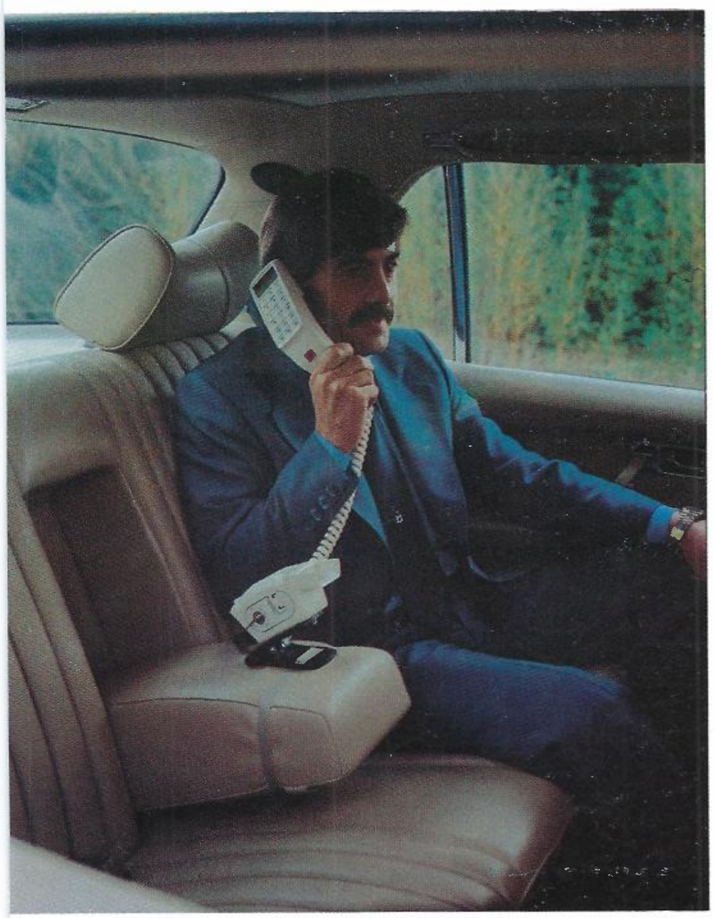
Volume 31, No. 3, 1981

the telecommunication journal of Australia



IN THIS ISSUE

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EDITORIAL

The whole telecommunication industry in Australia is going through a cycle of rapid and dramatic change and it is reasonable to expect that the people within the industry are experiencing changes in their needs for information or at least changes in the frequency with which their knowledge needs to be updated.

The Board of Editors of the Telecommunication Journal of Australia, is committed to keep pace with these changes and to satisfy the needs of the members (and prospective members) of the Society.

The Journal is, however, many things to many people. To an author, it is a means of publishing ideas and concepts and gaining recognition, to a reader, it is a source of information, to an administration, it is a record of achievement and, to the Society, it is a means towards meeting objectives.

Your Board of Editors, in reviewing papers submitted for publication, need standards by which their work might be guided and these standards come from the perceived needs of the 'users' of the Journal. From time to time it is necessary to check our perceptions and that is why a 'user' survey has been included in this edition.

Would you please take 15 minutes of your time to complete the questionnaire and return it to me at the address below. If you feel that the questionnaire does not offer you sufficient scope to get your view across, then please write to me and I will undertake to ensure that your requirements are met.

RON KEIGHLEY
Editor in Chief
P.O. Box 4050
MELBOURNE 3001.

TELECOMMUNICATION JOURNAL OF AUSTRALIA

USER SURVEY 1981

The objective of this survey is to determine the degree to which the Journal meets the needs and expectations of the members (and prospective members) of the Society. It is expected that members will have needs as:

- authors of papers
- readers of the Journal.

Another need, which will not be surveyed, is that of the Society in publicising its activities and meeting its stated objectives.

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Volume 31, No. 3, 1981

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Telecom's Mobile Telephone Service

COVER: Automatic Mobile Telephone.

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The Telecommunication Journal of Australia

The Journal is issued three times a year (February, June and October) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

Residents of Australia may order the journal from the State Secretary of their State of residence; others should apply to the General Secretary. The current subscription rates for both Telecommunication Journal of Australia and Australian Telecommunications Research are shown on the back cover of this issue. All rates are post free (by surface mail). Remittances should be in Australian currency and made payable to the Telecommunication Society of Australia.

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The General Secretary, Telecommunication Society of Australia,
Box 4050, G.P.O., Melbourne, Victoria, Australia, 3001.

Introduction of a Fully Automatic Service in Australia

K. J. SIMPSON, M.I.E. Aust.

On 10 September 1981 the first fully automatic Mobile Telephone Service in Australia commenced operation in Melbourne. This Service enables a customer in a moving vehicle, such as a motor-car, to have full access to the National telephone network including facilities such as STD and ISD. The service is due to be extended to Sydney later this year.

The introduction of these new services represents the successful outcome of a project which began in the mid 1970's when it was becoming increasingly clear that public demand for a mobile telephone service could not be met by the small (100 subscribers) manual systems then operating. At the same time, advances in technology suggested that the time was right to look towards meeting this demand with a fully automatic system capable of connecting several thousand subscribers.

World-wide tenders were called in March 1977 seeking Mobile Telephone Service equipment for Melbourne and Sydney. Detailed evaluation of the offers received showed that they would provide a basis for the introduction of a technically and financially viable automatic Mobile Telephone Service. NEC (Australia) Pty. Ltd. was selected as the equipment supplier.

The project has involved the application of both switching and transmission technologies to answer a defined market demand and has required contributions from many specialist areas of Telecom, at both Headquarters and State Administrations, and from NEC. The authors of the three articles in this edition and the further six articles — to be included in the next two editions — come from these areas and have been closely involved with the project. Their articles cover marketing, planning, design, manufacturing, construction, operating and maintenance aspects of the system.

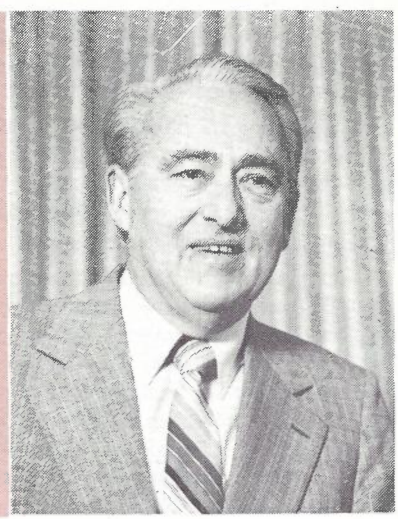
The successful completion of the project is a tribute to the close co-operation between these specialist areas. As well, it is a tribute to the efforts made by NEC to develop the Mobile Telephone Service to meet Telecom requirements and to manufacture and deliver the equipment as called for by the contract timetable.

KEITH J. SIMPSON is nominally the Chief Development Engineer in the Engineering Department of Telecom Australia. He began as a Telegraph Messenger in Lismore in 1938, becoming a Junior Mechanic in 1940. Following war service he qualified as an Engineer in 1950 and was engaged in planning and installation activities in both the metropolitan and country areas of New South Wales.

Since transferring to Central Administration in 1962, he has held key engineering positions in Planning, Design and Development areas. As Chief Development Engineer, Mr Simpson has taken a leading role in developing close relationships between Telecom Australia and the Australian telecommunications manufacturing industry.

Since the establishment of the need to provide an enhanced Mobile Telephone Service, Mr Simpson has taken a personal interest in this project.

Mr Simpson is currently acting General Manager, Engineering, in Telecom Australia Headquarters.



Need for a Modern Automatic Mobile Telephone Service

M. SIVYER

Current trends towards a mobile society and rapid developments in technology have thrust the mobile communictions industry into a complex market whose needs include the automatic interfacing of the switched telephone network with radio communications.

This article will attempt to identify that market and its needs in relation to mobile automatic telephone services. As the theme of the article is marketing oriented, the basic elements of the marketing mix involved in providing a mobile telephone service are discussed.

Subsequent papers will cover the technical and operational implications of providing and maintaining such a service.

DEVELOPMENTS IN AUTOMATIC MOBILE TELEPHONE SYSTEMS

Radio Communications

The most significant impact on mobile communications has been brought about by the ready availability of CB radio, which in turn has led to expectations for an automatic interface between the mobile user and the fixed telephone network.

Devices which have enabled illegal 'patching' of calls between the mobile and fixed customer have become more sophisticated, subsequently requiring more stringent controls or provision of approved devices for interfacing.

Overseas Experience

New systems offering features that enhance facilities available to fixed telephone customers and provide capacities of 5,000 to 200,000 customers are now being provided in Europe, Asia and North America.

In 1979 the Nippon Telegraph and Telephone Public Corporation (NTT) introduced a high capacity mobile radio telephone service in Tokyo. Connections had reached 3,200 by January 1981 when there was still a high level of unsatisfied demand.

In the USA, it has been reported, approximately 50,000 Americans are waiting for the mobile radio telephone. An experimental service offered by AT&T in Chicago since 1978, has provided about 1,300 customers with a mobile telephone service. In Los Angeles there are about 3,000 mobile telephone owners but the limit of 27 radio channels restricts traffic to 27 conversations at any one time. In New York there is a five year waiting list for mobile telephones.

Televerket in Sweden intends providing the Nordic Mobile Telephone Service later this year. The system, which will be compatible with the fixed networks of Denmark, Norway, Finland and Sweden, will have a maximum of 180 radio channels.

IDENTIFICATION OF NEED FOR AN AUTOMATIC MOBILE TELEPHONE SYSTEM (MTS) IN AUSTRALIA.

A customer's need for any product is based on a customer's perception of the benefits that product offers, eg the taste of a cigarette or the comfort of a modern car. In the case of MTS, there are two separate needs to be satisfied, viz convenience of communication and status. However, marketing does not only involve satisfying customer's needs. There are also organisational (Telecom) needs to be considered which with MTS are concerned with an economic return on investment.

All these needs were temporarily satisfied in Sydney, Melbourne and Adelaide with the introduction of a manual mobile system in the early 1950s. However, with the limited capacity of the system and associated facilities, the needs quickly returned.

Therefore the manual system will be replaced initially, in Melbourne and Sydney, by an automatic system. Plans for an automatic system in Adelaide are still being considered.

In line with marketing needs mentioned above, the decision to close the manual service is based on:

- the system inability to be extended to meet unsatisfied demand.
- increasing labour costs incurred in providing the essential operator intervention on every call.
- the obsolescence of equipment which exacerbates maintenance requirements and increases related costs.

The unprofitability of the manual system highlights Telecom's need for MTS, ie a need for an economic product with profit making potential, to comply with the business element of Telecom's charter, viz revenue must cover expenses each year and provide not less than half of the capital requirements.

It must be acknowledged that, to comply with Telecom's charter, cash flows from MTS must reflect an economic return on total investment. Perhaps the most basic of Telecom's economic needs is for revenue from sale and rental of mobile units to fully finance annual purchases of new mobiles by 1983/84.

THE AUSTRALIAN MARKET

Having established that a customer need exists for MTS in Australia it is now necessary to quantify that need through market analysis eg market segmentation, identification of level of demand and setting targets. A basic quantification has been achieved through studies carried out by the Australian Sales Research Bureau Pty Ltd in 1977. The studies which included a survey of 1 268 residents in Sydney, Newcastle, Wollongong, Melbourne and Geelong indicated a total potential demand for some 5 600 mobile telephones at a 'price' of $1 600 per year. More recent forecasts calculated in line with growth in the market and inflated monetary values, and therefore based on an annual rental figure of $1 800, indicate significantly higher demand for MTS: see Table 1.

Year	Market Potential		Potential Services in Operation		% Penetration	
	Sydney	Melb.	Sydney	Melb.	Sydney	Melb.
1982	5 100	5 050	1 900	1 700	37	33
1983	5 350	5 100	2 800	2 500	52	49
1984	5 550	5 200	3 500	3 150	63	60
1985	5 750	5 300	4 100	3 700	71	69
1986	5 950	5 400	4 700	4 200	79	77

Table 1 — MTS Market Potential — Sydney and Melbourne

Segmentation of the MTS market undertaken during the aforementioned study revealed that the mobile telephone meets the needs of various groups.

The largest groups are those persons who spend much time in, or in association with, their vehicles and who frequently need to speak to a changing group of persons (who are not members of the vehicle driver's own organisation) via the telephone network.

A small group of important persons whose organisations wish to maintain close contact as well as to provide them with the facility of a direct telephone service. We are speaking here of heads of government, senior civil servants, managing directors of large companies who wish to make effective use of time spent in cars, top professional men whose time has to be organised as efficiently as possible.

The study results suggest that the largest proportion of the market contains small operations or larger businesses in which sales staff act as independent operators, or builders and building contractors working at sites not serviced by a telephone (see Table 2). However, as the studies were undertaken before MTS was available and tariffs had been set, some variation in actual segmentation is expected within 12 months of operation of MTS. This is supported by evidence from a small study in 1981 of waiting applicants who knew when MTS would be available and how much it would cost. The results indicated that typical early acceptors of MTS would belong to different segments like individuals who are self employed, business executives, and 'status seekers'.

Industry	% Demand for MTS
Transport	22
Building	20
Real Estate	13
Plumbing	9
Motor Schools	8
Medical Practitioning	6
Electrical Contracting	4
Others	18
Total	100%

Table 2 — Market Segmentation on Industry Basis

THE PRODUCT

Telecom will market MTS in Melbourne and Sydney from September and November 1981 respectively. The system will have a capacity for about 4 000 customers using 120 radio channels in the 500 MHz band. A special numbering scheme, with the prefix 007 will be allocated to MTS customers. MTS customers will have access to all the facilities of a fixed telephone service as well as some facilities usually associated with premium telephones, eg abbreviated dialling, visual display of called number, etc.

The Price

The decision on the pricing of MTS has taken into account that demand is sensitive to price, radio frequency spectrum resources are limited, and Telecom's need for an economic return on investment.

Therefore MTS will be offered to customers on both a rental and sale basis, and call charges will be subject to a minimum equivalent to the STD 'F' rate.

The following basic charges are proposed:

Connection fee (excluding installation of mechanical components in vehicle) $350.00
Annual Rental — mobile unit $1000.00
— network and servicing ... $800.00
Sale (network and servicing rental also applies) $5300.00

In the long term, prices will be varied in line with market demand conditions and economic returns.

Promotion

Promotion of MTS will be contained for the first year of operation due to the already established demand for the service. Through close monitoring of sales during that period, the need for active promotion will be ascertained.

Place

Customers will be able to apply for MTS at Telecom Business Offices but a designated office in Melbourne and Sydney will process applications. Installations will be carried out by staff at the MTS Service Centre.

Long Term Goals and Objectives

Telecom has a responsibility for satisfying customer needs for mobile telephone communications while achieving an economic return on the investment required. Therefore Telecom must contain costs associated with MTS in Melbourne and Sydney so that the service can be extended to all capital cities and still remain an economical proposition.

However, consideration must be given to the present political climate in Australia and Telecom's ability to satisfy the huge mobile market. A policy yet to be determined is whether Telecom will monopolise the market, compete with or complement other communications suppliers, for MTS and similar services.

CONCLUSION

At the time of writing, automatic mobile telephone services seem the logical answer to satisfying the communications needs of our mobile society. However, MTS is only one step towards a totally mobile society where the cordless telephone could be the normal, every-day means of voice communciation.

References

1. 'Telecom PAMTS Market Research Study', ASRB, Nov. 1977.

MAUREEN SIVYER joined the Australian Post Office in Sydney in 1963 working as a Sales Consultant until 1976. She then transferred to Headquarters where, after working in the Sales and Service Branches, joined the Product Planning Branch of the Marketing Division. She is currently acting Product Manager of Mobile and Local Networks in Commercial Services Department.

System Planning and Design

V. SARGEANT, Dip.E.E., B.E.(Hons), M.Eng Sc.

Network connected mobile telephone services (car telephones) have been in operation overseas for many years. In Australia a manually switched telephone service has been available to mobile users in major capital cities since about 1952. However the number of customers provided with such a service has been only a few hundred.

Early in 1976 Telecom senior management gave approval to a plan to provide customers in Australia with a mobile telephone service equal to or better in performance, facilities and cost, than any found in other parts of the world.

On the engineering side, the world market was surveyed to establish the capability of current systems and the trends emerging in developing mobile systems. This article outlines the various system philosophies which were developed from the need to provide the service required in geographically large Australian capital cities. The article also discusses the special requirements of the customer, the facilities provided, and some features of the common equipment which are unique to a mobile telephone system.

Much of the information contained in this paper on the topic of design of Telecom's new mobile telephone system was written directly into the specifications for the system.

DEVELOPMENT OF MOBILE RADIO TELEPHONY

Early Mobile Radio Systems

Communicating by means of radio to people in vehicles has been a practice which has been in popular use since early this century, and has since found many applications including military, police and delivery fleets.

One early practical radio despatch service was the Detroit Police Department in USA in 1922. This system was a one-way service for messages to police cars. By the mid-1930's the concept of using radio for directing the movements of people in cars had become popular, and radio frequencies in the Very High Frequency (VHF) bands of 30 to 40 MHz were then used to gain benefits in better radio propagation and lower levels of interference from vehicle ignition systems compared with the High Frequency (HF) bands formerly used.

In more recent years two-way systems were introduced, giving the person in the vehicle an opportunity to respond to the message. The major application for two-way mobile radio systems has been for fleet control eg. for taxis and delivery vans in which a radio base station is set up in a prominent location, from which orders and messages are exchanged with the driver. Of course the drivers and operators quickly learnt that the signal strength was weaker in some locations as good uniform radio coverage was not easily attainable.

High base station antennas located in a commanding position (hill top or tall building) were required to improve radio coverage areas. However, as taxi company staff are well aware, coverage of whole metropolitan areas such as Melbourne and Sydney necessitated a number of base stations — each serving a portion of the overall area. To avoid interference between the radio signals, each area is operated on a different frequency.

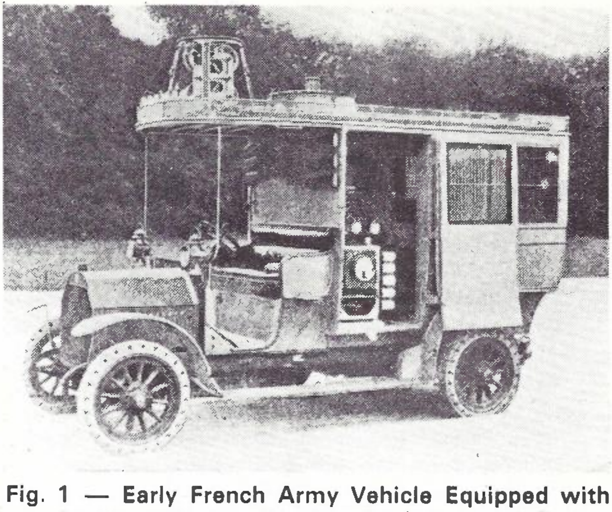


Fig. 1 — Early French Army Vehicle Equipped with Mobile 'Wireless' Equipment (Circa 1916).

Manual Mobile Radio Telephony

Mobile Radio Telephony, that is the connection of a call from a mobile radio into the telephone network, has been a service offered in USA, UK, Europe and Australia since the early 1950's. The inter-connection is performed manually by a telephone operator.

In Australia, Telecom provides a small manual mobile service of early vintage in major capital cities. The system comprises a single circuit (two radio frequencies — one for send and the other receive) and utilizes one base transmitter and up to four base receivers at various locations. The system serves up to one hundred customers who supply and maintain their own mobile units.

Simplex working (push-to-talk) is utilized in the mobile unit, whilst duplex operations at the base station is provided. The operator can select automatically any mobile unit using a three digit selective code, and inter-connect the selected mobile unit to the telephone network. To initiate a call, the mobile customer lifts the handset to receive dial tone (channel free) then turns on the transmitter, thus indicating to the operator that a mobile unit is calling.

The basic problems that result in poor service to the current manual mobile telephone users in Australia include:

- Extreme crowding of the single radio circuit used. It is necessary for the operator to interrupt a conversation and request call-termination.
- Lack of privacy; users can overhear other conversations on the systems if they wish.
- Push-to-talk simplex system is an obsolete technology.
- Excessive delays and necessity to use an operator for call set-up and charging procedures.

Despite the obvious short-comings of the system, users place a very high utility on the service and are prepared to pay many thousands of dollars to "buy" another user's right of access.

Manual mobile systems operating in various parts of the world are shown in Table 1.

Fig. 2 — Manual Mobile Telephone Equipment (Europe, early 1970's).

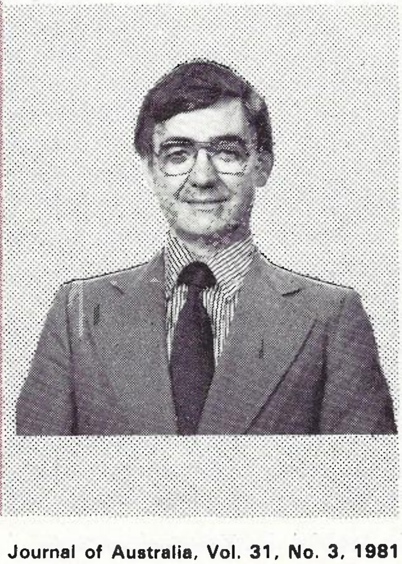
Country	System-Name	No. of Channels Accessible by Mobile Unit
UK	ILRP	9
Europe	CEPT	Various
Netherlands	MOBILOPHONE	12
Sweden	MTD	16 or 25
Canada	MTS	13
Australia	—	1

Table 1— Manual Mobile Telephone Systems

VIC SARGEANT was appointed as an engineer with the Department of Supply in 1960, and engaged in the development of new military communications equipment. He later up-dated his qualifications at Monash and Queensland Universities and joined the APO Research Laboratories in 1970 to work on PCM codec design, development of an analogue video transmission system, research into digital radio systems and radio paging system development.

In 1975, he was appointed Engineer Class 4 in HQ Development Division where one of his major activities was the planning and systems design of Telecom's new Mobile Telephone System, described in this article. In 1978 he was appointed Engineer Class 5 in Engineering Planning Division. Major activities include rural and remote area planning and the planned development of the Digital Radio Concentrator System.

Currently Mr Sargeant is A/G Superintending Engineer on secondment to the South Pacific Bureau for Economic Co-operation, where he is leader of an international team whose task is to investigate the development of a modern telecommunications network for the South Pacific Countries.



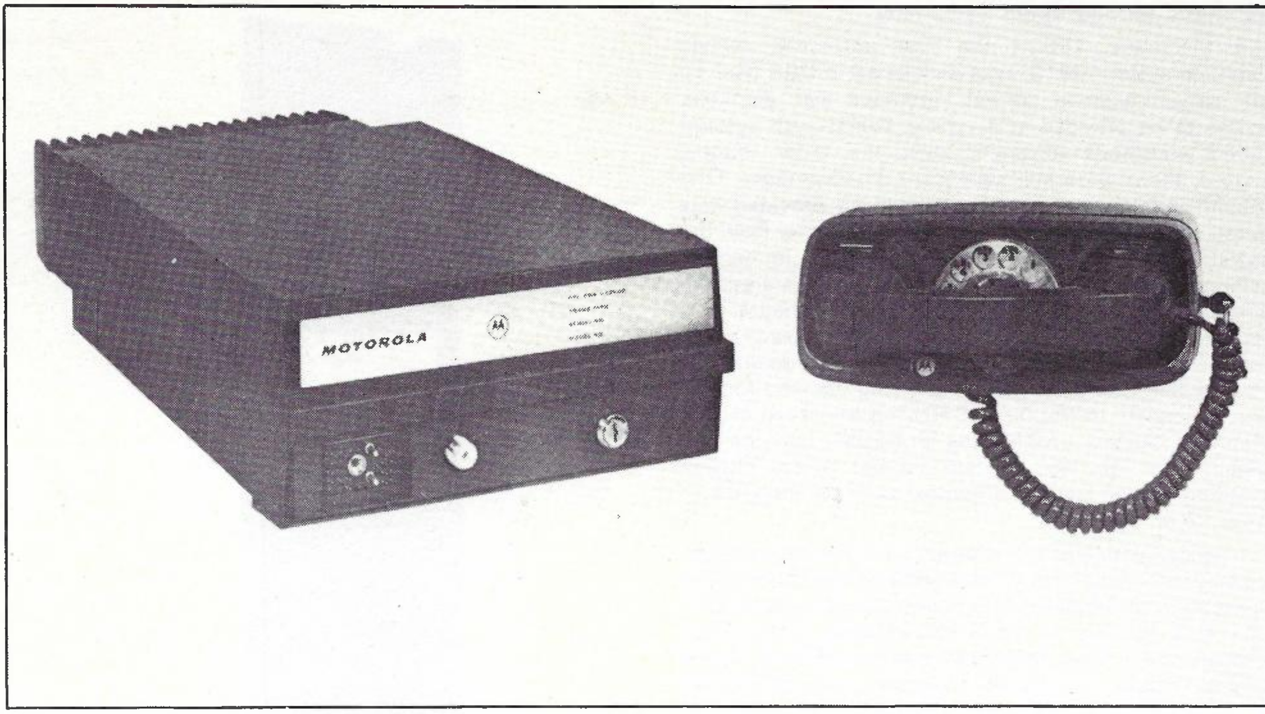
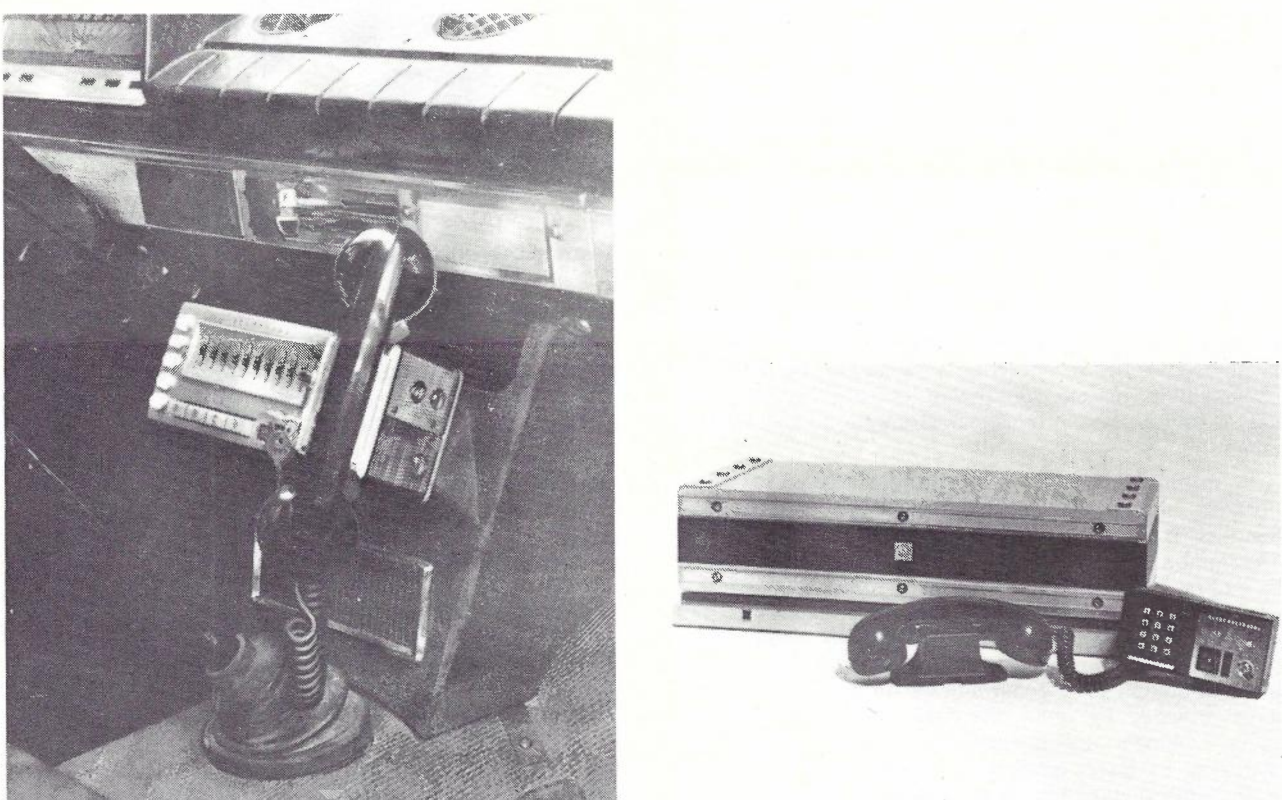


Fig. 3 — IMTS (USA) Automatic Mobile Telephone System, first introduced in late 1960's — Mobile Unit Showing Radio and Control Unit (Mounted in Vehicle Boot) and Handset.



Early Development — late 1960's

Development Mid 1970's

Fig. 4 — IMTP (Italy) Automatic Mobile Telephone Systems.

Automatic Mobile Radio Telephony

In the early 1960's the first automatic mobile telephone system (MTS) was developed in USA (Ref 1). This system enabled normal automatic dial telephone services to be provided in a vehicle. Whilst such systems offered enormous advances over the older manual services, there were still significant disadvantages. One problem was that service could only be provided in a limited coverage area which extended only over (say) the central part of the city and some of the immediate surrounding inner suburban areas. Beyond this area, the signalling necessary for establishing and terminating calls would become unreliable. Another problem was that the system capacity of 4 or 8 channels was not large enough, in some cases, to cater for the growing demand for this type of service. In the late 1960's an Improved Mobile Telephone System (IMTS) was introduced into the Bell System (Ref 2). This system utilized more efficient signalling and an increased number of radio channels — up to 12 or 16.

A typical installation in a large city utilized a very high powered, centrally-located base station transmitter. Good reception from the base station was possible over a fairly large area (25 km or so radius). Mobile transmitters, however, are limited in power, and therefore so-called 'satellite' receivers are used to receive the signals from the mobile unit and relay them back to the base station by paired cable or cable carrier system.

In other countries automatic mobile systems of varying capabilities and philosophy were introduced in the late 1960's and early 1970's. These countries included Sweden, France, Germany and Italy. The Swedish system, the MTB, utilized a philosophy similar to the MTS/IMTS of USA. All mobile units were automatically tuned to a 'marked-idle' channel. This idle channel would be used to establish a mobile-originated call or alternatively it could be used for an incoming call to a mobile unit (mobile-terminating call). When the marked channel became occupied, another channel would be marked and all mobile units would search for the new marked channel.

More advanced systems introduced into major cities in France and Italy used a dedicated signalling (or paging) channel for mobile terminating calls whilst the marked-idle system was used for mobile originated calls. These systems provided service in more than one radio zone, each operating with a given allocation of radio channels. However problems at zone boundaries existed if the user established a call in one zone and, during the course of conversation, his car was driven into another zone, the call suffered from low signal strength and eventually failed.

A further disadvantage of these systems as far as potential application in Australia was concerned was insufficient system capacity to meet projected demand. The number of radio channels available and accessible by a mobile set was 12, 16 or 24. Telephone traffic engineering theory tells us that given a particular grade of service objective, a limited number of users, each generating an expected level of traffic (calls) can be accommodated on a given number of circuits — in this case provided by radio channels. However, when the radio channels are divided into smaller groups and allocated to given geographic areas (radio zones), the traffic efficiency of the small groups of channels is less efficient therefore limiting the overall capacity. Hence the number of subscribers which can be served by a multi-zoned system is less than that of a single zone system, using the same number of radio channels.

While the problem of 'handing over' calls between zones was not yet solved, the disadvantage of system capacity was overcome to a great extent in a modern system introduced in Germany in 1972 (Ref 3) in which 40 radio channels were accessible by all mobile units. At the time this represented a significant step in technology. The system — the 'Netz B' was the first system in the world to offer service to customers over a whole national geographic area — in this case West Germany. The user was provided with a map of the country, which showed all of the radio zones. When initiating a mobile originated call, a customer first determines the radio zone in which his car is located. He then selects his zone identity number using a 'thumb-wheel' selection (or in later years a dial pad), then dials the desired telephone number. **Fig 6** shows a photograph of the mobile customers unit.

If a call is established in one Netz B zone and the cars travelled out of range into another radio zone, a drop in signal strength is experienced. System supervisory equipment monitors the level received at the base station from the mobile unit. If the level is below a given reference for more than a pre-set time (some 10 seconds) the call will be released.

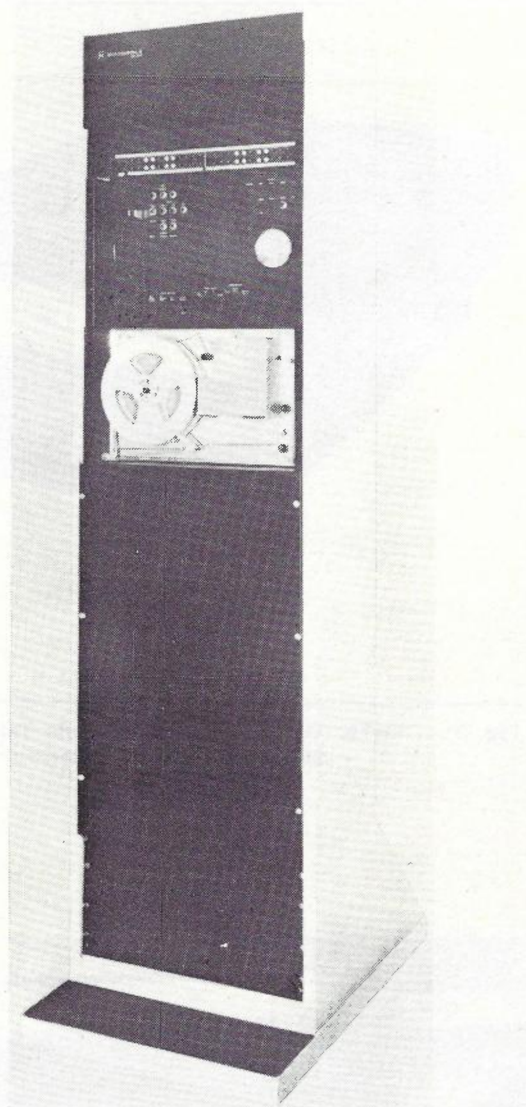


Fig. 5 — IMTS (USA) Automatic Mobile Telephone System Stored Program Controlled Terminal (1977).

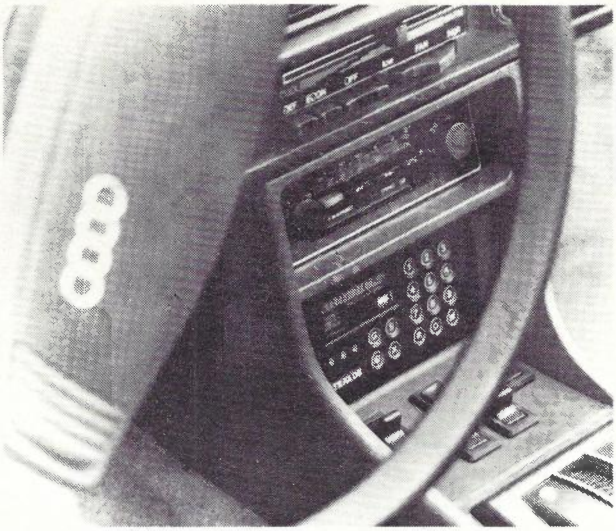


Fig. 6 — Netz B (W. Germany) Automatic Mobile Telephone System, First Introduced 1972 — Photograph shows a Mobile Unit available in 1976.

Research and Development into High Capacity Mobile Telephone Systems

The American Telephone and Telegraph Company (AT & T) research laboratories (Bell Laboratories) carried out research into the problem of designing a mobile system covering many radio zones yet providing service to a large number of subscribers. The system developed is the Bell 'HiCap' System or High Capacity Mobile Telephone System (Ref 4). The system operates in the 825-900 MHz band with 500 radio channels accessible by a mobile unit. Such a system proposed the utilization of a cellular type of zone structure, with 3 directional antennae located at zone boundaries — each directed inwards **(Fig 7)**. Field trials of this system were commenced in Chicago in 1977.

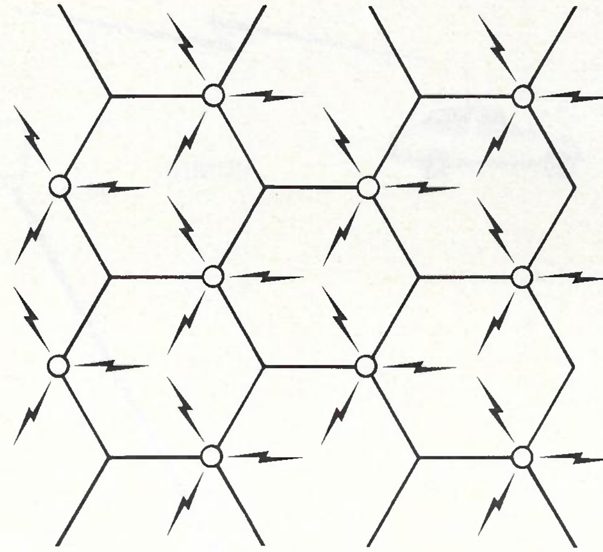
Meanwhile the Nippon Telephone and Telegraph Corporation (NTT) in Japan had commissioned manufacturers to develop a high capacity cellular system for Japan. Prototype equipment was developed and field trials were commenced in 1976 in Tokyo. The frequency band used in this system is also in the UHF (900 MHz) band.

SYSTEM DESIGN OF TELECOM'S NEW MOBILE TELEPHONE SERVICE (Refs. 5, 6)

General Factors Influencing the System Design

Against the background of mobile system development in overseas countries, the Australian requirement was examined. It was clear at the outset that the following factors applied in Australia:

- The demand in Australian cities for automatic mobile service necessitated design and provision of a larger system than was currently available on world markets.
- The UHF bands offered more potential capacity. Utilizing first the VHF band for an initial system was not preferred, as this would necessitate a move to UHF shortly after introducing the first system.
- Australian cities, being geographically large, required a number of radio zones. (See **Fig 8**).



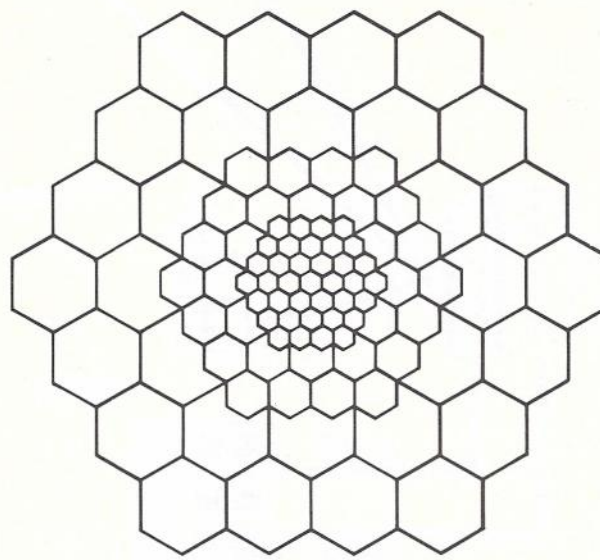


Fig. 7 — Future High Capacity 900 MHz Mobile Telephone System Cellular Zone Structure. Base stations are located at zone corners as indicated.

A number of choices were available in the development of systems technology. These included the following:

(1) An existing system could be expanded in capacity by increasing the number of channels or alternatively overlaying systems of smaller capacity.
(2) Up-dating of existing systems to enable some form of automatic zone hand-over during call progress at zone boundaries or areas of low signal strength.
(3) Adoption of the new high capacity systems of USA and in Japan — at the time not proven in field trials or cost.
(4) System design and specification of a new large-zone system in the UHF band of sufficient capacity to meet

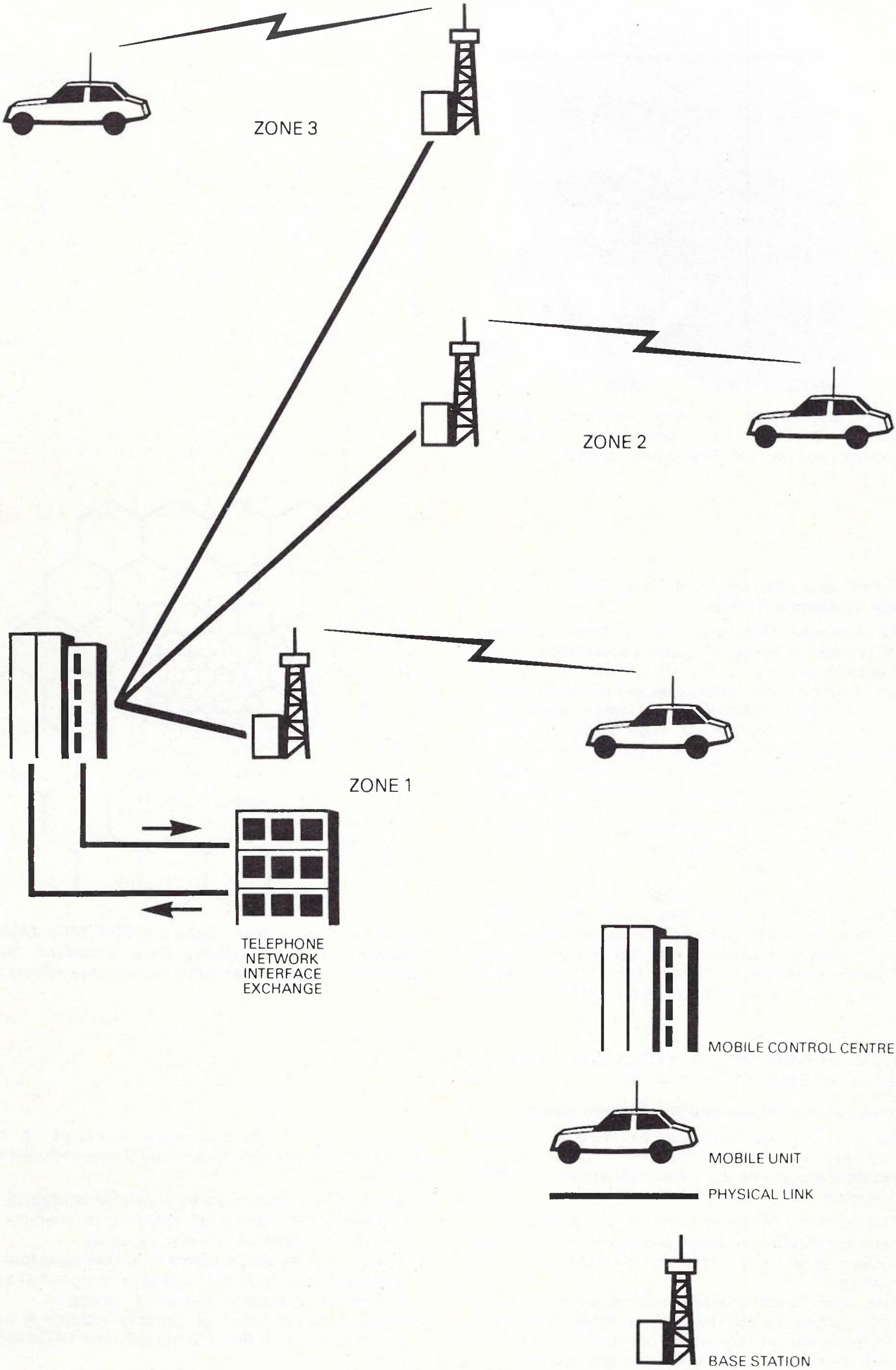


Fig. 8 — Large City Mobile Telephone System using 3 Radio Zones.

Country	System		Frequency Band (MHz)	Number of Channels	Duplex Spacing (MHz)	Channel Spacing (kHz)
US	IMTS	(VHF)	150	12	5	30
	IMTS	(UHF)	460	16	5	25
SWEDEN	MTB	(UHF)	460	4 or 8	—	—
ITALY	IMTP	(VHF)	160	32	5	25
FRANCE	PARIS 1 & 2	(VHF)	150	16	4.6	20
GERMANY	NETZ B	(VHF)	150	40	4.5	20

Table 2 — Automatic Mobile Telephone Systems in Service at the Time of Design of Telecom's New Mobile Telephone System

our requirements and utilizing the best possible customer facilities including, if possible, automatic zone hand-over.

Option (3) was examined in the first instance: High Capacity systems were attractive as they had more than enough capacity to meet Australian requirements — forever! However two factors rendered these systems inappropriate at the time (early 1976). Firstly, this type of system had not been tested either in service or field trial. Secondly, the shorter propagation range of the 900 MHz systems would necessitate a greater number of base stations than would a system at 500 MHz. Base station establishment and operating costs together with the cost of physical links to the mobile exchange form a very significant component of the overall system costs. Therefore this latter factor was critical to system profitability. For this reason the proposed introduction of such systems in Australia was deferred to the late 1980's.

At the same time it was known that Sweden was planning the development of a new large zone NORDIC system (Ref 7); however traffic studies showed that the capacity of our system would be larger than that of the planned 80 channel NORDIC system and also that of a new system planned by British Columbia Telephone Company in Canada. Further, the NORDIC system was a co-operative venture by Sweden, Norway and Denmark telephone administrations for implementation in their own countries, and at the time little or no system hardware had been developed.

Alternatively, options (1) and (2) were changes of such magnitude that effectively a total new design would be required.

If option (4) was to be the choice, we could not be sure of obtaining flow-on benefits from systems being proposed in overseas countries. Further, we may be dependent on variations in timetables in overseas administrations — clearly an undesirable situation.

Electronic Technology Development

On the practical design side, a new large scale mobile system would be successful only if the price of the mobile unit to Telecom customers was at a figure consistent with a satisfactory customer demand level. A mobile unit with the capacity and facilities required for the Australian market necessitated the application of micro-processors instead of hard-wired integrated circuit logic. However the application of CMOS in either the micro-processors or the associated memories were required to keep car battery consumption at low enough levels. At the time such a micro-processor was still not available, although it was expected to be available for application in the system.

On the radio side, the most significant development required was a frequency synthesiser of much larger capacity than had hitherto been developed for application in the 500 MHz band.

Development of prototype high capacity equipment for USA and Japan, together with hardware developments in Europe were sufficiently encouraging to support the adoption of the option to develop a new system for Australian requirements.

Number of System Channels

As indicated in the Appendix the expected traffic generated by automatic mobile telephone users was examined, and a range of 0.01 to 0.03 Erlang (E) per mobile telephone service was anticipated, comprising both originating and terminating traffic. These estimates included allowances for conversation traffic plus appropriate provision for call set-up, awaiting answer and ineffective calls. For example the value of 0.029 E comprises 0.02 conversation and 0.009 for the other factors indicated above.

Discussion with British Post Office staff during the course of the development of the system philosophy showed that awaiting dial-tone and dialling were wasteful and consuming of active system time and therefore system capacity. Calculations were subsequently made to show that the average traffic for each user could be reduced by 14% from 0.029 E to 0.025 E. That is, the system capacity could be increased by about 14% if dialling were performed prior to seizure of a radio channel. In operation then a user does not wait for and receive dial tone — the digits are first selected and displayed — then the call is initiated at the selection of the user. Dialling error would be reduced to negligible levels.

When designing a new telecommunication service or facility and the average traffic generated by each user is unknown, it is prudent to ensure that the service will provide an economic return whichever way the actual traffic levels eventuate. The pessimistic case is where the whole of the available system capacity is taken up by a smaller number of users each with a higher average level of traffic. Call charge revenue would be the same but fixed cost (rental charge) revenue would be lower than the case where a larger number of users each with a lower traffic level fill the system. For this reason the system design and economic evaluation was made on the basis of a higher expected traffic level of 0.025 E. If, however, service experience shows that the actual traffic

No. of Channels Accessible to Mobile Units (N)	No. of Systems Overlaid for 120 Channels	No. of Radio Zones in Service Area	Traffic per Zone for each N channel System (Erlangs)	Number of Mobile Services			
				0.025 Erlang		0.012 Erlang	
				Per Radio Channel	120 Radio Channels	Per Radio Channel	120 Radio Channels
12	10	1	7.95	26.5	3200	55.2	6600
		2	2.96	19.7	2400	41	4900
		3	1.52	15.2	1800	31.7	3700
		4	0.9	12	1400	25	3000
40	3	1	34.6	34.6	4100	72	8600
		2	15.26	30.5	3600	63.6	7600
		3	8.84	26.5	3200	55.3	6600
		4	6.22	24.9	3000	51.8	6200
		5	4.54	22.7	2700	47.3	5700
60	2	1	54.4	36.3	4300	75.6	9000
		2	24.8	33	4000	68.9	8200
		3	15.25	30.5	3600	63.5	7600
		4	10.63	28.3	3400	59	7100
		5	7.95	26.5	3200	55.2	6600
		6	6.22	25	3000	51.8	6200
120 (PREFERRED SYSTEM)	1	1	115.72	38.6	4600	80.4	9600
		2	54.4	36.3	4300	75.5	9000
		3	34.6	34.4	4100	72	8600
		4	24.8	33	4000	68.9	8200
		5	19.03	31.7	3800	66	7900
		6	15.25	30.5	3650	63.5	7600

Table 3 — Number of Mobile Services occupying 3 MHz Duplex Bandwidth for 0.05 Grade of Service, and Total Traffic 0.025 Erlang and 0.012 Erlang

level is lower, say 0.012 E, advantage can then be taken of the spare traffic capacity of the system by attracting more customers. The common equipment at the Mobile Control Centre (MCC) should therefore be dimensioned such that a correspondingly greater number of mobile services can be provided by the system should this latter situation eventuate.

Market surveys (Ref 8) carried out in capital cities against expected price levels for the service indicated a range of demand which, at the lower level of expectation, would fill the largest system which was technically feasible up to at least 50% occupancy within a short period of time. Against this background, the technical system alternatives were examined for provision of service in a multi-zone configuration. Given the upper limit traffic assumption of 0.025 E, a maximum available bandwidth for one system of 3 MHz, a RF channel spacing of 25 kHz and a maximum number of radio zones in a service area as 5 or 6, an examination was made to determine what system configuration was required. Table 3 shows the number of subscribers which can be served using an overall bandwidth of 3 MHz — using 'overlaid' systems of 12, 40 or 60 channels, against a single system of 120 channel capacity. It can be seen, that if the maximum number of customers to be served was to be around 4000, then a single 120 channel system was required.

It was concluded then, after consultation with industry, that a system capacity of 120 channels using off-air dialling facility for a multi-zone system of 5 or 6 zones would be specified to serve 4000 subscribers in a large capital city. Further, if the overall traffic levels realized in practice were lower than expected (say 0.012 E), then the system should have an ultimate potential capacity of around 8000 services.

Customer Facilities

The mobile unit facilities are described under 'System Requirements' (Ref 9).

A mobile telephone should provide to the user a service similar to that available to ordinary telephone network users. These include:

- Automatic dialled access to all telephone network customers — at present 9 decimal digits required.
- Access to Manual Assistance Operators and other services.
- International subscriber dialling (ISD) — at present up to 16 digits required.

Like ordinary network customers, a mobile network customer should be provided with network barring facilities by having an 'originating classification' status which he can select from one of the following:

- Open, including ISD;
- Open, ISD barred;
- Barred: ISD, STD and Trunk Operators;
- Barred: ISD, STD, Open: Trunk Operators.

Similarly a number of network terminating classifications are available for special requirements — for example a customer requests that the service be placed on interception in the case of malicious and nuisance calls.

Some facilities are unique to a mobile telephone service. These include the following:

Roaming facility — Mobile customers should be able to make and receive calls in any area in which service is provided, for example a resident of Melbourne should be able to use his mobile telephone in other regional areas, when available, and also other capital cities.

Service validation — A mobile unit may be the property of the customer, and may pass into other hands by sale or theft. A customer may wish to cancel his service from a certain date and time. Alternatively, he may not pay his mobile telephone network account and his service may lapse. Unlike a cable network service, a mobile service can be disconnected only by denying service on a call by call basis. This is effected by transmitting the mobile unit identity with each call initiation. The number is checked for validity in the system software. Similarly, calls to the mobile unit are subject to validation check. The validation operation is rapid and does not add any significant delay in call processing.

Paging and Access Channels

Early mobile telephone systems used the common radio channels for call set-up, using the 'marked — idle' technique referred to above. However when the number of the circuits available in the system is large, this technique is very inefficient. In this case dedicated paging and access channels are assigned in which data relating to call set-up information is exchanged between the moible unit/base station/mobile control centre (MCC).

Special consideration is required for the signalling in the paging and access channel. Unlike most terrestrial communications networks, signal to noise ratio is highly variable and hence data error rates will vary widely. The most critical requirement of these channels is to enable calls to be initiated by a mobile user under extreme ranges of error rate, so that there is a near zero probability that an error in transmission of data during call set up results in a customer being wrongly charged for a call. For example, if the 'calling line identification' of a mobile unit is received with a digit error by the MCC and accepted as a valid number. Even the most sophisticated coding structures — convolutional block coding, for example, can through multiple transmission errors due to noise, be subject to the case where an erroneous digit is interpreted and accepted. Such a probability may be very very low but could cause incorrect identification of a calling mobile unit. This probability of error can be reduced to near zero by the use of 'hand shaking'. That is, when a paging channel is seized by a mobile user for call initiation, and calling line identification is necessarily sent for validation and call charging purposes, the data received by the MCC is acknowledged by a hand-shake call directed back to the same mobile number as was interpreted by the MCC software. Should a data error occur in either transmission, the hand-shake and subsequent call set-up will fail. However in normal course of operation, service areas are designed such that call failure during call initiation or termination is a very unlikely event.

Special attention was therefore paid in the specifications to the capabilities of the paging and access channel signalling. It was anticipated that this signalling would be digital at a rate between 300 and 1200 baud using block error correcting coding and hand-shaking.

System Supervision (Automatic Monitoring of System Conditions to Ensure Correct Functioning)

A mobile radio telephone system requires a number of supervisory functions to ensure both good and continuous service to mobile customers, but also to ensure that call charging is efficient. The following are examples.

For Mobile Originated Calls

Time supervision is required to provide for disconnection of the radio channel after a predetermined time following detection of an invalid condition, eg —

- error in radio signalling sequences;
- calling mobile customer's number is invalid (in case of non-payment of account etc.);
- telephone network congestion.

For Mobile Terminated Calls

If the connection to a mobile customer becomes ineffective due to system mal-function, a time-out is required to prevent excessive use of radio channel time.

For Both Originating and Terminating Calls

After a call has been established, the radio carrier level may fall below acceptable limits. This could occur, for instance, when driving out of town, and going out of radio range. Of course in this case, the mobile unit cannot communicate with the base station, and therefore when a customer replaces the handset he cannot terminate the call. Such a condition shall be detected by the system and a time-out be applied after a suitable period, for example 10 seconds.

Mobile Telephone Numbering Plan

A unique national number is necessary to identify all mobile units, regardless of location — whether 'home area' operation or roaming.

A six digit mobile number gives flexibility to allocate number groups to 'home' areas in each Australian State.

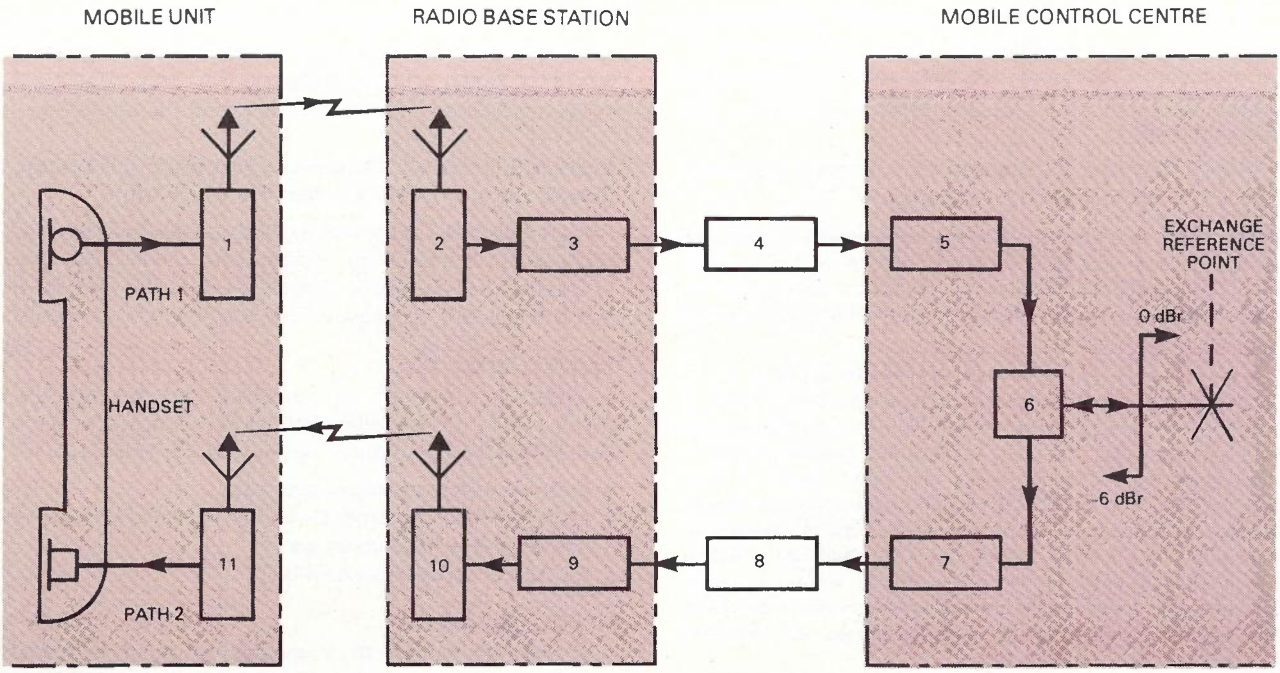
For access from the telephone network, an interface exchange is designated. Access to this exchange is obtained by dialling the prefix 007 for home area operation. To call a roaming mobile unit, a special number sequence is required commencing with digits 007 then followed by the number of the foreign service area plus the mobile customer's allocated number.

Call Charging — Local Automatic Message Accounting LAMA

A Mobile Control Centre must be equipped for Local Automatic Message Accounting and record the information listed below. Centralized Automatic Message Accounting must also be provided for future application.

For Mobile Originated Calls

- Mobile customer directory number;
- Mobile customer selected barring status;
- Called (B) party address digits;
- Time of day equipment seized;
- Time of day B party answer signal;
- Time of day clear forward signal sent;



PATH 1

1. Mobile transmitter incorporating modulation limiter.
2. Base receiver, incorporating V.F. noise performance monitoring.
3. Line amplifier*, transformer, pre-equaliser*.
4. Line.
5. Exchange equipment (transformer, equaliser, amplifier*, cabling, relay-set, loss adjustment).

PATH 2

7. Exchange equipment (transformer, cabling, relay-set, pre-equaliser*, etc.).
8. Line.
9. Constant-volume amplifier.
10. Base transmitter, incorporating modulation limiter.
11. Mobile receiver incorporating V.F. noise performance monitoring.

PATH 1 and PATH 2

6. 4-Wire-2-wire terminating set to Telecom Australia Specification No. 1020.

* This item may or may not be provided in an actual installation.

Fig. 9 — Hypothetical Voice-Frequency Reference Paths in a Mobile Telephone Service.

- Time of day receipt of congestion signal (if received);
- Date

For Mobile Terminated Calls

- Mobile customer directory number;
- Time of day for seizure and mobile B party answer;
- Time of day clear forward is received;
- Time of day B party clear signal (clear back)
- Date

Statistical Logging

In addition to call charging functions, the automatic message accounting system must log statistical data to enable the system operation to be monitored. Information to be logged includes:

- Individual radio channel seizure -- events and duration;
- Invalid operation attempts;
- Calls to unallotted mobile numbers (pirate operation attempts);
- Mobile unit busy;
- All channels busy;
- Call to mobile units unsuccessful.

Dial Tone

To a telephone network customer, receipt of dial tone signifies that the exchange register is ready to receive dialled digits. The mobile system specified uses 'off-air' dialling and dial tone is not appropriate. However, a 'network ready' signal is required from the interface exchange to indicate that the MCC should commence to pass on the mobile customers dialled digits.

Overall Transmission Performance

To ensure satisfactory speech levels into the mobile radio system, automatic level adjustment should be provided to voice frequency signals from the telephone network. A so-called 'constant volume' amplifier was specified for this purpose so that the mean speech level from the network was adjusted to the preferred level of −6dBr, where the subscript r indicates the relevant exchange reference level. To enable a constant volume amplifier to be designed it is necessary to specify attack and decay times plus the statistical variation in levels for successive calls from the telephone networks (assumed gaussian with a mean of −25.5 vu with a standard deviation of 5.5 vu.)

In the mobile unit handset, the preferred output from the microphone insert was −32 vu in 150Ω. At the point of inter-connection with the telephone network, the mean speech volume level over a range of customers using the mobile radio system was −12 vu.

Fig 9 shows a diagramatic representation of the elements affecting or controlling transmission performance.

Design of Radio Service Areas

An objective for the service area was to achieve more than a minimum performance figure for 90% of locations. One performance measure was 20 dB SINAD ratio — signal plus interference plus noise plus distortion to interference plus noise plus distortion represented as a demodulated audio frequency power ratio. The locus of points of minimum acceptable performance level would then represent the boundary of a service area. Service areas were designed by two methods:

- By computer prediction
- By field measurement

Computer prediction was based on modelling the service areas in detail ranging down to a grain size of several hundred metres square area. A given area was allocated a representative altitude. For various hypothetical base station locations, a computer printout of service area locii of constant received rf levels was obtained.

Extensive field strength measurements were carried out using a unique and sophisticated automatic field strength measuring set designed by Telecom Research Department.

The radio service areas are described in more detail in an associated article by Boland and De Jong in this issue of the Journal (Ref 9).

CONCLUSION

This paper has described the history of mobile radio development, a brief appraisal of current overseas mobile telephone systems and a look at research and development activities for future systems, thus providing a background to preparation of specifications for a new mobile telephone system for Australia.

Fundamental constraints were considered — those of radio frequency availability, limits of existing system technology, the demand in Australia for mobile telephone service and the demography of Australian cities.

April 1976	— Telecom commission policy approval to proceed to develop System Specifications and seek World-Wide Tenders
Feb. 1977	— Specifications completed
Mar. 1977	— Tender Schedule Issued
Sept. 1977	— Tenders Closed
July 1978	— Telecom Commission approval to develop the system
July 1979	— Contract to Manufacturers
July 1980	— First delivery of equipment for evaluation
Sept. 1981	— In Service Melbourne, followed by Sydney

Table 4 — Key Milestones in System Development

A summary of the main characteristics of the system is given together with the rationale leading to the system specification.

The system which has been developed and which is currently being placed into service to the timetable shown in Table 4, very closely meets all of the requirements of the original specification outlined in this paper.

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APPENDIX — TELEPHONE TRAFFIC CONSIDERATIONS FOR MOBILE TELEPHONE SYSTEMS

EXPECTED AVERAGE TRAFFIC GENERATED BY A MOBILE CUSTOMER

The first considerations in designing the configuration of a mobile system are the traffic generated by each user and the number of users. The expected traffic generated by Australian users of a new automatic mobile system is not known with any degree of certainty. However estimates from overseas are available as a guide — these range from 0.01 to 0.03 Erlang.*

Call statistics in Australia show that the average duration of a telephone call is around 115 to 120 seconds. If, for instance, an average user initiated or received six 120 second duration calls uniformly distributed over a ten hour day, the busy-hour traffic

* 1 Erlang is the telephone traffic which would be expected, on average, to fully utilize one circuit completely during any given statistical 'busy hour' (3600 seconds).

Operation	Time (s)	
Pre-dialling delay	2.5	13
Dialling (7 digits decadic)	10.5	
Post dialling delay	5	20
Speed of answer	15	
Conversation time and Clear-down	115	
Overall holding time — successful call	148	

Table A1 — Telephone Network Average Statistics: Effective Calls

Cause	% of all Calls	Overall Holding Time (s)
Pre-dialling delay		2.5
Mis-dialling or abandoned call attempt	7.5	13
Switching Loss	1.5	18
Plant Congestion	1	18
Called party busy	12.5	18
Called party does not answer	12.5	55
Average holding time — Unsuccessful call	35	32.5

Table A2 — Telephone Network Average Statistics: Ineffective Calls

generated would be 72 seconds corresponding to 0.02 Erlang conversation time. In a communication system which utilizes common channels for direct subscriber access, the overall traffic efficiency of the system is affected by the time the channel is seized before and after the conversation period. The time taken, for instance for the following telephone network activities is, on average, shown in Table A1.

Ineffective calls make up 35% of all call attempts in the Australian network. Table A2 shows cause and some statistics. It can be deduced, after making due allowance for call set-up times and ineffective calls, that the total traffic generated by 0.02 E conversation is 0.029 E. For a mobile originated call an additional 0.001 E is applicable due to access channel seizure during call set up yielding a total of 0.03 E.

A significant improvement in circuit efficiency can be achieved by adopting a system design in which both dialling and verification of the dialled number in a visual display is performed before call initiation (Off-Air Dialling). Tables A3 and A4 show expected holding times and probabilities of occurrence of events applicable to a system of this type.

The foregoing discussion on call holding times has focussed primarily on originating traffic. Mobile terminating traffic ie. calls from the telephone network to a mobile unit will cause a single paging signal to be transmitted by the relevant paging channel for the zone paged. This signal is transmitted in each zone of the service area and is repeated several times until the call attempt is released as unsuccessful, or alternatively the mobile customer responds. For an effective call the mobile customer answers by lifting the handset which would transmit a signal identifying the mobile customer directory number in the common access channel. A speech channel would then be allocated. For a system using such common channel signalling, the radio channel usage for terminating calls is predominantly for conversation time and clear down and can be approximated by the conversation time.

Early statistics from overseas indicated that mobile originated calls comprise 75% to 90% of all mobile calls whilst mobile terminated calls are around 10% to 30%. The rationale here is that the mobile customer uses his mobile telephone when he is in the vehicle (obviously). However, telephone network customers tend to call a mobile number only when they think the mobile customer can be contacted in his car — as this creates an uncertainty, mobile terminated calls are much less frequent than mobile originated calls. The total originating and

Operation	Time (s)
Post-dialling delay	5
Speed of Answer	15
Conversation and Clear-down	115
Overall holding time for a successful call	135

Table A3 — Telephone Network Average Statistics Applicable for a Mobile System using Off-Air-Dialling

Cause	% of all Calls	Overall Holding Time (s)
Switching Loss	1.5	18
Plant Congestion	1	18
Called party busy	12.5	18
Called party does not answer	12.5	55
Average holding time — unsuccessful time	27.5	34.8

Table A4 — Ineffective Call Statistics Applicable for a Mobile System using Off-Air-Dialling

terminating traffic can be calculated by weighted averages, and results indicate that a figure of 0.025 E is a reasonable upper limit.

For the purpose of calculating the system capacity in terms of number of mobile customers which can be served, the following was assumed:

- Total Originating and Terminating Traffic:
  0.025 E (upper limit)
  0.012 E (lower limit)
- Grade of service: 0.05
  (ie, probability of mobile system congestion)

System Description and Radio Coverage

J.E. BOLAND and H. de JONG

Telecom Australia is replacing the existing manual mobile telephone systems in Melbourne and Sydney with a fully automatic system providing all the facilities available to subscribers connected to the fixed telephone network as well as additional features. The Melbourne system went into operation in September 1981 and will be followed by the Sydney system. Each system will provide a service for about 4000 mobile customers on 120 radio channels.

The radio channels are distributed at base station sites selected to provide the required coverage throughout the nominated service area. The number of channels at each site has been determined from a study of the expected coverage from each site, the expected number of subscribers likely to require service during the busy hour within this area, and the need to provide a reasonable grade of service while ensuring the economical use of the radio spectrum.

This article will describe briefly the overall configuration of the system, the signalling procedures used in establishing calls and the functions of the major components which comprise a Mobile Control Centre, the base station network and the mobile unit installed in the customer's vehicle. The aspects considered in determining the radio utilization plan and coverage are outlined and a description is given of the base station and mobile radio equipment used in the system.

INTRODUCTION

In 1977 Telecom Australia called tenders for the supply and delivery of equipment for a public automatic mobile telephone system providing a service for at least 4000 mobile customers. Telecom studies indicated that an economical system with a capacity between 1000 and 10 000 customers could be provided using medium size radio zones in the 500 MHz frequency band. Following tender analysis and economic viability studies, a contract was placed in 1979 with the Nippon Electric Company (Australia) Pty Ltd for two systems, one in Melbourne and one in Sydney.

These systems were to be initially equipped with sufficient radio channels for 1000 customers and be capable of progressive expansion up to a maximum of 120 channels which would be suitable for about 4000 customers. The Melbourne service commenced operation in September 1981 and will be followed later by the Sydney service. Included in the order was a model of the stored programmed controlled Mobile Control Centre (MCC) to be used for initial system evaluation and the production of software programmes for the operating systems, and also to provide a software national support centre in Australia.

SYSTEM REQUIREMENTS

The mobile telephone customer should have all the facilities that are available to the normal telephone customer. The basic requirements of Telecom's MTS system are shown in Table 1. To achieve these requirements in a mobile environment, the mobile subscriber's set (MSS) has to be provided with a certain amount of intelligence to assist in establishing and maintaining a telephone conversation, with the result that the cost of the MSS unit becomes a significant proportion of the overall system cost.

The handset shown in **Fig 1** was specially designed to meet the Telecom requirements as listed in Table 2. This handset, in addition to the normal receiver and trans-

Service Area — Melbourne and Sydney Telephone Districts
No. of Customers — 4000 to 8000 depending on customer traffic
Dialling access to:

- All numbers in the Australian Telephone Network
- All Manual Operators
- All ISD numbers

Simultaneous bothway speech
One call allocated to one channel at one time
Record of call information for charging purposes
Choice of originating classification
Choice of terminating classification for network use
Ability to roam to other service areas and make and receive calls
'Hand off' of Telephone call between radio zones.

Table 1 — System Requirements

Fig. 1 — Customer Handset Unit

Push Button Control
Visual Display of Called Number
Repertory Dialling — Sixteen 16-Digit Numbers
Automatic Recall of Last Number Dialled
On-Hook Call Initiation
Illuminated Control Panel
Power "On" Indication
Out of Range Indication
Control Lock Operation

- Off
- Incoming Calls Only
- Choice of 2 Originating Classifications
- Memory Store Access.

Table 2 — Customer Facility Requirements

mitter inserts, incorporates a LED dial number display, numeric dial pad and function keys and a microprocessor to simplify the signalling with the boot mounted transceiver unit. The cradle unit incorporates a control lock and a speaker which allows monitoring of call initiation progress while the handset is 'on-hook'. Further, an optional auxiliary call alert facility is provided which allows the customer to connect an external alarm, such as the horn or headlights of the car, to indicate an incoming call. This is useful for a user who is near, but not in, the car. This facility operates for a period of 10 seconds only. The handset and cradle are mounted in a convenient location on the vehicle dash or control console according to customer preference.

Each customer has the choice, under key control, of any two of the following four originating classifications:

- Unrestricted Access.
- Access to local area, manual assistance operators, and STD, but barred access to ISD.
- Access to local area and operators but barred access to STD and ISD.
- Access to local area only.

This choice together with the customer's telephone number is programmed into an identity code read only memory (ROM) which is fitted to the transceiver unit during installation in the vehicle.

The customer can make and receive telephone calls anywhere within the home service area and be able to roam to a foreign service area and still obtain automatic access to the network. That is, a Melbourne registered customer can initiate and receive calls when he roams or moves into the Sydney Service area.

A special closed numbering scheme with an 007 access code has been developed for the mobile system. As shown in **Fig 2**, additional digits must be inserted in a mobile customer's number to contact him in a foreign service area and so a roaming customer must advise intending callers of their whereabouts in order to receive calls.

HOME AREA NUMBERING PLAN

007 C_1D_1 x $Y_1Y_2Y_3$

Where 007 is mobile access code
C_1D_1 is home area code
x any digit in range 1 to 9
Y_1-Y_3 any digit in range 0 to 9

FOREIGN AREA NUMBER

007 C_2D_2O C_1D_1 x $Y_1Y_2Y_3$
Where C_2D_2 is the foreign area code
O indicate a roaming customer
other digits as for home number
e.g. to dial a Melbourne mobile in Home Service Area
007 331234
To dial Melbourne mobile in Foreign Service Area (Sydney)
007 210 331234.

Fig. 2 — Mobile Telephone Numbering Scheme

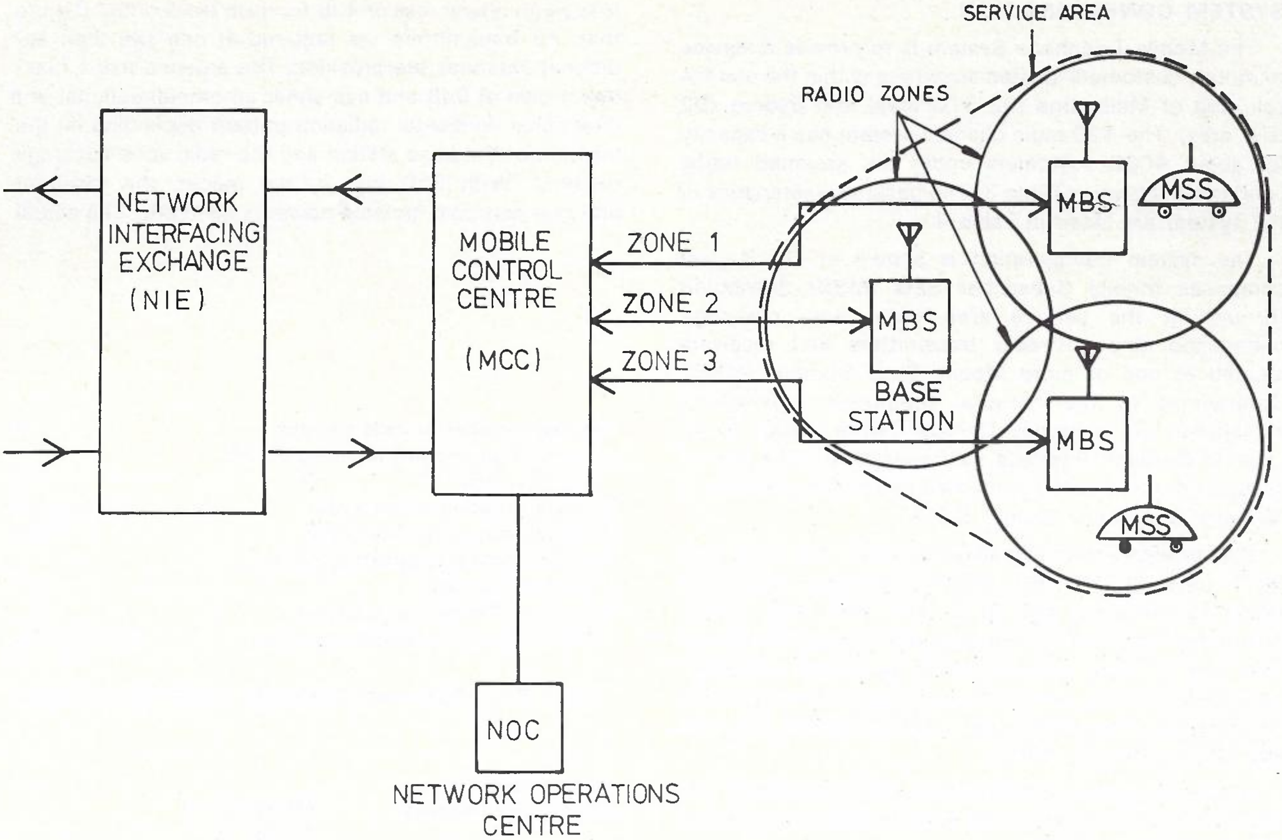


Fig. 3 — MTS System Configuration

J. E. BOLAND (left) is Principal Engineer in the Customer Section of the Radiocommunications Construction Branch, Telecom Australia Headquarters. In 1960 he completed the Diploma of Radio Engineering at RMIT under the RAAF Apprentice Scheme and was involved in the installation of communication and navigational aid equipment. In 1966 he joined the Headquarters Radio Section of the PMG Department and occupied a number of positions involved in the design and provisioning of broadband microwave radio relay systems. Since 1976 he has been involved with, and is currently project manager of, the public automatic mobile telephone project.

H. de JONG (right) graduated from Monash University in 1971 with a Bachelor of Engineering (Hons) (Electrical) degree and was appointed an Engineer Class 1 in the Headquarters Radio Section of the Postmaster General's Department. In 1973 he was appointed an Engineer Class 2 and was involved in the design and provisioning of HF Subscribers' Equipment, Small Capacity Radio Telephone Systems, Telecom Mobile and Public Automatic Mobile Telephone Systems (MTS). Since late 1979 he has been acting Senior Engineer, MTS Project.

SYSTEM CONFIGURATION

The Mobile Telephone System is to provide a service to mobile customers located anywhere within the unit fee call area of Melbourne (03 STD area) and Sydney (02 STD area). The 120 radio channel system has a capacity for about 4000 customers under the assumed traffic conditions shown in Table 3. The basic characteristics of the system are listed in Table 4.

The system configuration is shown in **Fig 3**, and comprises Mobile Subscriber Sets (MSS) distributed throughout the service area with radio coverage maintained through radio transmitters and receivers located at one or more Mobile Base Stations (MBS). Connection to the national telephone network is established via a Mobile Control Centre (MCC) to an existing Network Interface Exchange (NIE). The overall system can be remotely controlled and maintained from a Network Operations Centre (NOC).

Call establishment signalling between the MSS and MCC uses 300 bit/sec digital signalling while the signalling between the MCC and NIE uses Multi-Frequency Code (MFC) signalling for mobile terminated calls and VF touch tone signalling for mobile originated calls. Details of the network signalling procedures will be described in a separate paper to be published in a later issue of the journal (Ref 1).

A detailed system block diagram of a typical MBS, the MCC and NOC is shown in **Fig 4** and a brief description of the equipment follows.

Mobile Subscriber Set

The MSS consists of three main units, the boot mounted transceiver unit, the customer handset unit and the antenna, together with interconnecting cables and mounting hardware. The local oscillator frequency for the UHF transmitter/receiver is provided by a programmable frequency synthesizer incorporating voltage controlled oscillator and phase locked loop. The MSS is normally monitoring the paging channel frequency when not in use, and automatically transmits and receives the coded signalling information through the MBS to the MCC equipment during call establishment procedures, and changes to selected speech and access channels as required. The signalling and channel switching is controlled by a microprocessor based on the Intel 8085.

Mobile Base Station

The MBS provides radio coverage with a range of from 20 to 30 km radius, depending on the surrounding terrain, and is the radio frequency interface between the MSS and MCC. Up to 15 different base stations can be connected to the one MCC to ensure adequate coverage is achieved within the service area. The MBS equipment also monitors the received field intensity (FI) and sends information to the MCC for selection of the MBS with the highest FI thus ensuring an acceptable quality for the speech path.

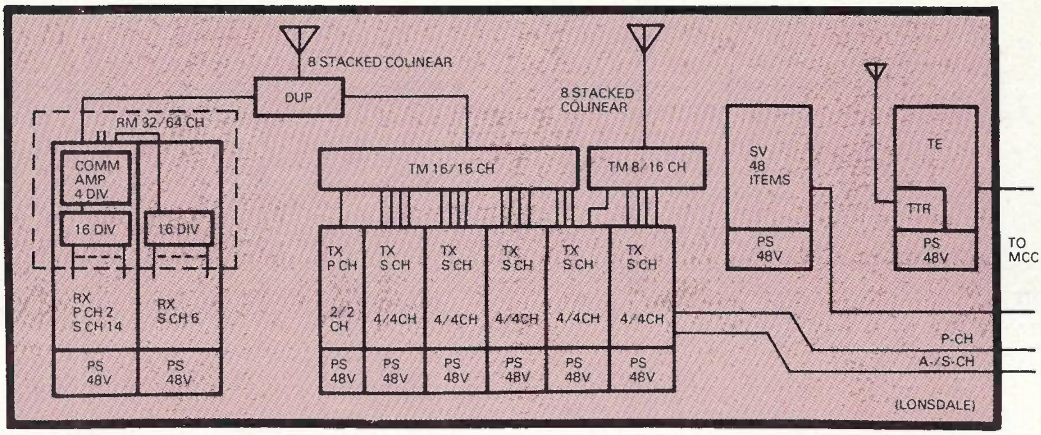
The base station comprises dedicated paging channel transmitters and receivers equipped in a main and stand-by configuration plus sufficient speech and access transmitters and receivers to provide the number of radio channels required in that zone as determined by the expected traffic distribution. Up to 16 transmitters and 64 receivers can be multiplexed onto one antenna with a maximum power loss of 4dB for each transmitter. If more than 16 transmitters are required at one site then additional antennas are provided. The antenna has a maximum gain of 9dB and has either an omnidirectional or a directional horizontal radiation pattern depending on the location of the base station and the radio zone coverage required. With 3dB loss in the feeder, the resultant effective isotropic radiated power is 83 Watts. The actual

Average number of calls per day	6
Probability of one call occurring during the busy hour	0.1
Average duration of each call	120 seconds
Grade of Service in Busy Hour	0.05
Ratio of Mobile Originating Calls to Terminating Calls	3:1
Busy Hour Traffic per customer (Including call establishment time)	0.025 Erlang

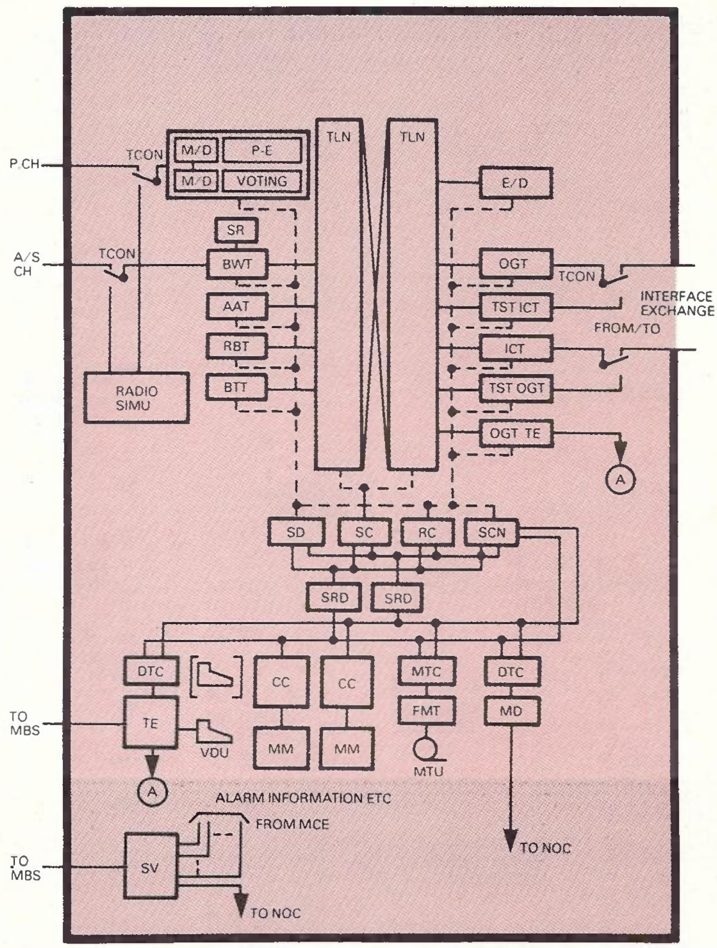
Table 3 — Assumed Customer Traffic Conditions

Service Area	
Number of radio zones	Melbourne : 3 Sydney : 5 Maximum 15 per system
Size of Zone	20-30 km radius depending on terrain
Radio Frequency	
Number of channels	120
Base Transmit band	501-504MHz
Mobile Transmit band	511-514MHZ
Channel spacing	25kHz
Duplex spacing	10MHz
Transmitter Power	Base Station 25 W Mobile Unit 10 W
Modulation	Speech — Phase modulation Data — Frequency modulation
Radio Signalling	
Type	300 BPS Manchester coded digital
Error Correction	BCH (44,32) 1 bit correction, 2 bit detection Recycling of word — maximum 4 times.
Mobile Control Centre	
Full Stored Program Control	16 bit word length duplicated central processors and memory
Reed Relay Switch Matrix	512 x 512 (max) inlet/outlets
Network Interface	
Originating Calls	4 routes (1 per originating classifications) VF touch tone signalling ARE-11 interface exchange
Terminating Calls	1 route MFC signalling 10C interface exchange

Table 4 — System Characteristics

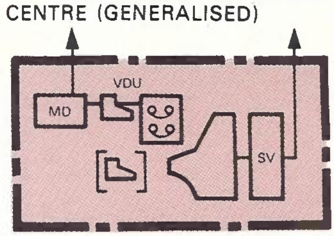


TYPICAL BASE STATION



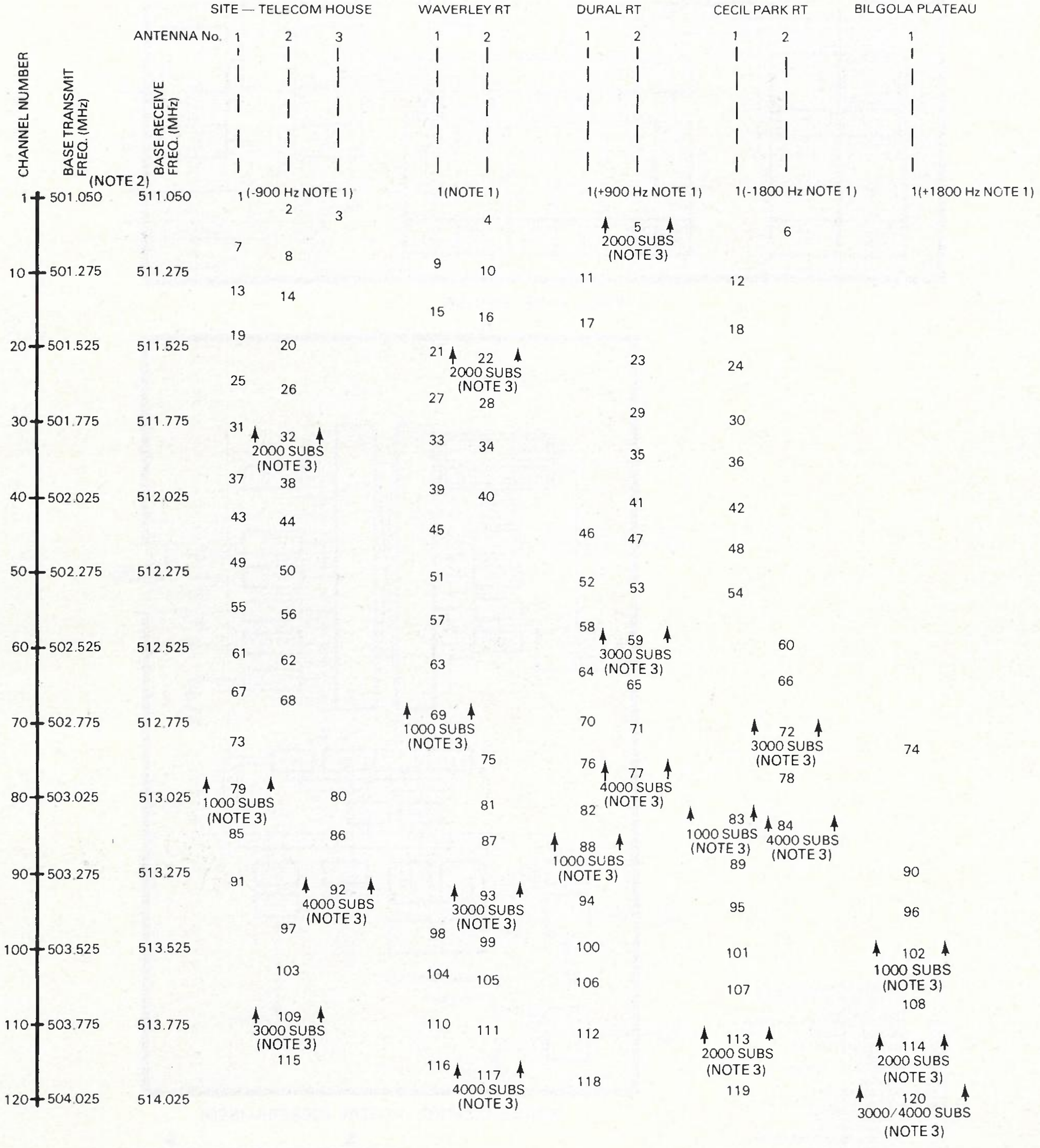
MOBILE CONTROL CENTRE (GENERALISED)

TM	TRANSMITTER MULTIPLEX
SV	SUPERVISORY EQUIPMENT
TE	TEST EQUIPMENT
TTR	TEST TRANSMITTER/RECEIVER
DIV	ANTENNA DIVIDER
RM	RECEIVER MULTIPLEX
DUP	DUPLEXER
TLN	TRUNK LINE NETWORK
M/D	MODEMS
P-E	PAGING ENCODER
E/D	ENCODER/DECODER
SR	SIGNAL RECEIVER
BWT	BOTH WAY TRUNK
AAT	AUTOMATIC ANSWER TRUNK
RBT	RING BACK TRUNK
BTT	BUSY TONE TRUNK
OGT	OUT GOING TRUNK
ICT	INCOMING TRUNK
SD	SIGNAL DISTRIBUTOR
SC	SWITCH CONTROLLER
RC	RELAY CONTROLLER
SCN	SCANNER
SRD	SIGNAL RECEIVER & DISTRIBUTOR
CC	CENTRAL CONTROLLER
MM	MAIN MEMORY
MTC	MAGNETIC TAPE CONTROLLER
DTC	DATA TRANSMISSION CONTROLLER
FMT	FORMATTER
TCON	TEST CONNECTOR
MTU	MAGNETIC TAPE UNIT



NETWORK OPERATION CENTRE

Fig. 4 — MTS System Block Diagram



NOTE 1 CHANNEL 1 IS PAGING CHANNEL COMMON TO ALL ZONES AND HAS A FREQUENCY OFFSET IN EACH ZONE AS SHOWN WAVERLEY HAS NO OFFSET

2 CHANNEL FREQUENCIES COMMENCE AT 501 050 MHz BASE TRANSMIT AND 511 050 MHz BASE RECEIVE FREQUENCY SPACING BETWEEN CHANNELS IS 25 KHz

3 UP TO 16 CHANNELS ARE CONNECTED TO ONE ANTENNA WITH THE NUMBER OF ANTENNAS INSTALLED AT EACH SITE DEPENDING ON SUBSCRIBER CAPACITY CHANNEL REQUIREMENTS FOR SUBSCRIBER CAPACITY IN 1000 SUBSCRIBER INCREMENTS ARE INDICATED FOR EACH SITE, BY SHOWING THE SUBSCRIBER GROUP WITH CHANNELS ALLOCATED, LISTED ABOVE, FOR EACH ANTENNA

Fig. 5 — RF Channel Arrangement — Sydney

RF channel allocation at each site is determined by the minimum frequency spacing allowed by the antenna multiplex filters and the number of channels required by each MBS. The Sydney RF channel assignment is shown in **Fig 5**.

Mobile Control Centre

The MCC (Ref 2) basically comprises a stored programmed controlled (SPC) switching system developed from the NEC ND20 switching system, and equipped with additional encoding and decoding (E/D) devices for signalling to and from the MSS, and also mobile radio 'voting' equipment which is used for selection of the MBS with the highest FI in establishing calls. The MCC equipment, realised in both hardware and software, is used basically for:

- switching radio channels to the incoming or outgoing trunks connecting to the national telephone network
- storing call charge records (CCR) on magnetic tape for accounting purposes
- storing of system office data (number of MBS, number of channels at each MBS, RF channel number, number of trunks, etc)
- system management.

Supervisory and Test Equipment

All the equipment is designed to be operated at unattended sites and a telesignalling supervisory system (SV) is provided to relay MBS and MCC alarms back to a centralised monitoring position. In addition special microprocessor controlled system test equipment (TE), including a fixed Test Mobile Unit (TTR) installed at each MBS, is provided to allow test calls to be set up on any channel to check radio equipment characteristics and signalling procedures.

RADIO CHANNEL UTILIZATION

Radio channels used in the system are divided into either control channels or speech channels. The Speech channels (S-ch) are distributed on different frequencies throughout the base stations with the quantity at each base determined by the vehicle traffic density in each zone, and the radio zone coverage as described in a later section of this paper. Two different types of control channels are provided, one a dedicated Paging channel (P-ch) which transmits simultaneously from each MBS on the same nominal frequency, and the second called an Access channel (A-ch) which is a nominated speech channel on a different frequency in each zone.

The P-ch is used:

- to establish calls from the network and terminating at the MSS.
- to 'hand off' an established call to a MBS with a higher F1 than the MBS in use when the call quality has deteriorated below a set level.
- to advise the MSS of the nominated speech channel allocated as an access channel in each zone.

The paging channel transmitters are fitted with high stability oscillators (1×10^{-7}) with specific frequency offsets between base stations.

The A-ch is used as the control channel and for radio

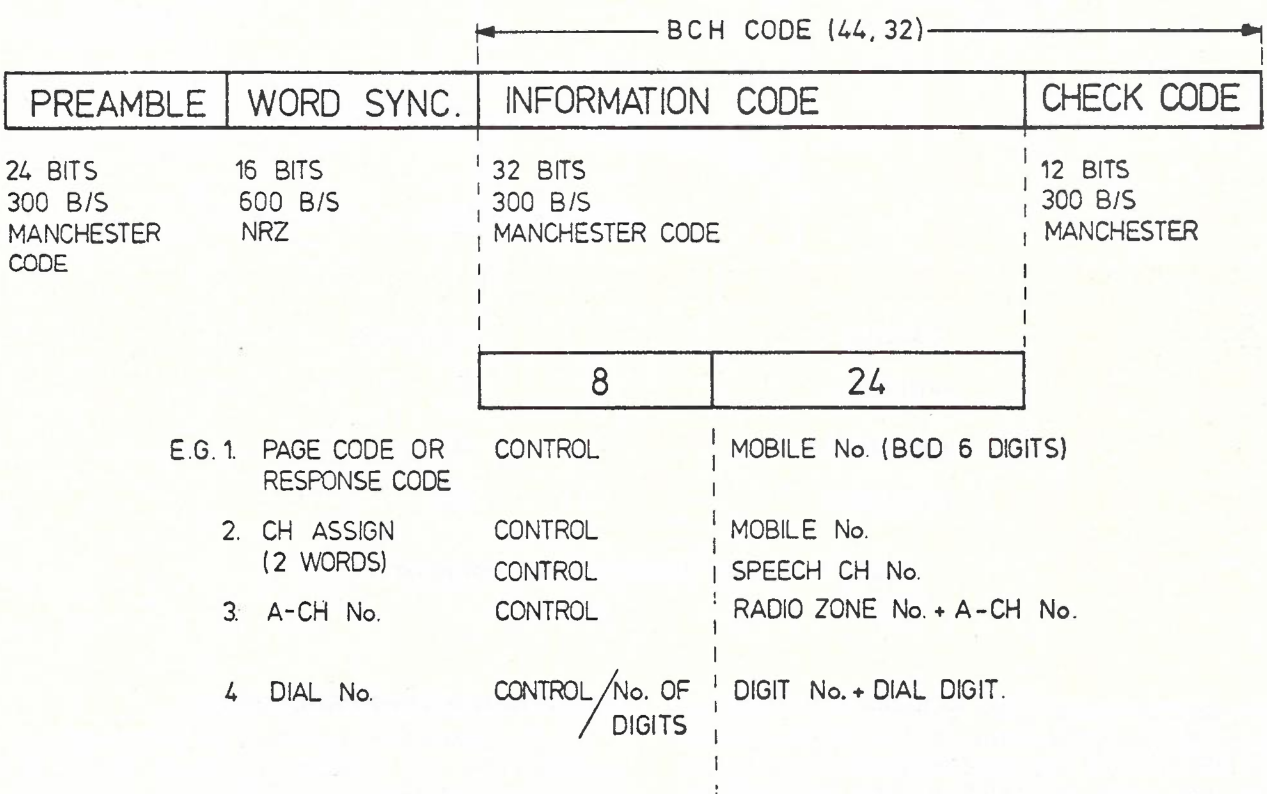
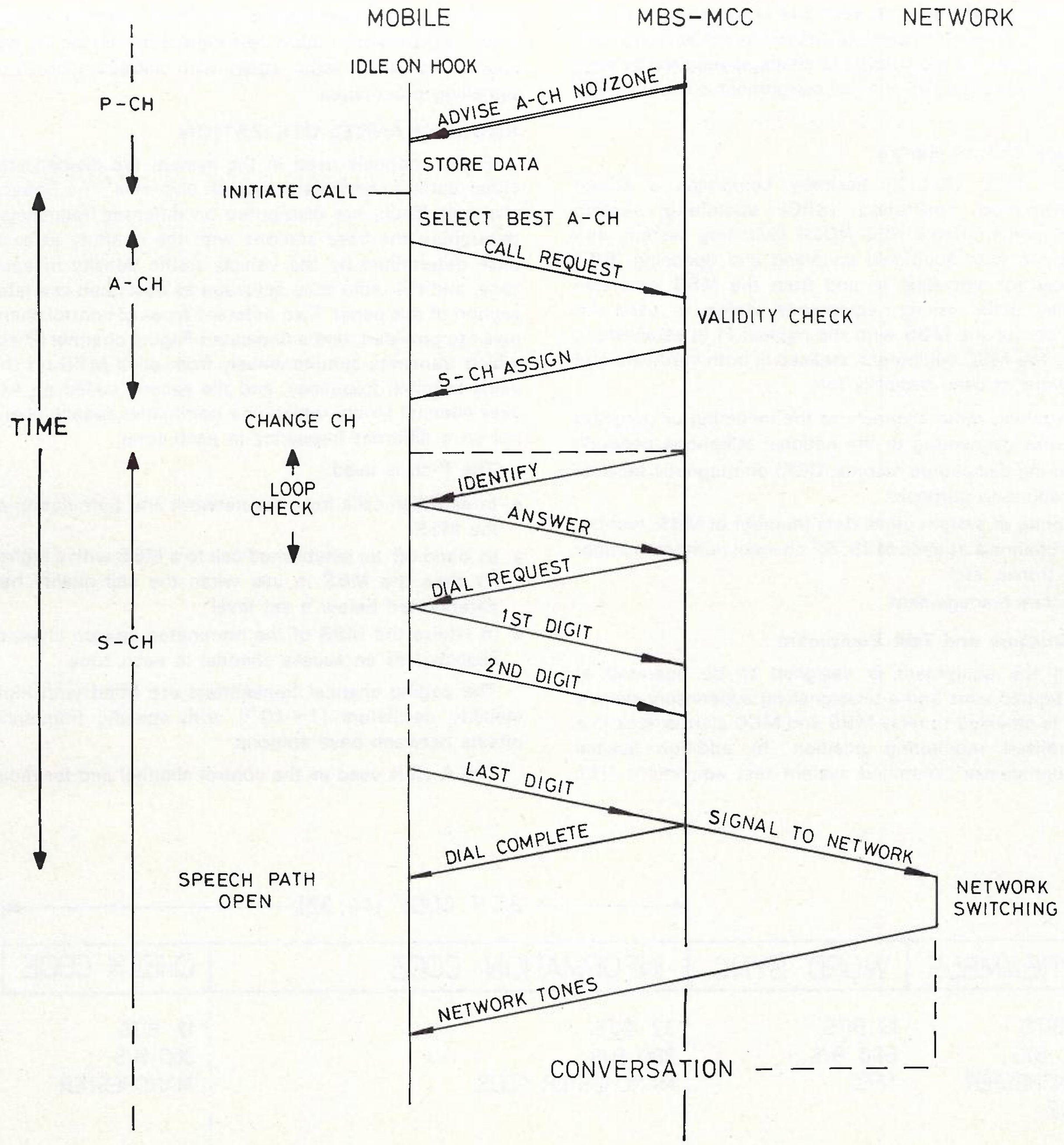


Fig. 6 — General Radio Code Format



TIMING:	SECONDS
MINIMUM	5
AVERAGE	8·5
MAXIMUM	30

Fig. 7 — Mobile Originating Call Procedure

zone selection during mobile originating calls. The A-ch can be used as a speech channel when all other S-ch in that MBS are busy and, when this occurs, the next S-ch to become idle in that MBS is allocated as the MBS A-ch. All mobiles are then advised of the change in A-ch frequency over the P-ch.

RADIO SIGNALLING PROCEDURES

The data transmitted to and from the MSS during call establishment and clearing procedures consist of 'Manchester' coded digital signals (Ref 12) transmitted at a rate of 300 bit/second. High reliability is achieved by using error control and recycling of transmission. A BCH

(44,32) word code (Ref 12) allowing 1 bit error correction and 2 bit error detection is used against random errors while re-cycling of each data word, up to 4 times, is used against bursts of errors. The general code word format is shown in **Fig 6.** Data signals on the P-ch, in the MBS to MSS direction, is transmitted using direct FSK modulation while all other channels transmit data signals using sub-carrier FSK modulation.

Call establishment procedures for both mobile originated and mobile teminated calls are shown in **Fig 7** and **Fig 8** respectively.

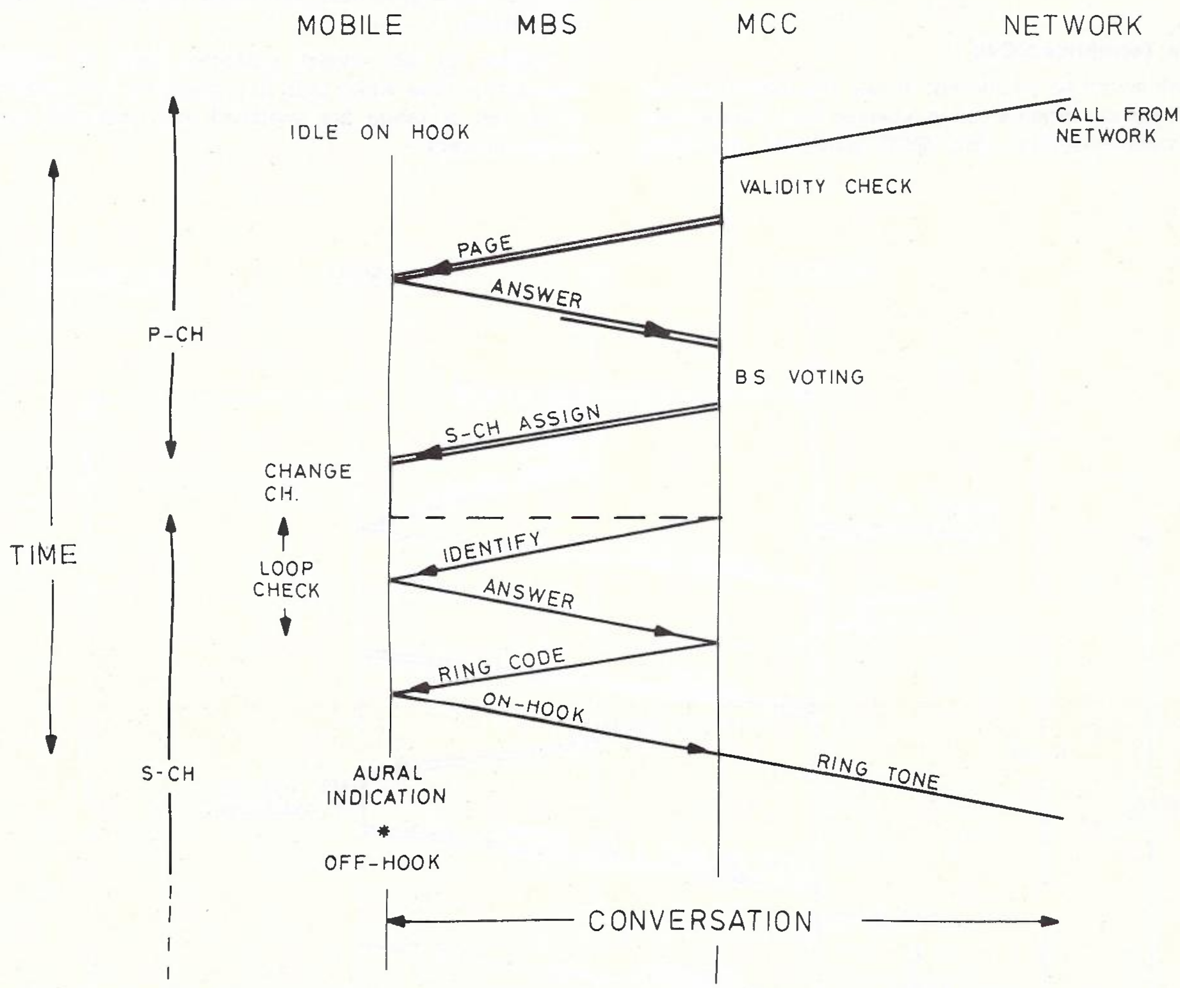
Mobile Originating Call

The mobile customer enters the required telephone number via the dial pad and presses the send (SD) button. The MSS automatically scans each of the A-ch as advised via the P-ch and selects the A-ch with the highest FI. If an idle code is received on that A-ch, ie. no other MSS is using it, the MSS transmits to the MCC via the MBS its identification code (ID Code) which includes the originating classification as selected under key control by the mobile customer.

Providing the number is valid, one of the free S-ch in the MSS radio zone identified by the A-ch, is selected by the MCC and advised over that A-ch to the MSS. The MSS will then switch to the nominated S-ch.

The MCC after a short delay will transmit the MSS identification number over the S-ch and if the MSS has correctly locked onto that channel, the MSS will send the ID code to the MCC thus completing a loop check.

The MCC then requests the dial information from the



TIMING:	SECONDS
MINIMUM	3
AVERAGE	6
MAXIMUM	13

Fig. 8 — Mobile Terminating Call Procedure

MSS and if received correctly will send a 'dial complete' code, or it will send a 'dial repeat' code if errors are detected.

The dial information is then signalled to the NIE on an outgoing trunk route determined by the originating classification, and if the required telephone B-party (viz the called party) number is in accordance with that classification, the call is processed through the telephone network.

While the signalling procedure is taking place the mobile customer hears a locally generated call assurance tone followed by normal network tones, eg ring tone, busy tone, etc, indicating progress of the call.

The processing time to set up the mobile originated call (excluding network post dialling delay) is a minimum of about 5 seconds when no data word recycling occurs, and up to a maximum of 30 seconds in the unlikely case when every data word is re-cycled the maximum of 4 times.

Mobile Terminated Call

When switched on and not in use, the MSS is locked on to the P-ch. When a call is received from the network to a valid customer, the MCC transmits the MSS identification number over the P-ch simultaneously from all base stations.

The MSS, whose number coresponds to that ID code, will send the response code on the P-ch. Each base station within range forwards the response code, with FI information, to the P-ch voting equipment at the MCC.

The MCC determines the base station with the highest FI and transmits a S-ch assign code via the P-ch to the MSS. If a free S-ch is not available at that MBS then a S-ch is selected from the MBS with the second highest FI. The MSS will then switch to the nominated S-ch.

The MCC after a short delay will transmit the MSS identification number over the S-ch and if the MSS has correctly locked onto that channel, the MSS will send the ID code to the MCC thus completing a loop check.

The MCC then sends the ring code which will initiate a locally generated ring tone at the MSS. When the handset is removed from the cradle, conversation will be established.

Callers to an invalid customer hear a number unavailable tone while calls to a customer not switched on or out of range are switched to a recorded voice announcement.

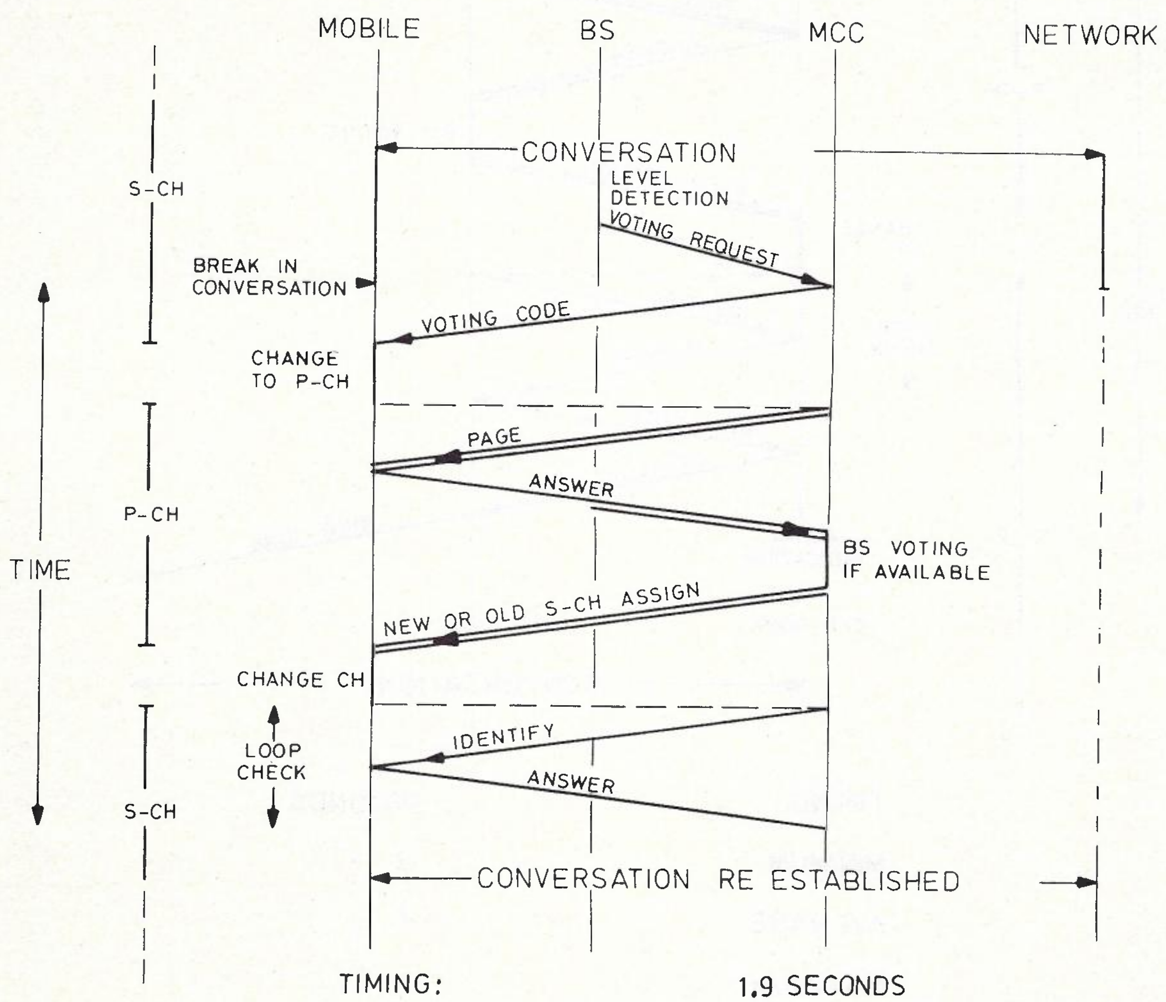


Fig. 9 — Base Station Handoff Procedure

Hand off Procedure

Once a call is established, the quality of the conversation is checked by monitoring the FI levels of the S-ch at the MBS. If the FI falls below a set value an attempt is made to find another base station that has a field intensity level at least 5dB better. The signalling procedure for this process which is called 'hand off' is shown in **Fig 9** and described below.

The base station signals to the MCC when the received FI on the S-ch falls below a set level. The MCC closes the speech path and commands the MSS to switch to the P-ch for voting.

The mobile sends a voting response code via the P-ch which is received by all base stations within range. The base stations add the FI information and send it to the MCC for voting purposes.

If the MBS in use has the highest FI level, or if the FI level of the MBS with the highest FI level is less than 5dB greater than the MBS in use, 'hand off' will not proceed and the conversation is re-established on the old

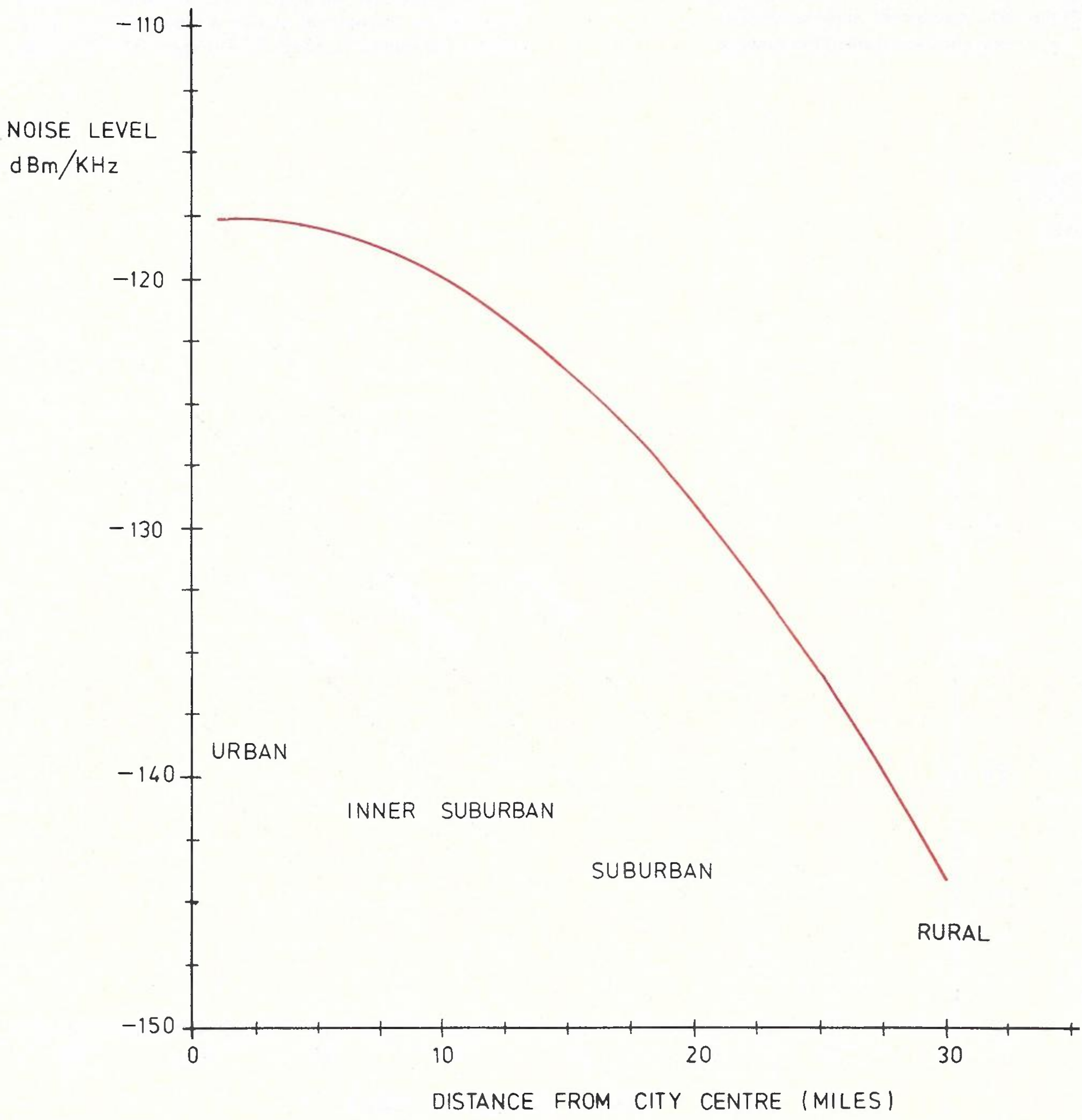


Fig. 10 — Noise Levels in Metropolitan Area

speech channel. 'Hand off' will occur if there is an MBS with a FI level greater than 5dB above the FI level of the MBS in use and a free speech channel is available.

The break in conversation while the above process is being carried out is about 1.9 seconds during which a tone is generated by the MSS to indicate to the mobile customer that 'hand off' is occurring. The land subscriber has a break in the conversation but a tone is not heard.

DETERMINATION OF RADIO BASE STATION SITES

The determination of the number and location of the radio base station sites depends on:

(1) the service area required
(2) the signal-to-noise objective
(3) the site and external radio noise levels
(4) the radio equipment parameters, viz:
- mobile and base transmitter powers
- antenna gains, transmit multicoupler and feeder losses
- receiver noise figures

(5) the site availability (established Telecom sites preferred).

Service Area

The area requiring coverage by the MTS is the Melbourne Telephone District and the Sydney Telephone District. In this area the service must be operable for at least 90% of the locations and 90% of the time.

Signal-to-Noise Objective

At the present time no objective or standard exists for the noise performance of network connected mobile radio telephone equipment. However CCIR Rec 339-3 (Ref 3) states that the audio signal-to-noise ratio (S/N) for marginal commercial quality is 15dB and for good commercial quality is 33dB. CCIR Report 352-2 (Ref 4)

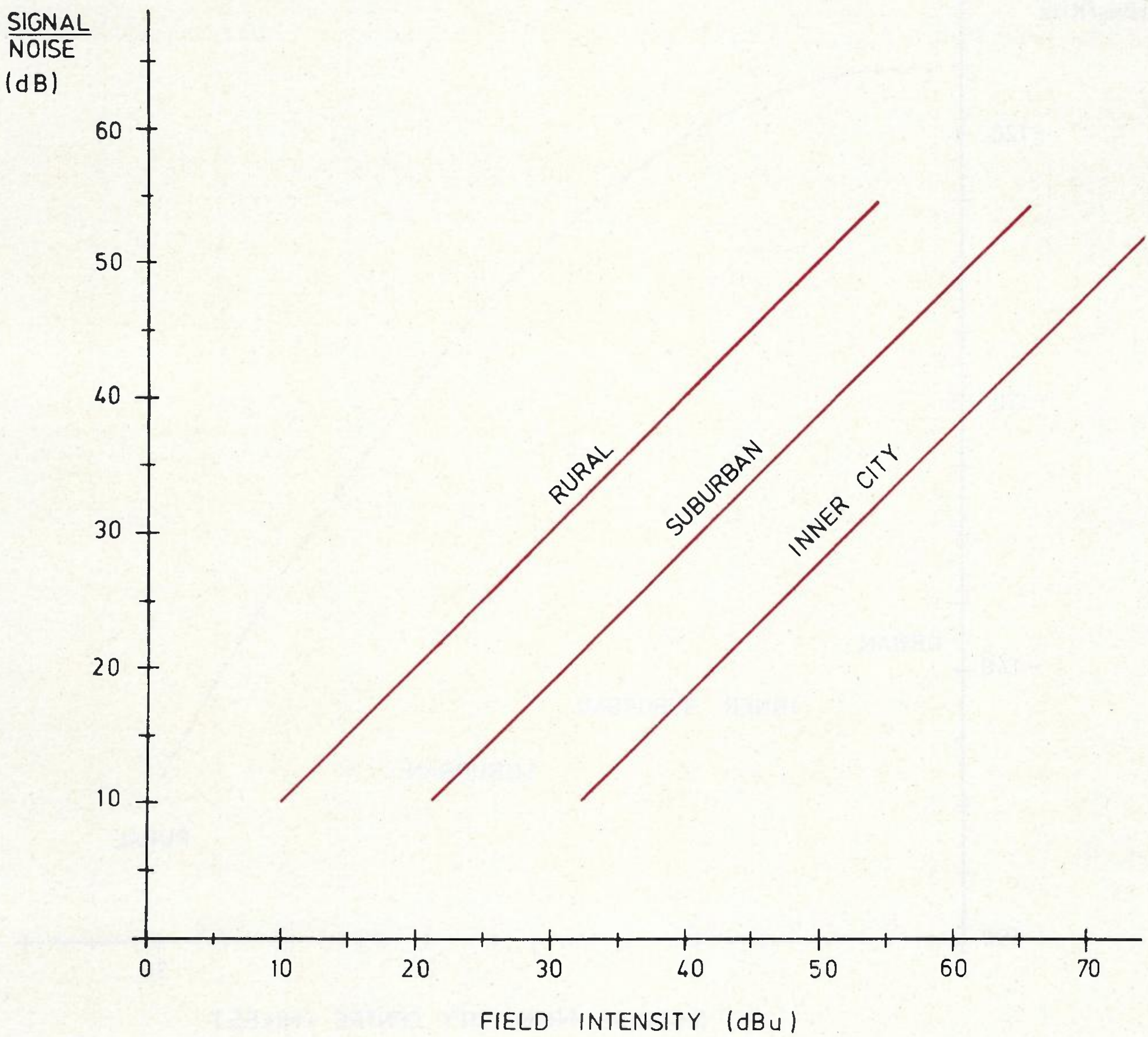


Fig. 11 — Signal/Noise Versus Field Intensity

indicates that 14dB signal-to-(noise+interference) ratio is the minimum acceptable quality of service. The minimum S/N performance objective for the MTS was selected to be 20dB.

Field Intensity Levels Required In the Service Area

The FI levels required to meet the S/N objectives are not constant throughout the service area and are a function of the man-made site noise. A study of the literature available on man-made noise indicate that it is mainly of an impulsive type with automotive ignition systems, gaseous discharge devices, ac heating equipment and electrical transmission lines being the major noise sources.

The noise levels tabulated by Skomal (Ref. 5) have been found to be representative of those quoted in the literature. In his article Skomal found a relationship between noise power in dBm/kHz, frequency and the distance from a city centre. This relationship is graphed for 500MHz in **Fig. 10.** Using this relationship and the radio equipment parameters a graph of signal-to-noise versus field intensity can be obtained for various types of locations, refer to **Fig. 11** (this procedure is described in more detail in Ref. 6). From this figure it can be seen that in a low noise rural environment a minimum FI of 20dB above 1 microvolt/metre (20dBu) can be used while in a suburban environment around 30dBu is required and in an inner city area 43dBu is necessary.

Base Station Site Selection

The base station sites were selected to ensure the FI levels determined above are obtained throughout the service area. The techniques to determine the base sites are described in more detail in Ref. 6 and Ref. 7. Briefly two methods were used to obtain the FI levels throughout the service area from a particular base station site:

- computer predictions
- measurement using the automatic FI measuring set.

A computer program was developed to enable FI levels to be determined in a given service area for any transmitter location, power and frequency and for specified transmitter and receiver antenna heights.

The program requires height data information for the service area to be tabulated and stored on a magnetic

```
FILE   1 , BLOCK   139 , SAMPLES/BLOCK  1000 , SEQ. FILE   1 ,

THE MEAN FROM   1000 SAMPLES IS    65.11 DBU
PERCENTAGE READINGS ABOVE 53.0 DBU(REF 50W EIRP) IS  97.4 PERCENT

PERCENTAGE READINGS ABOVE 57.0 DBU(REF 50W EIRP) IS  93.7 PERCENT

PERCENTAGE READINGS ABOVE 61.0 DBU(REF 50W EIRP) IS  82.7 PERCENT

PERCENTAGE READINGS ABOVE 65.0 DBU(REF 50W EIRP) IS  54.8 PERCENT

PERCENTAGE READINGS ABOVE 69.0 DBU(REF 50W EIRP) IS  32.4 PERCENT

PERCENTAGE READINGS ABOVE 73.0 DBU(REF 50W EIRP) IS   2.6 PERCENT


FILE   1 , BLOCK   140 , SAMPLES/BLOCK  1000 , SEQ. FILE

THE MEAN FROM   1000 SAMPLES IS    61.39 DBU
PERCENTAGE READINGS ABOVE 49.0 DBU(REF 50W EIRP) IS  90.0 PERCENT

PERCENTAGE READINGS ABOVE 53.0 DBU(REF 50W EIRP) IS  83.0 PERCENT

PERCENTAGE READINGS ABOVE 57.0 DBU(REF 50W EIRP) IS  72.2 PERCENT

PERCENTAGE READINGS ABOVE 61.0 DBU(REF 50W EIRP) IS  57.9 PERCENT

PERCENTAGE READINGS ABOVE 65.0 DBU(REF 50W EIRP) IS  36.6 PERCENT

PERCENTAGE READINGS ABOVE 69.0 DBU(REF 50W EIRP) IS  23.8 PERCENT
```

Fig. 12 — Typical Output From Analysis Program

Zone	Portion of Traffic	Telecom House %	Waverley %	Bilgola Plateau %	Dural %	Cecil Park %
1. North Shore	18.6%	1.3	5.4	5.3	6.1	0
2. North West	11.6%	4.8	3.5	0	8.0	2.9
3. Outer North West	7.4%	0	0	0	5.1	1.8
4. City & Eastern Suburbs	15.6%	14.7	15.6	0	0.5	0
5. Inner Sth. West	17.2%	10.3	11.7	0	5.9	4.5
6. Outer Sth. West	11.4%	0.6	2.4	0	5.4	11.2
7. Non-Metro North	2.6%	0	0	0.2	0.7	0
8. Newcastle	11.8%	0	0	0	0	0
9. Non-Metro South	3.2%	0	0.7	0	0	1.0
10. Wollongong	0.6%	0	0	0	0	0
TOTALS	100.0%	31.7%	39.3%	5.5%	31.7%	21.4%
Total including overlapped area = 129.6%						

Table 5 — Proportion of Traffic Per District

tape. The height data is determined by dividing the service area into 0.5 km squares and selecting a representative height for each square.

Given the transmitter position, the program steps the receiver position throughout the service area and generates path profiles from the transmitter position to each receiver position using two - dimensional interpolation.

A propagation model is used to determine the FI level at each receiver position by analysing the path profile and computing the free space path loss and any diffraction loss due to obstructions. Also, in a mobile radio situation where most ground reflection occur close to the mobile receiver an additional foreground loss is calculated using the theory of reflection from finite dielectric surfaces and added to the above losses. A study (Ref. 8) has shown that the propagation model used in the program is as accurate as other models developed overseas.

The FI levels are stored as X, Y, Z co-ordinates on a magnetic tape which is then utilised by another computer program to generate contours of equal FI. The contouring method requires only two rows of data points to be stored at any time. The program joins the two rows of data points to form triangles, generating additional data points at the interstices where necessary for finer division and smoother contours. Treating each triangle as a planar facet, the program computes where a particular 'height' or F1 level occurs. These points are joined with line segments to form contours lines.

The Automatic FI Measuring Set

An automatic field intensity measuring set has been developed (Ref. 9) which enables continuous measurements of FI to be made from a moving vehicle. Typically, measurements were made once every metre along major roads, grouped into blocks of 1000, and recorded onto magnetic tape for subsequent computer statistical analysis (Ref. 10). A typical computer printout is shown in **Fig. 12.** The FI level exceeded for 90% of examples per bloc was used to determine FI contours, refer to **Fig. 13** and **Fig. 14.**

Using the above FI prediction and FI measuring technique, the sites for the Melbourne base stations were fixed at Lonsdale Exchange (in the inner city area), Dunn's Hill and Mt. Dandenong while Telecom House (in the inner city area), Waverley, Dural, Cecil Park and the Bilgola Plateau were selected for the Sydney system. It was subsequently decided to relocate the Mt. Dandenong MBS to Mt. Saint Leonard due to an interference problem with a proposed UHF TV service in the adjacent frequency band.

Determination Of Radio Channel Requirements At Each Base Station

Having determined the location of the base station sites an estimate was made of the number of radio channels that are required at each base station site to cover the expected traffic generated by the mobile customer. This estimate was based on the radio coverage of each base station (the 30dBu level being used in this analysis as the limit of a base station's coverage), the amount of overlap that exists between base stations and the predicted distribution of mobile traffic throughout the telephone district.

Information about the distribution of mobile traffic was obtained from a customer market survey carried out on behalf of Telecom Australia (Ref. 11).

Sydney System

The customer survey divided the Sydney metropolitan area into 10 districts and detailed the proportion of time a mobile customer is expected to spend in each district. Assuming the amount of traffic generated in each district is directly proportional to the amount of time a mobile customer spends in that district and that the telephone calls are uniformly distributed over an entire district, then the proportion of that district adequately covered by a particular base station multiplied by the percentage of traffic in that district will give the percentage of traffic going to that base station.

Table 5 details the proportion of traffic from each district expected by each base station. Note that the

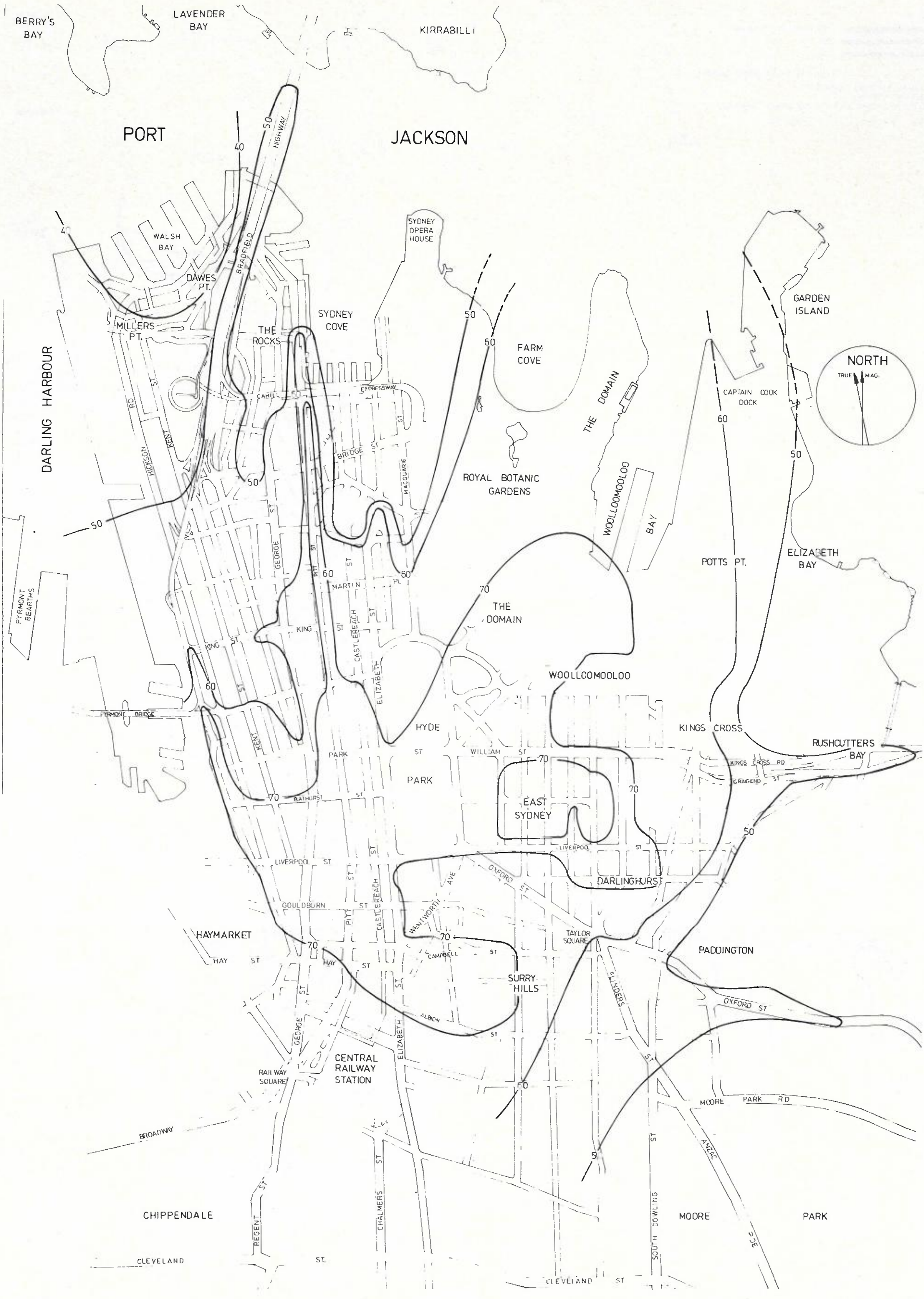


Fig. 13 — Field Strength Contours — Sydney City Area

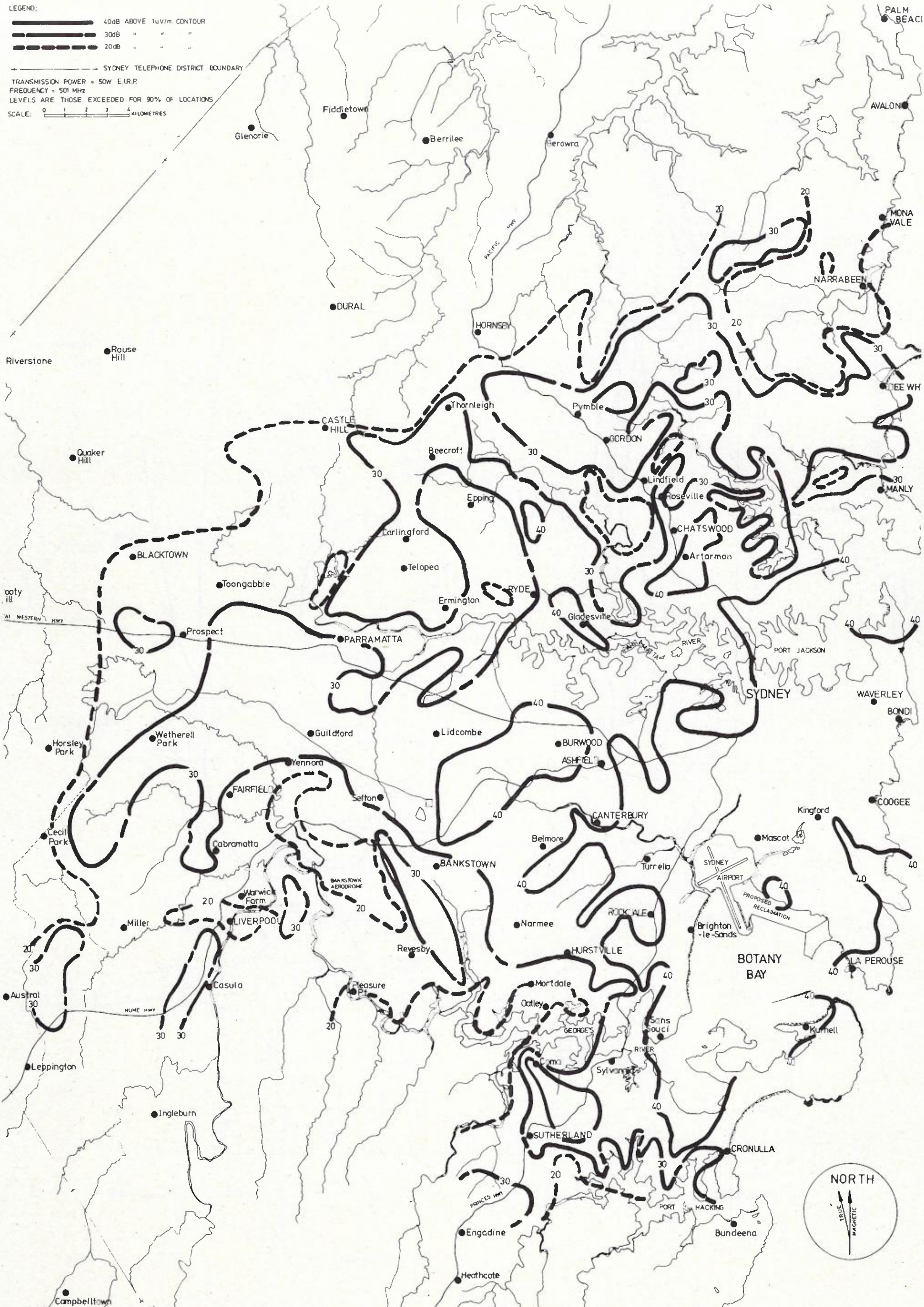
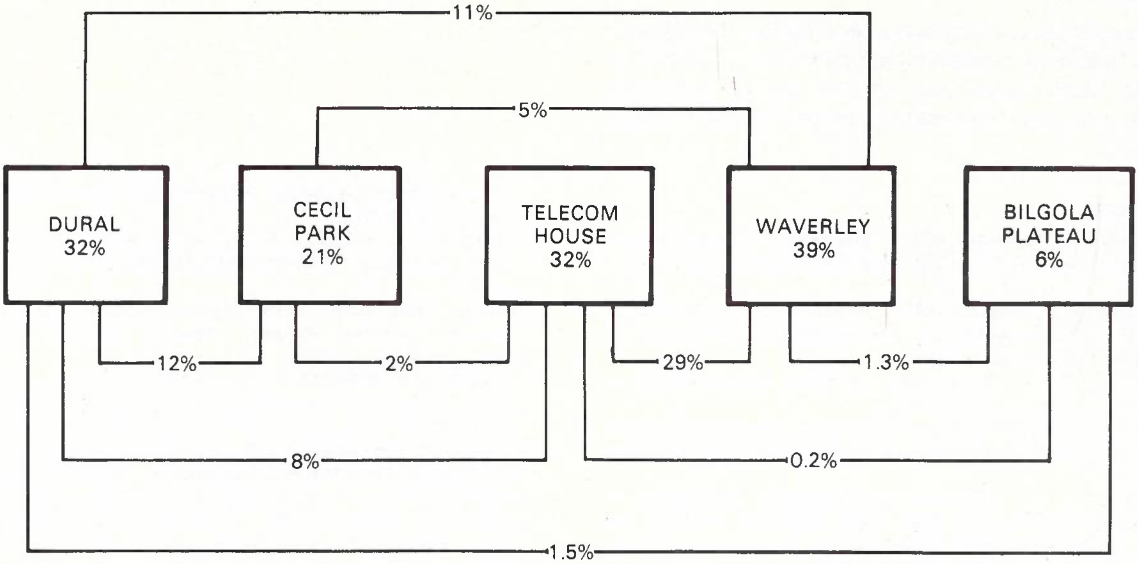


Fig. 14 — Field Strength Contours — Sydney From Waverley MBS.

Newcastle and Wollongong districts have been excluded from the analysis and that the boundary of the outer districts has been limited to the boundary of the Sydney Telephone District. Table 6 summarises the maximum predicted traffic (figures in boxes) and the proportion of traffic common to two base stations, for example 29% of all traffic is shared between Telecom House and Waverley. The maximum predicted traffic must now be modified to allow for coverage overlap of the radio base stations. Refer to Table 7.

The customer survey did not distinguish between the city and eastern suburbs district however it is expected that at certain periods of the day, more traffic will be initiated in the city district in which Telecom House provides the better coverage. Telecom House should therefore have its maximum traffic increased to allow for these peak periods (from 32% to 35%).

Bilgola Plateau and Cecil Park base stations do not share large portions of traffic with other base stations so their maximum traffic figures should not be changed significantly. On the other hand Waverley and Dural are overlapped by other base stations and so their traffic loading has been reduced to account for this.



NOTE: NO OVERLAP BETWEEN BILGOLA PLATEAU AND CECIL PARK.
TOTAL INCLUDING OVERLAPPED AREA = 130%

Table 6 — Proportion of Traffic Included in Areas Common to Two Base Stations.

Base Station Site	% of Traffic		Number of Channels	
	Pred. Max.	Estimated	1000 subs.	4000 subs.
Waverley	39	30	11	30
Telecom House	32	35	13	35
Dural	32	25	10	26
Cecil Park	21	20	9	21
Bilgola Plateau	6	5	4	7
TOTAL	130%	115%	47	119*

Notes: Channel estimates based on a Grade of Service of 0.05 (1 call lost in 20 calls). Traffic per subscriber is 0.023 E
* For 4000 subscribers 133 channels would be required whereas only 120 channels are available in this band. The number of channels in each zone has been proportionately reduced so as not to exceed the 120 channels (including 1 for a dedicated paging channel).

Table 7 — Traffic Level per Site and Number of Channels as Estimated, Sydney.

Melbourne System

A similar exercise to the above was conducted for the Melbourne system, refer to Table 8. However as noted above, subsequent to this analysis and the ordering of equipment, the Mt. Dandenong site could no longer be used and so it became necessary to relocate the equipment for Mt. Dandenong to Dunn's Hill and the Dunn's Hill equipment to Mt. St. Leonard. As the Mt. St. Leonard base station has a large coverage area it may be necessary to re-distribute the radio channels between the three Melbourne base station sites and this will be determined after actual traffic measurements on the system and implemented at the first expansion of the MTS planned to commence in mid 1982.

Base Station Site	% of Traffic	Number of Channels	
		1000 Subs	4000 Subs
Lonsdale	65%	20	62
Mt. Dandenong*	35%	13	38
Dunn's Hill*	10%	6	14
TOTAL	110%	39	114

Note: Channel estimates based on a Grade of Service of 0.05 (1 call lost in 20 calls). Traffic per subscriber is 0.023 E.
* Sites have since been rearranged as per text.

Table 8 — Traffic Level Per Site and Number of Channels as Estimated, Melbourne

CONCLUSION

This paper gave a brief overall description of Telecom's Mobile Telephone System which combined a number of different technologies used in the normal telephone network including transmission, switching and terminal equipment.

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Inward Wide Area Telephone Service (INWATS)

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Wide Area Telephone Services have gained considerable acceptance in the USA and Canada. A similar service has now been introduced by Telecom in Australia and this paper presents an overview of the history and development of the service and its implementation within Australia.

INTRODUCTION

The Inward Wide Area Telephone Service (INWATS) allows telephone users to call INWATS customers over distances normally involving trunk rates, for the cost of a local call. The INWATS customer pays for all other costs. The service was initially introduced in Tasmania in late 1979 and, in the other Australian States during the first half of 1980. The service as it exists at the present is an interim arrangement subject to the limitation that the call charging information is manually transcribed from the recording equipment for billing purposes. It is expected that a more comprehensive service will become available when Calling Line Identification (CLI) is widely introduced and a more sophisticated billing system is developed.

The INWATS facility has been available overseas in the USA and Canada for some years. The experience of overseas administrations suggests that INWATS will be attractive to companies within Australia and of benefit to Telecom and the general community.

DEVELOPMENTS IN USA

In the USA, two services are available. One is Inward WATS and the other is Outward WATS. Customers who want to use WATS for calling to and from their premises must contract for both of these services. Customers can subscribe to WATS on an intra — or interstate basis. Interstate Outward WATS enables customers to dial diverse geographic locations, whilst with Inward WATS, the customer pays for calls dialled by telephone users, as is the case in Australia with INWATS. Both WATS services in the USA only apply to directly-dialled calls although a manual system, known as ZENITH, is also available and offers similar facilities. Customers in the USA can choose from two, monthly pricing plans.

- Full Business Day Service (WATS 240) which allows for up to 240 hours of calling within the geographic areas selected.
- Measured Time (WATS 10) gives a different fixed rate for their first ten hours of calling per month.

Overtime for both options is billed in units of one-tenth an hour.

Inward WATS is known as the '800' Service in the USA because of the national access codes chosen for the service. Initially customers saw it as primarily aimed at reservation services with airlines, hotels and car rental agencies being typical users. Today, however, many customers see the service as ideal for direct marketing. Retail stores use the service to enable their customers to phone in their catalogue orders. Credit card companies are also big users of the service. The service is used extensively by many social agencies and doctors. Outward WATS users are a diverse group, ranging from law firms, accountants and football teams, to colleges of education.

ADVANTAGES OF THE SERVICE

In Australia INWATS is expected to provide the following benefits:

To Customers:

- It will provide businesses in Australia with a new and powerful marketing tool;
- It will allow expansion of operations by opening up new marketing areas;
- It will allow the rationalisation and in some cases, concentration of operations, thereby effecting major savings in manpower and overhead costs;
- It will improve existing operations by encouraging more efficient communications;
- It will allow customers to choose the area of service (Statewide or Australia wide) to suit their operational requirements;
- The service is considered to be particularly attractive to the following types of organisations and industries:
  Airlines
  Hotels/Motels
  Tourist Agencies
  Car Dealers
  Government Departments
  Schools and Colleges
  Charitable Institutions
  Banks and Finance Companies
  Recorded Announcement Services
  Community Welfare Organisations
  Totalisator Agency Boards

Insurance Industries
Manufacturers and Distributors (Sales and Service)
Credit Card Companies
Mail Order Firms.

To Telecom:

- It will encourage greater utilisation of the switched trunk network and make more efficient use of circuits when compared to alternative means of providing similar services, such as Distant Exchange Lines and Private Lines;
- It will provide a good return on investment;
- It will provide a service that the customers themselves will promote and advertise;
- It will encourage wider use of telecommunications as against other forms of communications.

To The Community:

- It will make trunk distance calls to INWATS customers cheaper;
- It will improve access to community services such as welfare organisations;
- It has the potential to be used as a tool for decentralisation.

FEATURES OF THE INWATS SERVICE

General Features

- INWATS customers can be located anywhere in Australia (there is no access to the INWATS service from overseas);
- Callers to an INWATS number pay a local call fee only, irrespective of their trunk call distance from the INWATS customer;
- The INWATS customer may elect to take a 'Statewide' (inward calling from an area approximating the State boundaries) or an 'Austwide' (Australia wide) service;
- A total of four service options will be provided for INWATS Customers. Customers may have a Statewide or an Austwide service with the option of either including or excluding calls from their own capital city metropolitan area;
- Customers may also have a variation of the Statewide service. A customer requiring a service with the same calling number in two or more States may obtain a Statewide common number. Although the same number is called in each State, calls are confined within State boundaries as with the normal Statewide service;
- Callers to INWATS services dial a nine (9) digit code commencing with '008';
- All STD subscribers and users of CT3 public telephones are able to dial INWATS customers. Initially trunk access barred services and public telephones without access to booking levels will not be able to call INWATS services. This facility will, however, be made available in the future;
- Local automatic exchange subscribers without STD access, local manual exchange subscribers and multi-coin public telephone users in both types of exchange areas may book calls to INWATS numbers via the appropriate manual assistance operator;
- The INWATS customer pays a connection fee, a line rental and an inward traffic (i.e. line usage) charge based on the time of day and the type of service.

INWATS Service Areas

The INWATS Statewide service areas fall within the main switching areas and generally conform to State boundaries as follows:

- New South Wales — service area includes the ACT;
- Victoria — service area includes Tasmania, Albury and some other NSW border areas;
- Queensland — service area includes Tweed Heads and some other NSW border areas;
- South Australia — service area includes Broken Hill;
- Western Australia — service area confined to State boundaries;
- Tasmania — two service areas available — as part of the Victorian Statewide service which provides access for both Victorian and Tasmanian subscribers; or — as a Taswide service which covers the State of Tasmania only. The Taswide service is charged at a cheaper rate than the normal Statewide service;
- Northern Territory — Statewide calling from the Northern Territory via Darwin will not be offered initially but may be provided in the future if demand warrants.

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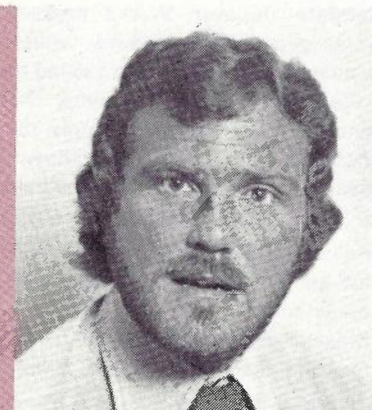
On gaining his engineering qualifications he was promoted, in 1972, to Engineer, Class 1 in the Department of Shipping and Transport, Melbourne, where he was involved with the installation of marine navigational aids throughout Australia. In 1976 he was promoted to Engineer, Class 2, in the Department of Transport, Air Transport Group, Melbourne, where he worked on the installation of airways navigational aids and visual aids throughout Australia and Papua New Guinea.

In 1979 he joined Telecom Headquarters as an Engineer, Class 3, in the Installation Engineering Section of Telephone Switching Construction Branch.



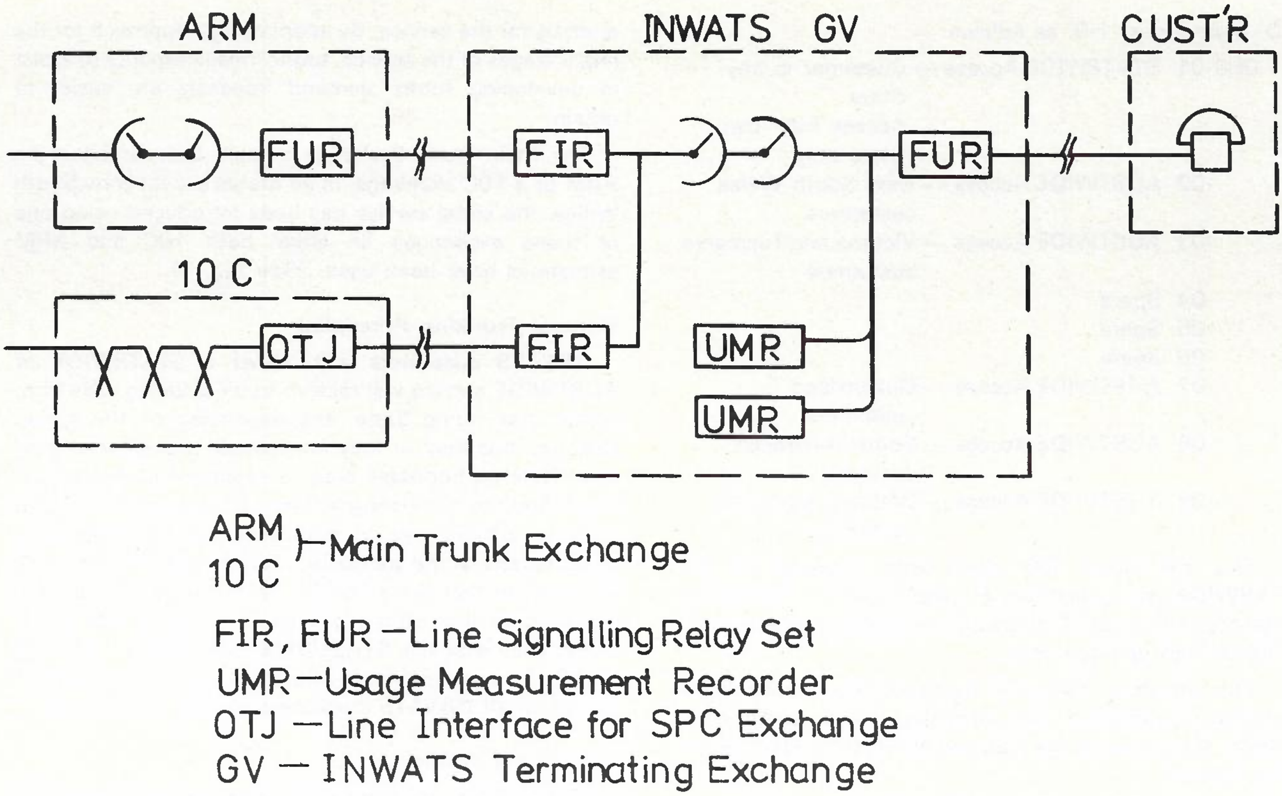


Fig. 1 — INWATS Trunking from Main Trunk Exchanges

NUMBERING SCHEME

A nine digit customer telephone number has been adopted for the INWATS service. The numbering scheme allows routing analysis to be performed within the analysis limit of 0 plus 5 digits of the ARM trunk exchanges. The last three digits of the customer number, bringing the total to nine, will be used at the appropriate terminal switching stage to select the individual INWATS customer.

Thus the INWATS customer has a nine digit telephone number made up of the following code groups:

OAB — special access code '008'.

CDE — determines State location of customer and the service area option selected (e.g. Statewide, Austwide, Taswide, common number Statewide, barred metropolitan access).

FGH — identifies particular INWATS customer.

The special access code '008' was selected for the INWATS service for the following reasons:

Marketing: A special access code that is clearly identified nationally as an INWATS code prefix is preferred for marketing and sales purposes;

Routing: A special code minimises the analysis needed to identify INWATS numbers.

Charging: Similarly, a special code minimises the analysis needed at charging centres. INWATS calls require only 3 digit analysis to identify that a local call fee is to be charged.

The 'C' digits '1-9' are used to identify the service options which exclude access from own State metropolitan areas:

008-1 STATEWIDE Access — Customer in any State. Access from own State only
-2 AUSTWIDE Access — New South Wales customers
-3 AUSTWIDE Access — Victoria and Tasmania customers
-4 Spare
-5 Spare
-6 Spare
-7 AUSTWIDE Access — Queensland customers
-8 AUSTWIDE Access — South Australian customers
-9 AUSTWIDE Access — Western Australian customers
-0

The 'C' digit '0' has been allocated for service options which include access from own State metropolitan areas. Subdivision of these options is provided by allocation of

'D' digit codes '1-9' as follows:

008-01	STATEWIDE Access	— Customer in any State Access from own State only
-02	AUSTWIDE Access	— New South Wales customers
-03	AUSTWIDE Access	— Victoria and Tasmania customers
-04	Spare	
-05	Spare	
-06	Spare	
-07	AUSTWIDE Access	— Queensland customers
-08	AUSTWIDE Access	— South Australian customers
-09	AUSTWIDE Access	— Western Australian customers.

The 'CD' digits 'OO' have been allocated for the TASWIDE service and the "E" digit is used in this case to identify the option of including or excluding access to the Hobart metropolitan area.

The remaining 'D' and 'E' digits are allocated to define suitable geographic and switching areas within each State, thus forming the National Numbering Plan for the the service.

For the customer option of having the same Statewide number in two or more States the following code allocations apply:

- Excluding own Capital City metropolitan area: 'CD' digits '11' are allocated;
- Including own Capital City metropolitan area: 'CDE' digits '011' are allocated.

NETWORK TRUNKING

As all capital cities in Australia have multiple trunk exchanges there are several ways to trunk INWATS calls. For the introduction of the service in each State it was decided that all calls would be routed where possible via the Main Trunk Exchange which will perform the routing analysis for the service. By adopting this approach for the initial stages of the service, traffic measurements to assist in developing future demand forecasts are easier to obtain.

The Main Trunk Exchange in each State is either an ARM or a 10C exchange. In all States except New South Wales, the initial service has been introduced using one of these exchanges. In NSW both 10C and ARM exchanges have been used. **(See Fig. 1).**

General Trunking Principles

INWATS customers with either a STATEWIDE or AUSTWIDE service will receive trunk distance calls from within their home State, and depending on the option selected, this may or may not include access from their own State metropolitan area as explained in the section describing the numbering scheme. If access is to exclude the metropolitan area, all metropolitan area callers need to be barred to the particular "008Y" AUSTWIDE code allocated to that State ('008Y' being the particular code allocated for that State e.g. Victoria — 0083, N.S.W. — 0082, etc.) and the STATEWIDE code '0081', but not '0080'. Non-metropolitan intrastate callers are permitted access to all INWATS customers in their own State.

Originating Traffic

Metropolitan crossbar exchanges route '008' codes via their parent tandem exchange. '008Y' and '0081' codes are barred at the tandem exchange. Metropolitan Step by Step equipment route all '008' codes to the trunk switching centre where access barring of '008Y' and '0081' is performed by the Register EHY2 (ARM) or through the use of conditional routing if terminated on a 10C trunk exchange.

Country terminal exchanges route '008' codes via their parent minor and secondary switching centres to the main switching centre.

The main trunk switching centre will switch the INWATS traffic to interstate destinations, or alternatively it will route INWATS traffic terminating within the State

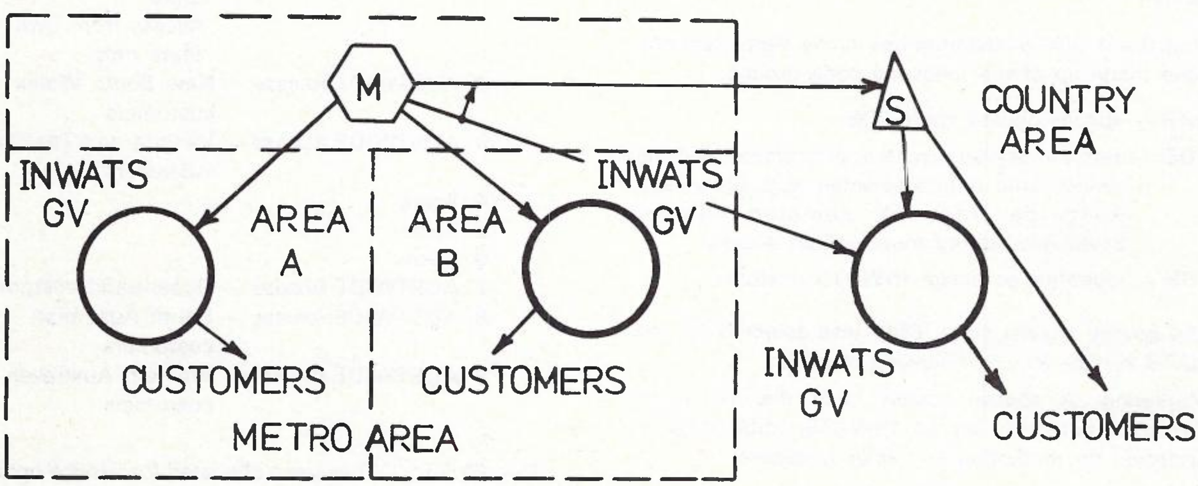


Fig. 2 — INWATS Long Term Trunking Arrangements

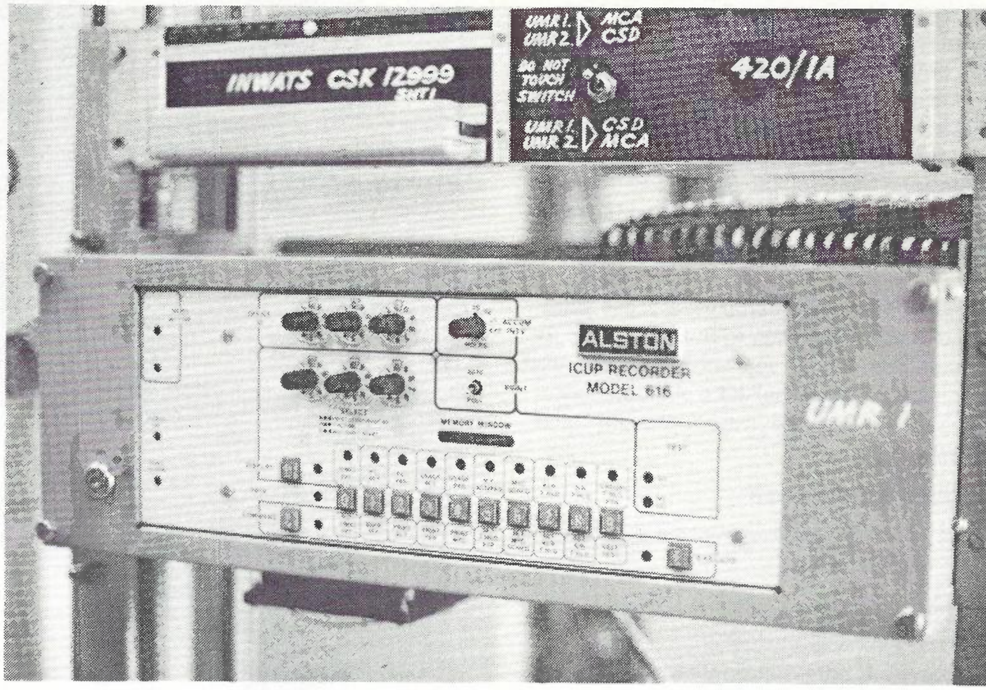


Fig. 3 — Alston 616 Usage Measurement Recorder

as described below.

Terminating Traffic

Initially a separate, fully provided route has been established from the main trunk exchange to a selected terminal exchange with large group GV facilities known as the INWATS GV stage. Only the last three digits of the INWATS number are sent to the selected GV stages to identify the customer.

The selected terminal exchanges in each State routes INWATS traffic direct to each customer on a separate, fully provided route, to facilitate administration of the service. As the service develops it may be necessary to install one or more group selector, GV, stages dedicated to INWATS in other metropolitan areas and possibly in selected country areas. **(See Fig. 2).**

INWATS CHARGES

The customer pays an installation charge and a rental fee for each line associated with the service. In addition, the customer is required to pay a charge for the use of the telephone trunk network. Call charges are based on the effective occupancy of each line, that is from called party answer to release of the call.

Separate, nationally consistent, charge rates, apply to each classification of INWATS service with the exception of the TASWIDE charges which are currently approximately half the mainland Statewide rate. Rates have been weighted according to the time of day and day of week in a similar fashion to STD. For each call made to an INWATS number, the calling party is required to pay a local call fee.

CALL MEASURING EQUIPMENT

In order to charge INWATS customers for the use of the telephone trunk network, the effective occupancy of each line must be measured and recorded. For the initial INWATS service the measuring and recording of the occupancy is carried out using traffic data recording devices known as Usage Measurement Recorders (UMRs).

The UMRs are ALSTON Model 616 Individual Circuit Data Recorders, manufactured in USA by Conrac Corporation of California. **(See Fig. 3).** The Alston 616 UMR is a microprocessor controlled solid state device which monitors telephone channels and can provide computors and/or teleprinters with data for analysis. The UMR is self-contained except for a teleprinter or other readout device and can accommodate a maximum of 1000 individual input leads from trunks or circuits to be monitored. Number of calls and usage in seconds are collected and stored from each lead then grouped within the system. The system provides for programming up to 250 output groups each containing any number of inputs. Any of the configured inputs can be programmed into any group.

The INWATS customer is allocated a group or groups, numbering from 0 to 249, depending on the service options taken. The individual lines are then programmed into the appropriate group. Selected combinations of groups are prepared on either paper or magnetic tape and input to the system for storage in memory modules. All inputs holding the same group number are totalled under that group's output.

The UMR can be programmed to automatically dump traffic data to a printer at the end of each accumulation period. During a data dump, total usage and number of calls for each group are output.

Data is recorded on two UMR's which will be located at the INWATS terminating exchange (See Fig. 1), and hard copy printout produced by two separate teleprinters linked to the UMR's. The simultaneous recording of data on two UMR's is to facilitate maintenance activities, ensure accuracy of records and prevent loss of data in the event of machine or line failure. One teleprinter is normally located near the UMR equipment in the terminating exchange. The other is located remote from the exchange in an appropriate district office area to permit convenient access for telephone billing purposes. A manual changeover facility exists at the UMR's to enable either UMR to be connected to either teleprinter to facilitate fault location.

District/Business office staff manually process printouts and produce a monthly INWATS Call Summary which is then forwarded to the appropriate accounting area prior to the issue of customer bills. Automation of this process is expected to be introduced for later versions of the service.

IMPLEMENTATION OF INWATS

The implementation of the service involved activities in the following two distinct areas.

Preparation of the Network

The routing of the INWATS access code '008' to the main trunk exchange from both metropolitan and country areas was completed in each State prior to the introduction of the service in that State. Also before the introduction date, all charging centres in each State were strapped to set code '008' as "unit fee" (local call) to ensure that all callers to INWATS numbers were charged at the correct rate.

Connection of the INWATS Customer

As shown in Fig. 1, the INWATS GV stage switches the call via an FUR (Line Signalling) relay set to the INWATS customer. Circuit occupancy information is recorded by the UMR's via monitor lead connections on the FUR relay set.

The FUR and other associated relay sets are installed on a special INWATS rack located within the terminal exchange and connected to the customer's lines via a Main Distribution Frame.

The UMR's, other equipment associated with the interface to the teleprinters (modems), power supply panel and an Intermediate Distribution Frame for connections between the UMR's and the FUR relay sets, are all mounted on another special INWATS rack located within the terminal exchange **(see Fig. 4)**. The racks and associated wiring were all installed and tested prior to the service introduction date.

The INWATS customer is allocated an INWATS '008' number or numbers depending on the service options chosen. A separate direct line, is provided between the customer's premises and the terminating exchange, for each line requested. The customer's line information is then programmed into the Alston UMR's and the service is ready for use.

CONCLUSION

Since the introduction of the service in late 1979, the number of INWATS lines has steadily increased.

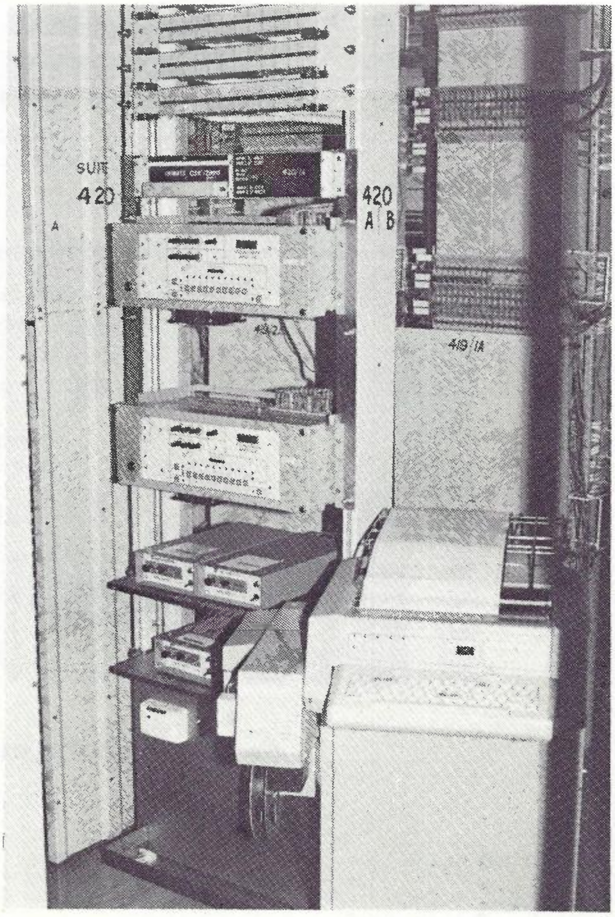


Fig. 4 — INWATS Rack

However, demand has not yet reached the levels that were initially predicted. One reason for this may be the relatively low level of product promotion that has taken place as Telecom has decided that it would follow a strategy that ensured the initial impact of the service on the telephone network was minimal.

With widespread marketing and advertising, and bearing in mind the success of the product in the USA, it is expected that the INWATS service will eventually become quite popular in Australia. Provision of the service constitutes an entirely new marketing opportunity for Australian business and will provide benefits not only for Telecom but the whole community.

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The CCITT No. 7 Common Channel Signalling System for Digital Networks

M. SUBOCZ, B.E., M.I.E. Aust.

Introduction of stored program controlled exchanges into the telephony network has resulted in cost savings but has done little to improve the performance or facilities provided by the existing network because of the limitations imposed by conventional signalling schemes. The development and introduction of common channel signalling systems will permit better utilisation of existing exchanges and the introduction of new services. This paper describes the features of the new CCITT No. 7 common channel signalling system which is optimised for use with the 64 kbit/s digital PCM links and which will provide the signalling requirements for either single service networks, e.g. telephony, or integrated services digital networks.

In a communications system such as the telephony network and probably in most other systems, very few actions can take place without an exchange of signals. In fact in most systems, the range of actions that can be taken and hence the range of facilities that can be provided very much depends on the signalling scheme and its performance, as well as on the capability of the system itself to provide the facilities.

The close interdependence between signalling and the rest of the system, particularly switching functions, requires co-ordinated development of both to make the best use of the total system. For example, the introduction of crossbar exchanges into a predominantly step-by-step network would provide little in added facilities if the decadic signalling scheme used in step-by-step exchanges was not replaced. With MFC signalling, alternate routing, STD dialling, etc. become possible.

With the introduction of stored program controlled (SPC) exchanges, the signalling system has again become a limiting factor, as these exchanges with their much greater capacity for 'intelligent' signal processing are in effect 'held back' by the relatively slow speed and lack of appropriate facilities in the signalling system that they must use in communication with the older exchanges. Some of the operations that the SPC exchanges could perform, for example, are much more complex alternate route selections and the interrogation of destination exchanges regarding information about the called number, so that for instance if the called subscriber is busy, no setting up of speech paths through the network is attempted.

The type of signalling scheme that can provide the necessary facilities to match the capabilities of SPC exchanges is the common channel signalling system. The first of such systems to be introduced was the CCITT No. 6 that was approved by CCITT in 1972 and is now in use in some parts of the world, e.g. across the Pacific and the Atlantic oceans and within North America for national use. This system however was still primarily designed for the conventional analogue network with transmission rates of the order of 2400 bit/s which resulted in fairly complex communication protocol and message formats. The relatively slow transmission rate requires the signalling messages to be broken up into small units to reduce retransmission times in case of error, and also requires priority messages to achieve acceptable call set up and post dialling delays.

With the increasing introduction of digital PCM links in which each voice channel is an equivalent data channel with a 64 kbit/s transmission rate, much of the complexity of the No. 6 Signalling System is unnecessary and becomes an unacceptable overhead in the processing of No. 6 signalling messages within the SPC exchanges. Since 1975 there has also been a great deal of work on the theory of communications protocols and their specification so that the time was right in the late 1970's for the development of an improved common channel signalling system specifically designed and optimised for the high speed 64 kbit/s PCM digital network.

This work was carried out by CCITT Study Group XI during the study period 1976-80, resulting in the specification of the No. 7 Common Channel Signalling System being approved by the CCITT's Plenary Assembly in November 1980 (Ref. 1). In the No. 7 system, all messages are independent, variable in length but byte oriented for easier processing, and there is no message priority. The signalling system consists of four functional layers, an approach which allows the system to be specified to provide signalling for current services e.g. telephony, circuit switched data, and also to be open ended so that signalling can be provided for services that may be introduced in the future.

Because of its intended versatility and reliability, the No. 7 signalling system specification is very complex, occupying approximately 450 pages of CCITT Recommendation Q.701-Q.707, Q.721-Q.725, and X.60-X.61. The No. 7 system is the first international signalling system to be specified using SDL, the CCITT graphical Specification and Description Language, which defines the required functional behaviour of the No. 7 system in a clear and unambiguous manner.

EVOLUTION OF COMMON CHANNEL SIGNALLING

In step-by-step systems and manual systems (if voice instructions are considered as signals) the path of the signalling information and the speech path are 'channel-associated' throughout the system, i.e. the same communications channel is used for signalling and speech, both within the exchange and in the transmission circuits between exchanges. There is no storage of signalling information and the switching equipment must act on the received information immediately.

With the introduction of common control switching equipment such as crossbar, the signalling information path and the speech path were separated in the switching equipment within the exchange but still remained channel-associated outside the exchange. Within the exchange the signalling information may now be stored in the common control equipment and analysed to a greater extent, particularly for alternate route selection and more efficient use of signalling and control equipment through resource sharing.

Even though considerable per-circuit signalling equipment is required when channel-associated signalling and speech paths outside the exchange are used, it does have several significant advantages, e.g. since the signalling information is sent in the selected speech circuit, the selected circuit is automatically checked for continuity.

In the evolutionary sense, SPC exchanges are no more than an improved common control equipment type, but of course have a capacity for information processing that is several orders of magnitude higher than for the electro-mechanical crossbar exchanges. The advantages of reduced processing requirements for channel - associated signalling and speech paths outside the exchange are no longer significant, but the additional signalling equipment necessary to provide this becomes quite significant.

The much greater processing capacity of SPC exchanges therefore allows separation of the signalling and speech paths not only within the exchanges but also in the transmission links between exchanges. Since the amount of signalling information per call set up is relatively small, the separate signalling path between exchanges may be used to control many speech circuits, leading to the concept of common channel signalling.

The common channel signalling link between exchanges is essentially a data link, allowing direct transfer of data between exchange processors at any time and it may be used for transfer of many other types of information other than just call set-up signalling. Network management and maintenance is one such possibility and it becomes feasible to think of a "stored processor controlled network" as an entity in its own right, adapting itself to various load conditions and exchange or trunk circuit outages in a much more efficient manner than with the present alternate routing scheme.

COMMON CHANNEL SIGNALLING NETWORKS

Signalling modes in a network describe the association between the path taken by the signalling information and the speech path or circuit to which the signalling information refers. The conventional **channel-associated mode** is shown in **Fig. 1a** where the signalling information always takes the same path as the channel to which it refers.

Common channel signalling is not so restricted, but

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He resigned from PMG in 1969 and spent five years working in United States, mainly as a systems engineer in manufacture and installation of computerized railroad freight classification yards.

On return to Australia, he rejoined the Research Laboratories in the Advanced Techniques Branch, transferring to the Switching and Signalling Branch in 1977. He has been the project leader for the CCITT No. 7 signalling system studies since their beginning in 1978, and is an Australian representative to the CCITT Study Group XI in the current 1981-84 study period.

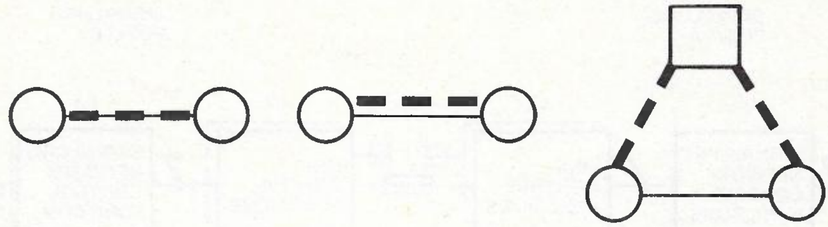


Fig. 1 — Mode of Operation.

the term **associated signalling mode** is still used if the signalling information referring to circuits or speech paths connecting two signalling points (SP) is conveyed over a link also directly interconnecting the two SP's **(Fig. 1b).**

However, frequently the number of circuits between two signalling points may not be sufficient to justify an associated signalling link. Better usage of signalling resources may be obtained by using a non-associated mode of signalling in which the signalling information is conveyed over two or more links passing through signalling points other than the originating and terminating point. The intermediate signalling points are then also performing a signalling transfer function and are termed signalling transfer points or STP's. In fully non-associated signalling, **(Fig. 1c)** the signalling message routing is decided independently at each SP or STP, based on the traffic pattern at that time and location, with the result that signalling messages arriving at the destination may be out of sequence since they need not have followed the same path.

The No. 7 common channel signalling system provides no facilities for avoiding such out of sequence messages or re-ordering them at the destination, so that only a limited form of non-associated mode, called quasi-associated, can be used. In this mode, the path taken by the signalling information through the signalling network is predetermined and all messages relating to a particular circuit or transaction are always conveyed over the same path, assuring correct sequence of arrival. Special precautions need to be taken to ensure against lost or out of sequence messages during network failure conditions when part of the network may need to be reconfigured to use back-up routes.

The quasi-associated signalling mode is expected to be the normal mode of operation in No. 7 signalling networks, with associated signalling routes, often called 'short-cut' routes, being used only in heavy traffic situations. These concepts lead to the development of an entirely separate signalling network of preassigned signalling routes that may be used to supervise the operation of the basic switching network.

The availability of the signalling network in these circumstances becomes very important. A single signalling link can be used to control a large number of service circuits (the actual number is still to be determined, but it may be of the order of 10,000 circuits for a 64 kbit/s link serving telephony circuits) and its failure would be catastrophic on the performance of a large section of the service network. In the general case therefore all signalling links from SP to STP, and from STP to STP, have one or more back-up links preassigned, and each route from SP to SP has one or more backup routes preassigned via different STP's. The protocol to control the selection of active links and routes in such a network is inbuilt in the No. 7 signalling system and will be discussed later when reliability is considered.

STRUCTURE OF THE NO. 7 COMMON CHANNEL SIGNALLING SYSTEM

General Overview

The No. 7 common channel signalling system is a data communications protocol specifically designed to provide reliable signalling and other information transfer between processors in a telecommunications network. As a data communications protocol, it borrows heavily from developments in computer communications protocols that have occurred in the past decade.

The major items that have been taken from computer communications protocols are the high-level data link control (HDLC) message frame structure, particularly the message delimitation and frame checking sequence algorithm, and the layering concept of protocol description.

The HDLC standard (Ref. 2) defines a frame structure that has several defined fields and an information field that may consist of any number of bits. Each frame starts and ends with a 'flag sequence' which consists of '01111110'. Immediately before the closing flag, a 16 bit frame checking sequence (FCS) is added by the transmitter, derived from modulo 2 division and multiplication of the contents of the frame and a generator polynomial. The FCS is used by the receiver to detect transmission errors in the frame. To ensure that the flag sequence is not imitated by any other part of the information field, a zero is inserted by the transmitter after every consecutive five ones in the information and FCS fields. At the receiver a zero immediately following five ones is deleted. In the No. 7 system, the special fields defined by HDLC are not used, and the length of the frame, called a signal unit, is always a multiple of 8 bits.

The layering concept attempts to produce independent protocol layers for each major function of the communications system. A given layer in the system is

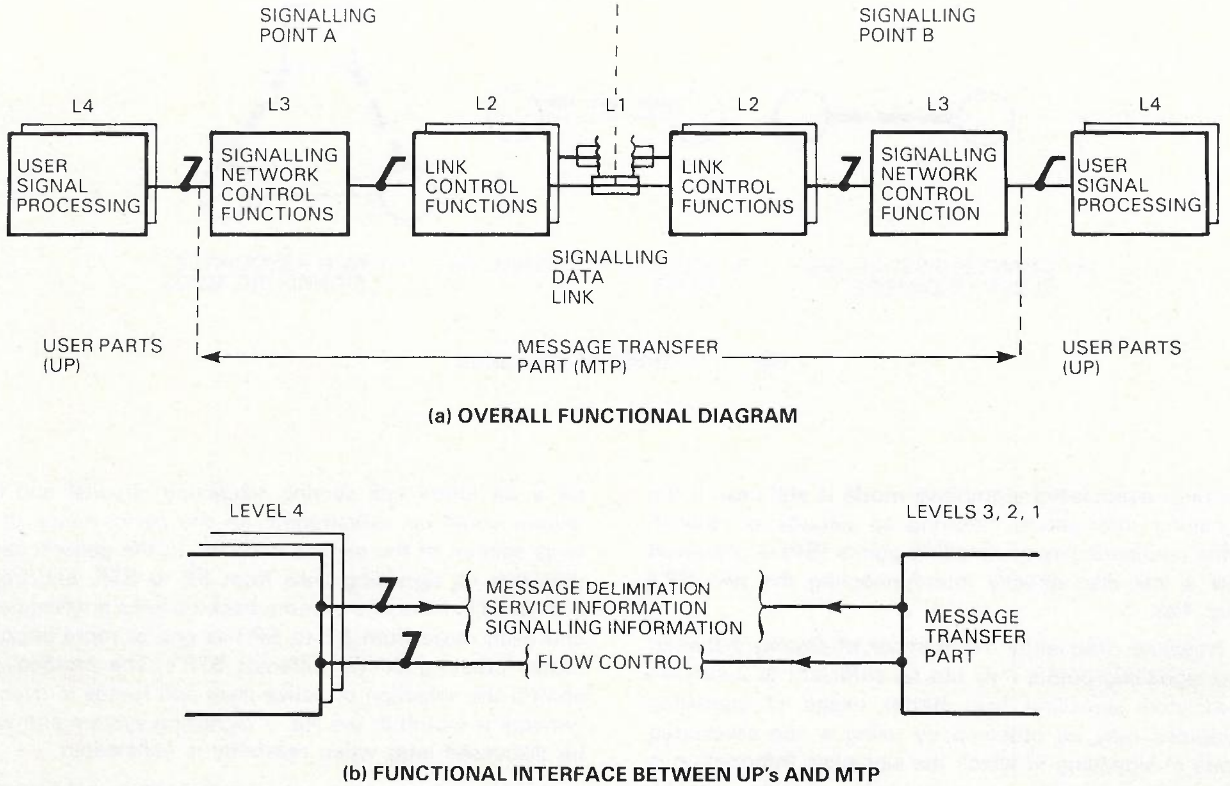


Fig. 2 — Functional Block Description of No. 7 Common Channel Signalling System.

intended to provide specified services to the layers above it, using the services of the layer(s) below it. The International Standards Organization has partitioned the communications process into seven layers, the so called Open System Interconnection architecture, but the No. 7 system has been partitioned into only four layers called levels, the functions of each level being fully specified.

Functional Structure

The layered design and specification process produces functionally independent blocks arranged in a hierarchical manner. **Fig 2a** shows the overall functional diagram for two directly connected signalling points, A and B. As shown, a further functional division has been made between the parts of the system which are identical and transparent to all users (the 'message transfer part') and the users themselves (the 'user part'), which generate and interpret the messages carried by the system. (In No. 7 system terminology a user is a functional entity, typically a telecommunications service, e.g. a telephone exchange, which uses the signalling network to transfer information. It is not to be confused with a subscriber).

This functional division into a message transfer part (MTP) and user part (UP) allows the same signalling system to be used either in a network dedicated to a single service, e.g. telephony, or in a multi-service network, the future integrated services digital networks (ISDN). The system is essentially open-ended, in that services which are as yet unknown can in future be included by the addition of appropriate user parts.

To permit easy addition of new user parts, the interface between user parts and message transfer parts must be clearly defined and in a manner which places minimum restrictions on the facilities that may be required by a future user. **Fig. 2b** shows the interface specification between the two parts and it is elegantly simple.

The main interaction is the transfer of signalling messages consisting of service information (i.e. identifying the user) and the signalling information. Message delimitation information allows the MTP to handle the message as a single entity and also to make use of the information in the label of the message for routing purposes.

The other possible interaction is 'flow control', e.g. information from a UP to change routing assignments, or an indication from the MTP that it is unable to serve a particular destination. This interface, and all other level to level interfaces, are purely functional and need not appear as equipment interfaces in any implementation of the system.

Message Transfer Part

The message transfer part consist of levels 1 to 3 (Fig. 2), and its overall function is to provide the reliable transfer of signalling messages and other information between the user parts at the originating and destination points. The MTP uses information in the label of the message to route the message, and of course facilities exist in the protocol to route the message over a number of links in tandem.

The three levels in the message transfer part have defined functions as follows:

Level 1 — Signalling Data Link Functions

Level 1 defines the physical, electrical and functional characteristics of a data link and the interface to access it. In digital networks, 64 kbit/s digital paths will normally be used, but other types of links, such as lower rate analogue links with modems, may also be used.

The No. 7 signalling system is, however, specifically designed to be optimum for the 64 kbit/s rate. To avoid unacceptable delays for some critical signals when using analogue links, it is expected that the transmission rate will need to be at least 4.8 kbit/s.

Level 2 — Signalling Link Functions

Level 2 defines the functions and procedures for the transfer of signalling messages over one individual link. The level 2 functions together with the level 1 signalling data link as bearer, provide a signalling link for reliable transfer of signalling messages between two points.

The major functions of level 2 are:

- initial link alignment, synchronization and 'proving' to ensure that the link's error rate performance is adequate.
- continuous link error rate monitoring using the signalling message, or fill-in signal units during idle time, and
- error detection by means of the FCS field included in each signal unit and error correction by message signal unit retransmission.

The result of this very close link monitoring is that there should be not more than one in 10^{10} signal units with undetected errors and not more than one in 10^7 lost signal units.

Level 3 — Signalling Network Functions

Level 3 defines in principle those transport functions and procedures that are common to and independent of the operation of individual signalling links. The functions fall into two major categories:

- Signalling message handling functions, which, at the actual transfer of a message, direct the message to the appropriate signalling or user part. **Fig. 3** shows a block diagram for these functions for the SP and STP.
- Signalling network management functions, which on the basis of predetermined data and information received about the present status of the signalling network, control the current message routing and configuration of signalling network facilities. In case of changes in status, they also control reconfigurations and other actions that may be necessary to preserve or restore the normal message transfer capability.

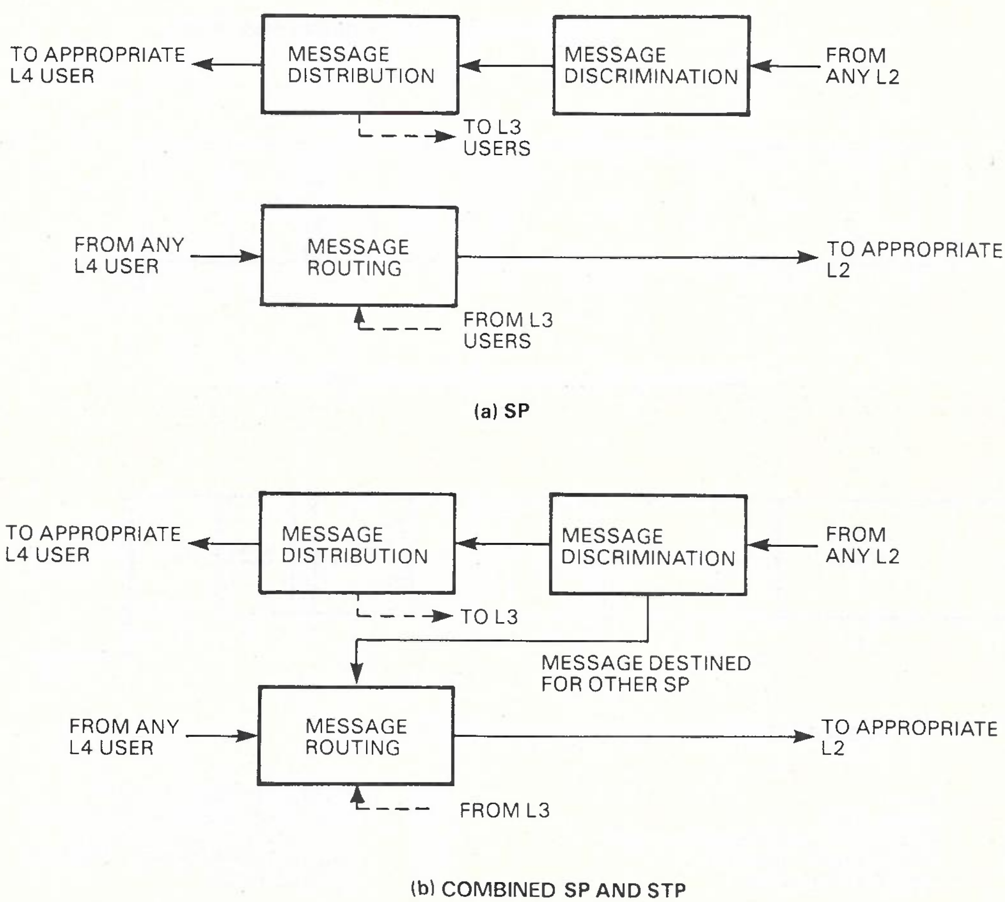


Fig. 3—Signalling Message Handling Functions for Signalling Points (SP) and Signalling Transfer Points (STP).

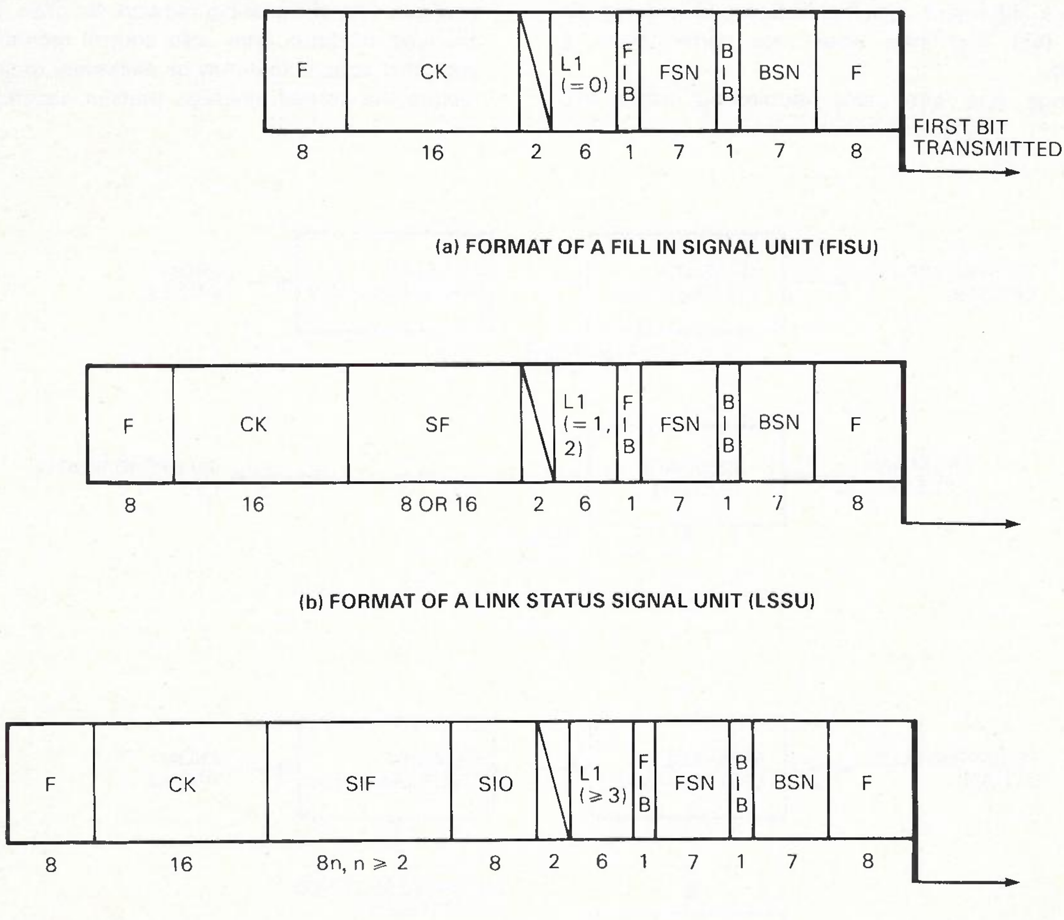
The level 3 functions specified in the CCITT recommendations are very comprehensive and also to a large extent optional depending on the exact requirements of the network. For example, a simple point to point link would require no signalling network management function and only a relatively simple (if any) message handling function. At the other extreme, procedures have been defined for signalling traffic, link and route management and automatic link selection, allocation and activation. Examples of some of the management functions will be considered under network security.

User Parts

The No. 7 signalling system is sometimes described as a general purpose signalling and data transmission system but it is not designed to be a carrier system. By that it is meant that all messages, signals, data or information conveyed by the No. 7 signalling system are defined and specified by the No. 7 specification as to their content, meaning, significance and usage procedures.

The above remarks apply particularly to the international signalling network, for which the No. 7 signalling system is specifically intended, but the national networks must follow similar rules to avoid complex gateway interworking with the international networks.

To cater for integrated services digital networks, each service is termed a user and the messages relating to that service are identified by a unique code in a sub-field of the service indicator octet. This concept of user identification extends to the No. 7 signalling system itself being identified as a user of the signalling network, two users in fact, to convey messages relating to (a) network management functions for distributing network status information and configuration control signals, and (b) network testing and maintenance function. This latter user is only briefly mentioned in the present CCITT Recommendations, with more work to be done in the future in developing appropriate techniques.



(a) FORMAT OF A FILL IN SIGNAL UNIT (FISU)

(b) FORMAT OF A LINK STATUS SIGNAL UNIT (LSSU)

(c) BASIC FORMAT OF A MESSAGE SIGNAL UNIT (MSU)

F — FLAG
CK — CHECK BITS
SIF — SIGNALLING INFORMATION FIELD
SIO — SERVICE INFORMATION OCTET
LI — LENGTH INDICATOR
FIB — FORWARD INDICATOR BIT
FSN — FORWARD SEQUENCE NUMBER
BIB — BACKWARD INDICATOR BIT
BSN — BACKWARD SEQUENCE NUMBER
SF — STATUS FIELD

Fig. 4 — Signal Unit Formats.

Both of the above users are within the message transfer part and are totally internal to that part. Two level 4 user parts have to date been defined, the Telephony User Part (TUP) defined by Study Group XI as Recommendations Q.721 to Q.725, and Data User Part (DUP) defined by Study Group VII as Recommendations X.60 and X.61. The DUP recommendation is applicable to circuit switched data networks only; the data packets in a packet switched network carry their own address information and require no external signalling system.

The major difference between the TUP and DUP is the need for a time slot control code as part of standard label in the DUP for multiplexing slow data terminals on to a 64 kbit/s bearer. In most other respects the two parts are similar in principle and contain the formats and codes for all messages, call set up and clear-down procedures, and other information that is required in a signalling system.

In the TUP, two signalling procedures are defined: the **overlap procedure** in which a partial address signal is sent forward, with remaining address digits sent later, somewhat similar to MFC register working; and the **en-block signalling procedure** in which all address digits are sent together. The latter method is preferable as it results in fewer messages per call set-up, and given the high signalling transmission rate, the effect on post-dialling delay should still be small.

In a channel-associated signalling system, the signals themselves provide a continuity check of the circuit. This advantage is lost in common channel signalling systems and specific continuity check signals must be provided. However these check signals are only used in mixed digital/analogue networks, since in purely digital networks the normal PCM circuit checking alarms provide sufficient indication.

ERROR CONTROL AND SECURITY

This is the area in which much of the strength of the No. 7 signalling system lies — the provision of very reliable transfer of signalling messages. The security aspects are provided at both the single link level through the use of error checking bits and retransmission, and at network level through the provision of a procedure for changeover to back-up links.

Before these aspects can be discussed in greater detail, it is necessary to look at the signal unit formats.

Signal Unit Formats

There are three basic signal unit (SU) types as shown in **Fig. 4.** The type of signal unit is differentiated by the length indicator (LI) contained in all the signal units. Other information carried in all signal units is the forward and reverse sequence numbers and indicator bits, and all signal units conform to the HDLC basic message structure.

The three signal units formats and their uses are as follows:

- Fill-in Signal Unit (FISU)

  This is the shortest of the signal units consisting only of the above information and check bits and flag. The length indicator, which is the count of the number of bytes between L1 and the first checkbit, is zero for this signal unit.

  FISU is generated by level 2 functions when there are no other signal units for transmission. It is used for the continuous monitoring of the long term link error rate, and also as a carrier for acknowledgement of signal units received by the signalling terminal.

- Link Status Signal Unit (LSSU)

  This unit contains an 8 or 16 bit status field following the length indicator, and hence LI may be 1 or 2 respectively.

  LSSU is also generated by level 2 functions, but only during initial link alignment and proving (verification of link error rate performance). Reception of LSSU at any other time is an indication of remote terminal failure and the link is removed from service.

  At present only an 8 bit status field has been defined, with possible status being: out of service, out of alignment, "normal" alignment, and "emergency" alignment (a shorter proving period is used during emergency alignment, which is performed when no other links are available). When the link is aligned, FISU's are sent.

- Message Signal Unit (MSU)

  In addition to the previous information, MSU's contain a service indicator octet to differentiate the various users, and a variable signalling information field (SIF) that may consist of 2 to 62 bytes in the international network, or 2 to 61 or 272 bytes in a national network. LI can therefore range from 3 to 63, with 63 in national networks indicating a length of 272 bytes.

  MSU's may be generated by the two level 3 user parts, signalling network management, and test and maintenance, or by level 4 user parts. **Fig. 5** shows an example of a complete Message Signal Unit, the Initial Address Message. The signalling information field consists of service indicator octet (SIO), a five byte standard label, and variable length user information field (the Initial Address Message in this case). The label contains destination and origin point codes, and the circuit identification code to which the message refers. The four least significant bits of the circuit identification code (CIC) together with origin and destination point codes (OPC, DPC) form the routing label, the four least significant bits being used to select the link for load-sharing the traffic. These fields must be present in all message signal units, but the contents of the user information field depends on the message signal unit.

  The forward and backward sequence numbers and indicator bits in all the signal units are used by the error control procedures to correct transmission error by retransmission of complete signal units.

Link Error Correction

There are two forms of error correction available for a link: the basic method for signalling links where the one-way propagation delay is less than 15 ms; and the preventive cyclic retransmission method for one-way delays longer than 15 ms including links established through a satellite. Both methods use non-compelled error correction by retransmission systems, but the preventive cyclic retransmission method is quicker in correcting errors on long transmission delay links.

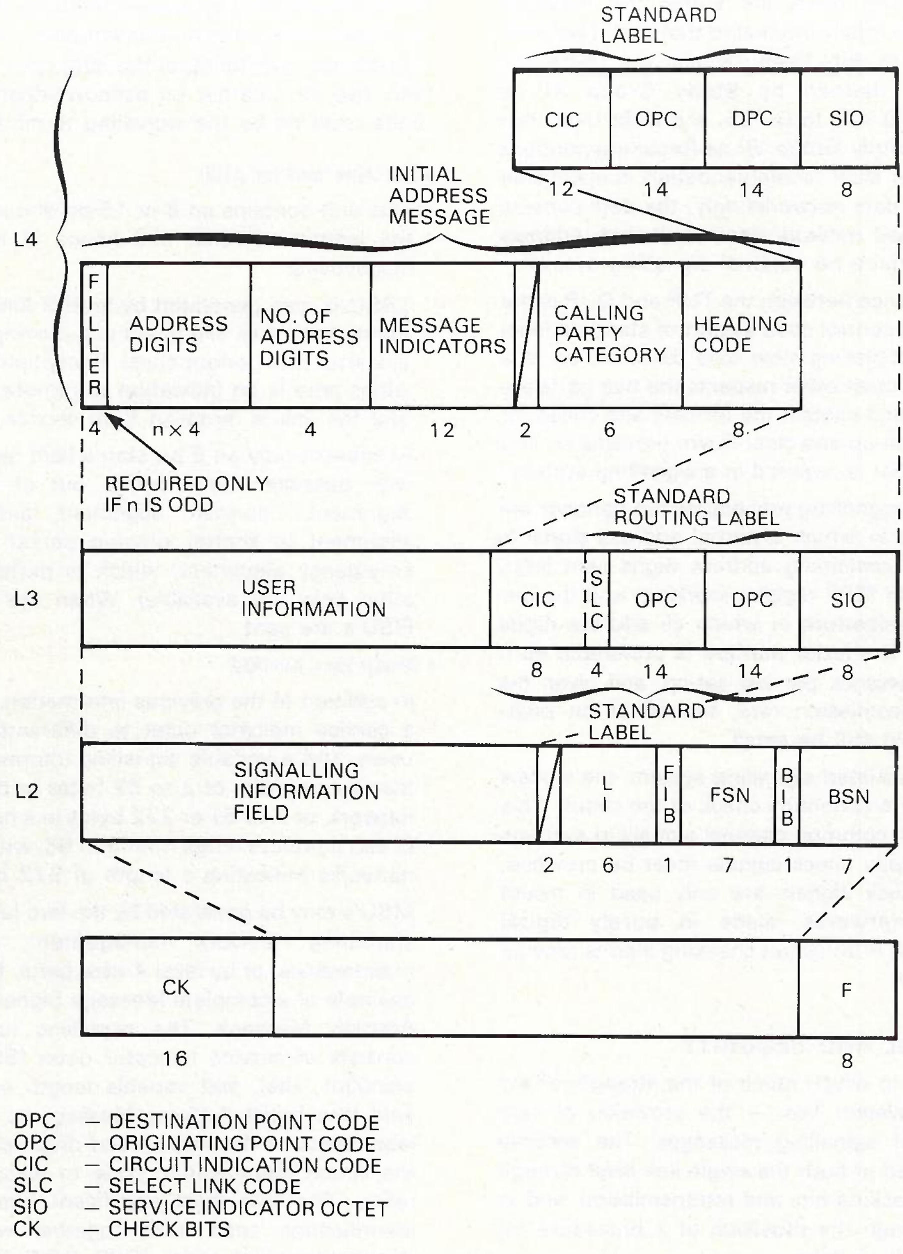


Fig. 5 — Message Signal Unit Format.

The basic method is a positive/negative acknowledgement system with the error correction procedure applying only to message signal units and not to link status or fill-in signal units, which are repetitive and carry no unique information. An MSU which has been transmitted from the transmission buffer is retained in a retransmission buffer in the transmitting terminal until a positive acknowledgement is received at which time it is deleted from the retransmission buffer. If a negative acknowledgement is received, then the transmission of new signal units is interrupted and the message signal units in the retransmission buffer are all retransmitted once in the same order as originally transmitted, followed by the message signal units, if any, in the transmission buffer.

The positive and negative acknowledgement is achieved through the use of the forward and backward sequence numbers and indicator bits. **Fig. 6** shows the system operation in one direction under error free conditions. Identical and completely independent acknowledgement procedures are performed in the reverse direction.

An MSU for transmission is initially entered into the transmission buffer (TB) which is essentially a first - in - first - out (FIFO) queue. When a link is available, the next MSU is taken from the TB, the next (Modulo 128), forward sequence number (FSN) is assigned and a copy is stored in the retransmission buffer (RTB). The remaining fields of the MSU are filled in and it is transmitted. At the receiving end, the received FSN is compared with the expected FSN (initialized during link alignment procedure) and if they agree, the FSN is copied into the

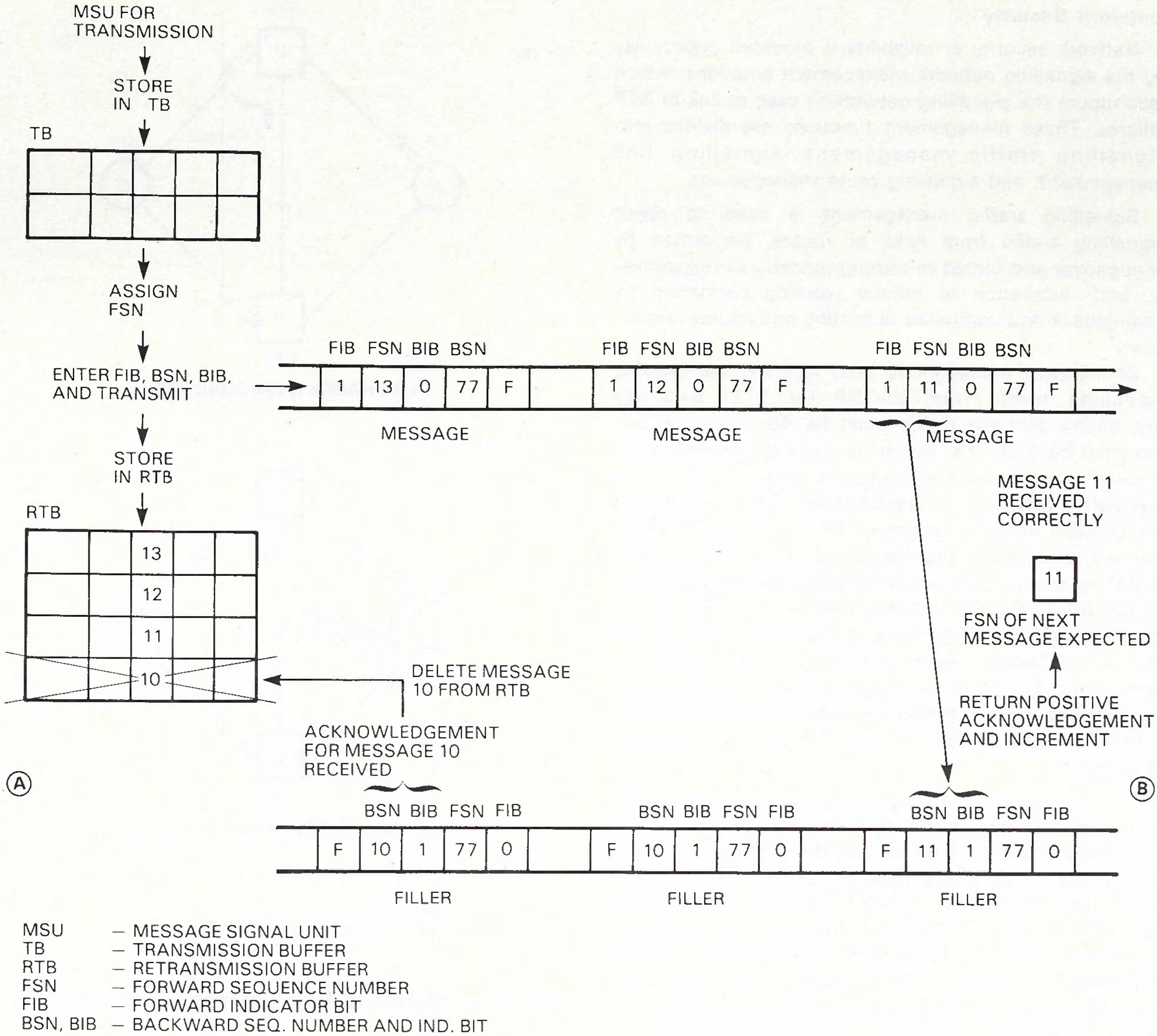


Fig. 6 — Operation of Basic Error-Correction in Error-Free Conditions.

BSN field of the next and subsequent signal units in the reverse direction as positive acknowledgement. The next expected FSN is also incremented modulo 128.

At the send end, the BSN of every correctly received signal unit is monitored and when it matches any FSN of message signal units in the RTB, all signal units up to and including that MSU are deleted from the retransmission buffer. Normally MSUs are acknowledged one at a time, but if the signal unit carrying an acknowledgement is lost, the following BSN is accepted as acknowledgement for more than one MSU in RTB. Repeat acknowledgements for MSU already deleted are ignored.

If an error is detected in a received message signal unit at the receiving end, the signal unit is discarded. When the next MSU is received correctly, its FSN will not match the expected FSN. The MSU is then also discarded and a negative acknowledgement is returned, indicated by complementing the backward indicator bit. The backward sequence number remains unchanged, thus continuing to acknowledge the last correctly received and sequenced MSU.

When the negative acknowledgement is received at the sending end, the transmission of new MSUs is stopped and all the MSUs in the RTB are retransmitted. When retransmission starts, the forward indicator bit is complemented to indicate start of retransmission and it now also matches the backward indicator bit.

In summary therefore FSN/BSN provide the means for positive acknowledgement and BIB/FIB for negative acknowledgement. BIB requests retransmission and FIB indicates the start of retransmission. In principle, with the 7 bit FSN/BSN field, the number of unacknowledged MSUs in the RTB may be up to 127, although practical buffer limitations may lower this limit. There are a few other validity checks on BSN and FIB to ensure logical operations, e.g. start of retransmission when not requested, and recovery procedures for restoring correct operation.

Network Security

Network security or reliability is provided collectively by the signalling network management functions, which reconfigure the signalling network in case of link or STP failures. These management functions are divided into signalling traffic management, signalling link management, and signalling route management.

Signalling traffic management is used to divert signalling traffic from links or routes, performed by changeover and forced re-routing procedures respectively, and restoration to normal working performed by changeback and controlled re-routing procedures respectively.

Changeover procedure is used when a link carrying signalling traffic from an SP (or STP) becomes unavailable and the traffic must be diverted to a pre-assigned back-up link. Forced re-routing procedures are invoked when there are failures in remote parts of the network, causing a destination SP to become inaccessible from the concerned SP or STP. Fig. 7 shows the two concepts. In **Fig. 7a,** failure of link BD causes B signalling transfer point to perform changeover procedure to link BC. In **Fig. 7b,** a further failure of link BC causes the D signalling point to become inaccessible from B and the A signalling point performs forced re-routing procedures. Forced re-routing only affects signalling traffic destined for D, traffic for other destinations may continue to be routed via link AB as it is still fully operational.

The signalling link management functions provide the facilities for control and management of locally connected signalling links so that the required capability to provide a signalling network always exists. As a minimum, facilities for activation and deactivation are needed to act on external network management commands, but a fully implemented function includes automatic activation, deactivation, restoration, and allocation of links as well as allocation and connection of level 1 signalling data links to level 2 terminals in cases where the level 1 signalling data links are switched by the digital switch of the accompanying exchange.

The signalling route management functions provide the facilities to select the back-up routes for the forced re-routing described earlier and restoration to normal routing. These facilities are provided by the use of 'transfer-inhibited' and 'transfer-allowed' messages generated by level 3 functions when links and/or signalling (transfer) point become unavailable or are restored. A 'signalling - route - set - test' message is also used to verify accessibility of destinations and for routing table updates in conjunction with, for example, a processor restart.

APPLICATIONS OF COMMON CHANNEL SIGNALLING SYSTEMS

It has been said before in this paper that the No. 7 signalling system is a general purpose signalling system, which is true, but as a data transmission system it is very specialised for the signalling requirements.

The reason for this is the peculiar nature of signalling information. Firstly, the signalling information is extremely important, since the whole process of call set up depends on it being transferred correctly, and yet the signalling phase is of very short duration compared with

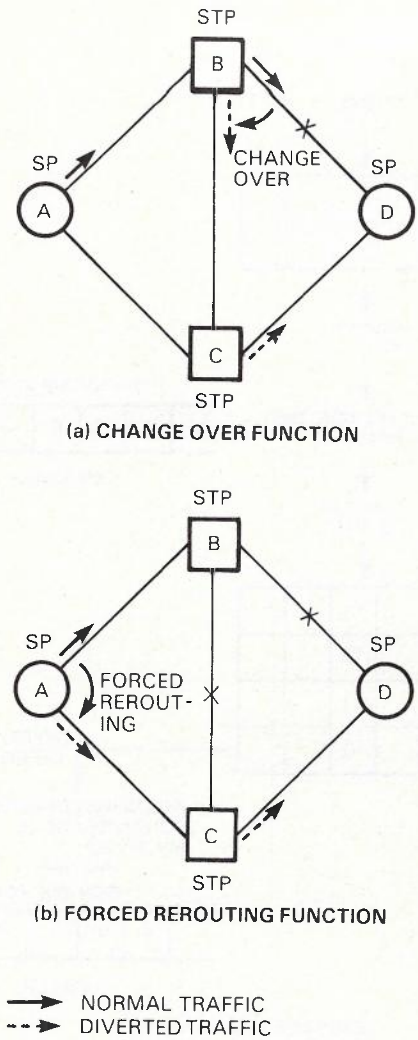


Fig. 7 — Signalling Traffic Management Functions.

the total call connection time. Therefore the back-up facilities that are justified for a signalling network are not normally feasible for the service network carrying all the traffic.

Secondly, the number of users in a signalling network changes very slowly with time, compared to a subscriber service network when the number of subscribers connected at any time would be fluctuating. The signalling routes between exchanges in the signalling network therefore are 'permanently' pre-assigned and exist all the time. The planning of these routes and the assignment of back-up routes will take even more effort than the planning of call routing in a normal network, as the signalling network is likely to be more fully intermeshed. In fact there are no specific facilities or procedures in the No. 7 Recommendations for revising the presetting of routing tables — these functions are very much implementation dependent, although the way is open for remote updating from a central planning location.

It is also implicitly assumed that the signalling network planning process will result in sufficient signalling network capacity to carry the expected signalling traffic. Flow control of traffic is very basic, consisting mainly of notifying Level 4 functions when destination points become inaccessible as a result of failure of links or STPs. There is as yet no facility to reduce signalling traffic generation at the source.

No. 7 and X.25 Comparison

In the study period 1972-76, CCITT Study Group VII produced Recommendations for a protocol to be used at the interface between a packet switched data network and computer communication terminals. This protocol is known as X.25 and was revised and improved in the 1977-80 study period. The question has often been posed to the author as to what are the essential differences between the X.25 and No. 7 protocols and facilities.

Although X.25 is not an inter-node communications protocol but only a terminal interface protocol, the end user, the subscriber in this case, often likes to talk about an X.25 network since that is the connection interface he sees. For some applications, therefore, such as collection of non-critical data or statistics from SPC exchanges which do not use common channel signalling, the X.25 'network' is sometimes viewed as a simpler alternative to the provision of No. 7 links.

The X.25 protocol is defined in only three levels. There is no level 4 or any equivalent functions; it is entirely up to the subscriber to assign codes and significance to the messages he generates and receives.

The functions of X.25 level 3, the Packet level, are entirely different from those of the No. 7 level 3. As an interface protocol, X.25 has little to say about the operation of the network behind the interface and the primary function of level 3 is to transform the single channel provided by level 2 into a number of logical channels so that several devices may be used simultaneously. Other facilities provided include error and flow control across the interface, error recovery by reset and flushing or purging of packets on a channel, end-to-end packet sequencing, and interrupt facilities to send a single byte of information which bypasses normal flow control.

The purpose of level 2 in X.25 is the same as that in the No. 7 signalling system, viz. to convert an error-prone physical circuit into a relatively error-free link. However apart from using the basic HDLC message format including the use of HDLC address and control fields, the method of operation is quite different. Since there is no link control or backup facilities, continual link error rate monitoring is not required. Although error correction is also by retransmission with positive and negative acknowledgements, since there is no equivalent to a fill in unit, a time-out mechanism must be included at the sending end to retransmit the last block if there are no others immediately following.

The X.25 level 1 is specified in greater detail including electrical characteristics, number of wires and pin assignments. These are covered by the CCITT X.21 recommendation.

From this brief comparison, it should be clear that X.25 is intended as a standardised access to a packet switching network, the operation of which is not part of the X.25 specification. On the other hand, the No. 7 signalling system Recommendations specify all aspects of the signalling network, how it is used, what messages are conveyed, link error rate performance monitoring, recovery from network and node failures. To use the No. 7 signalling system, the user must be part of the system.

Integrated Services Network Applications

The functional partition of the No. 7 signalling system into a common message transfer part and separate user parts for each service provides an elegantly simple system for satisfying signalling requirements in either a single service (e.g. telephony) or an integrated services digital network (ISDN). The addition of a new service is only a matter of defining and specifying a new user part and adding it to the signalling system.

Apart from level 3 network control user parts, the only level 4 user parts specified to date by the CCITT are for telephony and circuit switched data networks. Even these are primarily specified for international networks, which are relatively simple networks, not generally involving a hierarchy of transit exchanges. The several administrations that are planning the introduction of common channel signalling in their national network (Refs. 3, 4) have only briefly touched on the call set up procedures in their networks.

It is of course not essential for the service networks to be integrated, or digital. The same No. 7 signalling network can be readily used to provide signalling requirements for two or more entirely separate service networks. A possible problem that may arise in this case, or in an ISDN network, is that of message priority. Some future service may not be able to accept the signalling delays tolerated by other services even in a normally loaded network. Fortunately the No. 7 Recommendations permit facilities to be added to the message transfer part to handle messages with different priority based on their user code.

Network Management

A signalling system like the No. 7 Common Channel Signalling System is a pre-requisite to allow the service networks to advance to the next stage of development — to what may be called stored program controlled networks, as distinct from networks of individually stored program controlled exchanges. The No. 7 signalling system provides the necessary reliability to be able to centralise network control functions and to distribute information to SPC exchanges for call waiting and alternate path selection.

Facilities like these would be provided by a future Network Management and Maintenance user parts, that would collect information on the current status of the service network and its exchanges and configure the service network to provide the best possible service. This is an example of a non call-set up use of the signalling network, and this type of use is expected to be considerable, particularly in providing other centralised services such as call-charge recording, traffic data acquisition, automatic look-up of transferred numbers, and in general those services which become economic only if provided by a regionally centralised processing system.

CONCLUSION

The No. 7 signalling system is undoubtedly the most versatile signalling system yet developed and is probably the best described and documented.

Its introduction will revolutionize the networks of the future, particularly the national networks, since it will not only improve the performance of functions presently carried out but will also allow introduction of facilities that cannot be considered in the present network, especially for network management.

This paper has attempted to highlight the structure, operation, and facilities built into the No. 7 signalling system as well as to indicate its likely areas of application. It is a very versatile signalling system, open-ended to cater for services not yet specified, and with capabilities to allow much better use of SPC exchanges than is possible in the present network.

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GLOSSARY OF ABBREVIATIONS

CCITT — French abbreviation for International Telegraph and Telephone Consultative Committee.
SPC — Stored Program Controlled
HDLC — High-level Data Link Control
SP — Signalling Point
STP — Signalling Transfer Point
ISDN — Integrated Services Digital Network
MTP — Message Transfer Part
UP — User Part
TUP — Telephony User Part
DUP — Data User Part
OPC — Original Point Code
DPC — Destination Point Code
CIC — Circuit Identification Code
SLC — Select Link Code
SU — Signal Unit
FISU — Fill-In Signal Unit
LSSU — Link Status Signal Unit
MSU — Message Signal Unit
LI — Length Indicator
SIF — Service Information Field
TB — Transmission Buffer
RTB — Re-transmission Buffer
FIFO — First-in-First-Out
FSN — Forward Sequence Number
FIB — Forward Indicator Bit
BSN — Backward Sequence Number
BIB — Backward Indicator Bit
PCM — Pulse Code Modulation
MFC — Multi-Frequency Code

Active Filter Circuits

R. J. SPENCE, B.E.

Active filter techniques are discussed with particular reference to band-pass requirements. Single section band-pass active filters using one, two and three amplifiers are treated in turn and the limitations of each type pointed out. A technique for realising stable, easy to adjust, higher order filters using coupled three-amplifier sections is then explained, as a direct translation of a passive filter design into an equivalent active structure. A variation is then described which allows this approach to be extended to a band-stop filter.

INTRODUCTION

Electrical filters are extremely important elements of the equipment that makes up the Telecom Australia Communications Network. While many of those in use are bought as part of a complete system from a manufacturer, requirements for specially designed filters continually arise, as part of "one-off" circuits to solve particular and unique problems, or to modify existing equipment to cope with new requirements.

Originally, filters were exclusively passive devices using inductors, capacitors, and resistors. Of these components the inductor has usually been the hardest to realise satisfactorily, especially at voice frequencies and below. It is this problem that has been, and still is, the reason for the continued development of inductorless filters using capacitors, resistors and some form of amplifier — otherwise known as active filters.

The replacement of valve technology by transistors, with much more modest power supply and space requirements, made active filters more attractive, a process that has been enhanced still further by the availability of cheap, high performance, integrated operational amplifier circuits.

This article describes the features and design considerations of several active filter circuits, concentrating on band-pass designs, with one band-stop design treated as an extension of a particular technique. Most of the information is available from standard guides to active filter design and numerous articles on the topic already published in many places, but not often in a form easily and efficiently applied by a designer who lacks the time to study the subject in depth. The design suggestions made here are the result of such a study, which included measurements on test circuits, culminating in several practical designs. The first was a frequency shift keyed teletype decoder, shown in **Fig. 1**. Another was a signalling decoder for the HF radio telephone system between Brisbane and Birdsville (see **Fig. 2**).

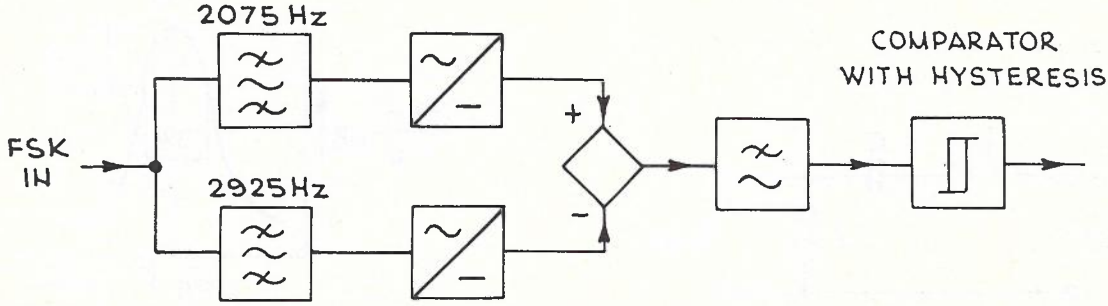

Fig. 1—FSK Teletype Decoder.

SIMPLE BAND-PASS FILTERS

The simplest band-pass filter characteristic is that corresponding to the resonant behaviour of a single tuned circuit, comprising an inductor and a capacitor, as in **Fig. 3(a)**. The response of this circuit to alternating voltages of varying frequency is shown in **Fig. 3(b)**.

The bandwith (BW) of such a circuit is most commonly defined between points where the response is 3dB down on the peak response at the natural resonant frequency (f_o). These two parameters, f_o and BW, completely define the shape of the frequency response of such a circuit. The 'sharpness' of the response is usually described by its 'Q' factor, where

$$Q = \frac{f_o}{BW}$$

This band-pass response is also referred to as 'second-order', because a minimum of two independent reactive components are required to produce it, either passively or actively, and is normally characterised by its frequency of maximum response f_o and its Q.

The gain (H) at any frequency (f), with output at f_o as reference, is given (in complex notation) by

$$H(f) = 1/(1 + jQ\ (f/f_o - f_o/f))$$

The attenuation at f with respect to f_o may be expressed by

$$\text{Loss} = 10\ \lg\ (1 + Q^2\ (f/f_o - f_o/f)^2)\ \text{dB}$$

Simple Active BP Filter

Fig. 4 shows a simple but practical active realisation of a second-order band-pass filter. Instead of the inductor and capacitor of the passive filter, we now have two capacitors, as well as additional resistors.

The characteristics of this circuit (Rp) (assuming an ideal, infinite-gain amplifier) are described by the following equations

$f_o = 1/2\pi\sqrt{(R_p R_3 C_1 C_2)}$
$H(f_o) = H_o = R_3/R_1(1 + C_1/C_2)$
$Q = \sqrt{(R_3/R_p)}/(\sqrt{(C_2/C_1)} + \sqrt{(C_1/C_2)})$
where $R_p = R_1 R_2/(R_1 + R_2)$
If $C_1 = C_2 = C$:
$Q = ½\sqrt{(R_3/R_p)}$
$BW = 1/\pi R_3 C$

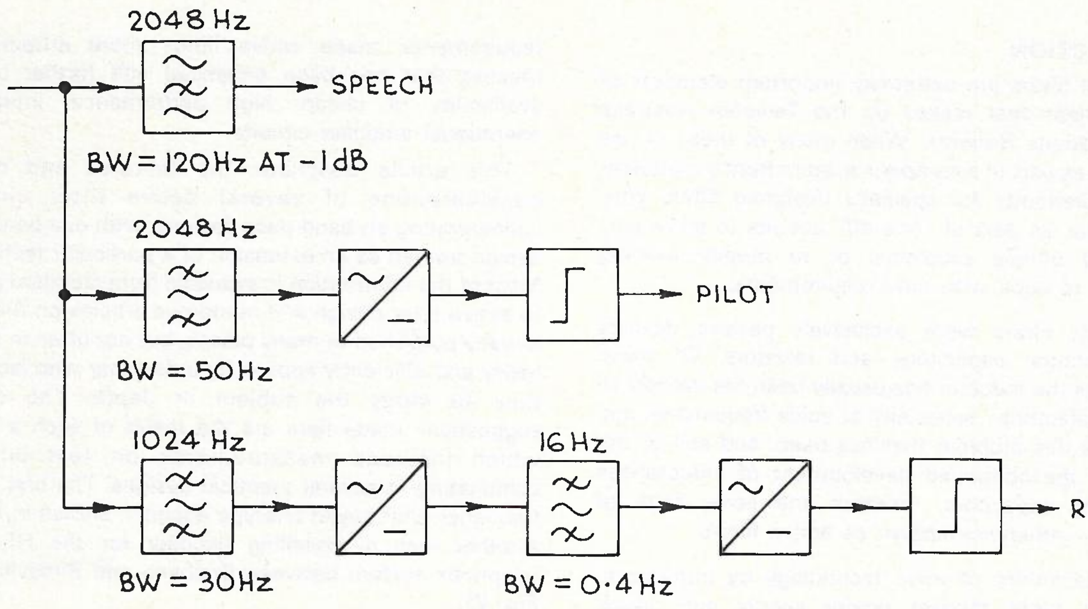

Fig. 2—HF Radio Telephony Signalling Decoder (Brisbane-Birdsville)

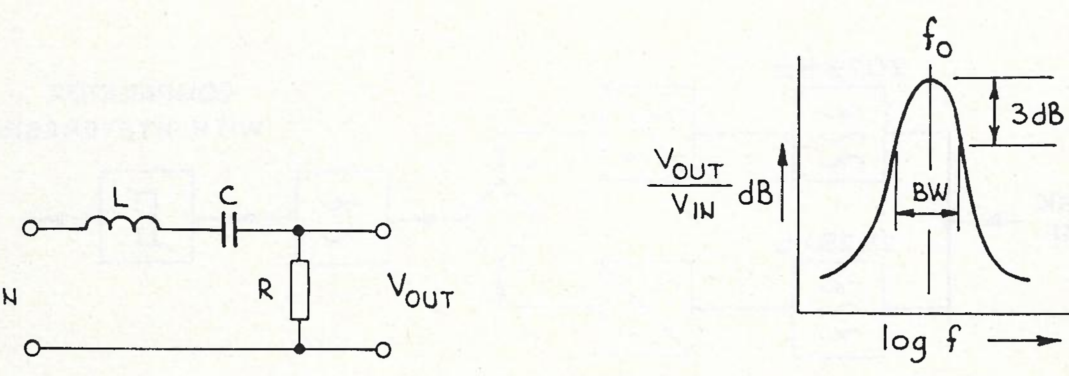

Fig. 3—Basic Tuned Circuit and its Frequency Response.

Limitations

Note that $R_3 = 4 Q^2 R_p$. This means that for a Q of 10, say, R_3 must be 400 times Rp.

The practical limit to the Q of this circuit is determined by the largest value of R_3 that can be used and the smallest value of R_2. R_3 will be limited by leakage problems and the input current of the amplifier. R_2 will be limited by the value at which wiring resistance and the series resistance of the capacitors becomes significant, depending on the accuracy and stability required.

A further consideration is that any stray capacitance (C_S) across R_3 will cause a phase shift which will severely reduce the realized Q when

$C_S R_3 >= 1/2 \pi f_0 Q$

e.g., if R_3 = 1M ohms, Q = 10, f_0 = 1kHz then $C_S <<$ 16 pF if it is not to significantly affect the circuit characteristics.

Effect of Amplifier Limitations

A standard IC operational amplifier using simple compensation for stability has a frequency response which falls at 6dB/octave to unity-gain at f_1.

It can be shown that this will modify f_0 and Q as follows:

$$f_0 = (1 - \frac{Qf_0}{f_1}) f_0$$

$$\text{and } Q' = (1 + \frac{Qf_0}{f_1}) Q$$

for $Qf_0 << f_1$.

To indicate the magnitude of these effects, for the case of f_0 = 1kHz, Q = 10, and f_1 = 1MHz, the shift in f_0 is about 10 Hz, i.e., about 10% of the bandwidth. For a Q of 20, the shift is 20Hz, which is now 40% of the nominal bandwidth of 50Hz. Therefore, if it is desired that the filter characteristics are not to be affected by the amplifier characteristics, then $Qf_0 < 0.1 f_1$.

Tuning

A common advantage of active circuits is shown up when we consider the way in which a circuit may be trimmed to achieve precise f_0 and Q. Only resistors need be adjusted, and variable resistors of wide range are much more readily obtained than variable inductors and capacitors, particularly if the large values required for low frequencies are considered.

R_3 may be adjusted to achieve the required bandwidth, then R_2 adjusted to correct f_0, without affecting BW.

For Higher Q

To obtain higher Q values with a given spread of resistor values, the circuit of **Fig. 5** may be used. This is simply the circuit of Fig. 4 to which positive feedback has been added via a second amplifier.

If $R_p = 1/(1/R_1 + 1/R_2 + 1/R_4)$

then $f_0 = 1/2 \pi \sqrt{(R_p R_3 C_1 C_2)}$

$Q = \sqrt{(R_3 C_2 / R_p C_1)} / (1 + C_1/C_2 - R_6 R_3 / R_5 R_4)$

The chief disadvantage of this circuit is that if large increases in Q are to be achieved, the Q and gain of the circuit become very sensitive to the exact values of the components. It is usually recommended that it be restricted to Q values of 50 or less.

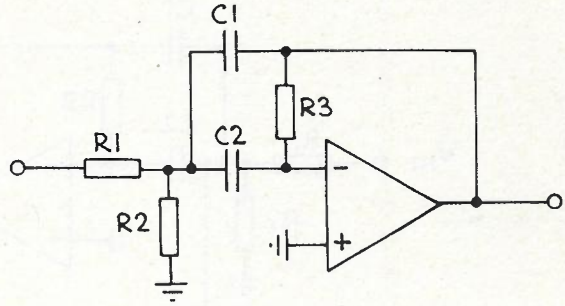

Fig. 4—Simple Active Band-Pass Filter.

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Mr Spence was transferred to Customer Networks and Equipment Section, Brisbane, as Engineer Class 2, Special Services at the beginning of 1980.

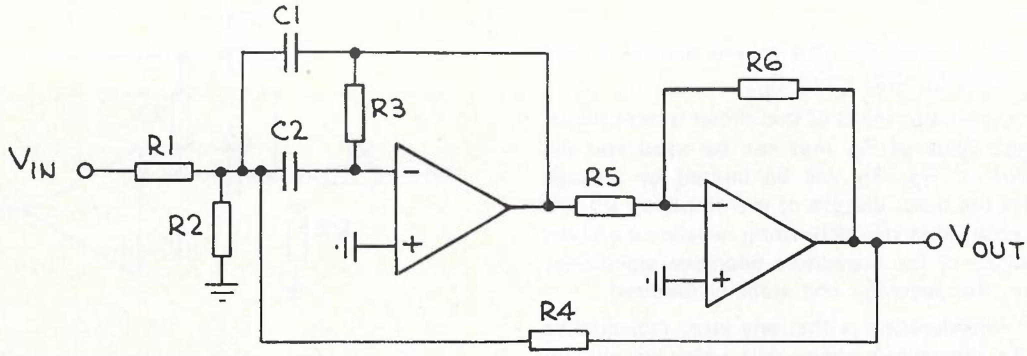

Fig. 5—Active Band-Pass Filter Suitable for Higher Q.

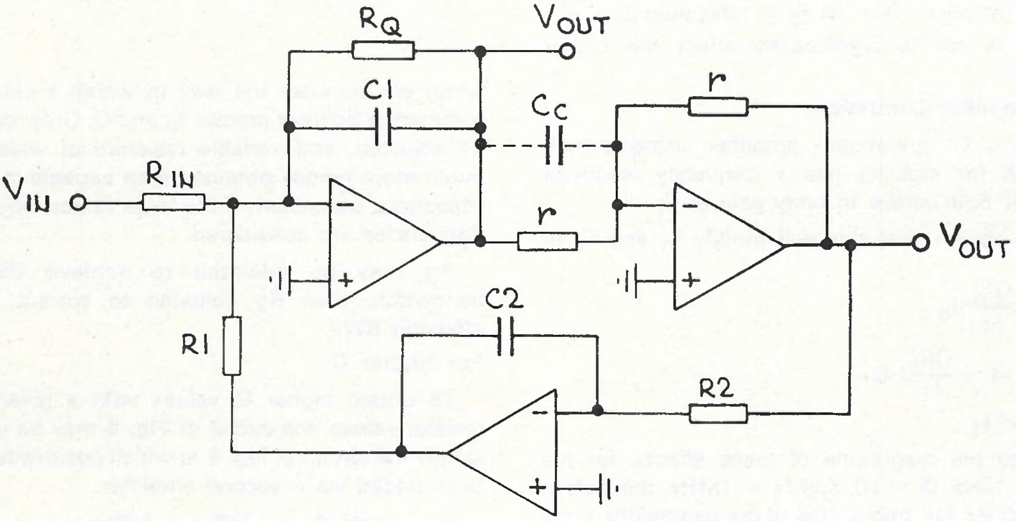

Fig. 6—Three Amplifier Band-Pass Filter.

Three Amplifier Resonator

The basic characteristics of the circuit of **Fig. 6** are defined by the following equations:

$f_o = 1/2\pi\sqrt{(R_1C_1R_2C_2)}$
$Q = R_Q/\sqrt{(R_1R_2)}$
$BW = 1/2\pi R_Q\sqrt{(C_1C_2)}$
$Ho = R_Q/Rin$

Effect of Amplifier Bandwidth

Limiting the amplifier bandwidth results in an increase in Q, viz

$Q' = Q/(1\text{-}4Qf_o/f_1)$

Similarly, the resonant frequency (f_o) is decreased, viz

$$f_o' = f_o\,(1 - \frac{2\,f_o}{f_1})$$

Compared to the single amplifier circuits, the error in Q is four times greater for this circuit, but the resonant frequency error is less for Q > 2. The shift in Q may be corrected by adding a small compensating capacitor as shown (Cc):

$Cc = 4/2\pi f_1\, r$

Where f_1 = unity gain frequency of amplifiers.

For typical circuits with equal capacitor values, the range of resistor values is Q : 1, as compared to $4Q^2$: 1, or 10 : 1 instead of 400 : 1 for Q = 10. This greatly reduces the problem of stray capacitance and resistance.

Adjustment

Varying R_1 or R_2 will trim f_o while bandwidth (BW) and gain (H_o) remain constant.

Adjusting Rin will vary H_o without affecting any other parameters.

Summary

This configuration has obvious advantages for high Q filters, in terms of relative insensitivity to amplifier characteristics, ease of adjustment, and a more modest range of component values required. The only major drawback is the requirement for three amplifiers, but the availability of cheap integrated operational amplifiers makes this point relatively insignificant.

Single section filters of this form were used for the 2048 Hz, 1024 Hz and 16 Hz filters in Fig. 2.

Other Configurations

There are many other arrangements with which the basic band-pass characteristic may be realised. Some of

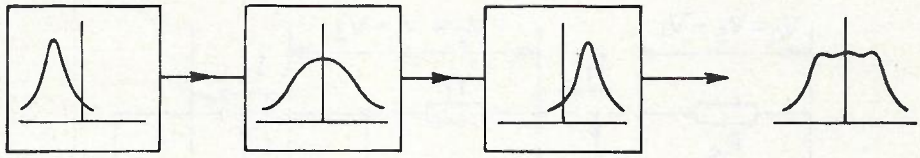

Fig. 7—Cascading Simple Filters to Obtain a Higher Order Band-pass Response.

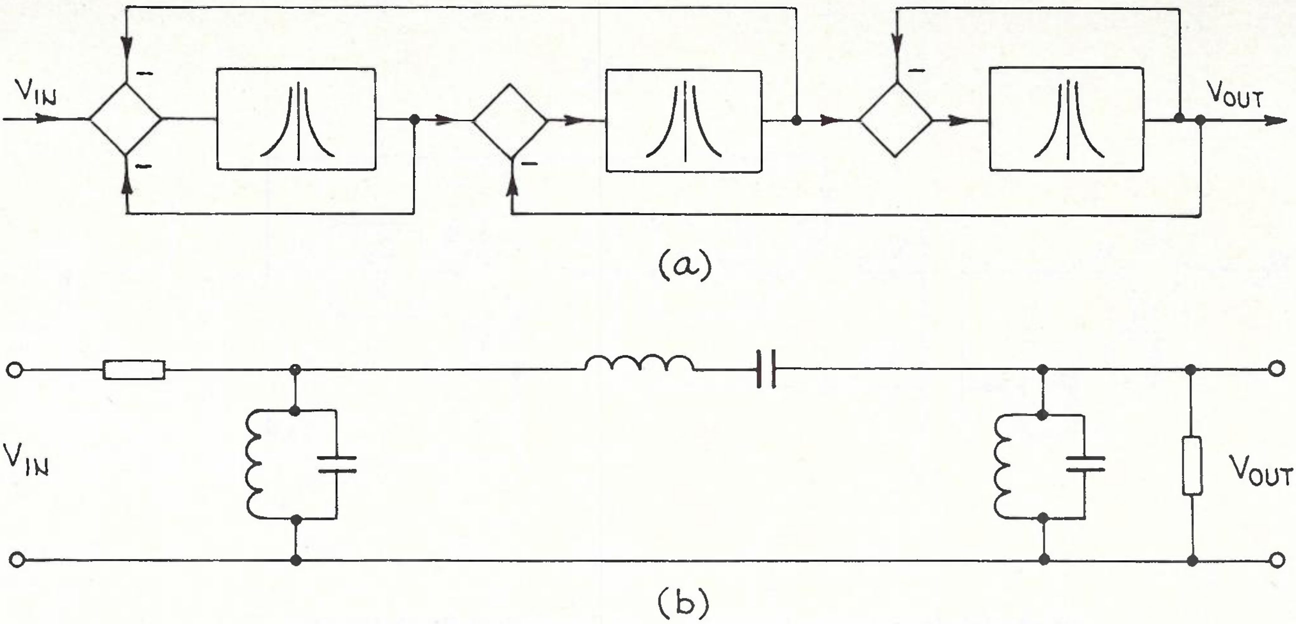

Fig. 8—(a) Coupled Resonators. (b) Equivalent Passive Network.

these were investigated theoretically as part of studies described in this article, but were considered not to offer advantages over the circuits so far discussed. The aspects considered were sensitivity to component values and active device parameters, as treated above, for a given level of circuit complexity. One aspect which was considered important was the use of standard active elements, in particular operational amplifiers, because of the low cost and ready availability of these devices in integrated-circuit form.

Most of the other circuits for basic band-pass filters may be found in the references quoted at the end of the article.

HIGHER ORDER FILTERS

In the simple second-order band-pass filter as described so far, increased rejection of frequencies well away from the wanted range can only be obtained at the expense of a narrower pass-band, by using a higher Q. If increased 'out of band' rejection is needed without restricting the pass-band, higher order filters are required.

'Classic' Approach

The standard technique for realising higher order filter characteristics is to cascade the required number of lower order sections. **Fig. 7** shows how a 6th order band-pass filter is produced by connecting three second-order circuits in series.

Each section in this circuit must be tuned to a different frequency and a particular Q. Small errors in frequency, particularly for high Q sections, will lead to large distortions in the overall pass band shape.

Coupled Filters

An alternative method is to use standard sections of nominally 'infinite' Q, and provide coupling between them, as shown in **Fig. 8a**. This arrangement is described in an article by Girling and Good (Ref. 2) and can be shown to be mathematically equivalent to a standard passive filter using inductors and capacitors, as in **Fig. 8b**. Each section in the active version is tuned to the same frequency as the corresponding L-C section in the passive network, and the summation points correspond to the Khirchoff Laws for voltages and currents in the passive network. The aim of this approach is to achieve a filter, less sensitive to errors in frequency and Q of individual sections than is the case for narrow band filters produced by the usual approach of cascading independent 'stagger-tuned' sections.

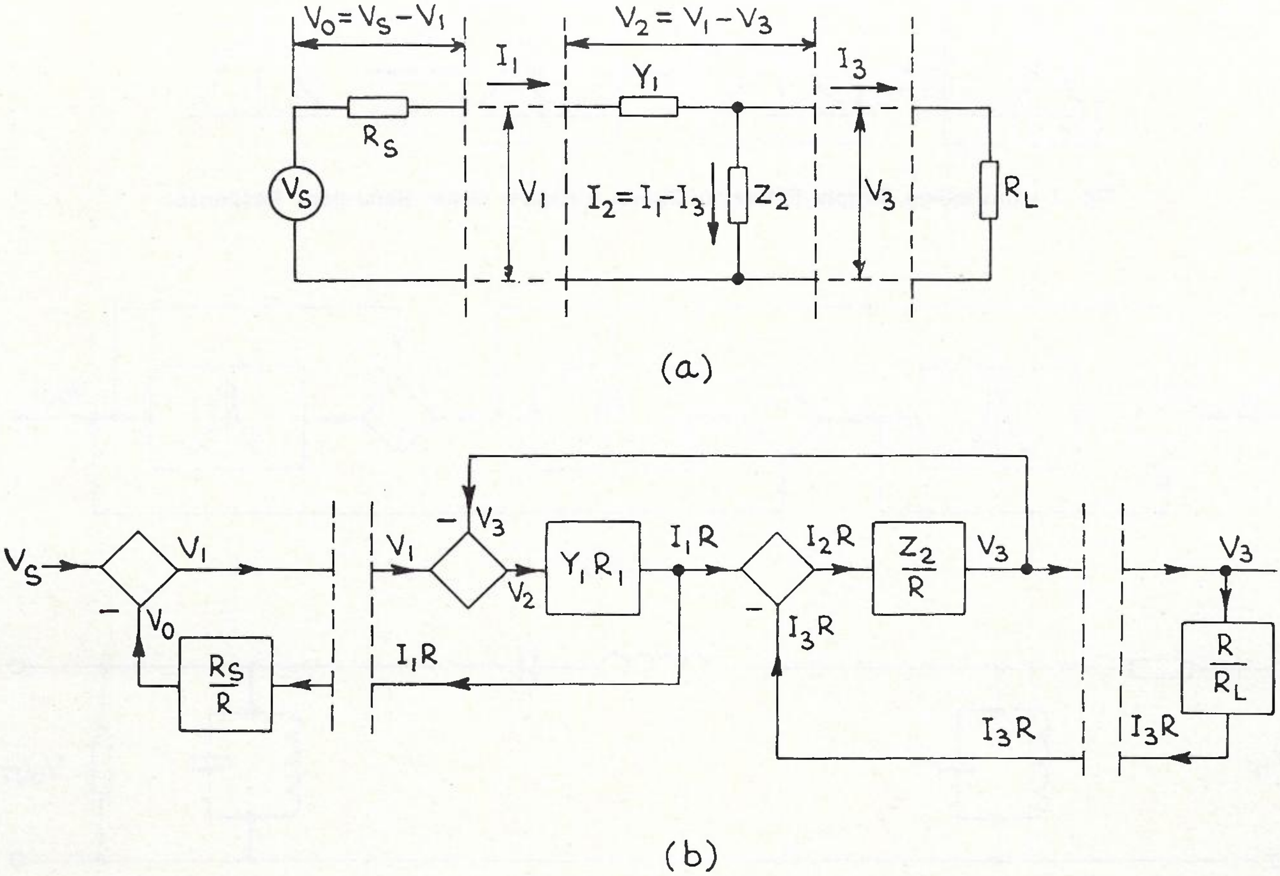

Fig. 9—(a) Basic Ladder Network. (b) Equivalent Block Diagram.

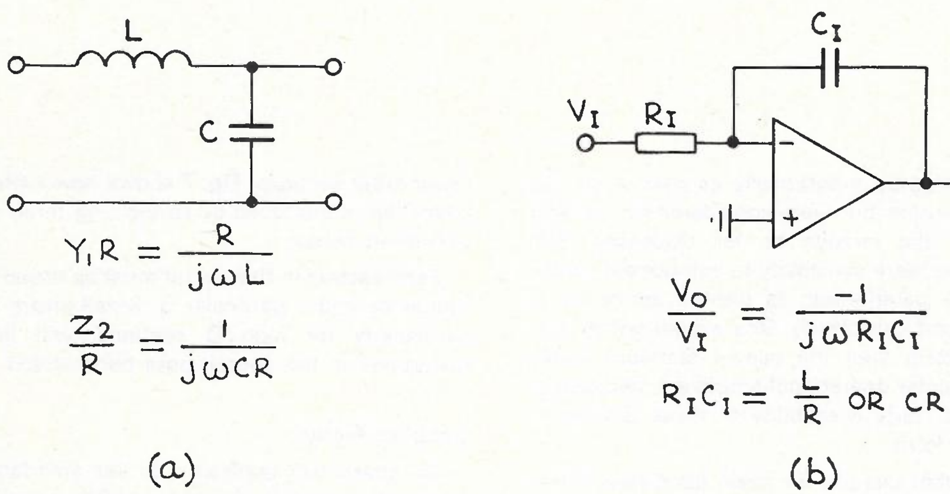

Fig. 10—(a) Low Pass LC Ladder Section and Required Functions.
(b) Basic Integrator to Realise Functions in (a).

Fig. 9 demonstrates how the operation of a section of a passive ladder network (a) on the voltages (V) and currents (I) passing through it, may be represented as a block diagram (b). The factor R is an arbitrary resistance value introduced to convert the I terms to voltages and Y is the admittance whilst Z is impedance. For a low-pass L-C network, as in **Fig. 10a**, each block in Fig. 9b is an integrator. The diagram of Fig. 9b can therefore be easily translated to a network of operational amplifiers providing both the integration and summation functions. A realisation of this is shown in **Fig. 11**, with some sign changes to allow for the inverting effect of the basic integrator. This would not normally be used for realizing such a filter because the relatively low Q's required can be satisfactorily implemented with cascaded single amplifier second-order sections.

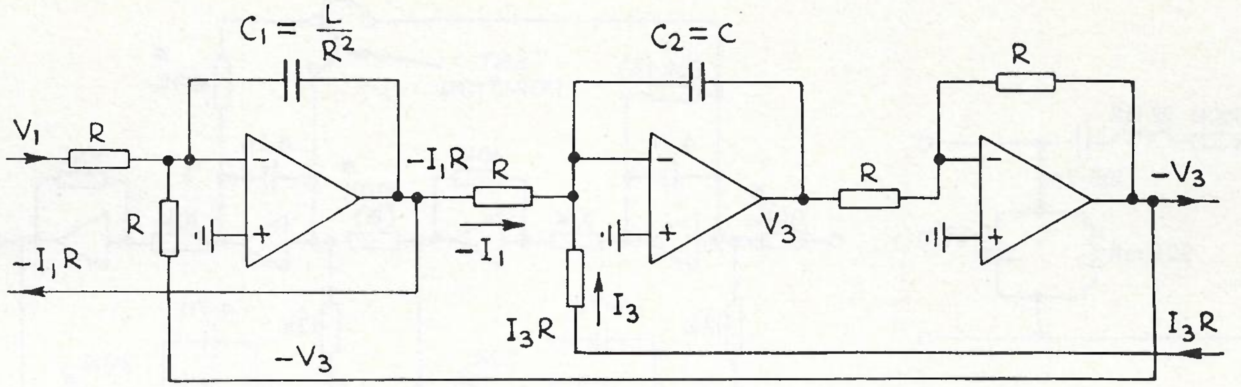

Fig. 11—Operational Amplifier Analogue of LC Section of Fig. 10a.

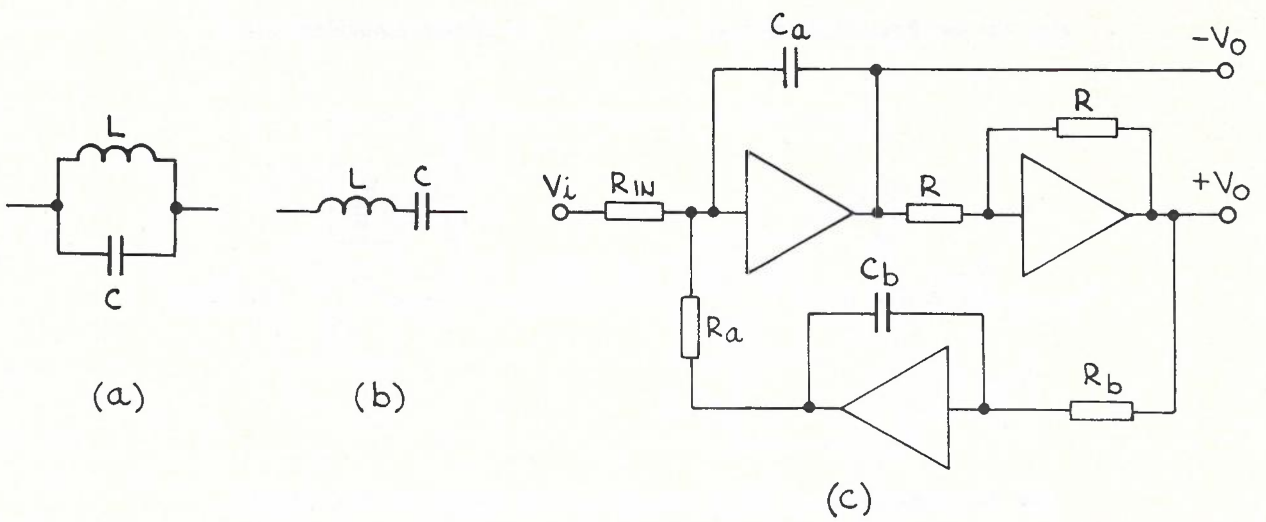

Fig. 12—(a) and (b): Resonating Elements of Passive Band-pass and Band-Stop Filters.
(c) Equivalent Resonating Element of Active Filter.

Band-pass type

Referring to **Fig. 12**, the basic elements of passive band-pass (and band-stop) filters are parallel tuned (12a) and series tuned (12b) LC networks.

If $\omega o = 1/\sqrt{(LC)}$

then, for the parallel tuned section, Fig. 12a,

$$\text{impedance } Z = \frac{V}{I} = \omega_o L \frac{j\omega/\omega_o}{(j\omega/\omega_o)^2 + 1}$$

For the series tuned section, Fig. 12b,

$$\text{admittance } Y = \frac{I}{V} = \omega_o C \frac{j\omega/\omega_o}{(j\omega/\omega_o)^2 + 1}$$

Referring to Fig. 12c, the corresponding equation for the three amplifier resonator is

$$\frac{V_o}{V_i} = (1/\omega_o RinCd)\frac{j\omega/\omega_o}{(j\omega/\omega_o)^2 + 1}$$

If Y_1 in fig. 9a is a series tuned circuit,

$$Y_1 R = \frac{I_1 R}{V_2} = \omega_o C_1 R \frac{j\omega/\omega_o}{(j\omega/\omega_o)^2 + 1}$$

To replace this by the circuit of Fig. 12c:

$$Rin = \frac{1}{\omega_o{}^2 R\ C_1\ Ca}$$

Similarly, if Z_2 is a parallel tuned circuit,

$$Rin = \frac{R}{\omega_o{}^2\ L_2\ Ca}$$

Varying Rin associated with each three-amplifier 'module' to suit the prototype filter constants allows each module to use the same component values. **Fig. 13** shows how the summations of the block diagram of **Fig. 12c** are realised.

The value of R in the above expressions may be arbitrarily chosen to yield convenient values for the coupling resistors. It should be close to the impedance level of the prototype network, as determined by the source or load resistance (R_S or R_L). This ensures that successive sections operate at similar voltage levels, by making the 'IR' terms in Fig. 9b comparable to the 'V' terms. Large variations could lead to noise or overload problems.

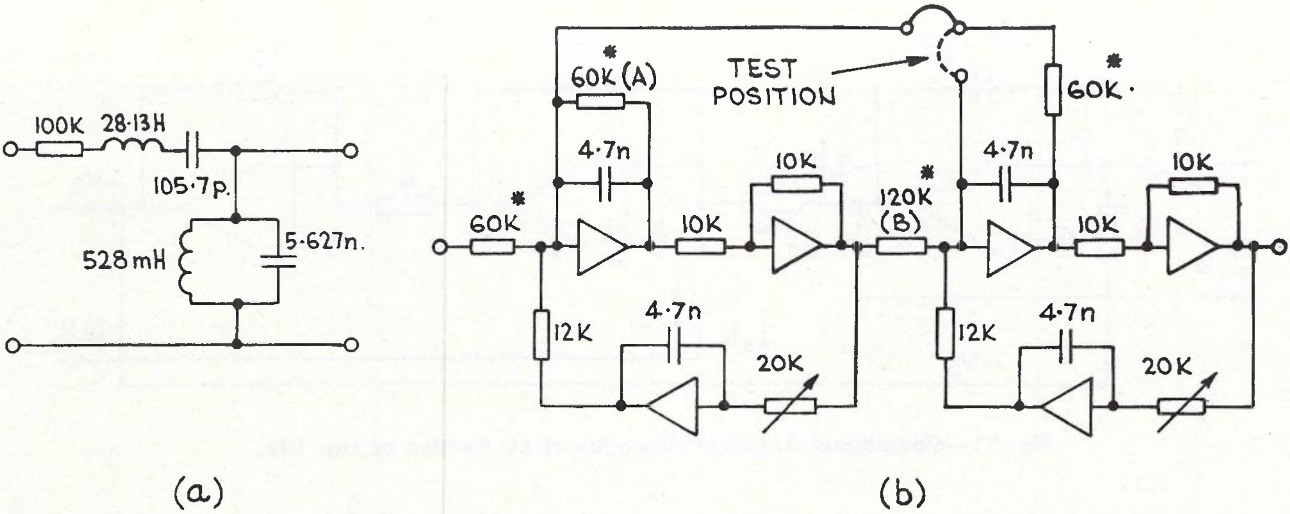

Fig. 13—(a) Passive Band-Pass Network. (b) Active Equivalent of (a).

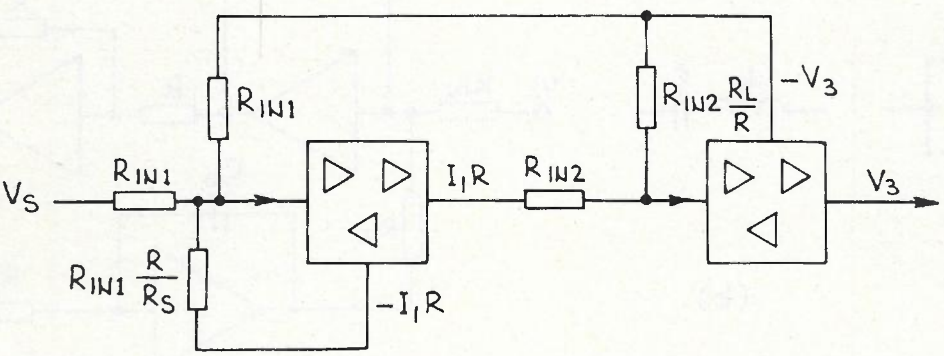

Fig. 14—Translation of Block Diagram of Fig. 9b into Active Circuitry.

Fig. 14 shows how the block diagram of Fig. 9b is translated into a circuit using the resonators of Fig. 12c.

A Practical Example

Fig. 13a shows a two section passive network having a Butterworth band-pass characteristic, with -3 dB points at 2725 Hz and 3125 Hz. This corresponds to the 2925 Hz filter in the FSK decoder (Fig. 1). The component values were calculated using standard network synthesis procedures. Fig. 13b is an active realisation of this filter using the above techniques, with R = Rs = 100K. The strap shown simplifies tuning, by allowing the circuit to be converted into two independent sections in cascade. They are tuned while in this condition to the same centre frequency.

Tuning in the coupled condition (strap normal) would required a sweep generator to display the whole pass-band.

Features of this Circuit.

It can be shown that the bandwidth and centre frequency of the filter may be varied quite independently. If only the components Ra, Rb, or Cb (of Fig. 12c) are used for tuning the individual sections, and all sections are tuned to the same frequency, the width and shape of the pass-band remain constant as the centre frequency is shifted.

On the other hand, if the tuning is left fixed, and the resistors marked (*) in Fig. 13b are all scaled by the same factor, the bandwidth will be scaled by the reciprocal of that factor. That is, if Rin 1 and Rin 2 in Fig. 14 are both doubled, the bandwidth will be halved. With the alternative, non-coupled version of this filter, careful re-tuning would be required to change bandwidth or centre frequency. In fact, it is possible to adjust the bandwidth of this particular circuit with only two resistors, marked A and B in Fig. 13b. If A is doubled and B increased four times, bandwidth is halved, but the two sections are no longer operating at similar signal levels.

Coupled Band-stop Filter

Fig. 15a shows an alternative block diagram representation of the basic ladder network of Fig. 9a. This allows realisation of high-pass and band-stop filters **(Fig. 15b)** with integrators and three amplifier resonators respectively.

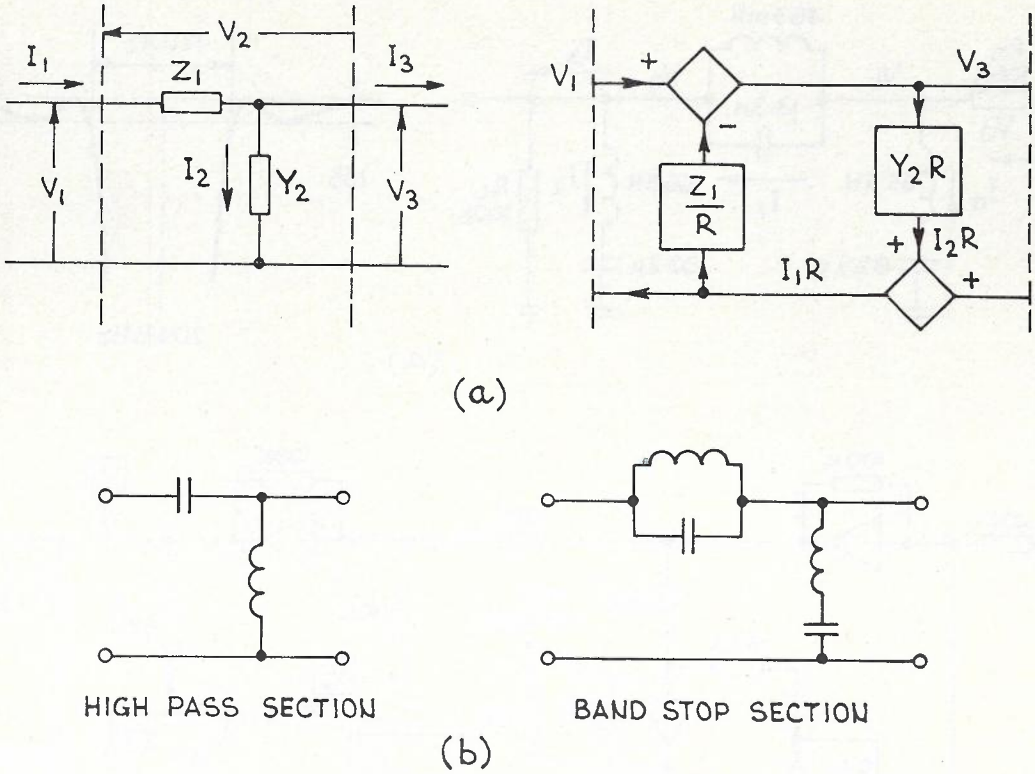

Fig. 15—(a) Development of Alternative Block Diagram for Ladder Section.
(b) Realisable Networks with this Configuration.

Fig. 16a details a passive band-stop filter based on a third-order, 1dB Tchebycheff prototype, with a stop band 120Hz wide centred on 2048Hz, as required for the pilot reject filter in the speech path of the Brisbane-Birdsville radio telephone system.

This can be translated into an active version, using the same approach as previously described for band-pass filters, but based on the configuration of Fig. 15a, and the actual circuit produced is shown in **Fig. 16b**.

Tuning is performed by connecting the test strap on all resonators except the one being tuned, to suppress them, then tuning for a minimum at the desired frequency (2048Hz in this case).

As in the bandpass case, changing the bandwidth is achieved by multiplying the resistance values of the resistors marked (*) by the factor by which the bandwidth is to be reduced, i.e. double the resistance value to halve the bandwidth.

Other High Order Techniques

An interesting alternative to the above approach to 'simulating' passive filters, uses an active circuit element known as a 'gyrator'. This is a two-port device which relates the voltage at one port to the current at the other by a factor with the dimensions of resistance. If a capacitor is connected across one port, the input impedance seen at the other port has the properties of inductance. Thus a 'passive' L-C filter may be constructed in which inductors are replaced by gyrators and capacitors. To be of general use, the gyrator must simulate a 'floating' element, and this is a problem with simple gyrator circuits.

Such a filter obviously has the same properties of stability and lack of sensitivity to component errors as the coupled band-pass filters previously described. However, it does not have the same ease of tuning of the individual sections or the simplicity of bandwidth and centre frequency variation. In addition, the gyrator elements are not as readily available as operational amplifiers. Such circuits would normally require buffer amplifiers at input and output, whereas the operational amplifier filters described do not.

For these reasons the gyrator filter realisations were not pursued further, but should still be considered, as they may have advantages in some applications.

The gyrator is the best known of a range of circuits using resistors, capacitors and active devices to realise some kind of frequency dependent impedance element which can be used, with capacitors, in an inductorless version of standard passive L-C filters. Some of them avoid the need for floating elements in particular cases. Many of these are described in Reference 2. In general, it is felt that they do not offer all the advantages of the approach described above.

CONCLUSION

All the circuits described in this article have been built, at least in 'breadboard' form, and tested. The tests have been compared to the results of theoretical analysis,

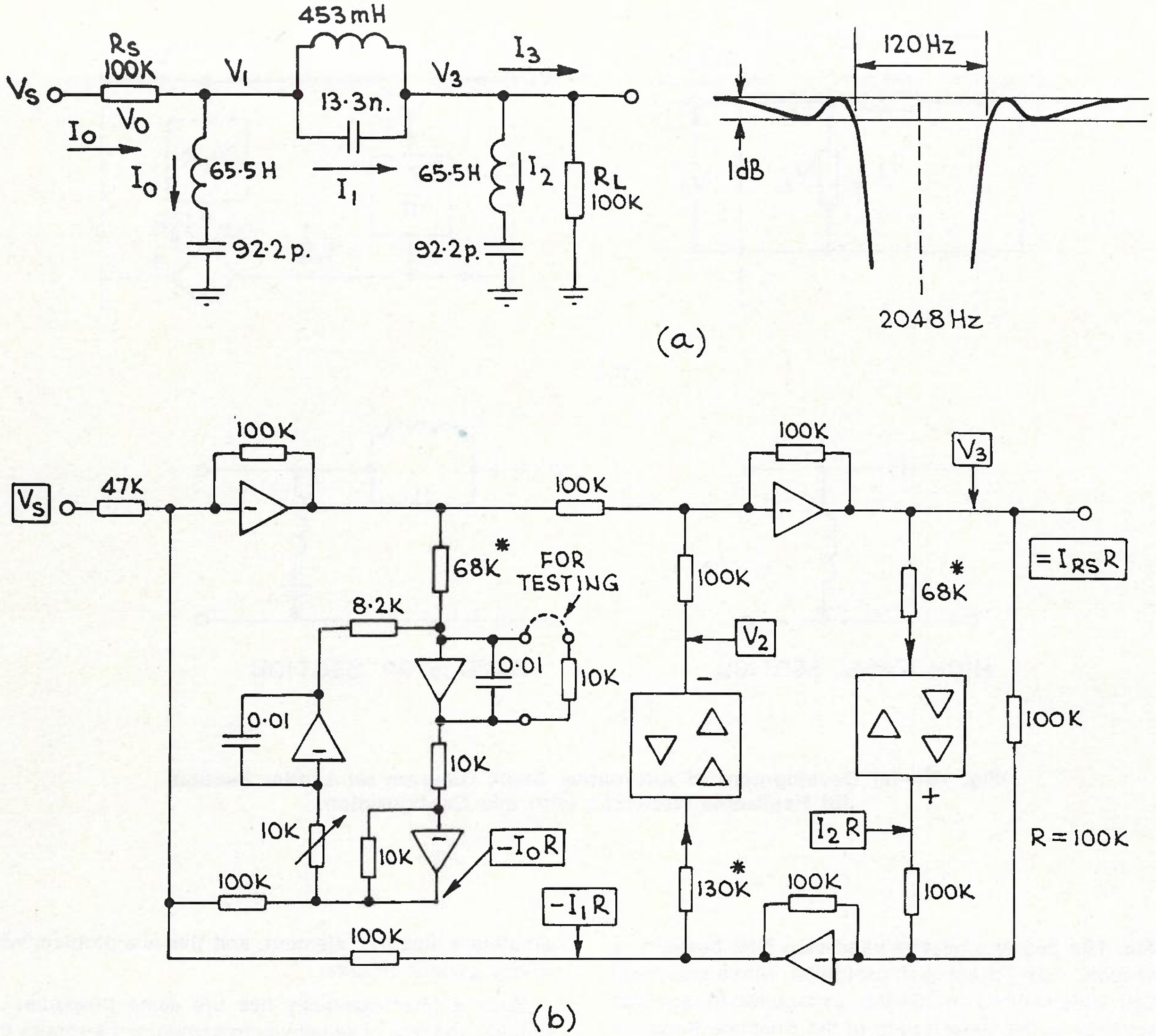

Fig.16—(a) Passive Band-Stop Filter. (b) Active Version of (a).

which included using a desk-top computer to study the effects of various departures from the ideal circuit on the calculated frequency response. This allowed identification of the main limitations of each circuit.

The author believes that the 'coupled resonator' type of band-pass or band-stop filter has significant advantages over the simple cascaded types, especially when narrower bandwidths are required:

- Ease of adjustment of individual tuned sections;
- Simple independent adjustment of bandwidth and centre frequency;
- Inherently less sensitive to small errors of tuning.

The next stage being investigated is the realisation of elliptic filters by this method, as part of a generalisation of the technique.

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SDL and Its Use in Australia and Overseas

Part I: Introduction to SDL

P. H. GERRAND, B.E., M.E.Sc.

In the past ten years the CCITT Specification and Description Language (SDL) has progressed from a speculative research topic to an international standard (CCITT 1976, 1980) gaining wide acceptance in the world-wide telecommunications industry. Part I of this paper provides an introduction to SDL and its methodology. A three-step procedure for applying SDL is described, using two examples: (a) specification of call set-up procedures in an ISDN (Integrated Services Digital Network) switching node, and (b) description of a multi-server queue managing process. In addition, the use of SDL with state pictures is illustrated with an extract from the specification of a telepone call-waiting facility. Part II surveys the use of SDL within Australia and overseas, and makes predictions concerning the nature of its future use by telecommunication administrations and manufacturers.

BACKGROUND

SDL is the official abbreviation for the CCITT's Specification and Description Language, a graphical language for either the specification of the required behaviour, or the description of the implemented behaviour, of functions, features and facilities in telecommunication switching systems (Refs. 1,2).

CCITT of course stands for the International Telegraph and Telephone Consultative Committee (of the International Telecommunications Union) and SDL was developed by experts from telecommunication administrations and manufacturers in Working Party Meetings of the CCITT's Study Group XI from 1973 onwards (see **Fig. 1**).

Australia has played a key role in the development of SDL. The Australian Call State Transition Diagram (Refs. 3,4) was one of the four candidate graphical languages from which the basic concepts of SDL were derived, and Australia has sent contributions on SDL and technical experts to SDL working meetings in the CCITT since 1973. One of the objectives of this investment of technical effort has been to significantly improve the quality of the upper level documentation supplied by manufacturers of telecommunications switching systems, through the creation of appropriate international standards, and this is now happening. However one of the lessons learned from our eight-year involvement with SDL within the CCITT has been that the improvement of manufacturers' documentation generally only occurs when there is a related improvement in the specification of requirements issued by the administrations, and fortunately this is also now starting to happen, too.

SDL was originally developed by the CCITT in order to meet administrations' needs for planning, operating and monitoring modern telephone switching systems. By 1977 it was evident that SDL was capable of far wider application and in fact the 1980 SDL recommendations, recommend its use for stored program controlled switching systems in general. Its use for specifying data-switching protocols and services has been recently confirmed by preliminary applications (refs. 8,9), and its very general scope for useful applications will be highlighted later in this paper.

INTRODUCTION TO SDL CONCEPTS

SDL can be applied via a simple three-step procedure which is broadly the same, whether SDL is being used in functional specification (ie defining the required behaviour of a system) or in functional description (ie representing the observed behaviour of an implemented system).

To make the three-step procedure more meaningful, it is illustrated in **Figs. 2 (a), (b) and (c)** in the form of an application of SDL to the specification of the call-handling control functions in a hypothetical telecommunications switching node. To keep this example down to manageable size, we shall ignore the additional functions needed to cope with line faults, system faults, overload controls, maintenance, call-charging, etc. — all of which can be specified very effectively using SDL. But to keep the example relevant and interesting, we shall specify this node to be capable of setting up and supervising circuit connections for telephony, data and a host of other services, using the same set of signalling sequences — in other words, we

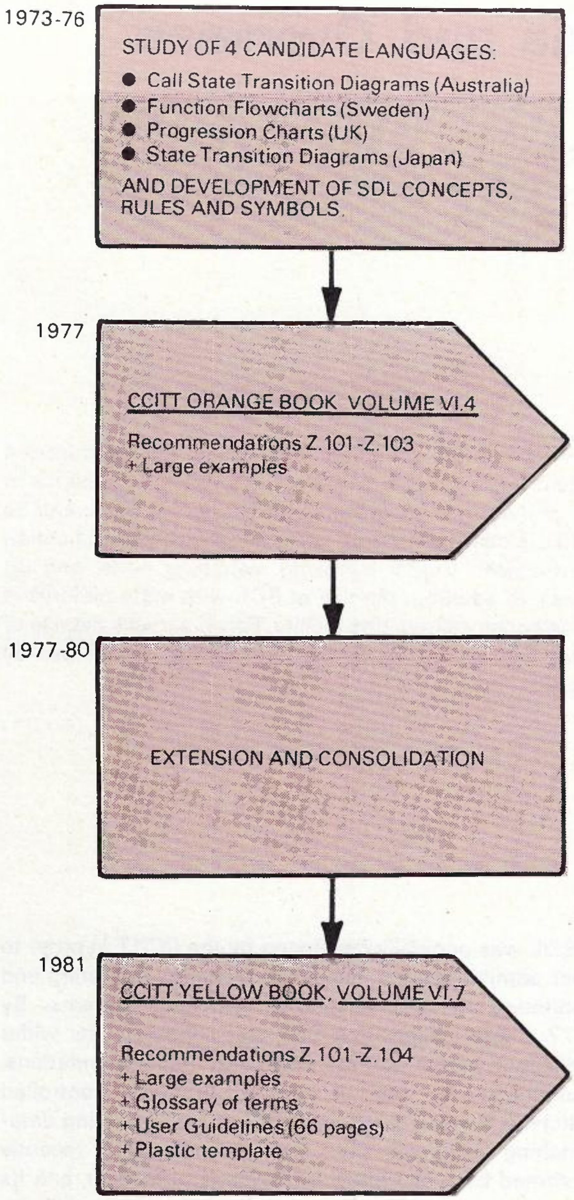

Fig. 1 — Historical Development of SDL by the CCITT.

are anticipating the era of the Integrated Services Digital Network (ISDN).

Step One in the procedure is to conceptually partition the given system into a finite number of abstract modules called Functional Blocks (FBs). Each of these FBs should be chosen so as to incorporate a common group of functions in the system. In a very complex system, it may be necessary to repeat Step One several times, treating each FB as the system to be repartitioned on the next (more detailed) level, until finally the original system is partitioned into a set of FBs each of which is capable of being conveniently modelled using SDL diagrams.

Fig. 2 (a) shows how we have chosen to carry out step one in the specification of an ISDN node. The motivation for this partitioning is the assumption that all signalling circuits (lines) connected to the node are uni-directional, in the sense of the direction of call set-up, and that therefore it is convenient to incorporate into a functional block FB2 all those functions needed to respond to signals detected arriving in the incoming circuits, and to incorporate into a functional block FB3 all those functions needed to respond to signals detected arriving in the outgoing circuits. (The control of bi-directional circuits can be specified just as effectively using SDL, but does not provide as convenient a tutorial example). The need for a third functional block FB5 within the system, to perform timing functions needed to supervise the execution of the call-handling functions, only became apparent after proceeding to draw the call-handling SDL diagrams in step three — so the three-step procedure must be regarded as being highly iterative, like any creative design process.

It is convenient to regard the system's environment as also composed of one or more FBs, as shown in Fig. 2 (a), but it is normally not necessary to specify the environment FBs using SDL diagrams if knowledge of the signals passing between the system and its environment is sufficient to define the interworking aspects of the environment.

The general SDL methodology assumes that each FB contains one or more 'processes', whose behaviour is modelled by SDL diagrams. The simple three-step procedure assumes that the system has been partitioned sufficiently so that only one process exists per FB. (The

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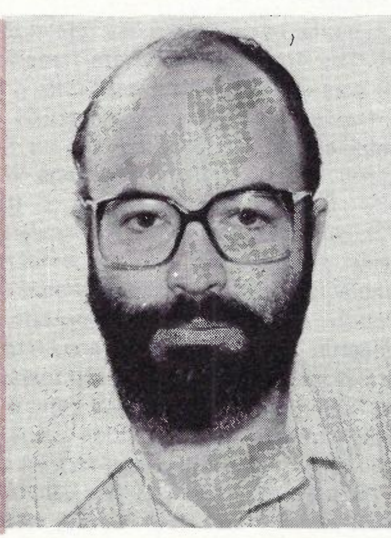
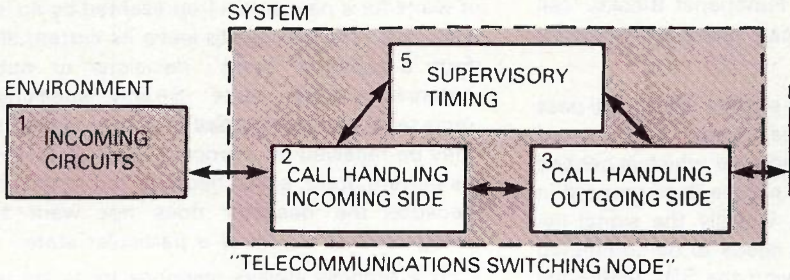
From 1977 to 1980 he was Chairman of the CCITT's Sub-Group X1/3-4 (Specification and Description Language for SPC telephone switching systems), and he is currently an Editor of Australian Telecommunication Research.

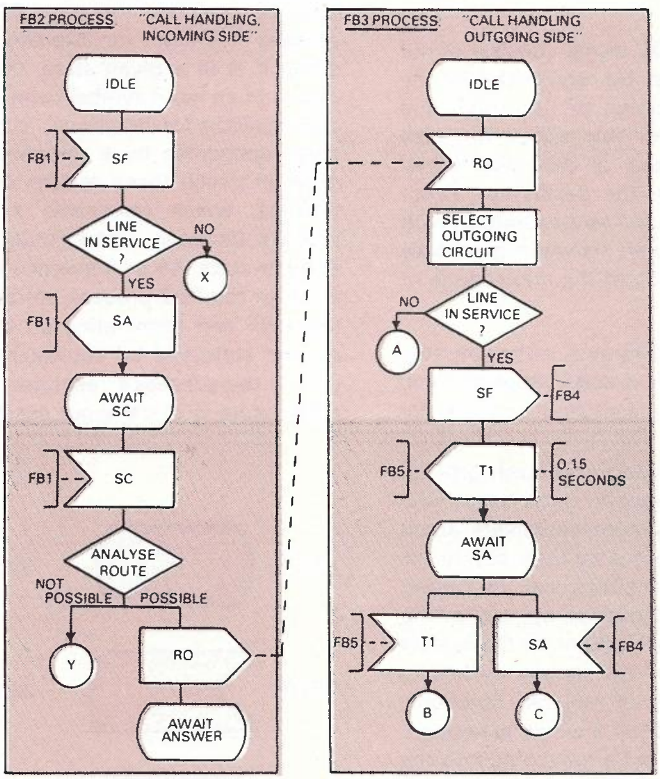




(a) STEP ONE: PARTITION THE SYSTEM AND ITS ENVIRONMENT INTO FUNCTIONAL BLOCKS (FB.), USING AN FB INTERACTION DIAGRAM.

ORIGIN, DESTINATION	SIGNAL NAME	SIGNAL MESSAGE
1,2	SF = SEIZE FORWARD	INCOMING LINE IDENTITY
1,2	SC = SET UP CALL	CALL DESTINATION ADDRESS
2,1	SA = SEIZURE ACKNOWLEDGE	INCOMING LINE IDENTITY
2,3	RO = REQUEST OUTLET	INCOMING LINE AND CALL DESTINATION
3,4	SF = SEIZE FORWARD	OUTGOING LINE IDENTITY
3,5	T1 = START TIMER T1	—
5,3	T1 = TIMER T1 EXPIRED	—
4,3	SA =	

(b) STEP TWO: LIST THE SIGNALS PASSING BETWEEN FBs. FOR EACH SIGNAL, TABULATE: (i) ITS ORIGIN AND DESTINATION FBs, (ii) ITS NAME AND (iii) ANY ASSOCIATED MESSAGE



(c) STEP THREE: DRAW THE SDL DIAGRAMS CORRESPONDING TO THE PROCESSES IN THE DIFFERENT FBs.

Fig. 2 — SDL's basic Three-Step Methodology: Partition the System, List the Signals, and Draw the SDL Diagrams.

more complex case is treated in Ref. 6). In our example (Fig. 2), the processes within FB2 and FB3 have been given the same names as their Functional Blocks, 'call handling, incoming side' and 'call handling, outgoing side'.

Step Two consists of listing the signals, which will pass between the FBs. By 'signal' is meant any flow of information from one process to another which is needed for an action to progress; signals can be implemented in hardware, software or firmware. Usually the signal list begins by being incomplete, and needs to be completed in the course of step three (drawing the SDL diagrams) as the interactive behaviour of the processes becomes more evident.

In our example, the signals passing between the environment and the system, i.e. between FB1 and FB2, and between FB3 and FB4, would be identifiable from prior knowledge of the environment in which the system is to work. Examples of these signals, shown in Fig. 2 (b), include the 'seize forward' signal sent at the beginning of a call, the 'seizure acknowledge' response, and a more powerful 'set up call' signal which conveys all information needed to identify the ultimate destination of the call. Additional signals, passing between FB2 and FB3, or between FB5 and FB3, etc., need to be invented by the system specifier, in order to functionally specify the interworking between the incoming and outgoing sides of the node. These additional signals, such as 'request outlet', do not force the choice of any particular technique for their implementation.

It should be noted that an SDL signal consists of not only a signal name (which must be recognised by the receiving process) plus identification of the origin and destination Functional Blocks for this signal, but also includes any additional parameters or data (the 'signal message') which are needed by the destination Functional Block process, and which can be transmitted with the signal. In SDL, communication between processes can only be represented by means of the interchange of signals.

Step Three, drawing the SDL diagrams, is the only step in which the SDL language itself is used; steps one and two are needed to provide the unambiguous context for each SDL diagram.

To be able to model the behaviour of each process using SDL, the author of the diagram must begin with some preconceived ideas, usually quite incomplete, about what kind of functions the process is to carry out. In the case of an SDL description, the author will be basing ideas on observations of an implemented system (or the lower level documentation of that system). In the case of an SDL specification, the author will usually be basing ideas on more tentative notions of required functions, perhaps written down in the form of a single paragraph. In either case, these ideas need to be translated into the form of sequences of actions which the given process will carry out in response to every one of the signals sent to that process, as previously identified in the signal list (step two).

An SDL diagram is drawn using the repertoire of basic symbols shown in **Fig. 3.** It is best to begin an SDL diagram by considering the simplest possible 'state' in which the process could be waiting, such as an 'idle' or 'normal' or most typical state. A state defines a condition in which the process's internal activity is suspended while it waits for a new signal (represented by an 'input') which will cause the process to leave its current state and perform a series of 'tasks', 'decisions' or 'outputs' before entering another state. Strictly speaking, an input represents the ***recognition*** of a new signal, since signals may be received by a process without causing it to leave its current state, either because the signals are invalid or because the designer does not want them to be recognised as inputs at a particular state.

If a process always responds to its set of valid input signals in the same way, irrespective of the sequence in which the signals arrive, then it is said to have only a single state. But if the way in which the process responds to a signal depends on the previous history of signals, it is most convenient to model the process with several different states in its SDL diagram. In this way, each SDL state serves to capture the essential information concerning the previous history of the process insofar as it will affect its future behaviour.

Having drawn an initial state, the author considers the process's response to each of the relevant signals appearing in the signal list. If the process ignores a particular signal when it is in a particular state, then this signal will simply not appear in an input symbol associated with that state — that is an important SDL convention. In Fig. 2 (c) for example, when the FB2 process is in an IDLE state it will ignore signal SC (Set up Call) but respond to signal SF (Seize Forward). If the process is known (or intended) to respond to a signal when it is in a given state, the signal name should be drawn in an input symbol connected to the state, and the SDL symbols for 'decisions', 'outputs' and 'tasks' are then used, connected by a sequential flowline, to show the order in which these actions are to be carried out; this flowline, which represents a 'transition' of the SDL process between states, must then be terminated on another state. An example of a transition is shown in Fig. 2 (c) for the FB2 process, starting at the IDLE state with input SF and terminating on the AWAIT SC state. The second state will be equivalent to the first state if and only if the process's response to all possible signals at either state is to carry out exactly equivalent transitions.

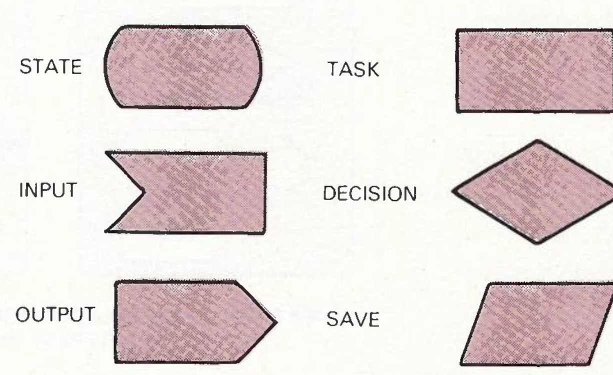


Fig. 3 — The Basic set of SDL Symbols (Ref. 2). (For simplicity, the minor differentiation between 'internal' and 'external' input and output symbols has been omitted).

It can be seen that SDL is heavily based upon state-transition principles, and can be regarded as a generalisation of the simple state transition diagrams of classical control theory.

The response of a process to an input may include sending a signal back to the originating process, e.g. the Seizure Acknowledge (SA) signal in Fig. 2 (c). All intercommunication between processes should be shown in SDL using 'output' and 'input' symbols. A further example is the passing of the RO (Request Outlet) signal between FB2 and FB3 in Fig. 2 (c). However in order to decide ***which*** signal to send via an output, it may be necessary for the process to ask a question of its local data, and in SDL this is represented by a 'decision'. An example of such a decision is the 'line in service?' decision shown in Fig. 2 (c). Decisions may also be used to determine the next state of the process. Innate in the concept of the SDL decision is the assumption that it can be carried out by testing data 'local' to that process; if a test is required on data belonging to another process, then the test must be represented in SDL by an output which transmits the question in the form of a signal, followed by a state in which the process awaits the answer, followed by inputs corresponding to different answers to the question which are returned in the form of different signals.

A 'task' is used to represent actions performed upon local data, whose results can be accessed by the same process in the form of 'decisions' at a later time, not necessarily in the same transition. An example of a task is the 'select outgoing circuit' task in the FB3 process SDL diagram in Fig. 2 (c). This task identifies a suitable outgoing circuit, based upon information concerning the incoming line and call destination — conveyed to FB3 in the message associated with the RO (Request Outlet) signal from FB2 — and the identity of the selected outgoing circuit is used in the following decision 'line in service?' when accessing another area of local data. An SDL task should not be used to represent actions performed upon data belonging to a different process; an output is the appropriate symbol for that purpose.

The SDL diagram is completed when the treatment of every possible valid signal has been accounted for at each state, and each transition has been terminated correctly on one of these states. The SDL diagrams shown in Fig. 2 (c) are necessarily incomplete because of space limitations; the circles which terminate some of the flowlines serve as connectors to other pages of the SDL diagrams, not shown.

The 'save' symbol shown in Fig. 3 is a new SDL feature, introduced by the CCITT in 1980. The save symbol can be used after a state symbol to show that the recognition of a given signal as an input is to be deferred until a subsequent state is reached (at which the signal name appears in an input symbol). The save symbol will be demonstrated in the next example.

A Queueing Example

A second example of the use of SDL to define process behaviour is given in **Fig. 4**; this time the SDL diagram will be complete. Fig. 4 specifies the behaviour of a finite queue, or more precisely the behaviour of a process managing a finite, first-in first-out, multi-server queue. Queues such as this (though generally much more complex) are found in telephone Automatic Call Distributors, and in the operating systems of stored program controlled telephone switching systems and packet-switching nodes, as well as in general purpose computing

Fig. 4(a) — Functional Block Interaction Diagram

OD	SIGNAL NAME and meaning	SIGNAL MESSAGE and meaning
12	c = arrival of next customer	i = identity of customer arriving
21	f = sorry, queue full	i = identity of rejected customer
23	c = customer ready to be served	j = identity of customer leaving a queue
32	s = server is now free	r = identity of server

Note: OD = origin destination pair

Fig. 4(b) — Signal List

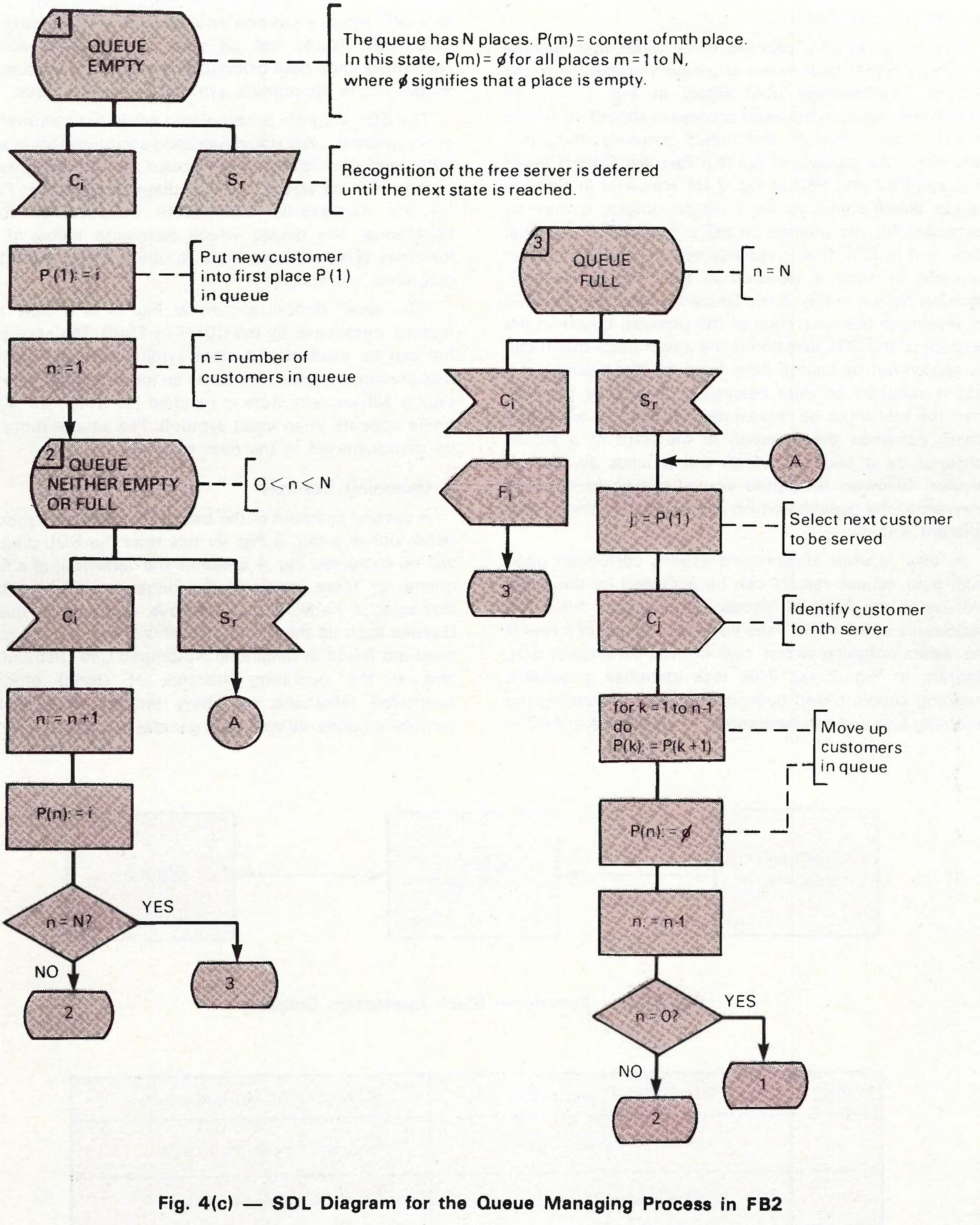


Fig. 4(c) — SDL Diagram for the Queue Managing Process in FB2

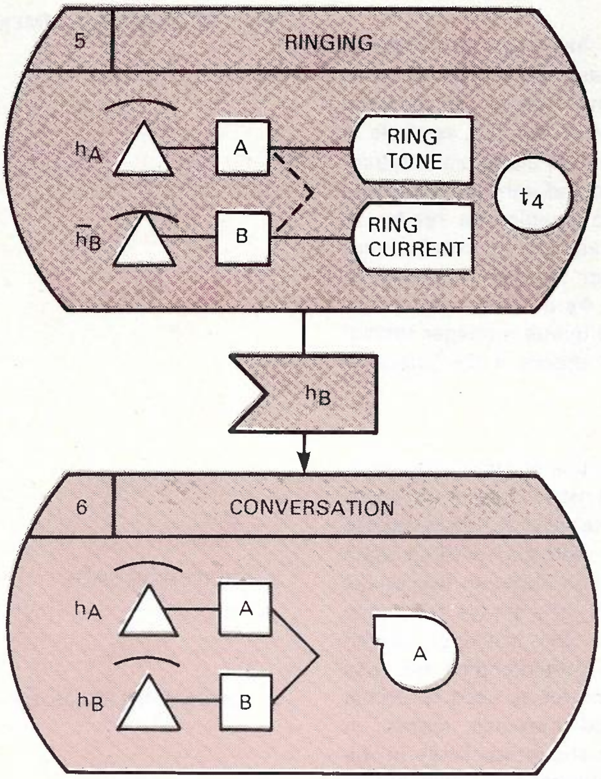
Note:

(i) The circle serves as a flowline connector, as in conventional flowcharts.

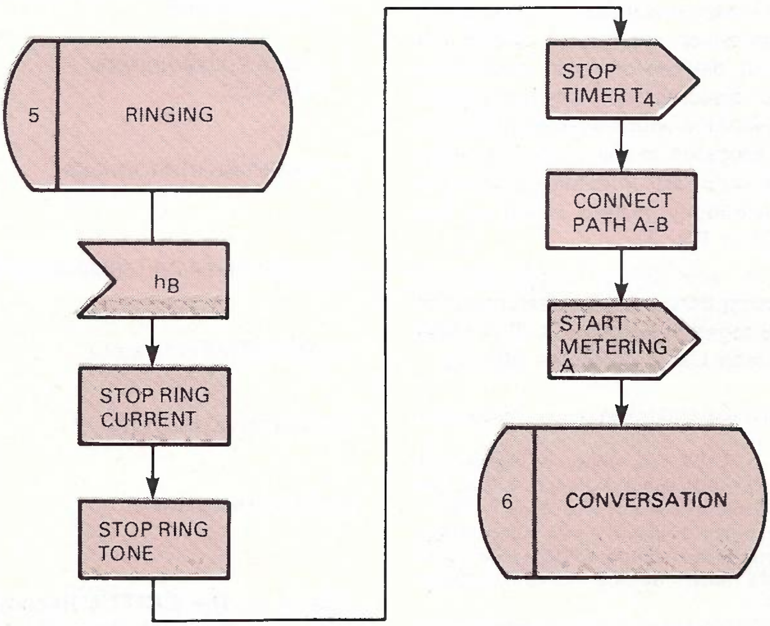
(ii) The small state symbols serve as connectors to the large state symbols having the same state numbers.

(iii) The algerbraic symbol = means 'is assigned the value'.

Fig. 4 — Definition of a Queue Managing Process, Using SDL.



(a) Example of the definition of a transition using state pictures



(b) Definition of the same transition without state pictures

Fig. 5 — Interpretation of SDL Transitions when Using State Pictures (Ref. 2). The total processing implied when going from one state to another is a combination of the processing required to effect the changes in the state pictures, plus the processing indicated by any decisions, tasks or outputs.

systems. They are also implicit in the management of control elements such as markers and registers in crossbar exchanges. All these queueing processes can be modelled using SDL.

The SDL diagram in Fig. 4 has been designed to demonstrate the use of all the basic set of SDL symbols shown in Fig. 3, including the save symbol. For the sake of compactness, the text in most of the SDL symbols in Fig. 4 has been expressed in a simple algebraic notation. It is intended that the comments and annotations to the diagram should be sufficient to enable the reader to check the logic of the SDL diagram and be satisfied that the queue manager does in fact function correctly to provide first-in first-out service. As a check, the reader should attempt to see where the queue manager tests if the queue is full, and where it checks if the queue is empty.

Use of State Pictures

A further feature of SDL is the use of state pictures to produce more informative (and in many cases much more compact) SDL diagrams. **Fig. 5 (a) and (b)** demonstrate equivalent methods, using SDL with and without state pictures, of representing a transition between two states 'RINGING' and 'CONVERSATION' of a simple telephony two-party call-handling process. The transition drawn using state pictures can be made more compact, because the difference between state pictures is used to define the processing actions required between states, in addition to any tasks or outputs shown explicitly in the transition. The CCITT has standardised a basic set of twelve pictorial elements for use in SDL state pictures, as shown in **Fig. 6**.

The state picture feature, which is optional within SDL, is useful for applications where it is important to know at each state in a process which supervisory timers are running, which circuits or devices or paths have been reserved or connected or disconnected, which customer is being charged, and generally which system resources have been dynamically allocated to the process at each state. An example of the use of SDL with state pictures in specifying a modern telephony facility called a 'call waiting' facility is shown in **Fig. 7**.

Those interested in specifying, modelling or documenting systems using SDL will find useful tutorial explanations in Refs. 5-9 together with the CCITT's 1980 SDL Recommendations and User Guidelines (Ref. 2).

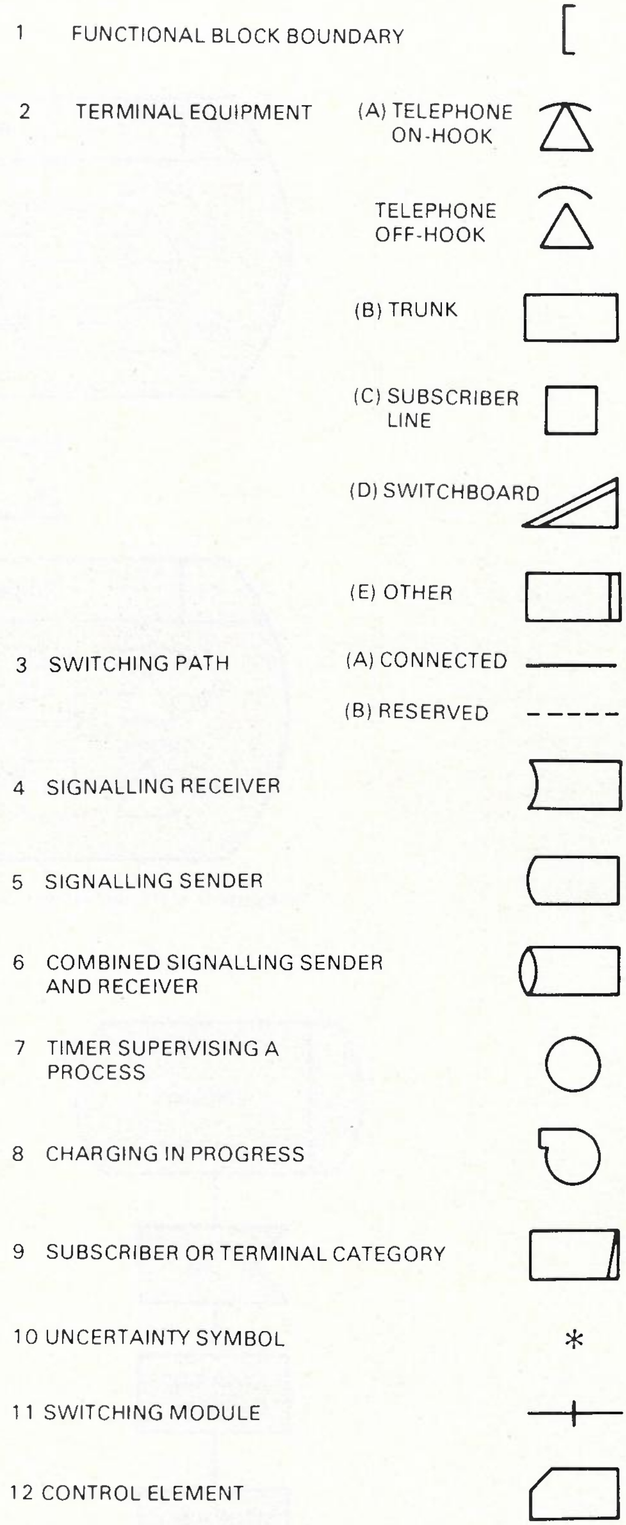


Fig. 6 — The CCITT's Recommended Symbols for Pictorial Elements for Use in SDL State Pictures (Ref. 2).

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KEY TO ABBREVIATIONS
CW — CALL WAITING
A — SUBSCRIBER A
B — SUBSCRIBER B
C — SUBSCRIBER C
h_A — A's HANDSET OFF-HOOK
Z — SWITCH-HOOK FLASH (i.e. HANDSET ON-HOOK <4 SECONDS)
r_A — REQUEST FOR SUBSCRIBER A
f — CLEAR FORWARD LINE SIGNAL
b — CLEAR BACK LINE SIGNAL
t_n — TIMER n HAS EXPIRED
✳ — EITHER HANDSET OR JUNCTION

SEE ALSO FIGURES 3 AND 6 FOR EXPLANATION OF THE BASIC SYMBOLS AND PICTORIAL ELEMENTS.

BAR OVER CHARACTER (eg $\bar{f}$) INDICATES THE OPPOSITE

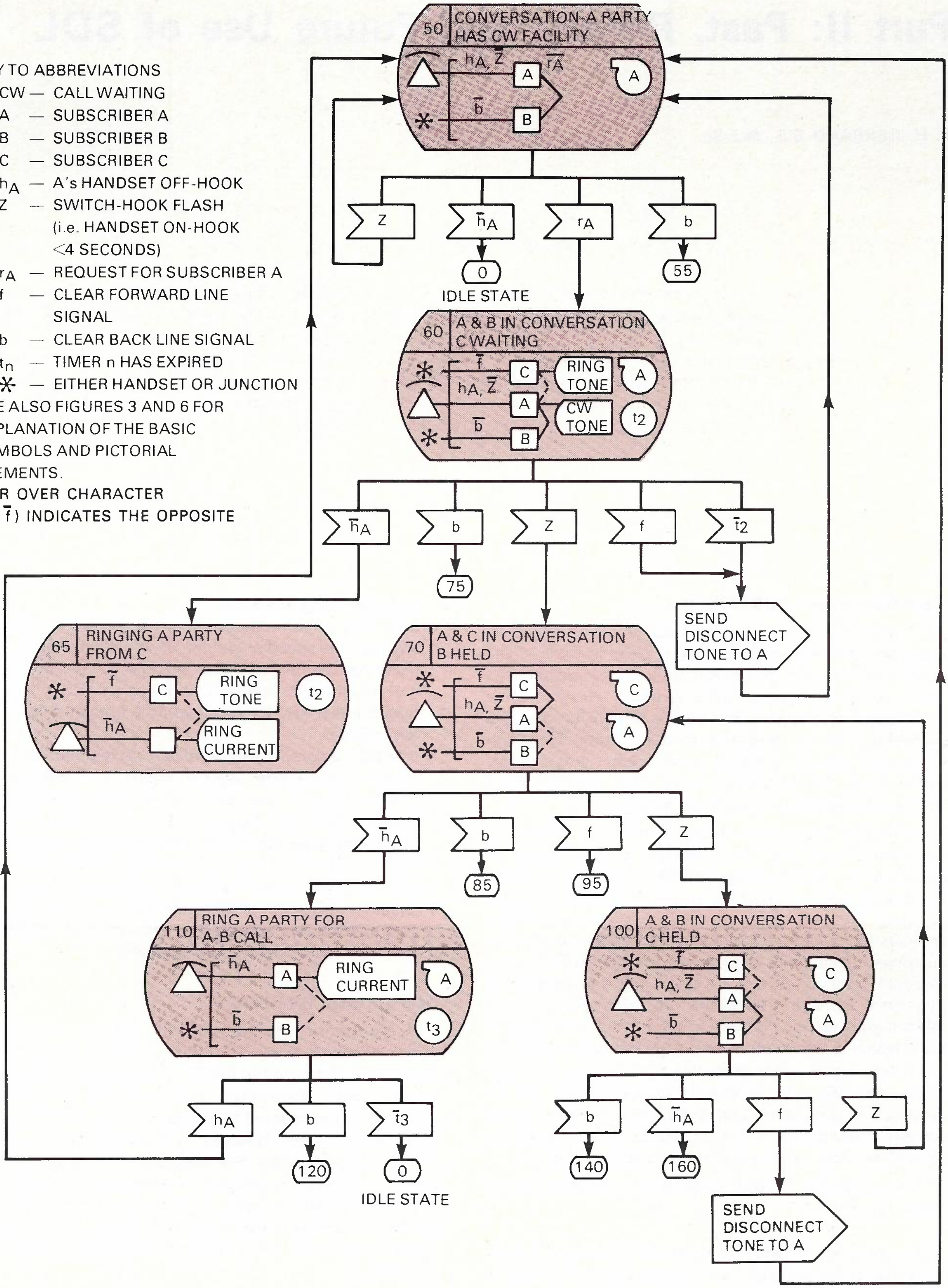


Fig. 7 — Example of the Use of State Pictures: Extract from the Specification of a Telephone Call-waiting Facility.

SDL and Its Use in Australia and Overseas
Part II: Past, Present and Future Use of SDL

P. H. GERRAND B.E., M.E.Sc.

Part I of this paper, provided an introduction to SDL, the CCITT Specification and Description Language. Part II surveys the use of SDL within Australia and overseas, and makes predictions concerning the nature of its future use by telecommunication administrations and manufacturers. The principal trends in SDL usage identified are its increasing use in CCITT Recommendations, the penetration of SDL into the specification of data services and protocols, the consolidation of the application of SDL to the specification and documentation of telephone switching and signalling systems, and the development of computer aids for SDL-based system specification and documentation packages.

USE OF SDL IN AUSTRALIA

A summary of the past and current use of SDL in Australia, as known to the author, is given in Table 1. The applications cited include not only those applications arising since 1976, when SDL's symbols, rules and name itself were first standardised by the CCITT, but also the preceding use in Australia of Call State Transition Diagrams, whose symbols have been progressively converted to conform with the CCITT SDL Recommendations as they have emerged.

It will be seen from Table 1 that the Australian experience with SDL has covered a wide range of applications: documenting pre-SPC (Stored Program Controlled) systems, such as crossbar switching, as well as early SPC analogue switching systems; specifying facilities for modern digital switching systems as well as customer equipment; developing highly experimental research facilities as well as specifying and developing systems to be installed in the Australian telecommunications network. The current emphasis of SDL research work in Australia is on data switching protocols, higher-order protocols and services in computer networks, and developing computer aids for the generation, simulation and validation of SDL-defined process interactions. A list of references to papers on several of these application areas is given in Ref. 1.

The advantage of SDL cited most frequently by its users are these:

- that as a specification medium SDL provides a high degree of unambiguity, and can highlight and resolve ambiguities hidden in narrative specifications by means of the discipline which SDL introduces;
- that as a specification medium it can be used independently of the technology used to implement the facilities being specified;
- that SDL is an effective communications medium between the specifier and the design implementor, and facilitates negotiations over changes to specifications;
- that the ability to specify and design using SDL can be taught effectively to specifiers and designers in a two day course;
- that SDL diagrams can be readily understood by most telecommunications people after a minimum of training, e.g. a two day course, and these people generally find SDL diagrams easier to understand than equivalent descriptions using programming languages, even modern high level programming languages;
- that as a description technique SDL can be used to document existing systems at 'higher', more functional, code-independent levels than the levels of software documentation traditionally supplied.

USE OF SDL OVERSEAS

A summary of the use of SDL in overseas organisations is given in Table 2, based partly upon information published in the first two issues of the international SDL Newsletter, and partly on information privately communicated to the author. This summary undoubtedly does not do justice to the extent of the use of SDL by organisations overseas, since this has not yet been the subject of a thorough international survey, but it at least provides evidence of the active use of SDL by many international organisations having business or peer relationships with the telecommunications industry in Australia.

In addition to the increasing use of the graphical form of SDL overseas, as outlined in Table 2, several telecommunications manufacturers have developed machine-readable program-like forms of SDL for use in

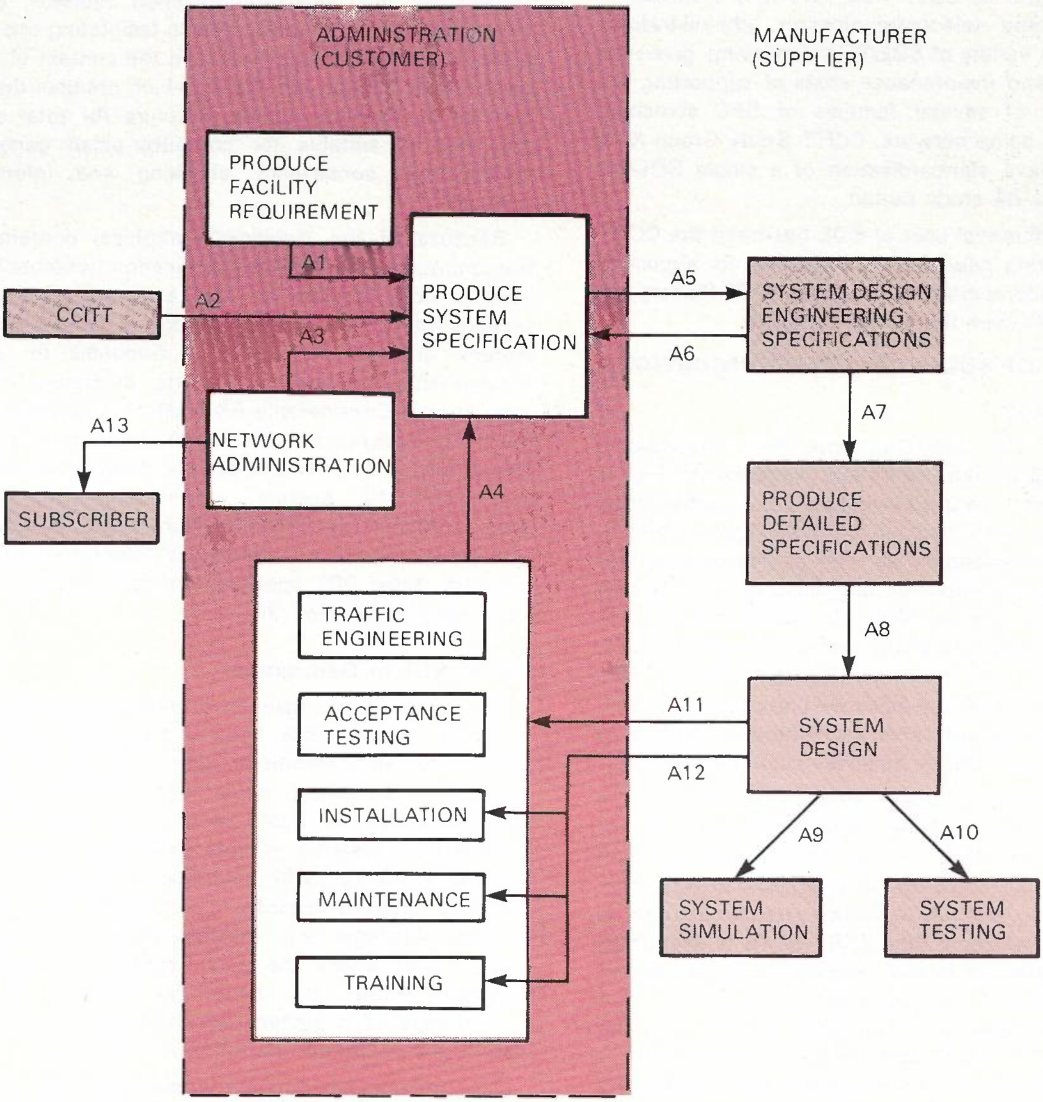
General Area of Application	Specific Examples	Originating Organization	Purpose of SDL Diagrams (with classification code*)	Dates of Diagrams	Nature of Project or Product
1. Telephony	1.1 Remotely controlled subscribers' line concentrator (with common channel signalling)	Telecom (formerly Australian Post Office)	Development of early SDL concepts Specification (A5); Design (A7,A8) Testing (A11)	1972-75	Experimental development as vehicle for research investigations of remotely controlled switching systems.
	1.2 Advanced telephone customer facilities e.g. call-waiting, voice store and forward etc.	Telecom	Specification (A1, A5)	1973 — (ongoing)	In-house planning of new customer facilities
	1.3 Interworking of CCITT No. 5 and No. 6 signalling systems.	OTC and Telecom	Specification (A2)	1975-80	New CCITT Standards
	1.4 PCM line signalling (loop, T6)	Telecom	Specification (A5) dialogue with manufacturers	1980-81	New national signalling specifications
	1.5 No. 7 common channel signalling	Telecom	Design (A7, A8) Simulation (A9), Testing (A10), plus Validation of CCITT No. 7 Specifications (A2)	1979-81	Development of laboratory implementation of No. 7 terminal, from CCITT SDL specification.
	1.6 Multi-phone office systems	Telecom	Specification (A5)	1977-79	Specification for manufacture
	1.7 Out-door extension for key telephone system	Telecom	Specification (A5)	1977-79	Specification for manufacture
	1.8 Crossbar Exchange (ARF) call-handling	Telecom	Description for training (A11)	1973-74	Training documentation
	1.9 Metaconta 10C trunk SPC exchange functions	Telecom	Description, simulation and monitoring (A11)	1974 — (ongoing)	Processor capacity studies; also system documentation at intermediate level
	1.10 Research IST digital tandem exchange	Sydney University and Telecom	Simulation (A9)	1977-78	Ph.D. study of processor capacity; validation of analytical methods
	1.11 AXE local SPC exchange	L. M. Ericsson Australia	Documentation (A11) "Function Flowcharts"	1979 — (ongoing)	Local SPC exchanges in national telephony network.
	1.12 Multifrequency code signalling monitor	Telecom	Design (A7, A8)	1980-81	Microprocessor-based specialised monitoring equipment
2. Data Communication	2.1 X.21 circuit-switching protocol	Telecom	Specification (A5) Design (A7, A8)	1978-79	Research investigation of DTE/DCE interface and application of SDL to data switching.
	2.2 X.25 packet-switching	Telecom	Specification (A5)	1979-80	Research investigations of DTE/DCE interface, and protocol validation
	2.3 ISO/CCITT transport layer protocol and service	Telecom	Specification (A1)	1981 — (ongoing)	Contribution to development of international standards
	2.4 Computer communication networks	CSIRO Division of Computing Research	Specification (A5), Design (A8), Simulation (A9)	1980 — (ongoing)	Design and validation of inter-networking protocols.
3. Testing	3.1 Automatic telephone exchange tester	Telecom	Design (A8)	1975-76	Research prototype for a microprocessor-based exchange tester
	3.2 Subscriber Line Testing Access Network (SULTAN)	Telecom	Design (A1, A8) Testing (A10)	1977-81	Development of SULTAN system for wide-spread application in the national telephone network
4. Computer-aided system documentation and modelling	4.1 General Exchange Simulator (GES)	Telecom	Simulation (A9)	1977-80	Software package providing analysis of system behaviour and processor capacity
	4.2 Computer aided SDL Specification (CADDIE)	Telecom	Specification (A1, A2, A3, A5, A6, A7)	1977-80	Computer graphics package for SDL-based specification
	4.3 Generation of CHILL code from SDL (MELBA)	RMIT/Telecom	Design (A7, A8)	1979 — (ongoing)	Computer-aided system design package

* **NOTE:** The classification codes (A1, A2 etc.) are explained in Figure 1, 'General Scenario for the Use of SDL'

Table 1 — Summary of Past and Current Use of SDL in Australia

Country	Organisation	Area of Application of SDL	Remarks on Support Facilities, Training Etc.
BELGIUM	RTT	Specification of telephony signalling	
FINLAND	Finish Telecom. Administration	Specification and description of switching systems	Computer aids for drawing SDL diagrams are under study at Helsinki University.
FRANCE	PTT	National specification of No. 7 signalling system and its interworking	
	Manufacturers (Alcitel, CGCT)	Telephony call-handling design documentation	Some computer aids are used for drawing SDL diagrams
GERMANY	Siemens AG	Specification and description of SPC telephony and telex functions and facilities. Also used for traffic capacity studies	Staff training is provided through courses and system-dependent SDL user guidelines. Computer aids are used for SDL syntax checking, drawing SDL diagrams, production of auxiliary documentation and generating of 'process skeleton code'
HOLLAND	PTT	Specification of SPC systems and facilities	Training courses and computer aids are currently being developed
	Philips	Design specification of signalling procedures	
INDIA	PTT	In-house specification and design of SPC switching facilities	
ISRAEL	KADIRAN	Product documentation for PABX system	
ITALY	SIP	Specification of subscriber facilities, switching functions, protocols and signalling	It is intended to use SDL description as an aid to operation and maintenance. Staff training courses are being developed.
	ITALTEL	Documentation of SPC switching systems e.g. new terminal exchanges	Computer aided testing tools, based on SDL system descriptions, are under development. Joint studies with CSELT are currently being undertaken. SDL has been used for information interchange among design groups
	CSELT	Computer aids for SDL drawing, document checking, production of auxiliary documentation and retrieval of SDL documents	Currently investigating the use of SDL for simulation and more generally for system design, operation and maintenance
JAPAN	KDD	Specification of interworking with international signalling systems	
	NTT and manufacturers (Fujitsu, Hitachi NEC, Oki)	Specification, design, documentation, simulation and testing of switching systems: telephony, data, facsimile, video etc.	Computer aids for drawing SDL diagrams, documentation modification and retrieval, and for SDL-based operations, maintenance and testing procedures
NORWAY	Norwegian Telecom. Administration	Specification and description of interworking for maritime and mobile systems	Computer aids for producing SDL diagrams are under study
SPAIN	CTNE	Specification of SPC telephony switching systems	Generation of SDL diagrams from a computer-form input
	SESA (ITT)	Design specification and documentation of SPC telephony (Metaconta and System 1240) switching systems	Computer aids for generating SDL documentation in program-like form
SWEDEN	Televerket	Specification of 'small systems,' and dialogue with manufacturers	
	LM Ericsson	Intermediate level description of AXE switching system	
UK	British Telecom	Specification of national No. 7 signalling and interworking	Computer aid for drawing SDL diagrams and generating PO CORAL code
	Plessey T.L.	Design specification of functions in System X switching system	
	STC (ITT)	Design specification of SPC systems	Generation of SDL diagrams from a computer-form input
USA	Bell System	High level description of SPC international telephony exchange functions and facilities	Computer aided support system for generation and modification of SDL documentation
(UNITED NATIONS)	CCITT	(a) Specification of No. 7 common channel signalling system: telephony user part, data user part and message transfer part. (Ref. 13). (b) Specification of interworking between international telephony signalling systems R2, No. 4, No. 5 and No. 6. (Ref. 14). (c) Specification of maritime signalling. (Ref. 15). (d) Specification of certain Man Machine language functions. (Ref 16).	Publication of SDL User Guideline (66 pages) plus plastic template in 1981 Yellow Book, Volume VI.7, to facilitate use of SDL.

Table 2 — Summary of the Known Use of SDL Overseas



LEGEND:

A 1	An implementation -independent and network-independent specification of a facility or feature.
A 2	CCITT Recommendations and guidelines.
A 3	Contributions to the system specification, showing the network administration and operational requirements.
A 4	Contributions to the system specification from specialized functional groups within the administration.
A 5	An implementation-independent and network-dependent system specification, including a description of the system environment.
A 6	Description of an implementation proposal.
A 7	A project specification.
A 8	A detailed design specification.
A 9	Appropriate system and environment description documentation for system simulation.
A10	Appropriate system and environment description documentation for system testing.
A11	A complete system description.
A12	Installation and operation manuals.
A13	A description of facilities and features available to the subscriber.

Fig. 1 — A General Scenario for the Use of SDL, as Foreseen by the CCITT (Ref. 2).

designing their latest-generation digital switching systems. In the absence of CCITT standardisation of a program-like form of SDL, 'SDL/PR', it is a matter of concern to some telecommunication administrations that a needless variety of SDL/PRs is evolving, given the extra training and maintenance costs of supporting the documentation of several families of SPC switching systems in the same network. CCITT Study Group XI is hoping to achieve standardisation of a single SDL/PR within its 1981-84 study period.

The most influential user of SDL has been the CCITT itself, in preparing new recommendations for signalling systems, for endorsement by the VIIth CCITT Plenary Assembly in 1980 (See the end of Table 2).

FUTURE USE OF SDL IN TELECOMMUNICATIONS

General Scenario

The CCITT's SDL User Guidelines (Ref. 2) suggest a general scenario for the use of SDL, illustrated in **Fig. 1.** SDL is expected to be used as part of the documentation associated with every flowline on this diagram, ranging from network-independent as well as implementation-independent specifications of new facilities (A1) through the development process (A5, A6, revised A5, A7, A8, A9, A10) to a complete set of system documents (A11, A12) supplied with the implemented system. This scenario even includes the selective use of pictorial SDL diagrams to explain advanced facilities and services to the subscriber, particularly business customers (A13).

For the new CCITT study period 1981-84, CCITT's Study Group VII is examining the potential application of SDL to the specification of the X-series protocols and services in data communications networks. Simultaneously, the ISO (International Standards Organisation's) subcommittee TC97/SC16 is examining the standardisation of formal description techniques for specifying protocols and services in the ISO's open systems interconnection reference model for the interconnection of future computer networks, and SDL is one of the candidate formal description techniques that has been proposed.

Use of SDL in Specification

Within the Australian telecommunications network there is considerable potential for the highly cost-effective use of SDL to specify:

- New subscriber facilities for existing stored program controlled switching systems, such as the 10C, ARE and AXE telephone exchanges;
- Signal interworking and supervisory facilities in the domestic satellite network RTSS (Remote Telephone Satellite Service) control facility;
- The Australian national version of the CCITT No. 7 signalling system, including interworking with existing national signalling systems;
- The detailed customer access network interface (based on X.25) to AUSTPAC, the future Australian public packet switching network;
- Interworking between AUSTPAC and private local data networks such as CSIRONET and TACONET;
- Interfaces between future Integrated Services Digital Network Switching nodes and specialised service networks such as AUSTPAC and the purely telephony network.

Clearly there are advantages in developing a systematic and unified approach to the total specification process for new telecommunication systems, and to make best use of computer aids in facilitating this highly complex process. To place SDL in the context of a total system specification see **Fig 2**, which predicts the likely form of a standard, unified structure for total system specification, suitable for computer-aided generation, modification, consistency checking and information retrieval.

Because of the significant graphical content of a telecommunication system specification (whether SDL is used or not), support for such a specification system exceeds the capability of a conventional word-processing system, and requires graphics terminals for editing requirements and a graphics plotter or printer for hard-copy output. Considerable R&D effort is currently being spent in several of the larger telecommunication laboratories in the world to develop comprehensive computer aids for system specification and design documentation. The CADDIE graphics system developed within the Research Laboratories of Telecom Australia for computer-aided SDL specification has been operational since early 1980 (Ref. 3).

Use of SDL in Description

The need to maintain up-to-date documentation of switching systems has been a traditional and costly problem for administrations, ever since the first use of automated switching equipment. Where switching systems differ in this regard from, for example, transmission systems is that switching systems are required to be frequently modified to introduce new or changing network facilities (e.g. alternate routing) and customer facilities (e.g. itemised billing of customers' calls), which affect the documentation of significant functions within the switching system. Effective maintenance of a system becomes very costly when system documentation is not kept up to date.

This problem has become worse in the era of stored program controlled (SPC) systems; indeed part of the attractiveness of SPC systems has been their perceived flexibility in permitting changes to network and customer facilities, and therefore a vast range of such facilities are bought with these systems. The early generation SPC switching systems have provided major problems to administrations, not only in maintaining documentation up-to-date but also in retrieving information, ie being able to quickly locate the parts of the system documentation relevant to a particular system fault. This problem persists even with some contemporary SPC switching systems.

It has become widely recognised in the telecommunication industry that for effective operations and maintenance problem solving, it is necessary to provide a hierarchical documentation scheme whereby functions described in simple global terms at the top level of the documentation are described in increasing detail at each lower level of documentation, with effective correlation being provided between the functional descriptions in adjacent layers, in order to permit rapid focussing on a particular design problem or fault, excluding the extraneous details. Some design problems may be diagnosed within the original functional

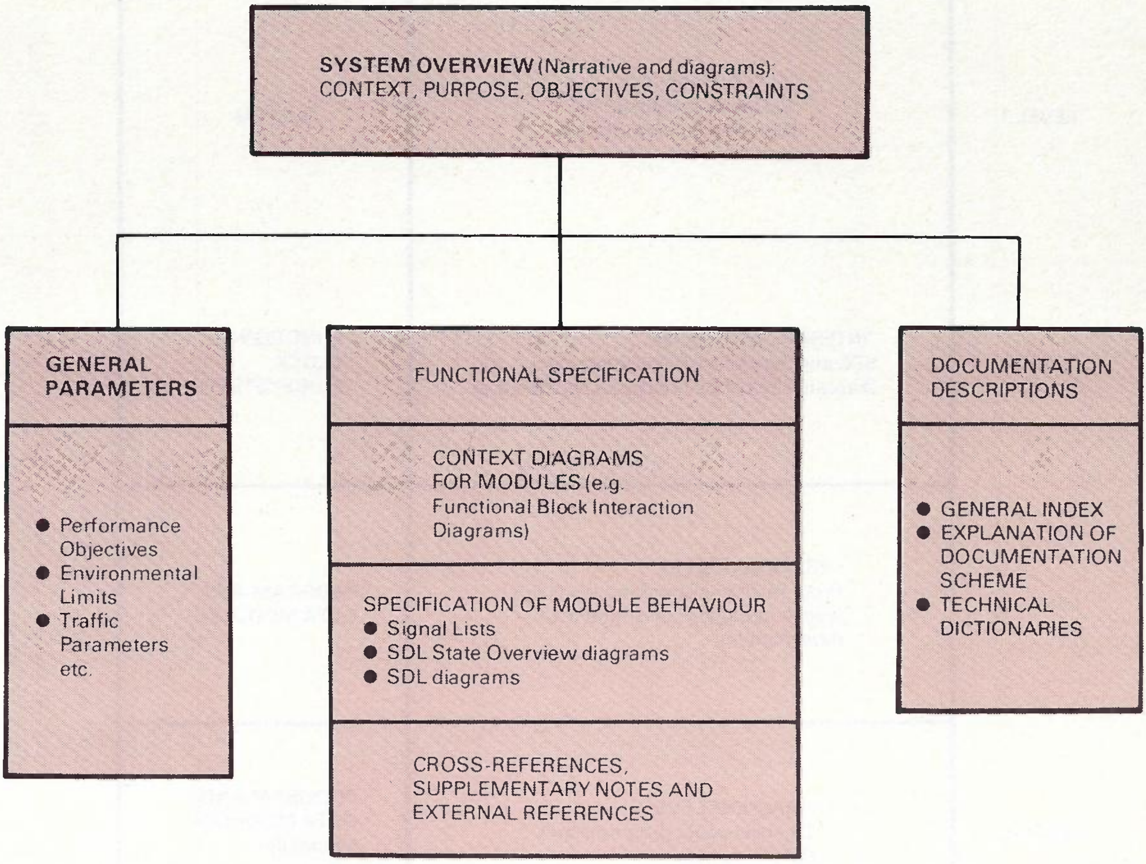


Fig. 2 — System Specification: Placing SDL within the Context of a Total System Specification.

specification; others may be diagnosable at an intermediate level of documentation; still others may be only diagnosable by examining the machine code or detailed logic circuitry at the lowest level of system documentation.

It has also become widely recognised in the telecommunication industry that computer aids are needed to minimise the otherwise excessive costs of maintaining an adequate set of system documentatior and, has already been noted, considerable efforts are currently being expended in telecommunication R&D laboratories to implement effective computer-based system documentation schemes.

It is in the interests of telecommunication administrations that a unified approach be taken to the structure and content of such documentation systems, in order to minimise the training costs associated with supporting several different families of SPC switching systems in the same network. It is predicted that a standard, hierarchical structure for a general SPC software documentation scheme will emerge as proposed in **Fig. 3.** In this scheme, SDL is used for high-level functional description of system modules at the 'intermediate level', directly above the 'program level' at which the program listings would reside. In an optimally effective documentation scheme, SDL will also be used at the highest level, 'system level', in the form of the functional specification from which the system was implemented.

Implications for Training

The traditional graphical languages taught to engineers and technical officers as a necessary background for their careers in telecommunications have included such standard techniques as analogue circuit diagrams, Nyquist charts, Venn diagrams, signal flow graphs, hardware logic circuit diagrams, trunking diagrams, switching 'chicken' diagrams, software flowcharts and relay logic diagrams. The SDL graphical language for specification and description should become equally well known and understood by telecommunication people because of the importance of 'requirements engineering' and 'systems engineering' as key disciplines employed by telecommunication administrations and manufacturers, and the increasing use of SDL as an 'industry standard' throughout the world for the specification of requirements and the documentation of implemented systems.

Within Telecom Australia this training requirement has been recognised by the engineering training group, which is currently developing short courses on the use of SDL in

LEVEL 1	"SYSTEM LEVEL" Narrative and diagrams (Can also include original specification)	SYSTEM
LEVEL 2	"INTERMEDIATE LEVEL" SDL and Functional Block Interaction Diagrams (to define the context of the FB's)	FUNCTIONAL BLOCK (SUBSYSTEM)
LEVEL 3	"PROGRAM LEVEL" Program listings (preferable in high level language) plus definition of data modules	PROGRAM AND DATA MODULES
LEVEL 4	"MACHINE LEVEL" Object code for programs and Data Parameters	PROGRAM AND DATA MODULES (or smaller units)

Fig. 3 — System Documentation: Placing SDL within the Context of a Standardised Hierarchical Software Documentation Scheme for SPC Switching Systems.

specification and documentation of SPC systems, to be incorporated within the organization's Engineer Development Programme. The first of these courses, on the use of SDL as a specification technique, has been successfully 'prototyped' and tried out within the Headquarters Research and Engineering Departments, and should be available before the end of 1981 to engineers throughout the organization.

CONCLUSIONS

This paper has endeavoured to provide a brief introduction to SDL and to highlight its growing acceptance and use within Australia and overseas as an 'industry standard' within the world-wide telecommunication industry.

The principal trends in SDL usage identified in this paper have been firstly its increasing use in CCITT recommendations, secondly the penetration of SDL into the specification of data services and protocols (including ISO higher level computer interconnections protocols), thirdly the consolidation of its use in the specification and documentation of telephone switching and signalling systems (old and new), and fourthly the development of computer aids for SDL-based system specification and documentation packages.

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People Talking to People: Understanding Interpersonal Communication

E. THUAN, B.A., M.A.

Humans communicate face-to-face in very complex patterns of word and gesture that have their bases in our biology and in our needs as social beings. We communicate a great deal with each other, not just to convey information but to form groups and to establish individual identities. Advances in communications technology extend and transcend human communication and represent a shift in the balance of communication within the human group. Understanding how humans communicate can provide insight into the operation, and the failure, of sophisticated devices and systems, and raises important questions about the impact of technology on the people it purports to serve.

INTRODUCTION

Human beings live in a world filled with communication. Our ability to communicate is as fundamental as our ability to walk upright, and it is just as characteristically human. We communicate a great deal with each other, not just to get things done, but as an accompaniment to a whole range of other activities and to confirm our identity as individuals and as members of a group. We crystallise ideas by talking them over, we talk in our sleep and while we eat, work, play and relax. Simply because it is so pervasive we tend to take speech and other forms of interpersonal communication very much for granted. We lose awareness of the extent to which we are bathed in a sea of words and gestures, and of the extent to which we make use of communication in our daily lives.

Communicating with other people is an almost incredibly complex activity. Research has not yet uncovered the full ramifications of even the most straightforward face-to-face interaction. However, quite a lot is known now about the ways and means of interpersonal communication. A rich stream of information flows between people present in the same situation. Words, gestures, patterns of eye-contact, non-verbal grunts and whistles, even smell and touch are all involved in our interactions.

The introduction of communications technology, from the development of writing, to the telephone, to the communicating word processor, has enabled us to extend our communications through time and space. We can now address others who are utterly remote from us or crowds too vast for the human voice to reach.

Technology does not just extend the human ability to communicate, it also transcends it. From personal communication face-to-face, we have moved into increasingly impersonal interchanges; to radio and television that speak to us, but do not listen; to telex and facsimile which allow answers from people, but lack the immediacy of speech; to interactive computer terminals; where man and machine use a special code to communicate; to digital data transmission, which does not rely on people or human language at all.

INTERPERSONAL COMMUNICATION

People use a large number of different communication systems when they communicate face-to-face. These systems interact to produce a composite message from speaker to hearer. The hearer decodes the total message, unravelling subtleties of meaning and interpreting ambiguous language in the light of cues from one or more of the other systems. How do we know if a speaker is joking or serious, lying or sincerely mistaken? How do we decode an utterance such as ***Have you seen my coat?*** Depending on the other cues available to us, we may have to decide whether we are being asked for praise or accused of theft.

The intermeshing of communication systems in face-to-face interaction decreases the significance of language as the carrier of content. We do not have to be verbally specific when we can point to an object or can illustrate 'about so big' with our hands. Language allows us to refer to abstractions and to objects not physically present, while gestures and eye-contact are by their nature restricted to the here-and-now of the interaction.

For much of the time, we communicate with each other easily and pleasurably. We use word and gesture as unthinkingly as a fish swims in the sea. It is only occasionally that we are faced with limits to our ability. We may stumble and falter, with a racing pulse, when asked to stand up and speak publicly, even if it is only to an audience of people we know. We shout at foreigners, patronize children and fall silent in the face of authority because we do not know what to say or how to say it. At these times, we begin to understand that communication is easy only within quite narrow limits. The boundaries may be obvious, as when two people do not share a language or a system of gestures, or they may be quite obscure, but none the less formidable, as when commuters agree tacitly not to acknowledge each others' existence on public transport.

Variability in Interpersonal Communication

Our biology provides us with the capacity to communicate. The circumstances of our upbringing initiate, develop and shape our competence in communication. We learn, over a long period of trial and error, to communicate with parents, peers and the wider community, using their language and gesture system and acquiring their patterns of interaction. People brought up in different communities learn to speak different languages or dialects of the same language. Less obvious may be the fact that other systems of face-to-face communication also vary between different groups. In Anglo-Saxon societies, for example, touching is relatively uncommon, except amongst close family members. In Latin societies touching, or at least increased proximity, is much more common and much more acceptable. Patterns of eye contact form another example. In some Eastern societies, prolonged eye contact is considered to be extremely rude or hostile. In other societies, failure to maintain eye contact can be seen as shiftiness or untrustworthiness.

To a very large extent, our communicative behaviour is unconscious. We learn the rules for communication in our infancy, and learn to handle a range of situations that gradually expands as we grow older. As long as we remain within our local cultural group, we know what to say, how to say it and when to say it (or not to say it). We are guided by the community at some points. Etiquette books, for example, offer instruction on how to make small talk or how to speak to a bishop. But other patterns of communicative behaviour are not as generally recognised. Consider what happens when Australians get into a lift. People tend to distribute themselves well away from each other, to avoid eye-contact and not to strike up conversations. People who were conversing together before they entered a lift with strangers will stop talking, lower their voices or become bland or cryptic in what they say.

Successful Communication

Within our own cultural group, we can communicate successfully because both speaker and hearer share a common understanding of the meaning of words and gestures and of how they are used in particular situations. In turn, success in communication is necessary if we are to be accorded status as adult members of a speech community. We are appraised on the basis of our communicative competence, in terms of our membership of the group, our status as adults, our sincerity, trustworthiness, intelligence and even of our sanity. Lower status is accorded children and foreigners, along with dispensations in the areas where they fail to cope. The appraisal seems to matter a great deal. People are often very afraid of unfamiliar situations, or situations in which they have recorded past communication failure. There are many examples of fear and vulnerability, and of behaviour derived from these reactions, in face of what can amount to a threat to one's identity. Job interviews inspire terror in some people, social gatherings afflict others, still others are awed by interactions with superiors, talking to strangers, making a speech . . . the list of threatening situations can go on and on.

Interpersonal communication is a skilled activity based upon a shared understanding of the meaning and appropriate use of words, gestures, glances and proximity in a given cultural context. All these sources of information are put to use in face-to-face interaction. The ability to send and decode the complex message from the sources is used as a measure of the adequacy of a person as a full member of a particular cultural group.

SPEAKING

Speech, unlike gesture, is not restricted to face-to-face situations. It is adaptable to different circumstances, and verbal strategies can be used to compensate for the information otherwise available through visual or tactile channels. Speech can be used to generate both a context and the activity which takes place within that context. It is a rich and complex means of communication, and is immensely powerful, flexible and subtle in its uses.

Learning to Speak

Accomplished adult speakers who use language constantly in their daily round forget very easily both how difficult it was to learn to speak and the complexities of the medium that they are using. Consider the infant. He takes a good five years to master the sounds of speech,

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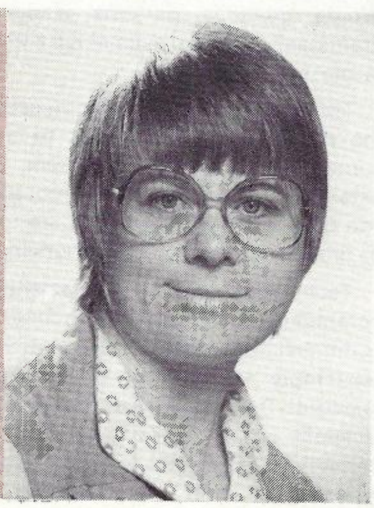


the ways of putting sentences together and learning to use these sentences appropriately in context. All of these activities are in themselves very complex, and small children can spend an immense amount of time and effort in their attempts at mastery.

In Australian English, for example, there are around forty-four speech sounds, distinguished from each other by the shape of the vocal tract and the presence or absence of vibration in the vocal cords. Learning to produce these sounds involves control of the various parts of the vocal tract — lips, jaw, tongue, velum, larynx — control over air pressure in the system and co-ordination of all these factors at any one time and sequentially over time. More than this, each individual has to develop for himself a systematic relationship between the various sounds he produces, so that when he says ***pin*** he is not heard to be saying ***pen,*** or ***kit*** when he means to say ***kick.*** This is not merely a question of imitation or conditioning — although both processes may be involved — but an active structuring of a system. Typically, the ability to learn the system of speech sounds declines at around age ten or twelve, and only rarely are adults able to master the sound system of another language to the point where they sound like native speakers.

Language Structure

Learning speech sounds is only the start. We also learn to put sounds in sequence to produce words, phrases, sentences and higher level discourse structures, roughly corresponding, for example, to the written paragraph. These structures include conversations, discussions, arguments, negotiations, invitations, greetings, enquiries, speeches and many others.

Above the base level of speech sounds, there is a pairing of meaning with structure. With words, meaning is associated with a stretch of sound. At the level of the sentence, 'meaning' also implies making sense, and at levels above the sentence, 'making sense' involves the sequential flow of content, the relationship of that content to the speech which has preceded it and to that which will follow it, and the appropriateness of the utterance in a particular context.

This may sound remarkably complicated, but it is only a brief description of our major communicative tool. How we put this tool to use and the purposes for which we use it are also complex issues. We do not talk the same way all the time, for example, but vary what we say and how we say it according to the situation in which we speak. The most obvious example is that of the bilingual who speaks one language at work and the other at home, but we all show lesser changes when talking to those in authority, when answering the telephone, when chatting to friends or conducting business, and so on. We alter sounds, the choice of words, sentence structure, complexity and length, and select meanings and discourse types.

The Speech Situation

The situation in which utterances are produced is itself very complex. Speaker, addressee, audience physical and psychological setting, time, communication channel are all components of situations in which speaking occurs: as many as sixteen components have been identified. The situation in which speaking occurs is not static, but develops during the progress of discourse, and the speaker is required to adjust what he says and how he says it, and even whether he speaks at all, according to the ongoing shifts in the situation. A change of topic, for example, may reveal the interlocutor as an expert, and reduce the previously equal speaker to a questioning role, or to silence. The shift from discussion to argument may be even more subtle.

More than this, the speaker must negotiate with his interlocutor, which of two differing views of a situation or of the significance of components of the situation, shall prevail at any point. This negotiation will depend on how the speaker views himself and on the manner and extent to which he projects this self-image in a particular situation. It matters very much to the speaker that all the complex factors should blend in the formation of a successful utterance — failure to demonstrate competence in using the language or handling the situation exposes the speaker to a possibly altered definition of himself. The danger he faces may involve loss of adult status, as adult immigrant language learners find, or he may find himself classified as socially unacceptable, deviant or even insane.

The Limits to Speaking

Speaking starts to look like remarkably hard work for the speaker. It is not surprising, then, to find that there are limits to our ability to speak easily with other people. These limits involve the obvious difficulties of lack of a common speech tool — the speaking of different languages — and a number of less obvious considerations.

If we depend on 'fine tuning' our speech to a particular set of circumstances, we need to be able to assess what circumstances we are facing before we can decide on how to speak appropriately. The presence of imponderables in the situation — strangers, the extent to which status differences are enforced, violations of our expectations, personal insecurity or rejection of our projected self-image, lack of command of an appropriate language variety, all these can paralyse us and make us find ways to avoid speaking in that situation, or they can motivate us to change the situation into something we can handle. An example of failure to cope with a speech situation occurred once while I was on a camping holiday. A passer-by stopped to chat with a group of campers, was uninhibited, and then discovered that the man drinking brandy was a minister of religion. She was covered in confusion, apologised many times for swearing, and departed in haste, without completing the conversation.

To sum up, people learn to handle the mechanics of speech at an early age and they learn the 'rules' for speaking to other people as they need them. Some people have the ability to speak to large numbers of people and acquire appropriate speech behaviour easily. Other people do not and they find that they will avoid contacts with unknown people, or people in situations where they feel that they cannot cope. The 'rules' for talking to others are very seldom stated overtly. In general, these rules are simply regular patterns of behaviour that occur in a specific social group, rather than regulations which prescribe how people should speak. Nevertheless, they do have force in their own cultural contexts and people will be made aware of their violations, perhaps painfully on occasion.

COMMUNICATING THROUGH TECHNOLOGY

What then is the connection which exists between the ways in which we learn to communicate with each other in person and the use of technological devices for communication? There seems to be a number of significant points to be made here. First, when we talk to each other face-to-face we have access to a complete situation. We use a number of channels of communication, verbal, visual, tactile. We know how the other person is responding. We know the effect that our words have on them, and we know the other factors in a surrounding situation which will influence both what we say and how they respond.

With mediated communication, we are immediately looking at a different situation. In the case of the telephone, we have no tactile or visual information, the stream of speech necessarily must carry all the information that goes into the message. We have no access to the surrounding physical situation so that we do not know if there are factors which inhibit communication. This means that the task of the speaker is made more difficult. He has lost several channels of feedback from the other person and he has to rely on factors such as tone of voice and phrasing to understand the circumstances and responses of the person to whom he is talking.

Using the Telephone

The telephone has been with us for some time now and has become part of a number of cultures. People have evolved ways of using the telephone which make it an extension of normal speech, and it has become subject to cultural constraints. That is, the purposes for which the telephone may be used will vary between different groups of people. Even within Australian society there will be differences in what is permissible for expression over the telephone and what must be done by other means. These differences can be significant, even in a business context. If a person is perceived to be rude or inept, or if he uses the telephone for functions which are not acceptable to the person he is talking to, this may result in loss of business or negative sanctions of one kind or another.

This is not as far-fetched as it may sound. Consider the case of an immigrant who rings a busy switchboard with a need for specialised information from a person whose name he does not know, in a department the name of which he likewise does not know. The task is daunting. He has to cope with an accent, inadequate sentence structures, lack of knowledge of how to phrase his request, the impatience of the operator and the probability of an unsuccessful call and perhaps personal humiliation. This situation is very real, even for immigrants who are apparently successful in the Australian community. It is also real for many speakers of English who have not learned through trial and error how to handle this kind of communication.

Using the telephone is a skilled activity and the skills are very seldom taught in our community. The result is that a surprisingly high number of people are afraid to use the telephone. Not afraid of the device itself, but afraid to initiate interactions that they have not learned how to handle. They will telephone friends without a second thought, but will procrastinate, or develop avoidance strategies when faced with the problem of communicating with those in authority. (I have heard employees say that they will wait days before telephoning a manager).

At one level, the problem can be understood very simply. The initiation of communication depends on the use of verbal formulas (or written ones, as the case may be) and facility in communication depends on the ability to produce these formulas appropriately. When we "ring" someone unknown to us, the success of our call will depend on how well we establish contact. We need to convince the person called of our bona fides before they are willing to respond to our requests for information, connection to an extension, or to locate an appropriate person to speak to us.

A major difference between face-to-face and mediated communication is that speech between persons is broadcast through air-waves and permits people to have freedom of movement. Telephones are designed so that the person using them is forced to address them. The device takes up a large portion of the person's attention and constrains both freedom of movement and the performance of manual tasks using two hands. Solutions to these problems do exist, but they are not a part of the telephone equipment that is generally available. A significant shift in emphasis also occurs. Speech in face-to-face situations may be casual, may accompany other activities, may be interspersed with silence. On the telephone, speaking is the focal point of the activity and other activities are subordinated to it. It forms, as it were, a bias in the configuration of the total situation, and alters the set of functions of speech. The functions are not necessarily narrowed. The telephone also permits a degree of safety and anonymity, as nuisance callers know, that is not available face-to-face.

The Limitations of Mediated Contact

The telephone makes use of the richness and flexibility of the stream of speech and acts, overall, to extend the possibilities of interpersonal interaction over distance without making major changes in naturally evolved patterns of communication. People still talk face-to-face and still write letters for purely social reasons. On the other side of the coin, people are still constrained by the limitations of face-to-face interaction. The possession of a telephone and a thick directory does not in practice give us any greater access to other individuals. We still tend not to talk to unknown people, except for restricted purposes, such as information gathering, where the persons concerned are limited to a fairly definite transactional role relationship. We have even developed a protocol for dealing with inadvertent contacts made by misuse or malfunction of the machine. This protocol normally involves some form of apology. In this regard, the global village is a myth. Mere extension of the lines of communication does not automatically ensure an increase in the number of our neighbours.

The telephone appears to be the most personal of the telecommunication devices and facilities. At first glance, videophones and teleconferencing facilities appear to offer greater personal contact through the provision of a visual channel. These devices have not proved entirely successful to date. One possible factor in their limited acceptance may be that the speakers are required to make two sets of adaptations: one is the use of speech to carry more of the communicative cues than would be necessary face-to-face, but less of these cues than are needed in a purely auditory communication situation. That is, a new level of information is needed in speech. At the same time, adaptation must be made to the fact that eye-contact does not occur, even though the interlocuter can be seen clearly. It may very well be that there is a dynamic factor involved in patterned eye-contact which assists interpersonal communication and helps to maintain a particular definition of a speech situation so that interaction can proceed. If this is in fact the case, it would not be surprising to find that a situation which mimics face-to-face interaction but which does not offer eye-contact could be very disturbing to the participants. Further, it is a subtle factor, one which is normally below the level of conscious awareness, so that people may feel that something is wrong yet not be able to put their finger on the trouble.

Specialisation of Function

Less personal means of communication are far more efficient than speech. They represent a specialisation of function. A few tasks are performed superlatively. Information has come to be highly valued in the economically dominant segment of our society. Information transmission is a task which machines can perform better than people. Information is gathered together at particular points, given an optimally efficient form and transmitted to a remote point. A new communication system has come about. The components of this communication system are similar in some respects to those of the human situation described earlier. Communication takes place in space and time, using a language, a communication channel, a sender, a receiver and so on. A critical difference, however, is in the range of functions served by machine communication. The focus on information subordinates all other factors except perhaps time. People can now transmit information to each other with little reference to their personal identity, to their general competence, to their status as adults, as members of a group or even as members of the human race.

Human Consequences of Technological Communication

We can, of course, adapt if we are given enough time. We have adapted to writing and to the telephone and our civilization is undoubtedly enriched by these technologies. Two of the questions we are facing are that of the nature and extent of the adaptation required, and that of the further consequences of particular kinds of adaptation.

What happens if we ask workers to communicate through machines that preclude human contact? What happens to people who spend most of their working life largely cut off from the personal benefits of interpersonal interaction or conversely, what happens if they are asked to increase their interpersonal interaction? Do we perhaps place increased demands on their domestic situations, asking that spouses and families learn to provide a varying range and volume of interaction than is usually forthcoming? And can they do it, or will the family come under stress?

These are not idle questions. Interpersonal communication is a vital part of our existence and forms a significant proportion of the way we spend our time. Deprivation of communication has traditionally been a punishment for humans — this is the point of sending people to 'Coventry' or of placing them in solitary confinement.

The importance of interpersonal contact in the work environment is recognised increasingly by organisations which are willing to spend money on teaching interpersonal skills to management and staff. And more questions arise here. Is there a connection between the use of technological communication devices and the need for training in interpersonal skills? Are these courses sometimes compensating for a deprived environment, in terms of human communication, rather than offering new skills as they purport to do? If so, are there more direct ways of compensating for restrictive jobs? Do we need to restructure the job, the coffee-break, the social club, the pattern of line control, the whole organisation? Do we need to do anything other than rely on the selective force of the new situation, so that the restrictive jobs will eventually be done by humans with greater tolerance for low levels of interpersonal interaction? These questions have important practical significance in the application of new systems, for example, those which undoubtably improve productivity but which may also alter the normal volume of interpersonal contact.

CONCLUSION

Each new technological development has acted to overcome some of the limitations of interpersonal communication. Distance, speed, volume of information, the redundancy and non-specificity of speech have all been mastered. However, even the most non-human of these communication systems must be finally translatable back into terms that are understandable by humans. This is a fairly significant point about technological communication. Human purposes determine what it is that is communicated and how this information is presented to the world. In other words, the actual means of communication may be very far away from what it is feasible for unaided humans to do, but ultimately a strictly human frame of reference bounds this kind of communication.

The entry of electronic means of communication and synthesis of the human voice represents a shift in the balance of communication within a human group and for individual members of the group. Mediated communication involves a narrow selection from the range of functions normally served in interpersonal communication. In particular, the information function has been elaborated. At the same time, the use of impersonal and non-human communication systems replaces the use of personal communication to varying degrees. Given the fundamental nature of human communication, the extensive use of speech in human society and the dependence of people on contact with one another, the question of how humans are affected by impersonal communication systems requires serious attention.

Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
T. S. Eliot

INTERNATIONAL DATA COMMUNICATIONS STANDARDS SEMINAR AND TELECOM DATA FORUM

MELBOURNE — 30TH AND 31ST MARCH 1982

Telecom Australia will host a SEMINAR on International Data Communications Standards and a FORUM on Telecom Australia Data Services following meetings in Melbourne of the International Telegraph and Telephone Consultative Committee (CCITT) Study Group VII from 9-26 March, 1982. These meetings will be attended by some of the world's foremost experts in data communications networks, and they have been instrumental in specifying Recommendations such as X25 and X75.

Arrangements have been made for several of the overseas experts to speak on the latest major developments and trends in data communications networks and standards at this SEMINAR.

The speakers and their topics will include:

VERN MACDONALD (Dept. of Communications, Canada) surveying the role and significance of international data communications standards.

KEITH KNIGHTSON (British Telecom) on the current status of X25, worldwide experience of connection to public data networks and the status and role of the CCITT Transport Service and Protocol.

TOM STEEL (AT&T, USA) discussing the role, status and future of the CCITT Reference Model of Data Communications and its relationship with the ISO Reference Model.

PAUL BARTOLI (Bell Labs., USA) overviewing developments and standards in electronic mail and electronic message handling and their relationship to Videotex and Teletex.

GARY DICKSON (Telecom Research, Australia) describing the contribution of Formal Description Techniques to the specification of international data communications standards.

Several PANEL DISCUSSIONS will allow attendees to question the speakers.

Following the SEMINAR, a free half-day Telecom Australia Data FORUM will be held during which Telecom experts will discuss Telecom's data communications services and plans for the future. The discussions will include technical and commercial aspects of the Digital Data Service (DDS) and AUSTPAC, both of which are scheduled to commence operation in December, 1982.

At the end of the FORUM presentation there will be a Panel Session where individual problems can be discussed.

For further information on the SEMINAR and the FORUM and for Registration Forms for the SEMINAR, please contact:

MS. M. LAMBERT
Telecom Research Laboratories
P.O Box 249,
CLAYTON, Vic. 3168
Phone (03) 541 6361 (M. Lambert)
or (03) 541 6310 (B. Dingle)

You are advised to REGISTER EARLY as numbers will be limited.

PERSONALITIES

APPOINTMENT OF NEW CHAIRMAN — AUSTRALIAN TELECOMMUNICATION COMMISSION

The Minister of Telecommunications announced in October 1981, that Mr Robert William Brack, AO, BA, FAIM, F. Inst. D.A., would be the new Chairman of the ATC. Mr Brack, presently the Managing Director of Australian Consolidated Industries, was a member of the Customs Department, representing that organisation in both London and Washington before being appointed to the position of Collector of Customs, NSW, in 1963. Mr Brack saw war service with the 8th Div. AIF and was a P.O.W. in Singapore and Thailand. He is presently also the Vice-Chairman of TAA. The Council and members of the Society, welcome Mr Brack and offer congratulations on his appointment.

APPOINTMENT OF NEW MANAGING DIRECTOR — TELECOM

It is with pleasure that this Journal records the appointment of Mr Bill Pollock, B.Com. to the position of Managing Director, Telecom Australia. In making the appointment, the Australian Government has recognised Mr Pollock's breadth of experience and depth of contribution, over the years, to the telecommunications industry. Mr Pollock started with the PMG Department in 1938 and, after war service, was promoted through the ranks of the Telecommunications Division before becoming the first head of the newly formed Industrial Relations Division. Mr Pollock was appointed Director, Victoria in 1974 and became Telecom's first Chief General Manager in 1975. Mr Pollock has been a contributor to this Journal and has supported the activities of the Society over many years.

RETIREMENT OF JACK CURTIS, CB, B.E.(Hons.), B.Sc., B.A.

Mr Jack Curtis, Managing Director of Telecom Australia since its inception in 1975, announced his retirement during August, 1981.

Mr Curtis commenced his career in Brisbane in 1949, as an Engineer and rose to become Director, Queensland before coming to HQ as Deputy Director General, in 1974.

Mr Curtis was honoured with the award of Companion of the Order of the Bath, in 1980, for public service.

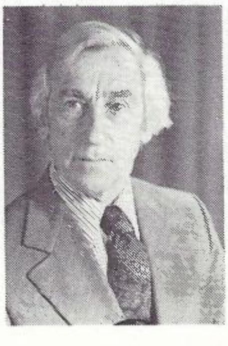
The members of the Society, in saying farewell to Mr Curtis, extend to him their best wishes for the full enjoyment of a well earned retirement after a notably active and effective career.

APPRECIATION TO LINDSAY MITTON

The Council of Control of the Society, in accepting the resignation of Mr Lindsay Mitton as Editor in Chief of the Journal, wishes to acknowledge the considerable contribution made by Lindsay, to the objectives of the Society during his term as leader of the Board of Editors.

Lindsay Mitton took over this burgeoning task not long after joining the Board of Editors, in 1977, and has maintained a high standard of Journal material and presentation throughout his term of office. It is pleasing to note that Lindsay will not be leaving the Board and will continue as the Editor for operational and service matters.

The Council expresses its appreciation to Lindsay Mitton for his excellent work.



RETIREMENT FROM BOARD OF EDITORS — R. W. E. HARNATH

Bill Harnath retired from Telecom during September 1981 after 26 years service and concurrently resigned from the Board of Editors. Bill joined the board in 1973 and has been assisting authors in the transmission equipment area since that date. The Council and Board of Editors desire to record their appreciation of his efforts and join with Bill's many friends in wishing him a long and happy retirement.

In Brief

RECENTLY RELEASED ASA STANDARDS

AS 1102.11 — GRAPHICAL SYMBOLS FOR ELECTROTECHNOLOGY

An updated part of a comprehensive series of standards of graphical symbols for electrotechnology, this edition deals with switching and protective devices and has extensive changes to the 1976 edition.

AS 1202.1 — A.C MOTOR STARTERS (UP TO AND INCLUDING 1000V).

A revised standard, which although technically identical to the 1972 edition, includes two amendments, editorial changes and an updated reference to Australian standards.

AS 1829 — ELECTRICAL EQUIPMENT FOR EXPLOSIVE ATMOSPHERES.

A revised edition dealing with intrinsically safe electrical apparatus for explosive atmospheres. The requirements ensure that intrinsically safe systems cannot constitute a source of ignition for hazardous gas or vapour.

AS 2480 — FLAMEPROOF ENCLOSURES

This new specification deals with flameproof enclosures for electrical equipment in explosive atmospheres. It replaces ASC98 and includes requirements by mining regulations or by SAA wiring rules together with constructional requirements and test procedures.

AS 2481 — ALL-OR-NOTHING ELECTRICAL RELAYS.

The specification covers all-or-nothing (instantaneous and timing) electrical relays and defines terms and standardizes values for the relays and for their environmental influencing factors.

DR 81247 — NOISE RATING FOR ACOUSTIC ENVIRONMENT

A draft revision of AS 1469, published for comment, and which contains an additional method for the calculation of NR value from the given set of octave band sound pressure levels by the use of both a formula which can be used in computer calculations and a table, while retaining the graphical method of estimating NR value.

DR 81256 — GUIDE TO THE SPECIFICATION OF COLOURS.

A draft standard, published for comment, which provides a guide to the specification of colours. It sets out the factors which should be taken into account in the specification of colours, including the use of colour names, material colour standards and the CIE colorimetric system.

DR 81266 — WINDING WIRES

A draft revision of AS 1194.2 — Enamelled Rectangular Copper Winding Wires and, when published, will supersede those parts of AS C73 which cover rectangular copper winding wires.

DR 81267/81268 — POWER TRANSFORMERS

Two draft revisions of parts of AS C61. Both revisions have been given considerable alignment with IEC standards.

DR 81269-72 — STABILIZED POWER SUPPLIES — DC OUTPUT

Draft revision, for comment, of a four part standard dealing with stabilized power supplies for such applications as computers, telecommunications, laboratory and industrial equipment.

DR 81276/81277 — TELECOMMUNICATION AND SIMILAR ELECTRONIC EQUIPMENT

Draft revision DR 81276 deals with reliability testing and is designed to improve reliability of telecommunication equipment. The major features are highly technical and are of interest to statisticians and practitioners in the RAM field. DR81277 deals with maintainability and provides guidance on the standardisation of maintenance practices. It describes practices in specification/contract writing and in the establishment of maintenance programmes.

DR 81278/81279 — SPECIFICATIONS FOR ELECTRONIC COMPONENTS

These drafts have been prepared to foster a standard approach to the problem of including requirements in specifications, tender documents and inspection procedures.

DR 81285 — LABELLING REQUIREMENTS FOR ENERGY DEVICES

This draft has been prepared as a useful adjunct to programs for energy conservation and more effective utilization of energy. Energy labelling can provide the means of giving information to the consumer on the likely running costs of appliances, motor vehicles, heating and cooling equipment.

In Brief

FROM THE STANDARDS ASSOCIATION OF AUSTRALIA

Australia Joins International Electronics Standards Commission

Australia has officially joined the International Electro-Technical Commission (IEC), a body set up to guarantee worldwide quality control of all components used in high technology equipment.

The IEC objective is to establish a global system of quality specifications for minimum performance levels of components used in professional equipment in the telecommunications sphere, no matter where in the world the parts are produced.

When fully operative the IEC system will mean that all components manufacturers worldwide will have to meet the minimum standards of quality control in accordance with the specifications laid down by the Commission.

As well, importers of components will have to establish tight stock control and checking systems to ensure all imports comply with the specifications.

The governing body of the IEC in Switzerland will be responsible for setting the specifications for all components following input from all member nations.

In Australia the Standards Association will be the body responsible for administering the regulations.

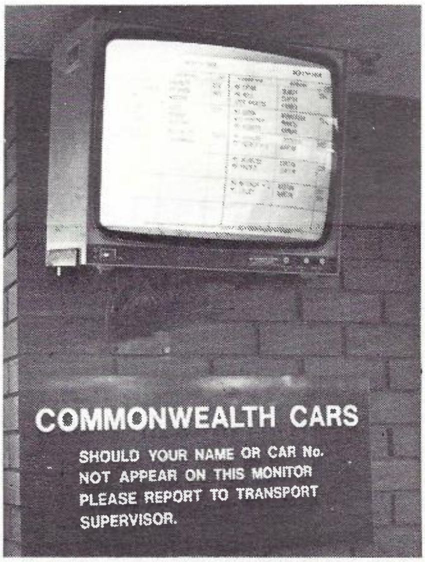
Estimated annual cost of administering the Australian end of the IEC operation is put at $60,000.

This will be borne by the Federal Government — 50 percent; Australian Electronics Industry Association (AEIA) — 33.3 percent; Telecom — the remaining 16.7 percent.

In Brief

TV SYSTEM SPEEDS COMMONWEALTH CAR ALLOCATION AT CANBERRA

Commonwealth employees arriving at Canberra Airport are finding it easier to get transport from the airport because of a new television system. The system, installed recently by GEC, provides a visual display of passenger name, destination and motor vehicle allocated to their transportation.



Designed to achieve greater efficiency, the documents transmission system has virtually abolished the long queues waiting at a Government vehicle allocation desk. It is a combination of a television camera, transmission cable and video monitors to display the information. Once motor vehicles have been assigned, the information is typed on a sheet of ruled paper and then placed on a transmission table beneath a National WV 1100 camera. The information is transmitted, via coaxial cable, to two monitors located adjacent to the TAA and Ansett arrival areas at the airport.

The system is duplicated to cover both arrival areas, but a built in switching system inter-relates the two systems for use in case of a camera or monitor failure.

BOOK REVIEW

Science and Technology Statement 1980-81

By the Minister for Science and Technology, The Honourable David Thompson, M.P.

This statement which runs to 130 pages, including two appendices and a list of acronyms and abbreviations, is the second Science Statement published, and has been produced to inform Parliament and the public about Commonwealth Government expenditures in science and technology (S&T).

The first Science Statement was tabled in Parliament in May 1980 and presented a consolidated overview of Commonwealth Government support activities for research and development (R&D). This second report, has been retitled Science and Technology Statement to represent its coverage more accurately, and to take proper account of the association between science and technology in Government policy machinery. It documents, at the broad programme expenditure level, the resources devoted by the Commonwealth Government to R&D in the financial years 1978-79 to 1980-81, and to a wider range of S&T activities in 1979-80 and 1980-81. A number of improvements have been incorporated in the second report:-

- a uniform methodology has been developed in consultation with the Australian Bureau of Statistics to improve the quality of the data, and to promote consistency with the Project SCORE R&D survey;
- intramural and extramural expenditures have been presented separately in the Ministry tables;
- intramural capital and current expenditures have been presented separately at the Ministry level; and
- coverage has been expanded to include a range of science and technology activities beyond R&D.

An outline of the methodology used in preparing the State Reports together with definitions of terms and descriptions of the activities included as science and technology are provided in appendix 1 to the Statement.

Appendix 2 to the Statement provides some interesting international comparisons and trends in regard to expenditure on science and technology activities and underlines the low level of private enterprise commitment to R&D in Australia.

Incorporated within the usual speech by the Minister in presenting the Statement to Parliament, which is included at the beginning of the Statement, is the declaration adopted by Ministers at the OECD Conference of Science and Technology held recently this year, which was attended by the Australian Minister.

The OECD declaration provides an interesting synopsis and indeed blueprint of activities that require attention in the formulation and implementation of policies for science and technology in Australia and other OECD countries.

The main body of the Statement, is however, directed to reporting on the range of science and technology activities being undertaken and to outline the broad programme of Commonwealth Government expenditures in these areas.

In summary, the Statement is a compendium of Commonwealth Government funded activities and objectives in the field of science and technology. The information contained in the Statement is balanced between providing detailed information on specific areas of undertaking, and the need to present a readily comprehensive overview. As such the Statement fulfills a real need and provides a useful addition to reference libraries on this subject.

Reviewed by R. HARDING,
Technology and Change Branch,
Telecom Australia.

ANNUAL REPORT 1980-81 — Department of Science and Technology

This book is not just an annual report in the business sense but a review of current science and technology policy together with reports from each functional area of the Department.

The report is important to those involved in the management of high technology industries because it is the first report of the Department which has now linked the responsibilities of Government support of science with measures devoted to assisting industry's technological development process. The linking recognises the distinct contribution science and technology make to national economic and social progress.

The book reports on progress towards the implementation of the plan outlined in the Science Statement (1980).

Although not having an in depth interest to most TJR readers, the report does contain some interesting chapters on:

- Science and Technology Policy
- Industrial Research and Development
- Productivity and Industrial Innovation
- Industrial Property (Trade Marks and Patents)
- Satellite Developments for Communication, Meterology, navigation, etc.
- Ionospheric Prediction
- International Agreements on Science and Technology

Recommended for the general interest of managers involved in research, development and implementation of contemporary technology and also for officers engaged on projects within those areas and who seek information on broad directions adopted by other groups. — E in C.

Both of the above books are available from the Australian Government Printing Service.

In Brief

TELEDON SIGNALS CARRIED BY LASER

A LASER communication link between a TELEDON (VIEWDATA) terminal located at Queens Park (Central Toronto) and the CN Tower (South Central Toronto) over a distance of about 4 km. was used recently to successfully transmit data to a Federal Department of Communication (Canadian DOC) computer in Ottawa.

The demonstration conducted by CNCP Telecommunications and the Ontario Ministry of Transportation and Communications, used the Teledon screen to retrieve and display information on telecommunications and transportation subjects stored in a computer at the Communications Research Centre laboratory in Ottawa.

The Ministry is considering the use of LASER communications in its traffic management systems and as a maintenance alternative to cable.

In addition to the long distance demonstration, two word processors were used to demonstrate the data carrying capability of LASERS in the "office of the future" concept.

In Brief

THE DECLARATION OF MEXICO ON INFORMATICS, DEVELOPMENT AND PEACE

Last June 22-23, twenty-six individuals — among them experts, ministers and high-level officials from twenty countries — drafted and signed the Declaration of Mexico on Informatics, Development and Peace. The signing ceremony was presided over by His Excellency, Jose Lopez Potillo, the President of Mexico, who signed the Declaration as a witness of rank.

The Declaration of Mexico concerns the role which informatics could play in solving the fundamental problems of today's world and, as a direct consequence, in maintaining peace. The Declaration of Mexico states that "informatics, to the extent it could become an effective instrument for promoting organizational, managerial and administrative structures, can assist in the solution of problems of development".

In a statement delivered during the signing ceremony, President Jose Lopez Portillo affirmed his commitment to involve other Heads of State in the Declaration and to support efforts to achieve its goals. President Mitterrand of France and King Hussein and Crown Prince Hassan of Jordan sent personal messages to President Lopez Portillo in support of the effort undertaken. A similar message was received from the Kingdom of Spain.

The meeting in Mexico, organized by the Intergovernmental Bureau for Informatics (IBI), was the first step in a vast plan which will culminate in the Second World Conference on Strategies and Policies for Informatics (SPIN 83), which will take place in Havana, Cuba, in July 1983.

Professor F. A. Bernasconi, Director General of IBI, stated at a meeting with the Press that the SPIN 83 Conference in Havana will be presided over by Dr. Fidel Castro, in the presence of at least ten Heads of State and Plenipotentiary representatives from about 100 countries. He also stated that the Conference would consider for approval and implementation a thousand million dollar five-year programme for the informatization of the Third World.

In proportion to the importance of the project, significant human and economic resources have been allocated by IBI for the preparation of the Havana Conference. During the two-year period from the meeting in Mexico to the SPIN 83 Conference, these resources will be used for the preparation of the five-year programme for the informatization of the Third World, the convening of ten preparatory sectoral meetings, six preparatory regional meetings and the creation of five special advisory groups.

(IBI, located in Rome, is an organization specializing in informatics and whose programme of activities is approved and financed by the Governments of its member countries. IBI's field of activities includes, besides methods and models of information processing, analyses of the political, economic and socio-cultured problems connected with the advent of the information society).

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3	161-256

(I.B. Refers to the In Brief Items included in the Journal)

Book Review

"Global talk"

J. N. Pelton, BS, MA, PhD
Executive Assistant to the Director General of the International Telecommunications Satellite Organization (INTELSAT)

Global talk provides a look into the foreseeable and distant future of communications, particularly space communications and satellites, and other related high technology industries.

The author makes a persuasive case that telecommunications advances are bringing enormous change and have the potential to change the world we live in even more radically in the years and decades ahead. He looks to the rest of this century as well as into and through the 21st century. He examines the interrelationships between technological, social, cultural and racial developments. He suggests that, as communications technologies and satellites have fewer national barriers, social and political developments will take place at a global level.

Global talk explores the helpful role that telecommunications, computers, energy and space applications can play in shaping tomorrow's world. It explores opportunities and alternatives and the author's aim of placing the reader in a better position to judge and assess basic trends in a technologically oriented society is largely achieved.

The book has chapters devoted to:

- technology; yesterday, today and tomorrow;
- the 21st century and beyond;
- humanised telecities for the 21st century; written in conjunction with Alfred Hsi Liu, a prominent American architect;
- toward a global electronic village;
- polite and proper conflict: how telecommunicators resolve their differences;
- the cosmic view, interstellar communications.

In addition there are a number of appendices including one which provides the interesting results of a Delphi survey on the future of space telecommunications and applications and the times at which certain critical events might occur. This survey involved leading experts in the field throughout the world, including an academic and a computer expert in Australia.

If you enjoy reading, for its own sake, you should read Global talk. If you are in the communications industry or interested in the future it is almost a must.

It is well written and nearly always easy to understand. The text is serious where necessary, and often witty to relieve any possible tedium. The text is supported by useful tables, charts and artistic drawings and there are several clever cartoons. The cost of this book is $25. Highly recommended.

Reviewed by W. F. Cox, B.Sc., Grad. Dip. Bus. (Admin.), Manager, Corporate Analysis Unit Telecom Australia.

ABSTRACTS: Vol. 31, No. 3 (Continued)

SUBOCZ, M.: 'The CCITT No. 7 Common Channel Signalling System for Digital Networks'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 203.

Introduction of stored program controlled exchanges into the telephony network has resulted in cost savings but has done little to improve the performance or facilities provided by the existing network because of the limitations imposed by conventional signalling schemes. The development and introduction of common channel signalling systems will permit better utilisation of existing exchanges and the introduction of new services. This paper describes the features of the new CCITT No. 7 common channel signalling system which is optimised for use with the 64 kbit/s digital PCM links and which will provide the signalling requirements for either single service networks, e.g. telephony, or integrated services digital networks.

THUAN, E.: 'People Talking to People: Understanding Interpersonal Relationships'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 241.

Humans communicate face-to-face in very complex patterns of word and gesture that have their bases in our biology and in our needs as social beings. We communicate a great deal with each other, not just to convey information but to form groups and to establish individual identities. Advances in communications technology extend and transcend human communication and represent a shift in the balance of communication within the human group. Understanding how humans communicate can provide insight into the operation, and the failure, of sophisticated devices and systems, and raises important questions about the impact of technology on the people it purports to service.

The Telecommunication Journal of Australia

ABSTRACTS: Vol. 31. No. 3

BOLAND, J. E. and De JONG, H.: 'Telecom's Mobile Telephone Service — System Description and Radio Coverage'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 179.

Telecom Australia is replacing the existing manual mobile telephone systems in Melbourne and Sydney with a fully automatic system providing all the facilities available to subscribers connected to the fixed telephone network as well as additional features. The Melbourne system went into operation in September 1981 and will be followed by the Sydney system. Each system will provide a service for about 4000 mobile customers on 120 radio channels.

The radio channels are distributed at base station sites selected to provide the required coverage throughout the nominated service area. The number of channels at each site has been determined from a study of the expected coverage from each site, the expected number of subscribers likely to require service during the busy hour within this area, and the need to provide a reasonable grade of service while ensuring the economical use of the radio spectrum.

This article will describe briefly the overall configuration of the system, the signalling procedures used in establishing calls and the functions of the major components which comprise a Mobile Control Centre, the base station network and the mobile unit installed in the customer's vehicle. The aspects considered in determining the radio utilization plan and coverage are outlined and a description is given of the base station and mobile radio equipment used in the system.

CHEESE, P: 'Inward Wide Area Telephone Service (INWATS)'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 197.

Wide Area Telephone Services have gained considerable acceptance in the USA and Canada. A similar service has now been introduced by Telecom in Australia and this paper presents an overview of the history and development of the service and its implementation within Australia.

GERRAND, P. H.: 'SDL and its use in Australia and Overseas — Part 1: Introduction to SDL'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 225.

In the past ten years the CCITT Specification and Description Language (SDL) has progressed from a speculative research topic to an international standard (CCITT 1976, 1980) gaining wide acceptance in the world-wide telecommunications industry. Part 1 of this paper provides an introduction to SDL and its methodology. A three-step procedure for applying SDL is described, using two examples: (a) specification of call set-up procedures in an ISDN (Integrated Services Digital Network) switching node, and (b) description of a multi-server queue managing process. In addition, the use of SDL with state pictures is illustrated with an extract from the specification of a telephone call-waiting facility. Part II surveys the use of SDL within Australia and overseas, and makes predictions concerning the nature of its future use by telecommunication administrations and manufacturers.

GERRAND, P. H.: 'SDL and its use in Australia and Overseas — Part 2: Past, Present and Future Use of SDL'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 234.

Part 1 of this paper, provided an introduction to SDL, the CCITT Specification and Description Language. Part II surveys the use of SDL within Australia and overseas, and makes predictions concerning the nature of its future use by telecommunication administrations and manufacturers. The principal trends in SDL usage identified are its increasing use in CCITT Recommendations, the penetration of SDL into the specification of data services and protocols, the consolidation of the application of SDL to the specification and documentation of telephone switching and signalling systems, and the development of computer aids for SDL-based system specification and documentation packages.

SARGEANT, V.: 'Telecom's Mobile Telephone Service — System Planning and Design'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 167.

Network connected mobile telephone services (car telephones) have been in operation overseas for many years. In Australia a manually switched telephone service has been available to mobile users in major capital cities since about 1952. However the number of customers provided with such a service has been only a few hundred.

Early in 1976 Telecom senior management gave approval to a plan to provide customers in Australia with a mobile telephone service equal to or better in performance, facilities and cost, than any found in other parts of the world.

On the engineering side, the world market was surveyed to establish the capability of current systems and the trends emerging in developing mobile systems. This article outlines the various system philosophies which were developed from the need to provide the service required in geographically large Australian capital cities. The article also discusses the special requirements of the customer, the facilities provided, and some features of the common equipment which are unique to a mobile telephone system.

Much of the information contained in this paper on the topic of design of Telecom's new mobile telephone system was written directly into the specifications for the system.

SIVYER, M.: 'Telecom's Mobile Telephone Service — Need for a Modern Automatic Service'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 164.

Current trends towards a mobile society and rapid developments in technology have thrust the mobile communications industry into a complex market whose needs include the automatic interfacing of the switched telephone network with radio communications.

This article attempts to identify that market and its needs in relation to mobile automatic telephone services. As the theme of the article is marketing oriented, the basic elements of the marketing mix involved in providing a mobile telephone service are discussed.

Subsequent papers cover the technical and operational implications of providing and maintaining such a service.

SPENCE, R. J.: 'Active Filter Circuits'; Telecom Journal of Aust., Vol. 31, No. 3, 1981, page 215.

Active filter techniques are discussed with particular reference to band-pass requirements. Single section band-pass active filters using one, two and three amplifiers are treated in turn and the limitations of each type pointed out. A technique for realising stable, easy to adjust, higher order filters using coupled three-amplifier sections is then explained, as a direct translation of a passive filter design into an equivalent active structure. A variation is then described which allows this approach to be extended to a band-stop filter.

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