorrected or inadequately corrected visual defect. (Ref. 2) It is highly unlikely that attempts to create perfect viewing conditions could succeed in achieving maximum visual acuity when such a large number of problems can exist with the operators themselves.

The most practical course of action therefore, is to offer specific eyesight examination to those people intending to become relatively continuous VDU operators. No stigma is attached to such an offer and indeed it is considered beneficial that a prospective VDU operator should become aware of a latent factor which may not become apparent for some years with normal office work but which could cause immediate distress, if the VDU tasks were commenced in the absence of such knowledge.

Some disfunctions of the "normal" eye are inevitable with increasing age and because of this, it is probable that VDU workers above the age of 45 or so will already have received some spectacle correction. (Ref. 6) Those who do may well discover that, provided the spectacles are correctly prescribed, they can perform VDU tasks equally as well as "hard copy" tasks.

It is worth noting however that work station layout must also be considered in relation to spectacle correction. Where reading from hard copy forms part of the VDT task, the prescribed spectacles must obviously be suitable for viewing both the VDU and the hard copy. This may pose a dilemma for an optometrist, unless the work station can be arranged for similar viewing distances for both tasks.

A COMFORTABLE VISUAL ENVIRONMENT

Having attempted to minimise all of the problems concerning the readability of a VDU display, one must then turn to a host of other factors which relate to the environment surrounding and including a VDT work station. These factors come within the ambit of building services engineers, interior designers, work station designers and of course the users themselves. Visual considerations will include minimisation of distractions due to disturbing reflections in the VDU screen, minimisation of discomfort and reflected glare from the VDU screens immediate surroundings and other room surfaces, correct choice of colour, and brightness distribution throughout the operator's visual fields. As visual comfort is known to be affected, both directly and indirectly, by the total working environment, in most cases it will be necessary to consider also the influence of postural comfort and thermal comfort, together with the actual working time using the VDTs and the length of rest periods.

TIME SPAN OF THE TASK

When considering the different types of VDT tasks which may be involved, it is essential in the first place to discriminate between long term tasks say, 2 hours or more at a stretch, and short term tasks. Many of the environmental factors mentioned previously may cause distress to the operator performing long term tasks. However in the case of, say, a spot verification of some message taking a few seconds or even a minute to perform, and followed by a visual rest period of several minutes or longer doing some other task, these visual environment defects usually will not matter at all. It is therefore unfair for the operator to demand perfect seeing conditions for a short term task under all circumstances.

For long term tasks, however, it is now realised that not only must the VDU equipment be of high quality, but the operators should also be as free as possible from eyesight defects as previously discussed. The eyesight examinations recommended may therefore also assist in determining whether or not a particular person should attempt long term VDU tasks.

There is nothing new about this situation; it has been obvious for many years that for instance, persons suffering from certain hereditary colour vision defects should not be employed in industries where colour signalling is essential to occupational safety. Railway engine drivers, aircraft pilots, or ships captains are in this category.

VISUAL FATIGUE

There can often be a tendency for operators to complain of fatigue associated with VDT tasks. It is also quite possible that office workers may complain about any visual task if the lighting conditions are considered to be unsatisfactory. Is there, however, something about the VDT task in particular which in itself can cause fatigue?

Inevitably some blame is immediately attached to the visual conditions within or peripheral to the task. It has by now been demonstrated that visual conditions are very often not the prime culprit although there can be some instances where they do make a significant contribution.

Fatigue at work can occur due to a large number of causes and may be physical (aches, pains, etc.) or mental (tiredness, poor work performance, lassitude etc.) or even a combination of these. Physical fatigue in all cases is symptomatic of excessive muscular activity and is always reversible in healthy persons by adequate rest from the particular activity involved. There is no doubt that back aches, neck pains, and the like, may result from poor working posture or ergonomically unsatisfactory working situations. Some of these are also a probable secondary result of unsatisfactory visual conditions which may cause or accentuate the incorrect working postures. So called "eye strain" however is found to be rarely (if ever) caused by excessive activity of the eye muscles which have relatively enormous reserves of energy available.

In passing, "eye strain" is a particularly unfortunate term as it has a connotation of permanent damage. Trauma can result from over-stress of the muscular systems in many parts of the human body. This is because the skeletal/muscular systems of the body in general consist of rigid components arranged in the form of levers or beams, with hinged or flexible joints incorporated in the structure. Excessive stress applied to these systems by the muscles may well induce firstly fatigue and pain in the soft tissues of the muscles, inflammation of the joints and other padding membranes and in the extreme, fracture of the rigid components. It is easy to understand therefore, that most people would believe a similar situation might exist with the visual system. In fact, this is not the case, as the eye and its associated nerve links with the brain although protected and surrounded by rigid bony structures are insulated and padded and contain only soft tissue. (Ref. 5) These may become fatigued or irritated due to prolonged overstress but cannot suffer structural damage due to forces applied from within their own system. Permanent damage to the ocular system can only occur due to external forces physically causing injury, from disease, from natural degeneration (aging) or from inherent structural abnormalities.

Similarly, it is known that certain radiations can cause trauma of the eye tissues. In the early days of using VDUs, because the VDU usually incorporates a cathode ray tube (CRT), many fears arose that ill-health would result from continued exposure to radiation from these devices. Much less publicity was ever given to similar fears arising from the use of TV screens (an identical form of CRT) when these are used for entertainment.

Sufficient investigation has now been carried out in many parts of the world to reassure everyone that neither the CRT as used in VDUs or the entertainment TV screen produce any more harmful effects than would be experienced in natural circumstances. In either case the amounts of harmful radiation are so low as to be practically unmeasurable. (Ref. 7)

MENTAL FATIGUE

Mental fatigue, which may have allied with it certain visual symptoms, is a somewhat different matter.

When subjected to mental stress the human body has tremendous reserves to call upon when motivated to do so. This motivation can take many forms, including, as a few examples, financial inducement, salubrious working conditions, or even fear. (Ref. 8) In the present context, financial and environmental considerations are the motivating forces most likely to prevail.

It is interesting to reflect that in a number of recent cases which have received much attention from the media, financial inducement was offered in an attempt to gain acceptance of unsuitable working conditions. From the claimant's point of view this was really saying "we believe the working conditions are bad and consider they are detrimental to health and efficiency, but for some extra salary or other benefit we may be prepared to ignore the defects". This argument cannot be accepted in the case of VDT operation, since the whole purpose of introducing this equipment is to increase productivity using, in the main, existing skills. The offer of over-award payments or shorter working hours, of course defeats this objective. In the writer's opinion, every attempt should be made to remove all of the possible physical causes leading to operator discomfort and dissatisfaction in each case. Discussion of over-award payments and the like, as a last resort would then apply only in the event of extreme technical difficulty.

LIGHTING STANDARDS, CODES AND GUIDES

When designing any workplace, engineers and architects usually refer to the appropriate standard specifications or codes of sound or safe practice, in order to specify the most suitable materials or products. Where special or unusual problems exist, further assistance may be sought from the many guides which are published by specialist groups or persons.

In the case of the VDT workplace, where hard copy visual tasks and VDU reading tasks may co-exist, there is obviously a need to consider all of the available information and recommendations.

There has often been criticism of standards and codes particularly those emanating from overseas. It is often argued that these are written, as it were, from an ivory tower and in an attempt to force people to achieve perfection, without necessarily recognising that we live in a practical world and everything (including good lighting), is a compromise between technical achievement and economics. This situation tends to become untenable when codes become the subject of legislation and therefore enforceable on designers, manufacturers and eventually the users who have to meet the costs.

Australian Standard AS1680 "Code of Practice for Interior Lighting and the Visual Environment" is the information source most often referenced in Australian lighting practice. This code is not a detailed design manual in the strictest sense, nevertheless as a matter of policy, it contains many of the necessary guidelines to advise the designer "what to do" in order to achieve good results. (Ref. 9)

In matters of industrial safety or public health, certain of the code recommendations are made mandatory, for instance by referral from Uniform Building Regulations, but in other cases, specifically the use of VDTs, it must be left to a competent designer to interpret and take advantage of these recommendations.

It has been noted that almost all of the standard code recommendations to date, relating to visual requirements, comfort conditions, ergonomic and anthropometric aspects of working environments have been biased towards normally horizontally arranged tasks, and a working group of the Standards Association of Australia (SAA) is currently charged with re-examination of the present Code. Its brief is to amend or revise such recommendations that may apply to the previously unforeseen set of circumstances resulting from the introduction of a visual display unit as a significant part of many worker's tasks. Much investigation work has been done in this area since the late 1970s, and many of the recommendations arising from these will find a place in a supplement to the present Code.

In accordance with SAA's normal practice, the personnel charged with the preparation of both the original Code and subsequent additions were drawn from a number of consultants, architects, engineers, optometrists and interior designers practising in the field of lighting, together with representatives of building owners and users. The writer of this article is a member of this working group.

REFLECTIONS IN THE VDU

Probably the most significant of several problems that exist at present with VDU viewing, is that of reflections.

These problems are caused by the VDT being placed in such a way that light from extraneous sources is reflected from the VDU screen, towards the operator's eyes. This 'extraneous' light can come from windows, luminaires, highly illuminated room surfaces or furniture, even from the operator's own face or clothing. The reflections can result in all sorts of difficulty, ranging from slightly distracting to full-scale obliteration of the VDU message.

The main thrust of present investigations therefore, is towards elimination or moderation of these problems by careful design of the workplace and VDT work stations. It is apparent at this stage that solutions will not be found easily, as all attempts so far, to eliminate troublesome reflections have resulted in producing or accentuating other difficulties with the workplace environment.

Fortunately, not all of the proposals are in conflict with established practice. Some trial installations have shown that provision of general lighting conditions and appropriate interior design have created a pleasant visual environment which can go a long way towards reducing unwanted reflection troubles to an acceptable level. (Ref. 10, 11)

DESIGN OF THE WORKPLACE

There is a sign on the writer's wall copied from a bar-room mirror which reads, "Please don't shoot the piano player, he's doing the best he can." This is a reminder of the problems which building designers face when it comes to dealing with all of the factors which can influence visual comfort and efficiency for the occupants of the building.

In the first instance it is important that the occupants must be well satisfied with their work place environment so that productivity can be achieved. It is also apparent that many tasks other than visual ones may be performed at a VDT work station, but because the visual task is the one most easily recognised, it is usually the one singled out if any faults appear to exist. The interior design of the room environment, colours, visual relief aspects, windows and interior lighting all must receive their share of consideration before comfortable conditions can be attained.

Having established appropriate visual conditions for the task and its immediate surroundings, attention must then be given to window areas and drapes and the reflections of interior room surfaces.

People working inside a building for long periods have a basic psychological need to relate to the world outside. The window areas necessary to satisfy this requirement need not be very large, (Ref. 9) but nevertheless can give rise to a number of problems with the internal visual environment, particularly where VDU viewing is necessary.

There is no doubt that very efficient installations can be designed where every part of the environment is artificially created. This is commonly called a good engineering solution but is now seen to be an unsatisfactory one for human occupation. In the long run the designer may be forced to compromise between psychological satisfaction and good visual efficiency for the work.

In blunt terms when all is considered, the operator is there to operate the VDT as well as possible, not to look out of the window! But every effort should be made to avoid this situation. Once having developed proposals for dealing with window treatment and unwanted reflections, the designer must give attention to interior factors which come within the working environment. These include consideration of all textures, colours and colour rendering properties of artificial light sources. The lighting schemes should provide adequate modelling of room objects and people's faces, freedom from distracting glare, freedom from excessive brightness contrasts and adequate opportunity for visual relief. The designer must also attempt to ensure that the environment so created still enables the operator some flexibility of movement or change in routine in order to avoid unnecessary fatigue. It is not an easy task to arrive at a perfect solution incorporating all of these do's and don't's, particularly when other restrictions such as room shapes, wall positions and ceiling heights may be imposed by economic or such other considerations.

It would seem advisable for design of the VDT equipped work place to proceed along the following lines:

- Determine the exact nature of the VDT Task and whether or not there are other visual tasks to be accomplished simultaneously or in association. Determine whether all of these tasks, VDT and other, are short term or long term.
- Determine the level of quality necessary for the VDU display equipment.
- Examine the environmental factors, e.g. natural light admitted or not; whether the VDT workplaces are large or small areas; is there a desire for subdued lighting conditions or otherwise?
- If it is found too difficult or costly to satisfy these environmental factors using a relatively low quality VDU, consider the use of higher quality VDU equipment.
- Make a value analysis of the whole system. By this, it is inferred that situations could arise where, for example in leased premises, where the cost of providing a satisfactory design may heavily out-weigh the advantages of using those particular premises, and therefore alternative accommodation should be considered.

CONCLUSION

The only apparent conclusion from the foregoing discussion is that there can be no universal panacea for the design of work stations using VDTs whereby one perfect solution for all problems will be achieved. The best result that can be hoped for is to reach agreement between equipment designers, work station designers, environmental designers and users for any particular situation. This means in essence that wherever a "package" installation is contemplated, positive agreement must be achieved at the planning stage as to which of the many factors are relevant to that package. It follows then that irrelevant considerations must be discarded so that individual designers and users will be able to proceed with consideration of the best possible selection of each component of the total result.

As some compromises seem to be inevitable, it is considered essential that all persons involved should understand the reasons for these compromises. It is hoped that this article may achieve some measure of this understanding.

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In Brief

THE ARMY, PROJECT RAVEN AND INDUSTRY

Raven, a new Australian-conceived and built combat radio system for the Army, is expected to attract world-wide interest and open overseas markets for Australian Industry in the next five years.

The Raven single channel radio system, planned for introduction into service from 1985, is the result of Defence-funded target studies placed with Australian industry to examine the Army's future requirements.

The Army's current range of combat radios was bought, in the main, from the United States, with some from the UK and Australia prior to and during the Vietnam conflict. These radios are now hard to maintain and do not offer all the facilities and capabilities needed to provide the range of communications required on the modern electronic battlefield. Project Raven was born in 1976 out of the necessity to keep up with modern technology and warfare.

The Raven system is to comprise a VHF and a HF transceiver both with appropriate power amplifiers and antennas. The system will have a range of common ancillaries including handsets, headsets, remote control units, data and message entry devices, batteries and vehicle mounting harness.

With the microprocessor technology now available many more facilities can be incorporated into the transceivers without increasing their size and weight beyond that of the current radios.

The Raven equipment will be designed to operate in the harsh Australian environment, particularly in the high temperatures and dusty conditions found in a large part of the country. A major requirement of the Raven system is that it be highly reliable and that each unit or sub-unit of equipment can be replaced quickly by non-technical users in the field. Also, it must be fully supportable in Australia.

Contracts for the second phase, Project Definition, were signed on October 15, 1980, with Plessey Australia Pty Ltd, and Racal Milcom Pty Ltd. The competitive contracts, for a total of $2.06m, require the companies to examine areas of technical risk, produce development models of these areas and produce equipment specifications and plans. Both Australian companies will be working in conjunction with their UK associates who have extensive research and development facilities.

The fostering of Australia industry is one of the primary considerations in Project Raven. The Army believes that industry here has the skills to produce equipment equal to any in the world. However, as Raven is the biggest major Army combat radio development in the post-war years, time and assistance is required for the capability to be developed.

Although the requirements of the Australian Defence Force are modest it is expected that the Raven radios will attract world-wide interest. Overseas markets could then open up to further consolidate the capability of Australian industry in this field.

Co-operation and mutual trust has developed between the Army and industry through close contact and a conscious policy by Army management to keep industry fully briefed and involved at all times.

The policy has already overcome a number of problems and has avoided complaints often heard from industry that it is not informed of, or involved in, Defence projects until it is too late to influence the equipment requirement.

The Army is making sure such a situation does not occur with Project Raven.

Trial of a Computer Directory Assistance System — Sydney

CHARLES J. DOUGALL, B. Com., ARMIT, MIE (Aust)

A trial was conducted in Sydney in 1979 of a computer information retrieval system which replaced paper records at directory assistance positions with visual display units. This paper describes the background to the trial and presents results which demonstrate the operational viability of computer directory assistance systems in Telecom Australia's Directory Assistance Service.

A trial in Telecom Australia's Directory Assistance Service (DAS) of computer directory information retrieval was conducted at the Sydney 013 Centre (GPO) over a period of 6 months from 7 February to 7 August 1979. In the trial, directory paper records on ten operator positions and one supervisor position were replaced by Visual Display Units (VDUs) which the operator used to access an information retrieval computer system located at East Sydney Telephone exchange.

The information retrieval system used as the vehicle for the trial was the Computer Consoles Incorporated (CCI) DAS/C system supplied through STC Australia Pty. Ltd. CCI are based in the United States and the DAS/C system has been in operation in US telephone companies since early 1977.

The implementation of the trial and data collection for trial evaluation purposes were conducted by Telecom's NSW Administration with overall project management being conducted by the Headquarters DAS Project Team. CCI and STC installed and maintained the DAS/C system. The network configuration established for the trial is shown in **Fig 1.**

TRIAL OBJECTIVES

The trial was not intended to prove the technical functioning of the CCI system as the system was acquired as a standard hardware/software package which was well proven in operation in the United States.

The objective of the trial was to enable the study of the application of computer DAS systems in Telecom Australia and specifically

- to assist in the planning and implementation of a national computer DAS network
- to assist in the preparation of a specification and tender schedule for a national computer DAS network and
- to form a basis for negotiations with staff associations on the national introduction of computer systems in the Directory Assistance Service.

OPERATING PERFORMANCE

The trial showed that computer information retrieval is an operationally viable alternative to the paper records system currently used in the Directory Assistance Service. Operator productivity gains in excess of 40% were achieved during the trial. The ten DAS/C positions were divided into two groups of five positions. One group, designated the "Control Group" comprised 12 operators who occupied five positions over all shifts for the full six month trial period; these operators only operated DAS/C positions and did not work on paper records positions. Furthermore, these 12 operators were selected to be representative of the cross-section of operating ability in the Sydney DAS centre. This was done to enable meaningful extrapolation of control group performance results to apply to the entire centre and other centres in Australia. The remaining five positions were occupied by the remaining operators in the Sydney DAS Centre on a rostered basis of 3 days training and two days of answering live traffic. In addition these remaining operators occupied available vacant DAS/C positions at any other time outside of the rostered sessions. This enabled all operators in the Sydney DAS/C Centre to have some experience in the operation of DAS/C.

Improvement in operator productivity was measured through improvement in Average Work Time (AWT) which is defined as the average, for all calls answered by the operator, of the time interval between the connect and disconnect of customers' calls. It therefore measures the average time that operators spend on customers' enquiries, including conversation and information retrieval time. An interface between the CCI system and the GPO call queue system was established to enable the compilation of this statistic on the CCI system.

Graphs of AWTs over the six month trial period for DAS/C and paper records positions are shown in **Fig 2.**

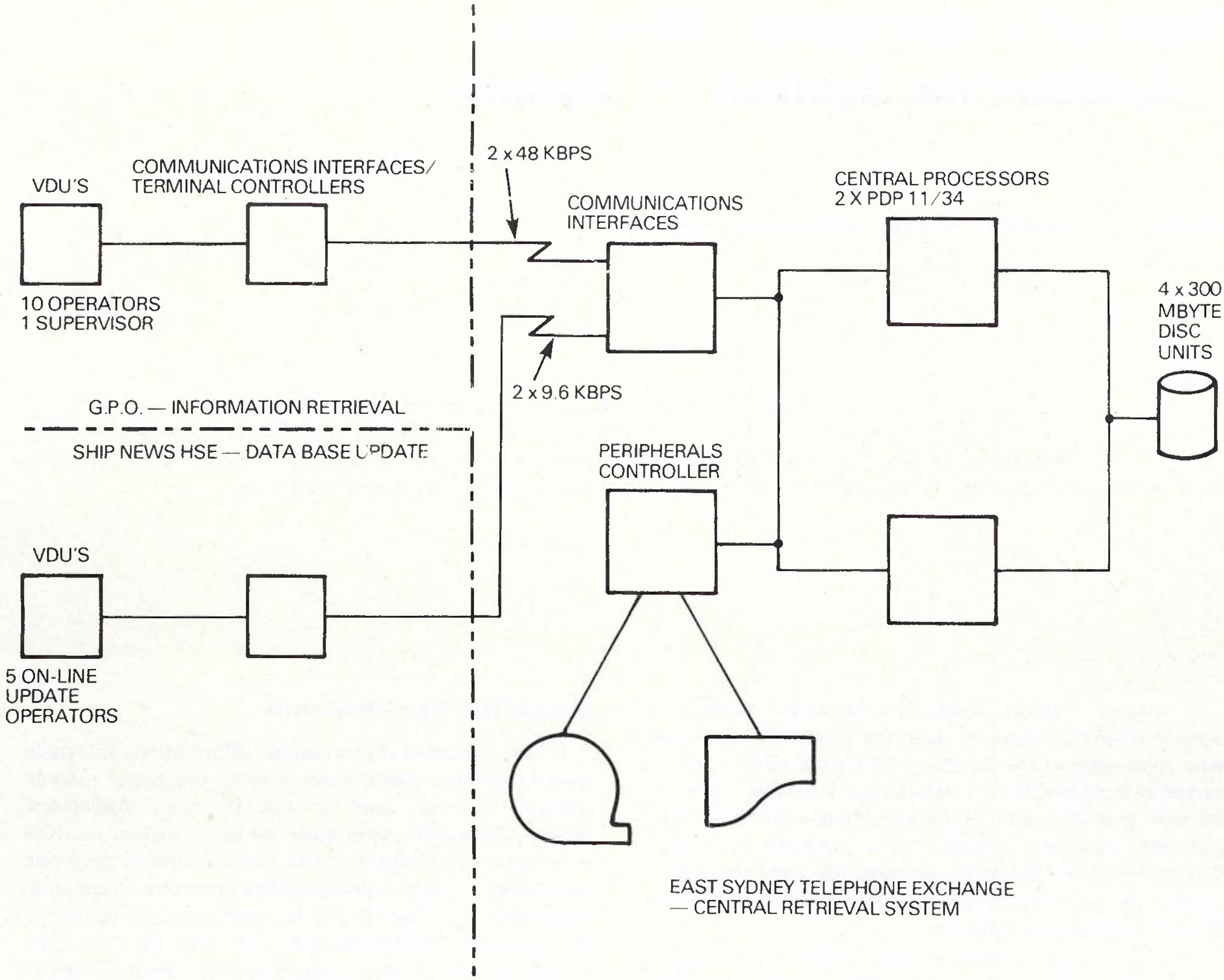
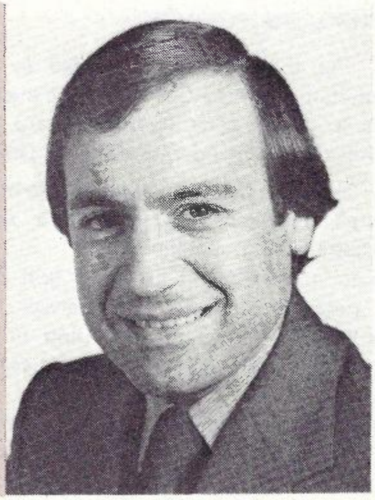


Fig. 1 — Network Configuration

CHARLES J. DOUGALL joined the APO in 1968 as a cadet engineer. In 1970 he was appointed engineer in the Victorian Planning Branch, and was transferred to Victorian Construction Branch in 1972 where he worked on installation of metropolitan exchanges including the first public ARE 11 installation at Elsternwick.

In 1976 he was appointed Senior Engineer in the Planning Division Headquarters and in 1978 was promoted to his current position in Telephone Switching Planning Branch as project manager for the Directory Assistance project.



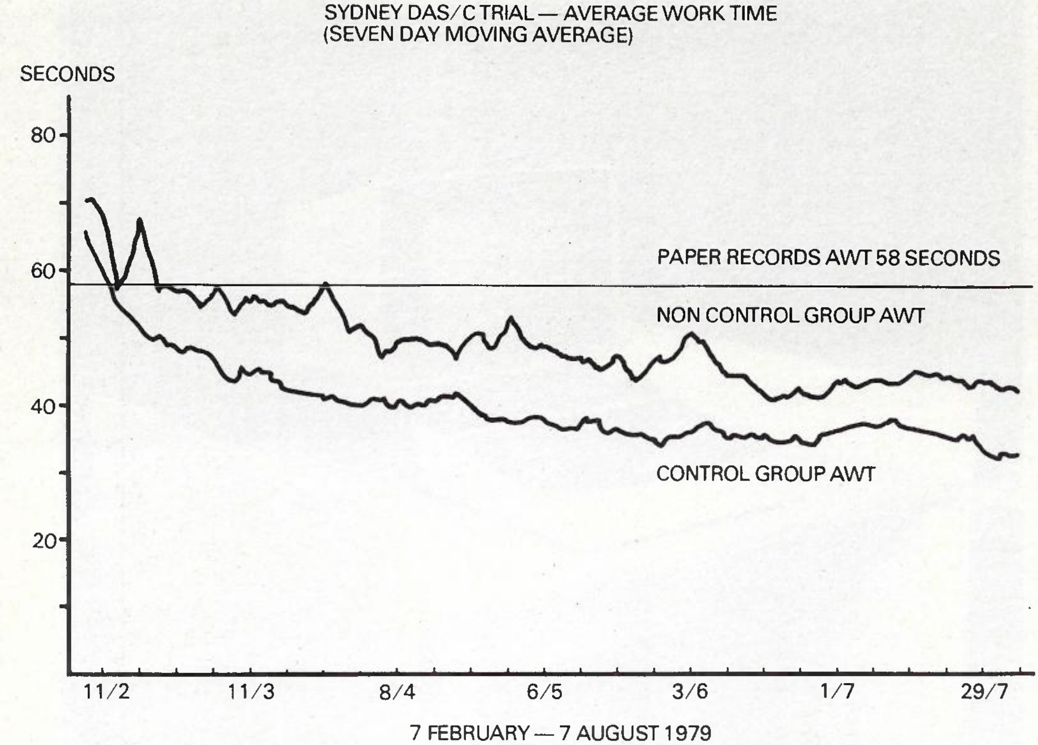


Fig. 2 — Average Work Time — Seven Day Moving Average.

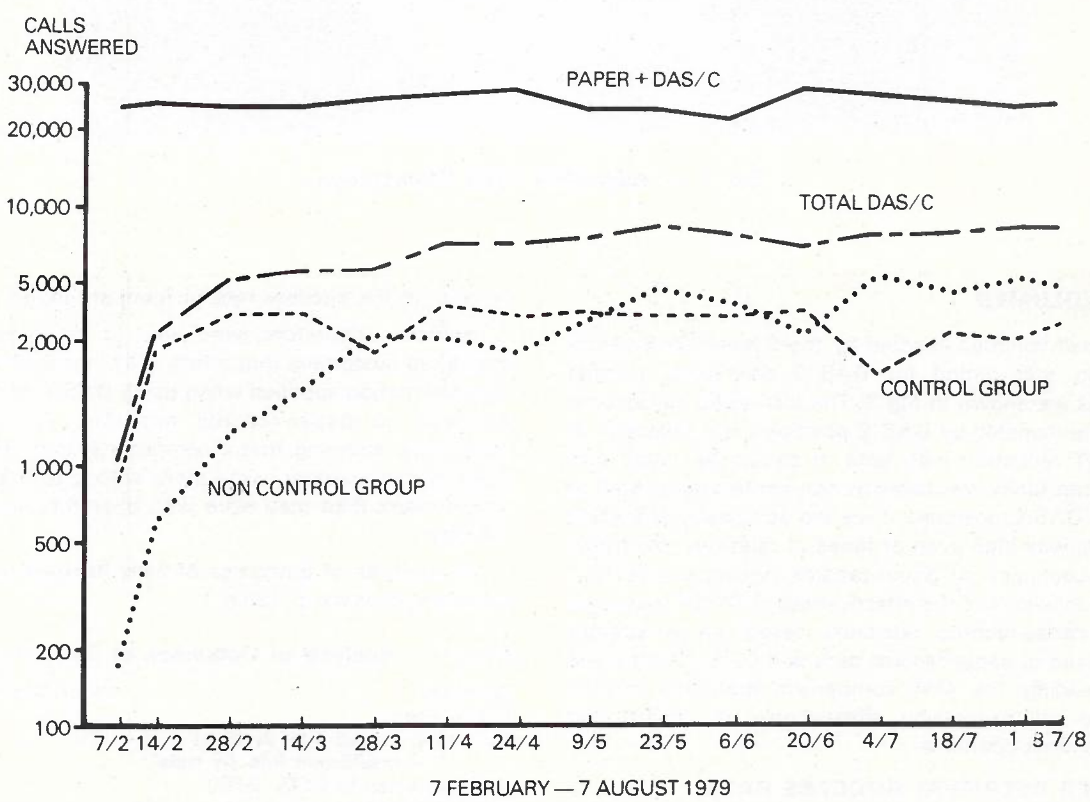


Fig. 3 — Call Volumes

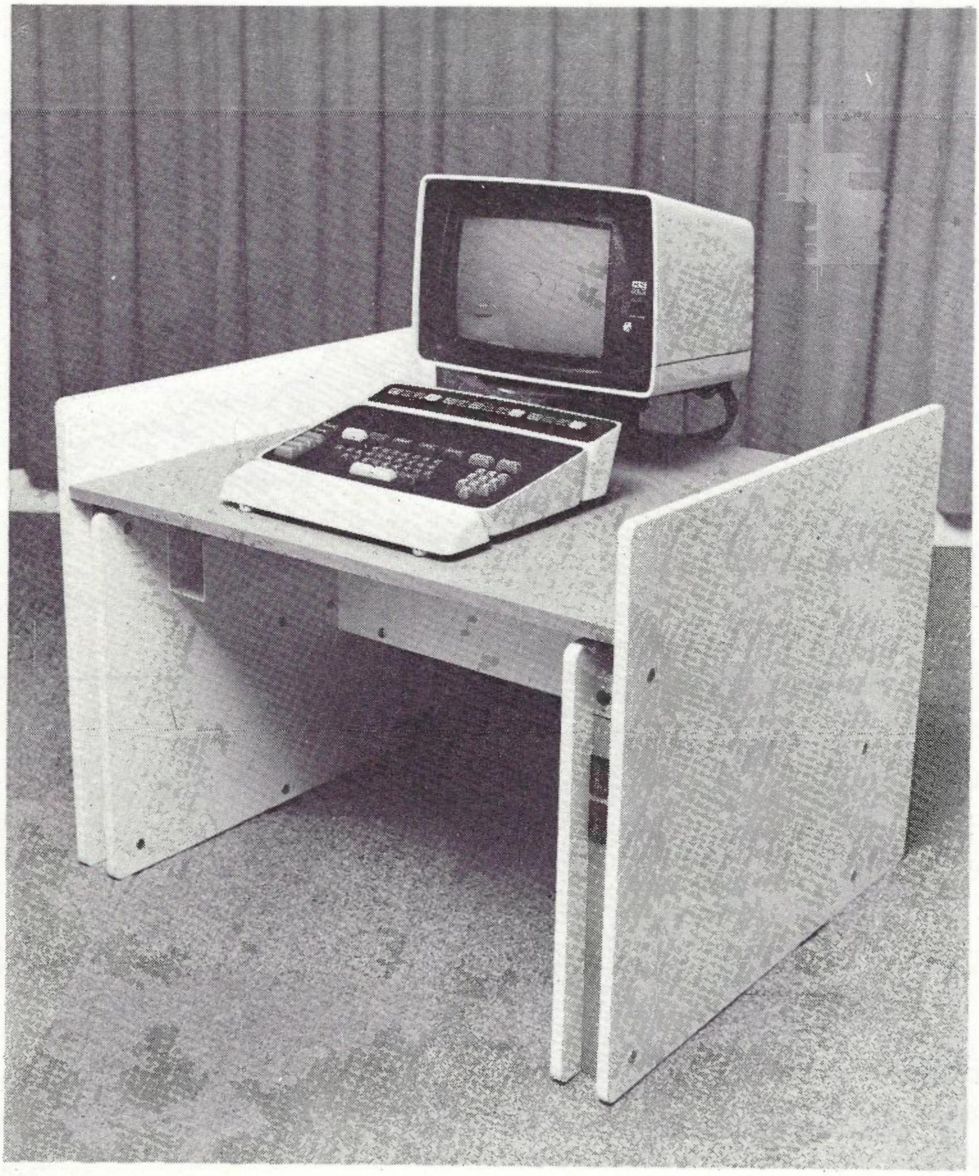


Fig. 4 — Adjustable VDU Workstation

CALL VOLUMES

The call volumes handled by the Sydney DAS centre over the trial period for DAS/C and paper records positions are shown in **Fig 3.** The increasing call volume with time, handled by DAS/C positions, is a reflection of the AWT reduction with time. It should be noted that every opportunity was taken by non-control-group staff to operate DAS/C positions. Thus the occupancy of DAS/C positions was high even at times of relatively low traffic when occupancy of paper-records positions was low. Thus conclusions of the effectiveness of DAS/C positions versus paper-records positions based on a straight comparison of paper-records calls and DAS/C calls could be misleading. The AWT comparison should be used to compare call processing effectiveness of DAS/C and paper-records positions.

NUMBER RETRIEVAL SUCCESS RATE

There was little difference between DAS/C and paper-records in the success rate of numbers found.

However, operators were able to more confidently convey to customers that a listing did not exist to match the information supplied when using DAS/C positions as opposed to paper-records positions. Furthermore, customers, knowing that a computer system was being used by the operator, were more willing to accept a no listing result than they were with operators using paper records.

An analysis of outcomes of calls handled by DAS/C positions appears in Table 1.

Table 1 : Analysis of Outcomes of Calls Handled

Outcome	% of Calls Handled
Listing Found	76
No Listing — Full Info. by caller	9
— Insufficient Info. by caller	5
Call Redirected to 0175, 0170	4
Call Redirected to other levels	3
Call Drop-Outs	3

OPERATIONAL REVIEW OF DAS/C SYSTEM

The CCI DAS/C system is designed with internal redundancy to provide a high level of up-time performance and a fast enquiry response time at the operator's terminal.

Total service loss due to equipment failure was not experienced during the trial although some equipment failure did occur which caused service degradation, i.e. increased system response time. The extent of partial service loss was interpreted to have resulted in an overall equipment percentage up-time over the trial of 99.87%. System response time, measured as the interval between depression of the last key by the operator and appearance of the last character on the terminal screen, averaged at about 0.9 seconds.

STAFF INVOLVEMENT

Operator staff and their staff association (ATPOA) were involved in the project a long time prior to the contract being let for the trial. An agreement was negotiated in early 1978 with ATPOA on the operation of the trial and in August 1978 seminars on the trial were held for all directory assistance operators in Sydney.

A staff consultative group was formed in September 1978 to consult on matters relating to the introduction and evaluation of the trial. This group held fortnightly meetings prior to and during the trial and provided valuable input to management in the preparation and evaluation of the trial. The meetings were a necessary aid to project development and a useful forum for testing of new ideas and obtaining feedback on problems at the work face, operator attitudes and system performance.

ERGONOMIC AND ACCOMMODATION ASPECTS

In the course of the trial, detailed studies were conducted into the design of workstations and lighting for visual display units (VDUs) with the aid of consultants from the Department of Productivity and Sydney University.

The workstation studies led to the development of an adjustable workstation (**Fig 4**) which enables adjustment by the operator of

- VDU screen angle
- VDU viewing distance
- VDU screen height
- Keyboard height and position independently from VDU screen position.

The workstation will undergo a further operational trial at the Sydney GPO prior to a decision on application in the future national computer DAS network.

An economical and effective lighting scheme was developed in the trial to overcome problems of screen reflections and high ambient light levels. The existing surface-mounted fluorescent fittings were modified to provide controlled lighting suitable for the task. A surround was installed over the fitting with a diffuser which emitted light at a cut off angle such that glare effects in the line of vision of the operator were reduced and reflections from the VDU screens minimised. The resulting lower level of illumination of the ceiling and work area was overcome by the use of floor mounted upright fittings which increased the ceiling illumination. These fittings are shown in **Fig 5.**

The principles of this lighting scheme do not require high ceilings and can be readily and economically applied in most buildings.

Fig. 5 — Lighting Scheme.

DATA BASE PREPARATION AND UPDATE

The data base was prepared mainly through automatic conversion from two computer directory compilation master files — one supplied by Telecom Australia's Information Systems Department for the Private Names section of the Sydney White Pages and the other by William Brooks Pty Ltd for the remainder. Programs for the conversion were written by STC who were also responsible for preparation of the data base.

Government entries were input manually and some business listings required manipulation to overcome problems encountered in automatic conversion.

In the early stages of the trial the data base was updated daily entirely by on-line manual methods, using 5 update terminals located at Shipnews House, North Sydney. Towards the end of the trial a batch update system was developed to handle the processing of new and deleted listings in the Telecom produced Private Names file with all other listings being updated manually on-line. STC developed software to read the Telecom produced magnetic tape file and convert the create and delete messages to CCI update compatible formats.

The updating of the data base functioned effectively; however there was a high reliance on direct manual update which is not recommended for future systems as this is costly and inevitably leads to data base errors and non-synchronisation of the data base with the published directory.

THE OUTCOME OF THE TRIAL

The trial was undoubtedly successful in demonstrating the operational viability of computer DAS systems. Significant productivity gains can be expected with a national DAS system as well as improvement in customer service through faster response and improvement in the quality of information. In addition, data base updating facilities will enable reduction in delays in updating directory assistance data thereby also contributing to improvement in customer service.

At the time of writing, installation work was well advanced on the conversion of all "013" paper-records positions at Sydney GPO to the CCI DAS/C system. This expansion of the limited 10 position trial is being undertaken to establish, under full scale operating conditions, organisational arrangements and operating procedures to be applied when the national computer DAS system is installed.

In late January 1981 Telecom Australia obtained Ministerial approval to let a contract with IBM Australia Ltd for a national DAS computer network. This will be installed progressively over the financial years 1981/82 to 1983/84.

Many people within and outside of Telecom Australia contributed to the successful installation and operation of the trial. The contribution made by the operating staff, through their enthusiastic support and participation in the consultative group, was particularly important.

In Brief

REVISED STANDARD FOR METRIC CABLES — AS 3116

The Standards Association of Australia has published a revision of its standard AS 3116 for Elastomer insulated cables.

The new specification revises the 1974 edition and covers elastomer insulated cables and flexible cables for operation at working voltages up to and including 0.6/1kV. It also provides requirements for conductors, insulation, length of lay of course, fillers, binders, tapes, coverings and sheaths, markings, construction and dimensions, and tests.

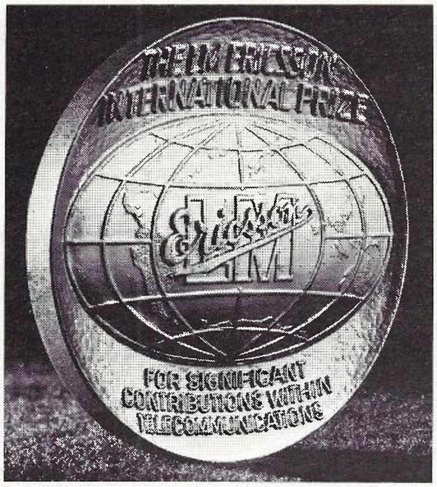
Principal changes from the earlier standard relate to deletion of R-60 elastomer insulation, and to the size of galvanised steel round armour wire. The deletion has been made because there is now very little demand for this material, and the metric Wiring Rules, AS 3000, no longer provide a rating for this insulation compound.

In the 1974 standard, 0.8mm diameter wire was specified, but this has now been replaced by two sizes 0.9mm and 1.25mm — because it is no longer readily available. The change in armour dimensions has brought the need for a recalculation of the dimensions of finished cables.

Appendices cover calculation of the dimensions of protective coverings and cables, rounding of numbers, colours of manufacturers' identification threads, and information required with enquiry and order.

Copies of AS 3116 may be obtained from any SAA office at a cost of $11.40, plus a charge of $1.50 to cover postage and handling.

For further information please contact:
Jack Moncrieff
Telephone (02) 929 6022



Nomination of candidates
is now invited for the

1982 AWARD

of the

LM ERICSSON INTERNATIONAL PRIZE

for notable contributions to

TELECOMMUNICATIONS RESEARCH AND DEVELOPMENT

The LM Ericsson International Prize was presented for the first time in May 1976, in connection with the celebration of the Company's 100th anniversary.

The Prize - which honors the memory of Lars Magnus Ericsson, founder of the Company - is designed to encourage and advance research and development within the field of telecommunications engineering.

The Prize is being awarded every third year in recognition of an outstandingly significant "scientific or technological contribution within telecommunications engineering" during the three-year period preceding the award year. Earlier contributions whose importance becomes established during the three years are also eligible for nomination.

The winner of the Prize is selected by an independent Prize Committee consisting of members appointed by the Royal Swedish Academy of Engineering Sciences, the Board of Directors of the Swedish Telecommunications Administration and representatives of leading Swedish institutes of technology.

Candidates may be nominated by members of the Prize Committee and by organizations or individuals active in the telecommunications field.

Nominations are now being accepted for the 1982 award. All nominations must be in writing and should be accompanied by all relevant supporting material. The closing date for nominations is October 1, 1981.

Only the winner's name will be disclosed. Where the Prize contribution results from the work of two or three people, the Prize may be awarded jointly.

Nomination of candidates, or requests for further information including the complete rules governing the award, should be addressed to: *The LM Ericsson Prize Committee, S-126 25 Stockholm, Sweden.*

Dr Charles K Kao and Dr Robert D Maurer, winners of the 1979 Ericsson International Prize, receive their award medals from King Carl Gustaf of Sweden at the presentation ceremonies in Stockholm in May, 1979.

Prize amount: 200,000 Swedish Crowns

The Telecommunication Journal of Australia

ABSTRACTS: Vol. 31, No. 1

DOUGALL, C. J.: 'Trial of a Computer Directory Assistance System — Sydney'; Telecom Journal of Aust., Vol. 31, No. 1, 1981, page 79

A trial was conducted in Sydney in 1979 of a computer information retrieval system which replaced paper records at directory assistance positions with visual display units. This paper describes the background to the trial and presents results which demonstrate the operational viability of computer directory assistance systems in Telecom Australia's Directory Assistance Service.

GUTHRIE, H. P.: 'A Discussion on Telecommunication Building Design'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 50

There is evidence of significant reduction in the space requirements of new telecommunication switching systems.

This reduction provides an opportunity to review the traditional bases of many parameters of telecommunication equipment building design. In 1978-9, a joint Telecom - Department of Housing and Construction study of equipment building design developed a series of conclusions after such a review.

Innovative in the method of approach, the study examined in some depth the complete building-equipment relationship and raised several matters which provided an indication of the likely development of future equipment buildings. This discussion considers these matters in a little more detail.

The overriding theme of this discussion is that the flexibility of modern telecommunication equipment systems must be utilised to effectively and economically overcome the lack of flexibility in the building system.

HARRISON, M. J.: 'Network Plan for AUSTPAC — The Australian National Packet Switching Service'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 28

Telecom Australia has announced its intention to provide a national packet switching service (AUSTPAC) by the end of 1982. This paper outlines the main features of the network plan for the initial establishment of AUSTPAC and its later expansion.

MICHAELIDES, A. T. and MACKIE, G.: '2048 kbit/s Transmission over Analogue Radio Relay Systems'; Telecom. Journal of Aust. Vol. 31, No. 1, 1981, page 12

Telecom's planned Digital Data Network (DDN) will require 2048 kbit/s intercapital data circuits by late 1982. Firstly, this paper outlines methods which can be used to provide these high-speed data circuits on existing trunk networks. The Data Above Voice (DAV) method of 2048 kbit/s transmission over radio systems is then discussed in some detail as DAV will be providing nearly all intercapital links in the initial stages of the DDN. The extent of the DAV network by 1982, performance objectives, operation of DAV modems, sources of errors in DAV transmission and results of field measurements are given. The conclusion, based on field measurements, is that DAV links are expected to meet, generally, the current DDN performance objectives. Performance of the very long radio routes and those with equipment approaching the end of its useful life is still in some doubt; these routes will be tested during 1981-82 when sufficient DAV modems become available.

POUSSARD T., BEARE, C. and FALKOVITZ, Y.: 'An Introduction to the Australian Digital Data Network (DDN)'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 19

The Digital Data Network (DDN) is a data communications network which is integrated into the national telecommunications system. Through this network new data communications services will be provided and marketed under the category Digital Data Service (DDS). Both point to point and multipoint synchronous dedicated services will be available, using the data rates 1200, 2400, 4800, 9600 bit/s and 48 kbit/s. These services are similar to those which have been provided over the past decade by the Datel Service, employing data modems operating over cable pairs and/or telephony transmission systems.

ROZENTAL, S.: 'PCM —Network Implications'; Telecom. Journal of Aust., Vol. 31, No. 1 1981, page 58

Costs associated with the provision of interexchange junction networks are significant. Capital investment in this area can be reduced or deferred by the efficient utilisation of available junction cable and duct plant through the application of primary Pulse Code Modulation (PCM) systems. PCM systems can also provide improved transmission performance and will interface readily with future digital switching systems. The use of digital switching and transmission would establish the integrated digital network (IDN) and provide for a possible evolution to the Integrated Services Digital Network — (ISDN).

This paper considers the motives for the adoption of primary PCM systems into Australian metropolitan telephone networks. Reference is made to their current application in the Melbourne metropolitan junction network and the strategies adopted in the planning of PCM systems in an analogue switched environment. The future role of PCM is also discussed, particularly in the digital switched environment.

TAYLOR, W. F. and McCALL, C.H.: 'Telecom Policy on Microprocessor Developments for Engineering Applications'; Telecom. Journal of Aust. Vol. 31, No. 1, 1981, page 44

In 1977 there were over 40 microprocessors on the Australian market; many of these devices were being utilised by Telecom design staff to solve previously impossible design problems.

It became apparent that, unless standards were adopted for microprocessor design, Telecom could face unnecessary expense over the whole area of equipment development and support.

TROUNSON, M. J.: 'Learning to Live with a Visual Display Terminal'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 72

The introduction of new technology, in many cases, produces some degree of resistance from the end user, particularly if its operation is noticeably different from previous experience. Quite often, all the results of introducing new devices to every day life cannot be foreseen at once, for example the road accident trauma resulting from the advent of motor transport. But with the widespread introduction of visual display terminals (VDT's) as an operator interface with computerised data processing, reactions have been often immediate, malicious, and antagonistic.

It is fair to say that, as with most other such advances, some mistakes have been made in the early stages of introducing VDT's through ignorance or uncertainty, and much ill feeling has been created.

It is apparent that Telecom Australia is rapidly becoming a major user of VDT equipment for many of its operations and it is likely that a very large proportion of its personnel will soon need to use VDTs for some or all of their daily work.

It is not the purpose of this article to take sides, but rather to attempt to disclose the inherent difficulties in the development of this interface between man and machine. All points of involvement are considered, but particular emphasis is placed on visual aspects. Specialist committees have been formed, to examine all aspects of VDT usage and work station environment. Their charter is initially to co-ordinate the findings of previous investigators in the various fields involved, and to then develop appropriate total designs for work places where VDTs will be used.

An outline is given of the areas in which these committees will work, and indications that, in some cases, tentative solutions are already at hand.

van der ZWAN, M., PHIZACKLEA, D. and RENTMEESTER, G.: 'Interactive Drafting System'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 3

Interactive drafting systems (IDS) are playing an increasingly important role in the provision of a drafting service compatible with the advanced manufacturing and design technologies available today and in the future. This article initially gives an overview of a typical system configuration, similar to that adopted for the first IDS installation in Telecom Australia. Finally, the article attempts to highlight some future developments and applications of interactive drafting system software and hardware.

WILSON, D. B. and KEATING, C. G.: 'Disabled People and Telecommunications'; Telecom. Journal of Aust., Vol. 31, No. 1, 1981, page 36

During 1978 and 1979 Telecom conducted an investigation into the needs of telephone users who are disabled. Available statistical data and studies published by overseas telecommunications organisations did not provide adequate data that would enable a rational approach to the planning, development and production of aids for the disabled.

The study, through the use of interviews, discussion groups, postal surveys and assessment of other local and overseas research provided an analysis of functional disability, categorised by severity. It also provided estimates of the number of people in Australia for each category and the types of aids requested by each group.

A more detailed summary of the study is available in a report entitled "Disabled People and Telecommunications" released by Telecom as a contribution to the International Year of Disabled Persons.

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Volume 31, No. 1 1981

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INTERACTIVE DRAFTING SYSTEM

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