VOLUME 11 PART 3 OCTOBER 1992

BRITISH TELECOMMUNICATIONS ENGINEERING

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The Journal of The Institution of British Telecommunications Engineers

BRITISH TELECOMMUNICATIONS ENGINEERING

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GUEST EDITORIAL

Tom Denniss

Planning for Success

Effective project planning and management tools are essential weapons in any large company's armoury if it is to manage investment and quality programmes effectively.

Over the past four years, major strides have been made in improving the overall quality and effectiveness of project management in BT.

The introduction of WASP/Hornet, featured in five articles beginning on p. 158 of this issue of the *Journal,* is an important milestone for BT Worldwide Networks' programme of continuous improvement for its management control system.

Effective project planning and management tools are essential weapons in any large company's armoury

The building and continual modernisation of telecommunications networks is one of the great unsung achievements of project management worldwide. Unlike civil engineering, there is no catenary arch to catch the eye and tug at the heart strings.

The effort which goes into network architecture and system design is totally invisible to the general public and receives scant recognition. The implementation phase of network development is fraught with the usual problems of physically realising a design within time, cost and quality parameters while running the risk of disrupting existing voice, data and vision communications services on which today's society so greatly depends. Risks abound from causing breakdowns through to delivering services late and over cost thereby jeopardising not only the launch date of a new product, but in an aggressive market environment, the viability of the product itself.

Traditional PTTs exposed to limited or no competition have learnt to live with political priorities impacting on their investment programmes. Constraints on capital generally, and hence the investment programmes, tend to wax and wane with the country's and Government's fortunes. Because of the lead times on procurement and the sheer logistics of deploying hardware, synchronisation of customer demand for service and functionality are rarely met on the customer's terms.

Where markets have been liberalised, countries are experiencing an industy in transition with early deployment of technology becoming a key issue for some market segments. With regulators seeking to impact on price, cost control and cost avoidance become real survival issues, while competitors are keen to attack profitable markets and exploit market niches as they emerge.

For the customers, this freeing of the market, has a liberating effect which leads not only to an expansion in the telecommunications market but also causes them to be volatile and very demanding.

These pressures increase the onus upon us to manage the continuous and accelerating rate of change in network design, deployment and operating skill to new levels of professional competence.

The management of programmes and projects requires the creation of processes which are well defined and effective in operation and which allow optimisation of capital, human resources, financial quality and available time for maximum impact on the marketplace.

WASP/Hornet is just such a tool.

All aspects of works planning, logistics control and overall project management can now be coordinated at national, directorate and task level.

By reviewing the process, the elements have been simplified and yet made more effective through developed commercial applications software. With WASP/Hornet in place, operational costs can be reduced, programme options can be evaluated and the programme can be optimised against a wide range of restrictions and imperatives.

By operating as a just-in-time and right-first-time planning control system, WASP/Hornet enhances BT's ability to build value for money networks on the customer's terms.

Tom Denniss

Director Operations London
BT Worldwide Networks

Chairman of the IBTE Council

Andrew Valdar, David Newman, Roger Wood and David Greenop

A Vision of the Future Network

The next decade will herald unprecedented changes in the structure and capabilities of telecommunications networks. These changes are being driven by increasing competition in the marketplace, technological advancements and demands from all customer segments for an increasingly sophisticated portfolio of services, tailored to their specific needs. This article presents some of the important elements of a future vision of BT's worldwide network and identifies some of the many challenges facing telcos, emphasising the important role that engineering and technical management have in ensuring business success and customer satisfaction.

The Changing Environment

As society's reliance on communications and information steadily strengthens, the role that telecommunications has to play is rapidly increasing in importance. For the large multinational corporations, the global public and leased line networks link managers to information systems which allow them to interact with their operations all over the world. The ability to communicate and exchange information freely is considered by many companies to be a key strategic factor in the successful execution of their business. Therefore, multinational businesses are increasingly looking to the major telecommunication companies for communication solutions that allow them to carry out their business activities transparently across commercial and national boundaries.

The domestic market sector must not be overlooked. The increasing penetration of the telephone into every household has facilitated subtle changes in social behaviour. Individual family members can now keep in touch more easily, independent of their specific location, thus allowing individuals greater freedom to choose and follow their preferred life styles. The trend by the more sophisticated domestic customer for enhanced communications facilities such as teleworking, tele-shopping and personalised services offers the prospects of new and exciting uses of communication facilities.

Within our vision, we need to be aware not only of the commercial issues that are driving this change in communications and information technology, but also the significant impact that this greater freedom to communicate and process information will have upon the evolution of an integrated global society.

Over the last decade, rapid change has occurred in the UK telecommunications market. A regulatory environment has been established to encourage competition and offer greater choice to the customer. Until recently, this competition has mainly concentrated on the business market and has had little impact upon domestic customers. In addition to the fixed-network carriers—BT and Mercury Communications—and the two cellular operators—Cellnet and Vodafone—the UK Government has issued licences for the operation of telepoint services using cordless technology (CT2), closely followed by the granting of licences for the operation of personal communication networks (PCNs). In addition, cable TV franchises now cover most of the UK's conurbations, heralding the advent of an alternative fixed infrastructure for the delivery of telecommunication services to the domestic customer.

The Duopoly Review in 1991 carried out by the UK Government set the scene for a further significant opening up of the UK market to competition. This includes, among others, opportunities for new long-distance operators (licences are to be given to Ionica, Millicon, National Networks and Worldcon Interna-

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Note: This article was first published and presented at the International Telecommunications Union's 6th Telecommunications Forum in Geneva, October 1991. The contents of the article have been revised to reflect changes occurring since then.

As we move towards the year 2000, we can expect to see a far greater integration and interworking between services which were previously delivered over separate networks

tional), extending the licences of the PCN and cellular operators to allow them to provide fixed network services over their networks and preserving the asymmetry that allows cable TV operators to provide telecommunications while barring BT from providing entertainment or broadcast TV directly to customers over its network.

BT's Response

BT is having to learn how to operate successfully in this increasingly competitive home market while meeting its licence obligations to provide a universal service within the UK. The challenge BT has is to build upon the capabilities of its current network and evolve it to a position where its quality, costs and capabilities are competitive, not only in the home market but globally as well.

Over the last few years, BT's network has grown to provide a comprehensive range of services to over 25 million customers. This growth has been achieved while maintaining a major programme of network modernisation. To date, 70% of older-technology local exchanges have been replaced with modern stored-program control (SPC) systems, of which nearly 90% are digital units, predominantly supported by optical-fibre line systems. CCITT No. 7 signalling systems have been introduced across the network reaching all modernised local exchanges. In addition, improved methods and practices for the management of the network have been introduced. All these achievements have been accomplished while offering customers both a continued reduction in the real level of call charges and improvements in quality of service. However, neither these network achievements nor BT's engineering and research excellence by themselves are going to be sufficient to meet customers' requirements and sustain the future financial strength of the company. Greater emphasis is now being placed on clearly putting customers first, recognising and understanding their individual needs, and focusing on the company's core business: the provision of network services.

In early 1991, BT went through a major organisational restructuring ('Sovereign'). This restructuring emphasised the increasingly important role of customer-facing activities and the need to respond quickly to the service requirements of all customers. This means providing, on demand, the services, products and support that the customers wish to buy, at a price they are willing to pay and to a quality specification appropriate to their purpose.

Increasingly, services are being personalised to individual needs with a user-friendly presentation and simplicity which conceals the complexity of the technology hidden beneath.

Future Network Characteristics

An important characteristic of BT's vision is being able to provide for its customers a full portfolio of products and services that meets their needs irrespective of their location. If we look at the growth in the service capabilities of our network, over the last few decades, see Figure 1, we see a large increase and diversification in the services offered. As we move towards the year 2000, we can expect to see a far greater integration and interworking between services which were previously delivered over separate networks.

The future telecommunications company will therefore need to build its networks to provide and deliver most, if not all, of these services. This must be achieved in a way that is transparent to the customer and forms part of an integrated global business operation. The competitive environment has helped BT to re-examine from first principles the fundamental issues affecting the future network.

Already today, BT's customers not only include the person to whom direct service is provided ('end-user'), but many others such as alternative network operators whose interconnect traffic BT handles, value-added service providers who transact business across BT's network, and the companies to whom in the future BT may be providing wholesale services.

To support its customers on a global dimension, BT is going to require a high level of interconnectivity of the physical network infrastructures. This emphasises the importance of correspondent relationships with other network operators. BT will also need interconnectivity of the supporting information systems so that customers can be provided with the same range of services seamlessly while away from their home base. Customers will need personal identification, probably via a unique personal number. Their range of services will be registered within a personal profile.

Customers will require full service management offering a consistent presentation format for services, and a central point of support and billing for all their service needs. Our vision of the future offers one-stop shopping for the customer who chooses to integrate his communications within a single management point. For example, fixed-network services from his office and home together with his mobile telephone and electronic mail box may all appear as part of his own service profile. With this integration comes the opportunity to exploit advanced processing techniques to provide a truly intelligent network capable of tailored communications that appear directly under the customer control.

We envisage an evolving role for what has become known as the *broker* or *intermediary* in front-office packaging of total service solutions for customers. Thus, the future role of the network operator will increasingly include the provision of wholesale services to these intermediaries, as well as the delivery of other service-providers' products. As a result, the capabilities of the network will have to evolve to be far more flexible in

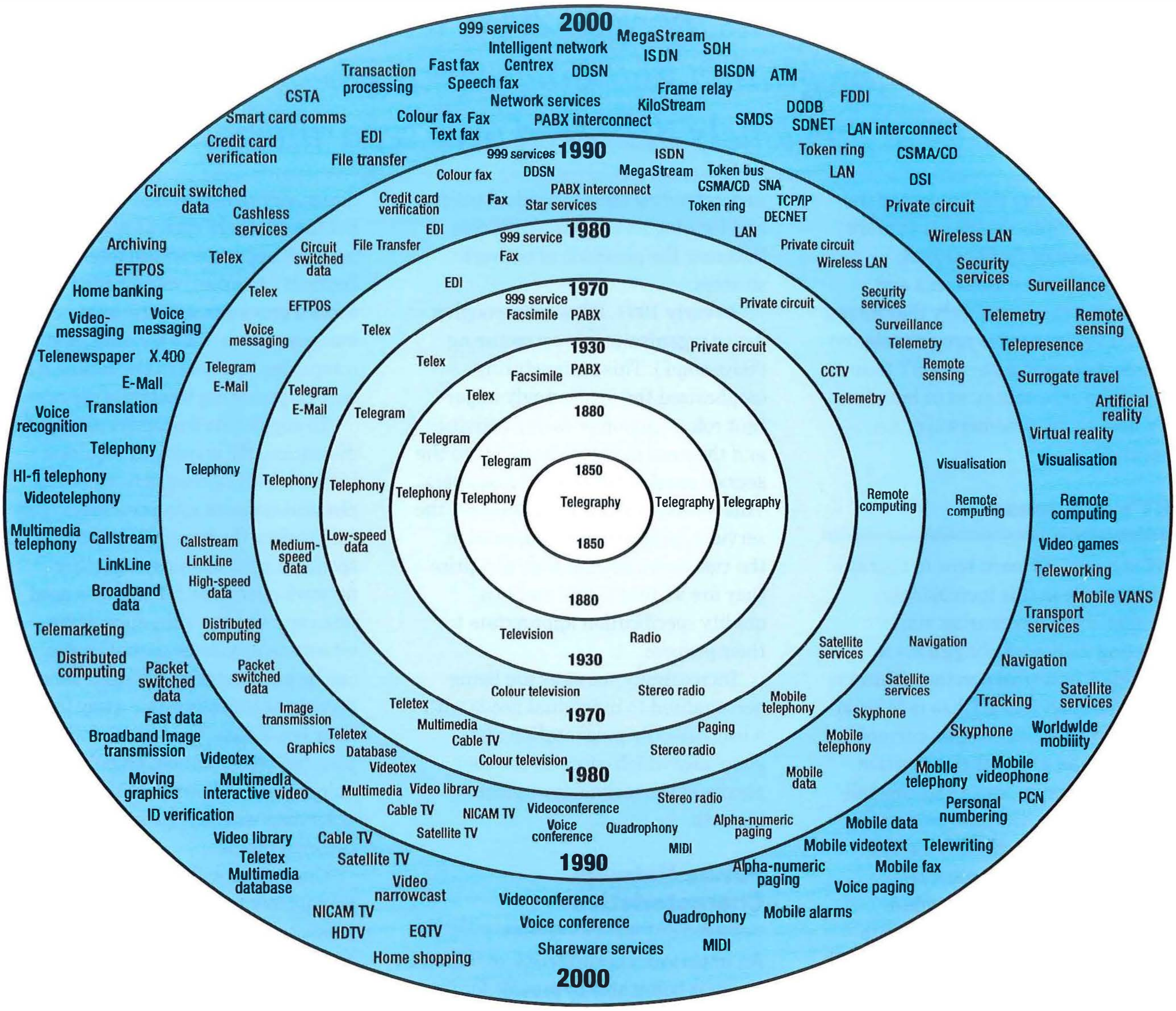


Figure 1—Future network services evolution

providing a range of service capabilities with multiple customer interfaces.

From the above, we can see that BT's future network needs to provide facilities for fast information processing and intelligent management and support systems, as well as a flexible transport mechanism capable of satisfying on-demand requests for variable bandwidth and multimedia services. It will need to support user domains managed by a variety of service providers, offer worldwide communication services on an individual, closed-user group, or universal basis. Customers will need to feel that the network is solely theirs and under their control.

Network Evolution—The Major Trends

Given the commercial and regulatory pressures on telephone operators and the features that the future network will need to exhibit, it is clear that the network infrastructure will undergo considerable change in the next decade. This evolution, rather than revolution, will progressively put into place the piece parts necessary to form a network structure providing the flexibility and responsiveness to meet each customer's needs in the most effective and economical way. Indeed, the hallmark of the evolving network will be that uniformity will not exist; customers will not all have the same requirements and so we can expect to see a range of network developments and technological steps geared to meeting these segmented needs. However, this must be within a coherent, consistent architecture with technology-independent service management.

Against this backcloth, the most significant trends can be examined:

The future of the access network

The use of optical fibre is already making steady inroads into the access network. However, costs are, and will continue to be for some time, the major drawback to widespread fibre deployment. Over the next 10 years, copper will still continue to be the principal means of access. But the growing use of fibre and radio will lead to an access network employing a mixture of transmission media. Copper will serve the large majority of customers directly from the exchange where the service requirements tend to be primarily telephony. Optical fibre will be the preferred method of connection for business customers and some green-field residential areas via a multiplexing arrangement; radio will be used where specific service advantage is evident, such as mobility, or for speed of provision.

The underlying trend will move towards the deployment of fibre where it can be cost justified, coupled with minimised provision of new copper and a greater exploitation of existing copper assets

The use of hybrid-access arrangements (see Figure 2), consisting of optical-fibre feeders and final distribution via copper, radio or fibre, will be a feature of the evolving access network as developers and planners strive to serve the customer by the most economical means.

Although optical local loops will figure strongly in the future, the often-held view of the access network based on ubiquitous fibre deployment has, in practice, given way to commercial realism where, increasingly, solutions will be targeted to meet segmented market needs.

The underlying trend will move towards the deployment of fibre where it can be cost justified, coupled with minimised provision of new copper and a greater exploitation of the existing copper assets.

Making copper 'sweat'

Copper-pair cable has proved to be enduring and it has been recognised for some time that much can be done to exploit further the potential of copper, both in terms of increased service-carrying capability and reduced fault liability. Recent developments have demonstrated digital transmission at 800 kbit/s over standard twisted-pair local-network cables at distances exceeding 4 km using high-rate digital subscriber loop (HDSL) technology[1]. The use of programmable digital signal processing and VLSI make this technology a cost-effective means of exploiting the embedded copper base. This can be used to support services such as videoconferencing, the integrated services digital network (ISDN), multi-channel pair gain and high-rate leased lines (private circuits).

Flexible fibre

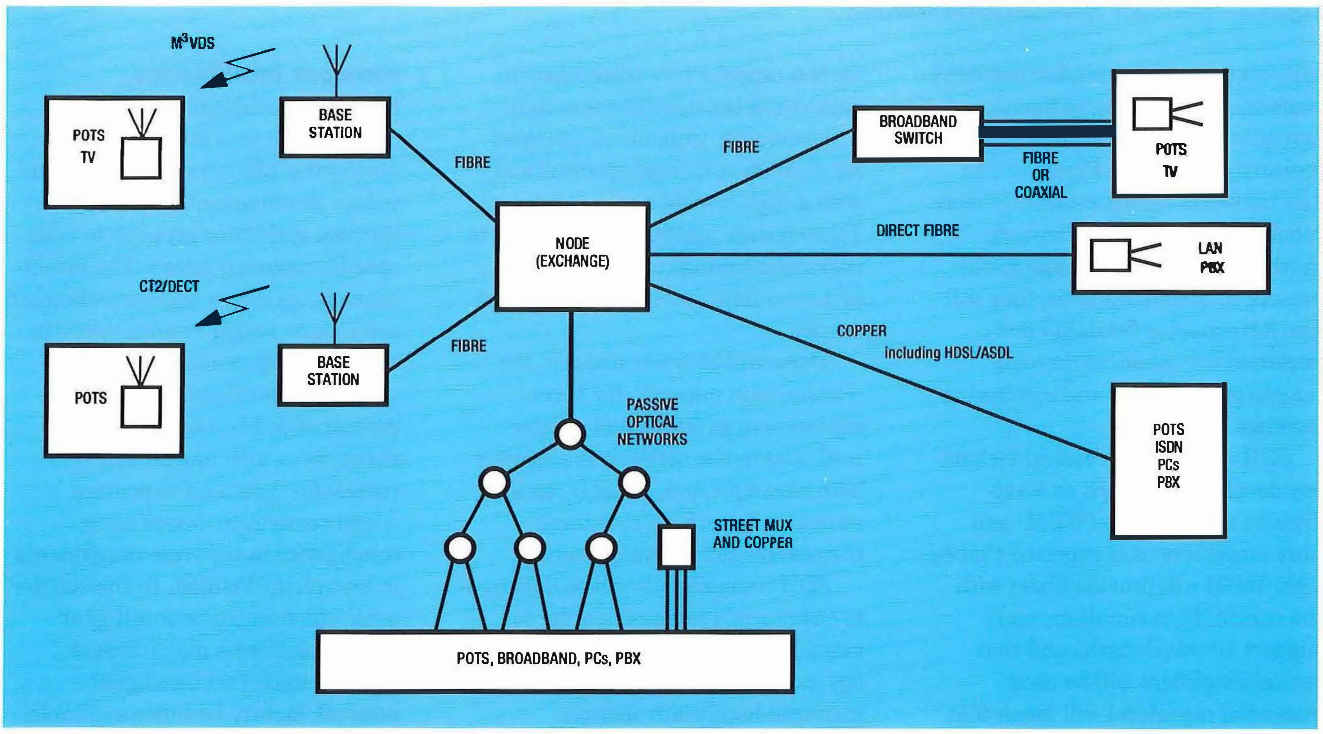
The initial focus of optical fibres in the access network is aimed at the largest business customers where cost savings and quality improvements can be made in transporting their large aggregated demands for services. As optical component and system costs reduce, fibre will become the standard method of provision for progressively smaller business customers. To meet cost targets for smaller customers, new fibre access topologies employing fibre-sharing schemes become attractive. Passive optical networks (PONs) will offer reduced installation and operating costs. They share exchange and fibre cable hardware between a number of customers by using optical splitters to connect customers to a single exchange-based transmitter[2].

A key advantage of PONs is that fibres can be installed relatively cheaply, initially to provide existing narrowband services using just part of the fibre's capacity. As demand grows for more services (including broadband), these can be provided over the same fibre infrastructure at different optical wavelengths. Looking much further into the future, an extension of the PON principle could manifest an optical 'ether' offering the same opportunities that the radio ether exhibits, with customer terminals 'tuning in' by selecting the appropriate light wavelength.

Synchronous Optical Networking

Today's plesiochronous long-haul network will give way to automati-

Figure 2—The future of access networks



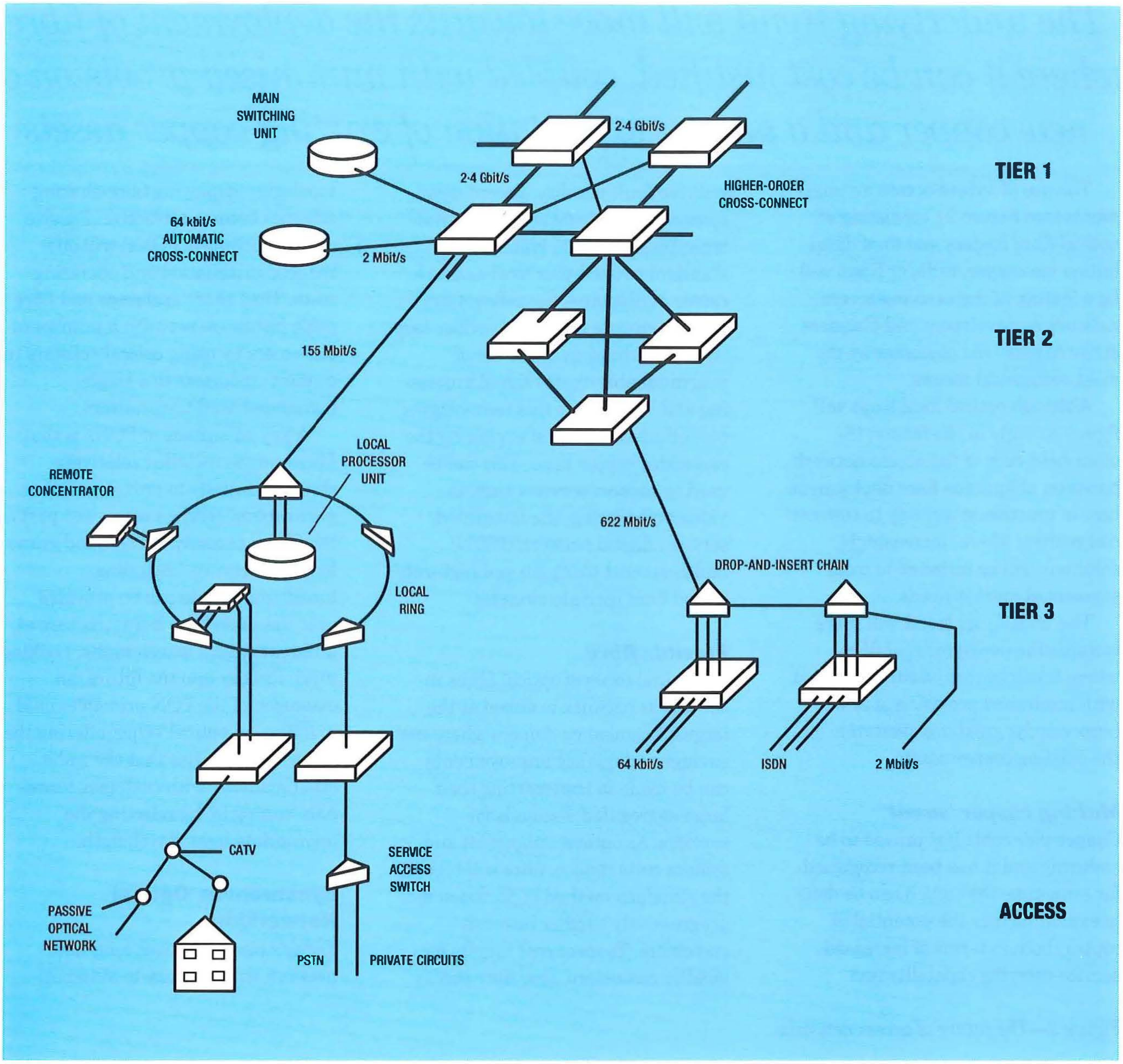


Figure 3—The future of transmission networks

cally-managed transmission networks conforming to the internationally-agreed standard synchronous digital hierarchy (SDH), see Figure 3. The new networks will be inherently more reliable since they will eliminate much of the multiplexer equipment present in current systems; they will also have greater flexibility and improved management through remote configuration and monitoring facilities.

SDH coupled with optical technology developments such as wave-division multiplexing (WDM) and fibre amplifiers (it is expected that by 1995 WDM will provide fibres with the capability to simultaneously support 10 wavelengths and that optical amplifiers will be used instead of repeaters) will mean that we can expect a core transmission network in the next 10 years that will be readily expandable in capacity, flexible in its management and with a high level of automation. These factors are likely to give rise to important savings in operational costs and improvements in quality of service.

There will be fewer nodes in the transmission network, far fewer repeaters to go wrong and greater resilience in the network by applying both electronic and, possibly, optical switching to perform re-routing, restoration and rearrangements.

SDH transmission will be deployed to customers' premises in order to extend the advantages of this technology, providing broadband and managed-bandwidth services.

Network intelligence

Increasing intelligence in the network will be a dominant theme during the 1990s as telcos strive to reduce development times for new services and tailor services to meet specific customer needs. The intelligence necessary to support advanced services no longer resides solely in the switching machine. In recent years, the worldwide trend in the context of public switched voice networks, which has proved very successful, has been to provide added services by introducing intelligence in separate components in an overlay fashion. In the shorter term, the number of 'intelligent' service platforms may increase before a universal intelligent network facility becomes available,

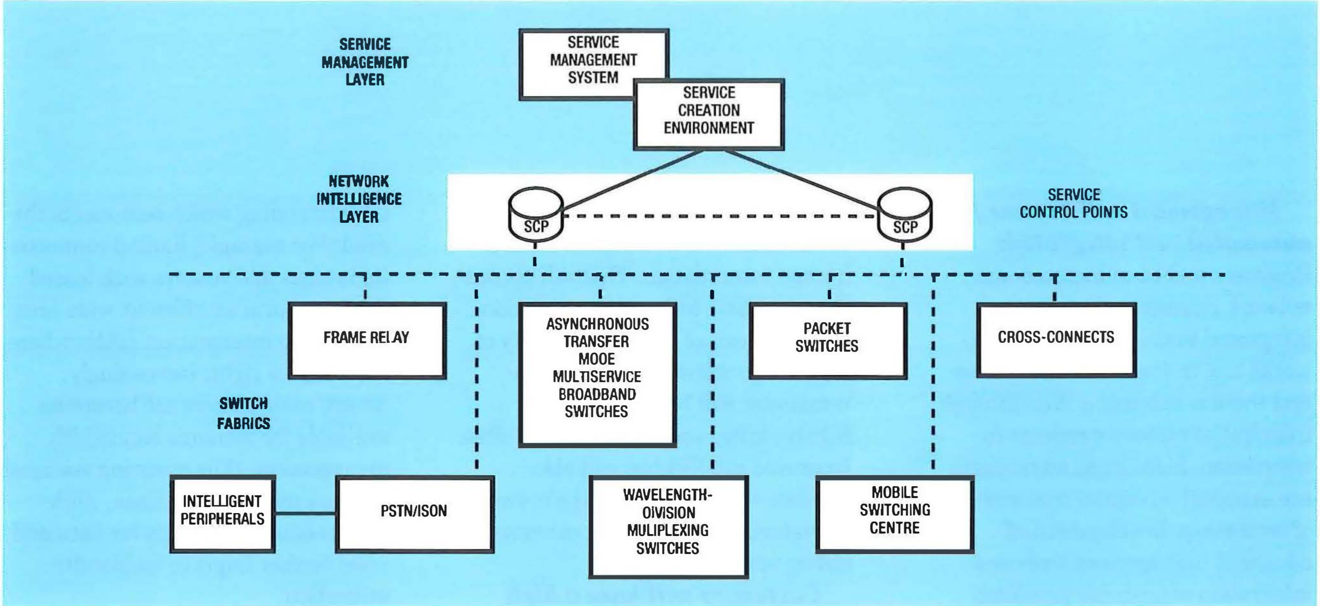


Figure 4—The future of switching and intelligence

leading to extra switching, maintenance cost and interworking difficulties.

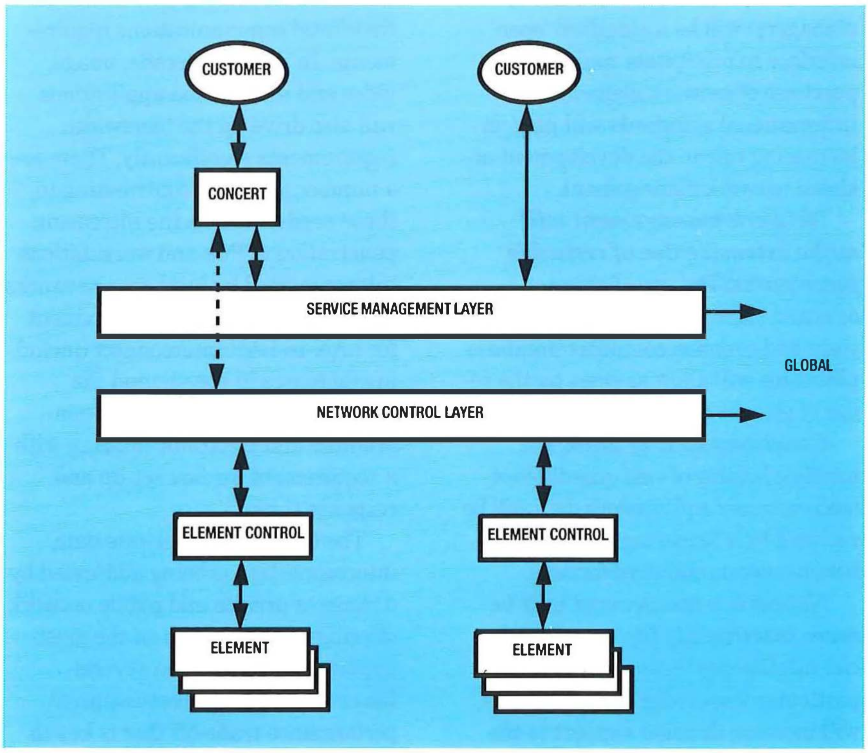
In the next decade, services will progressively be provided on platforms which fall within an intelligent network (IN) architecture. Service creation, control and management will reside on separate computer and database systems connected through defined interfaces to the switches. This advanced services platform will increasingly become switch independent, see Figure 4, and therefore better able to respond rapidly to new service requirements. The ultimate aim is to provide a service creation and management environment for the simplified and rapid development of new services from the front office. The degree of personalisation of service provision will be one of the hallmarks of the evolving intelligent network.

Technology is making it possible for individual customers to mix-and-match a number of standard features and create new, individually tailored telecommunication services. The range of services in the future will extend from enhanced voice to encompass data, image, video and multimedia. This will lead to increased emphasis on service management; that is, the uniform and consistent presentation of the service to the customers, administration of services, and the enabling of service combinations. The integration of these service management features will be one of the most significant challenges to strategists and development engineers over the next few years.

Improving the management of the network

In the future network, considerable importance will be attributed to the management of the increasingly complex array of network elements and network-based services, see Figure 5. Without an integrated management structure, it will not be possible to coordinate the rapid response of network elements to new service requests, provide protection to services affected by network problems or initiate on-demand network configuration requests. These are all factors which help maintain customer satisfaction and protect and grow revenue streams[3]. Current developments in network management technology are indicating a number of major trends in this area.

Figure 5—The future of network management



***Management will become fully automated and integrated*:** Processes will be automated and network management systems integrated to the point where networks are, in the main, hands-free and there is automatic flow-through from initial customer request to completion. Significant advantages are expected on capital cost and cost of ownership. Development of advanced management tools and integration of business processes promise considerable productivity gains, in operation and personnel.

***The network will be managed end-to-end*:** The management of network resources and services will progressively be provided on an end-to-end basis on a global scale: across different service networks (for example, fixed and mobile), across different operators' networks and across public-and-private network domains. Management across different operators' domains will be achieved by service-level agreements between the network operators.

***Management interfaces to network elements will be to 'open' standards*:** The interface between network control and the network elements (proprietary element managers) will be a standard 'open' interface to precipitate multi-vendor purchase of network elements. International standards will play an increasing role in the development of global network management.

***Network management will make extensive use of reusable piece parts*:** The use of object-oriented techniques, reusable software and common computer/database platforms will allow savings by the re-use of generic elemental parts.

***Consistent view of data*:** The multiple holding of vast quantities of both customer and network data will be replaced by a 'single' logical database holding data in standard formats.

***Network management will be more intelligent*:** The use of artificial intelligence techniques, in particular knowledge-based systems, will increase decision support to the point where all but the most unusual occurrences will be handled without human intervention. This will permit the automatic collection, correlation and diagnosis of the vast majority of network problems that occur; the remainder will be processed by highly-skilled operators at a few sites. Improved intelligence will also increase the flexibility of the network to customise features and increase billing options.

***Customers will have a high degree of control of network resources*:** Services will be able to be initiated and ceased under customer control. Business customers will have terminals on their premises that will support all routine requests to reconfigure services, order new services, interrogate the status of existing services, check billing and usage information, etc. Within the next 10 years, customers will also have the ability to initiate the provision of basic service instantly without human intervention.

The growing broadband market

The data needs of large corporations are already showing rapid growth and taking an increasing percentage of their total communications requirements. In the next decade, image, video and multimedia applications will also drive up the bandwidth requirements significantly. There are a number of factors contributing to these needs, such as the increasing penetration of PCs and workstations interconnected by local area networks (LANs); the increasing requirement for LAN-to-LAN interconnect (including increases in speed); and the increase in use of high-resolution graphics and electronic imaging with a requirement for fast set-up and response times.

The trend for higher-rate data interconnection is being addressed by a range of private and public network offerings. The decision on the most appropriate depends on several factors, but it is the cost/features/performance trade-off that is key to understanding which best meets the need. For example, limited connectivity bridges and routers with leased lines can form an efficient wide area network to interconnect LANs where the usage is right. Increasingly, 'smart' multiplexers are becoming available for dynamic bandwidth management, thus ensuring the most efficient use of leased lines, while compression techniques for data and voice further improve bandwidth utilisation.

Frame relay, which has been developed from packet switching techniques, offers efficient and flexible multiplexing at data speeds up to 2 Mbit/s and even beyond. Both private and public network offerings will exist and BT intends to offer a public service in competition to the available private network arrangements; for example, BT offers a global 64 kbit/s frame relay service which will be complemented by a 2 Mbit/s access service by the end of the year. ISDN will facilitate $n \times 64$ kbit/s switched service for voice, video and data applications including videoconferencing in the coming years, while a switched multimegabit data service (SMDS) will complement frame relay by supporting high-speed applications at 2 Mbit/s and above, initially on a metropolitan area network (MAN) type of architecture.

Although the SMDS is data oriented, it uses short fixed-length cells and can be interworked with asynchronous transfer mode (ATM) multiservice operations offering a natural evolution to a broadband ISDN network, based on internationally agreed 155/622 Mbit/s interface standards, towards the end of the decade.

SDH extended from the core network through to the customer also offers the opportunity for a future managed-bandwidth service at $n \times$ 2 Mbit/s slow-switched nationally or internationally.

Personal mobile communications

The concept of 'full personal mobility', where customers can communicate

The vision is of a universal radio interface into the telecommunications network where mobile and fixed networks are not seen as separate, but cooperatively working to give full personal mobility

anywhere, at any time, tailored to individual needs, is gaining credibility as technology develops and the market for mobile communications evolves.

Some elements of a full personal mobile communications service exist now in nationwide cellular systems, although the cost of ownership of these systems is high. The use of CT2 technology to provide lower-priced but less-flexible telepoint services was not the commercial success expected. It did, however, raise both public and business users awareness of the potential utility of personal (mobile) communications. Both cellular and cordless technologies are evolving to digital systems which are pan-European in scope, through the GSM and DECT initiatives. In the UK, PCN operators are developing systems based on GSM with radio interfaces at the higher 1710–1880 MHz band. Beyond these systems, developers are looking to '3rd generation' systems which not only succeed DECT and GSM but also fuse cellular and cordless technologies into a universal personal mobile service network. Within Europe, this is termed *Universal Mobile Telecom Service* (UMTS), while internationally the concept is termed *Future Public Land Mobile Telecommunications Systems* (FPLMTS). The vision is of a universal radio interface into the telecommunications network where mobile and fixed networks are not seen as separate, but cooperatively working to give full personal mobility, whether on a 'wired' or 'wireless' connection.

Making the Future Happen

Against these major network evolution trends, telcos around the world are moving ahead with trials and implementations at a bewildering pace. BT is no exception and is involved in programmes to test and evaluate network solutions in all the main theme areas. Several examples can be cited.

Fibre access

BT has already deployed some 1 300 000km of optical fibre within its long-distance network, giving it the highest proportion of fibre of any national telco. Some 140 000 km of optical fibre has also been deployed in the access network delivering 2 Mbit/s leased lines (MegaStream) and primary-rate ISDN (ISDN30) to customers' premises. An extensive fibre network has also been established in the centre of London for narrow-band leased lines. However, the current technology is not cost-effective for widespread provision.

New optical technology for the access network is currently being evaluated as part of a trial at Bishop's Stortford, near London. Both passive and active optical systems are under evaluation, to learn whether the expected advantages of fibre access networks translate into practice.

The passive optical network being trialled is referred to as *telephony on passive optical network* (TPON) and employs a time-division multiple-access technique over a single-mode optical-fibre feeder that is optically split to feed up to 32 customers from every fibre radiating from the exchange. Two types of TPON are being trialled: one which employs *fibre-to-the-home*, while the other is *fibre-to-the-kerb*, with the final customer drop being made with conventional copper pair. While the time-division access is optimised for economical introduction of telephony services, the same shared optical infrastructure can be upgraded to carry broadband services by enhancing the terminal equipment.

The active optical-fibre system is based on developments from switched-star CATV networks together with remote fibre-connected carrier systems. The system provides a complete range of interactive and broadband services on a single integrated customer feed from street-sited cabinets.

Both architectures are being assessed and compared with regard to cost, technical performance, ease of operation and customer response. A principal aim has been to gain experience in practical operational aspects such as installation, reliability, maintenance and dealing with churn.

Already, a number of important observations have been made. Practical fibre networks such as these can be engineered for the field, but further developments are needed. Example of such developments include improvement to fibre management and installation of home network terminations to reduce installation times; more effective power equipment, both in the home and in the street; and reduction in the size of the home-located equipment. Lastly, advanced optical components are not yet available in the quantities or at the price required.

Intelligent network implementations

Intelligent network capability already exists in BT's network through implementations which are currently proprietary or dedicated to particular types of service. For example, the derived services network is a self-contained IN structured overlay of switches and databases which currently provides basic and enhanced features for 0898 (Callstream, premium-rate services) and 0800 (freephone).

A number of deployment phases of IN capability are being planned by BT; the next being termed *IN phase 1*[4]. BT has recently awarded a contract for phase 1 equipment which will connect service control points to the BT trunk-level exchanges. Initially this will be for the efficient provision of enhanced routing services, but provides the potential to support a wider range of services in the future.

A major programme to introduce the intelligent network concept in a way that benefits all customers for all switched services is now being developed.

...extensive telecommunications networks take many years to change, with enhancement requiring carefully-managed roll-out programmes

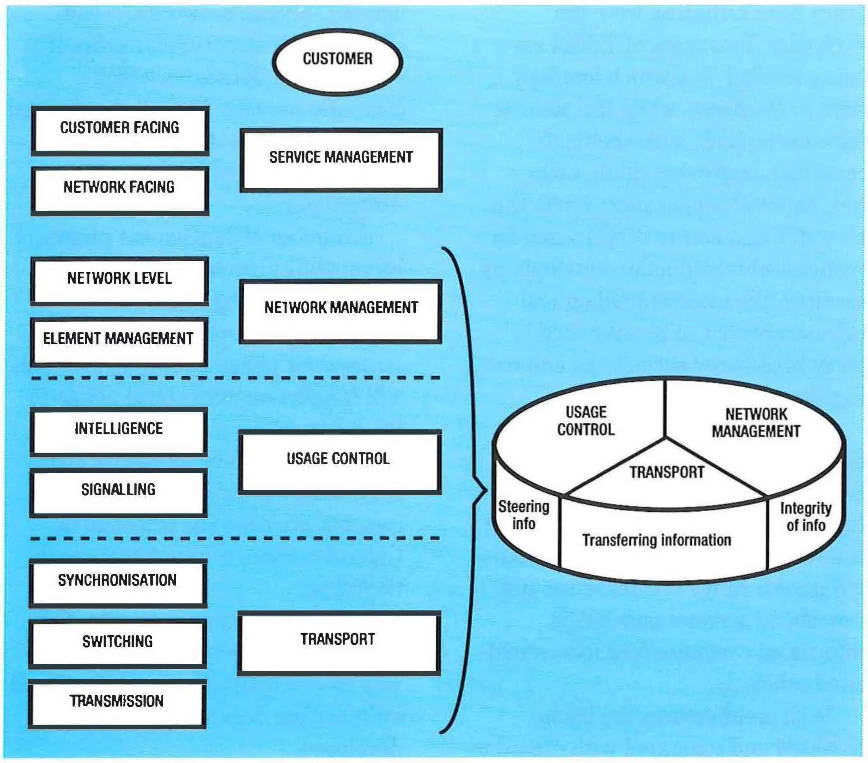
Concert™ network management integrator

Concert™ is a range of network management products recently launched by BT and is one of the world's first end-to-end network management systems designed on 'open' system principles (Open Systems Interconnection). Concert™ provides the capability for BT to deliver open, integrated management of communication systems for its corporate customers worldwide.

Using Concert™, the customer, or BT on the customer's behalf, has the ability to manage a communication system from end-to-end, across voice and data, public and private elements, using the customer's set of products and services in a coherent way.

Concert™ is not a single product, but a portfolio which can provide management across a range of systems from other suppliers; for example, around 100 leading computer and telecommunication vendors have agreed on the framework for interoperability through the OSI/ Network Management Forum.

Figure 6—Customer service stack



Concert™ allows end-to-end management from the customer's own site through an integrated management system which presents, for the first time, a complete view of the elements of his network on a single screen.

Not only can the individual elements be managed, whether public or private facilities, but the system is viewed as a whole through Concert™, providing improved service quality by reducing response times and allowing faster problem resolution. Progressive releases of products and services incorporated are now taking place.

The Future Network

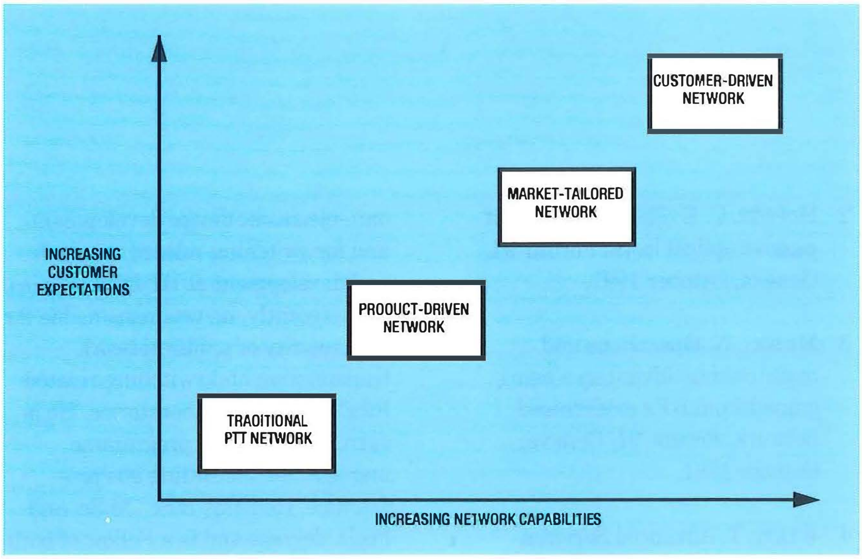
So what will BT's network look like towards the latter half of this decade? Clearly, the eventual topology, architecture and functionality of the network, and the extent to which new technology will be deployed, will depend greatly on the competitive and regulatory environment during the 1990s. The following description therefore represents only a possible view. It must be emphasised that extensive telecommunications networks take many years to change, with enhancement requiring carefully-managed roll-out programmes.

Figure 6 represents a useful model for thinking about and describing the future BT network. Using this model we can identify where the technologies and capabilities described in this article fit together. The model is based on the expansion of the customer-service stack comprising transport, usage control, network management and service management. For example, to understand the complexities of transport, it is necessary to view it as a series of logical networks, where each layer has its own nodes and links which need to be separately dimensioned, planned and developed.

To extend the model to cope with a variety of services, it is useful to consider the concept of service platforms. The basic platform represents the widespread (ubiquitous within the UK) network infrastructure supporting telephony (that is, the public switched telephone network (PSTN)) and leased lines as well as the transmission, signalling and synchronisation links for any advanced platform nodes. The latter are provided, where required, specifically for particular services. These specialised nodes can be introduced in a focused way in advance of enhancements to the basic platform.

Within the underlying transport network layers, the connections (narrow and broadband) will be controlled and managed for integrity and quality. Use of knowledge-based systems will provide a 'hands-off' network with the capability of self healing. SDH will provide an efficient bearer capability with add/drop multiplexers eliminating the 'multiplexing mountain' of plesiochronous digital hierarchy (PDH) networks. The core of this SDH transport network will comprise a two-level inner core, the top level being highly meshed. The outer core will have a ring topology. The higher-order line systems will terminate

Figure 7—Re-orientation of the network



directly on SDH ports on the switches and cross-connects. Performance of individual connections will be monitored end-to-end. The latter will be particularly important for leased lines and access to major customer sites, where SDH may be extended to customers' premises. Routing of transport capacity within the network may employ both wave-division multiplexing (WDM) and automatic cross-connection facilities. The SDH-based cross-connects provide a managed routing capability, perhaps with some degree of customer control of access bandwidth, to form an integral part of the layers that directly support services.

Within the transport layer that directly supports services, high-functionality circuit-switched exchanges which fully exploit the IN concept will support all the narrowband services. Additional functionality facilitating advanced customer interaction for voice or data applications will be provided by intelligent peripherals associated with the exchanges. In addition, this layer may comprise other switching fabrics, such as ATM, providing multiservice broadband capability.

Access transport networks will use a variety of media technologies: copper, fibre and microwave digital radio, according to circumstances. Fibreing will be based on an appropriate mix of passive optical technology and direct delivery to site.

A high-functionality signalling network will be the medium that allows customers' service needs to communicate directly with the intelligence that will increasingly control the service capabilities of the network. The signalling network will be a resource providing both circuit and non-circuit-related signalling capabilities associated with the switching and intelligence functions. Customer signalling covering public and private applications will provide full support for public and virtual services. Initially, intelligence will be specific to particular service switching nodes. However, we expect to see a convergence as service creation capabilities bring together services supported by the different networks, and provide the seamless integration that the customer needs through the use of customer service profiles.

Network management has to interface across all the physical elements of the network. Open standards will increasingly be required to all network elements and controlling systems. The operational cost of managing an increasingly complex network will be controlled through the use of integrated network management.

Service management provides the personalisation of service features that the customer requires, from the provision of service through to meeting individual changes in service requirements. Service management will impact upon many of the lower layers of the network and, in particular, the network intelligence layer. It is through comprehensive service management that we can meet customers' needs of more flexible tariffing and integrate the human and network aspects of the business.

Conclusion

To conclude:

- BT's future network will have to serve a variety of customers, both end-users and service providers, having a wide range of functional, cost and quality requirements. The network must be appropriately responsive to all.

- The increasing range of technology options (ATM, SDH, passive optical, radio, etc.) with intelligence and management systems will be deployed according to the prevailing market, commercial and regulatory conditions.

- BT will progressively develop its network operation on a global basis in order to match the needs of its customers.

Finally, it is instructive to consider the progressive reorientation of the network towards meeting BT's customers' actual requirements (see Figure 7).

Historically, the networks provided by traditional PTTs were very much restricted to a small set of services and features which the PTT thought it should offer. The next step is a network whose capabilities are product driven. Customers have a choice, but this is limited to a set of products. Further development leads to a network whose services and features reflect the various segments of the market. However, the ultimate goal is a network that can provide an individually-tailored set of services for each customer. So the exciting challenge for engineers over the next decade is to move the network to one which is truly customer-driven.

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Biographies

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BT Worldwide Networks

Andrew Valdar is Manager of Network Strategy, BT Worldwide Networks. He joined BT in 1969 after graduating from Loughborough University and gained a Masters degree in 1971 from Essex University. After 7 years in the Network Planning Department, he undertook a 3 year assignment with the ITU in India. Since returning he has had a variety of jobs covering ISDN standards, private circuit product management, and product development of Centrex. He is a co-author of a recently published book on SPC digital telephone exchanges.

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David Newman joined BT (then the British Post Office) in 1963. During his career he has been responsible for opto-electronic device development and for switching-related research and development at BT Laboratories. More recently, he was responsible for the majority of public network transmission and switching-related R&D within BT Laboratories. He is currently the R&D programme manager for the Billing 90s programme. He holds B.Sc., M.Sc. and Ph.D. degrees and is a Fellow of both the Institute of Physics and the IEE in the UK.

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David Greenop works in the Future Directions Unit, Network Strategy, BT Worldwide Networks. He has a B.Sc. degree in Physics and Logic, and a Masters degree in Telecommunications Systems. He joined BT in 1975 and spent a number of years on operational planning before moving to BT headquarters to work on the development of computer modelling tools for network planning. He has been involved in studies looking at various aspects of telecommunication networks. In recent years, he has concentrated on the longer term developments in telecommunications and their impact upon the future network.

Glossary

ADSL Asymmetric digital subscriber loop
ATM Asynchronous transfer mode
HDSL High-rate digital subscriber loop
IN Intelligent network
ISDN Integrated services digital network
MAN Metropolitan area network
M^3VDS Millimetre-wave multichannel multipoint video distribution service
OSI Open Systems Interconnection
PC Private circuit
PCN Personal communications network
PON Passive optical network
POTS Plain old telephone service
PSTN Public switched telephone network
PTO Public telecommunications operator
SDH Synchronous digital hierarchy
SMDS Switched multi-megabit data service
SPC Stored-program control
TPON Telephony on passive optical network
UMTS Universal Mobile Telecommunications Service
WDM Wave-division multiplexing

Gerald W. Thames

Outsourcing Global Telecommunications

Outsourcing offers international network solutions to multinational companies to relieve these companies of the cost and the burden of managing their communications resources and allow them to refocus instead on their core business activities. Syncordia, created by BT in September 1991, is creating a range of customer-specific solutions that address global business requirements.

Introduction

The concept of outsourcing international communications is relatively new. But outsourcing has a well-established history in fields as diverse as hospital administration and airline operations, and is widely practised in data processing.

Whatever the industry, the case for outsourcing is always the same: certain support functions that are critical to business success call for expertise outside of the core business. Companies managing these functions internally inevitably drain their resources and corporate energy away from their primary mission. Outsourcing enables them to maintain their focus by assigning these key support functions to outside specialists.

In telecommunications, outsourcing has two characteristics that differentiate it from other forms of service management:

- the provider can own or obtain the network, and
- the provider performs overall management (see Figure 1).

The management services provided by the outsourcing partner differentiate outsourcing from network services. In a network services or resale environment, the customer, not the network provider, is responsible for managing the telecommunications operation. Facilities management represents the reverse of the network services scenario, in that the provider manages the network but does not own it. At the other end of the spectrum from outsourcing, private networks are owned and internally managed by the customer.

Market Forces

Outsourcing of global telecommunications has emerged because of significant market realities that are by now a fact of life to the chief information officer. First, an exponential increase in international investment has occurred, because companies recognise that the evolution of the global marketplace has changed the face of commerce permanently. Over the past 10 years, foreign investment in the United States has grown nearly five-fold to $404 billion. At the same time, United States companies have nearly doubled their international investments from $215 billion to more than $420 billion. Similarly, multinationals are investing in European and in Asia Pacific markets, which make up larger shares of their worldwide sales revenues. This growth in investment presents a global communications demand that must be satisfied.

The second of these realities is the need for organisations to function within the lean infrastructure that resulted from widespread corporate downsizing within the last five years. These reorganisations have affected company operations at all levels. At the management level, the typical company has reduced its reporting layers of management from eleven to seven through massive corporate restructuring. The most streamlined companies now boast three- and four-layer organisational structures. The flattening of the pyramid structure has required corporations to widen organisational spans with nearly one of every four middle-management positions being eliminated since 1980. At the non-management level, many corporations are still reluctant to hire permanent employees when antici-

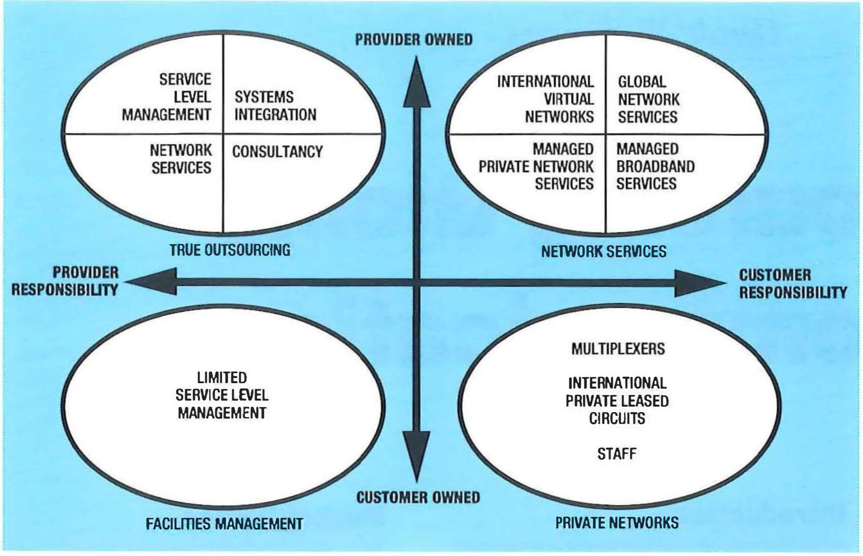


Figure 1—Outsourcing versus network services

pated needs are uncertain in a volatile economy. The new infrastructure has compelled companies to demand more from their information systems to replace the previous middle-management function lost to downsizing, yet with reduced technical and managerial support.

The third market reality is that information has become a strategic weapon. Companies require information at a fast rate, in a wider variety and in more remote geographical locations than ever before. This trend cuts across virtually all industries, and affects the front lines as well as the back office. Customer service representatives need instantaneous access to up-to-date customer data—correspondence, photos, account information, and so on. Indeed, in service industries, information itself is often the product, or is fundamental to service delivery. The financial services industry depends on information technology to support global round-the-clock trading, where split-second trading decisions are made without human intervention, and timely and accurate information may mark the difference between huge gains or devastating losses. Retailers reply on delivery systems that enable them to manage their inventories and make effective purchasing decisions from the point-of-sale.

While the communications needs of multinationals have increased, so has their frustration with the current state of international telecommunications. Leading multinational corporations across all industry sectors have been building and managing increasingly complex private international networks. Along the way, they have faced uneven service levels and network performance from country to country, a mosaic of regulatory environments, and a growing support infrastructure that requires an increasing level of technical skill. The most troubling issues are in the areas of service provisioning, problem management, and quality.

For example, oil companies today must shut down their operations at drill sites—at a cost of about $100 000 per day—while they obtain well readings and send data to an analysis centre. The consistent end-to-end quality provided through managed global telecommunications will result in speeded delivery, and thus less down time, and improved margins.

In the current environment, it is not easy to obtain adequate or flexible bandwidth, nor is there an efficient and timely way to identify and manage international network problems. Only 4% of surveyed telecommunications executives reported few or no problems with their international networks. Outsourcing allows the multinational to determine its own service requirements, then leave it to the outsourcing partner to meet them.

Outsourcing allows the multinational to determine its own service requirements, then leave it to the outsourcing partner to meet them

Administrative barriers add to the frustrations of multinationals who attempt to manage their global telecommunications usage and expenditure. In many cases, telecommunications managers are unable to ascertain how much they are spending on international communications. Unlike the US, international carriers do not routinely provide detailed usage data or cost breakdowns.

Outsourcing allows the customer to simplify its billing in several ways. First, the pricing basis can be flat fee, on a per transaction basis (per minute, per kbit, per packet), or on a fixed basis plus a per unit cost. The customer negotiates the pricing structure to meet his individual needs and provide the most value. Secondly, costs can be measured and distributed on an as-incurred basis, allowing appropriate scrutiny at the source. This is especially meaningful when compared to the task of allocating the costs of a private network, in an ever-changing pricing environment. Thirdly, billing can be provided in any format, including multiple languages, to multiple locations, and produced on any of a variety of media for further analysis and senior management review. Billing can thus serve as a strategic management information tool that provides customers with valuable information about their business operations and accountability at the divisional level.

The Syncordia Solution

Syncordia was launched by BT, in September 1991, with a key mission of providing international outsourced network solutions to the world's

Syncordia has created a service level management approach that integrates all of its management functions under a common scheme

largest multinational corporations. Although Syncordia uses network services as building blocks for solutions it develops for customers, it is not a network services company. It is an outsourcing company. As such, it manages and operates all or part of a customer's coummunications services and it can draw on services provided by BT or elsewhere. But Syncordia does more. As an outsourcing company, it can effectively replace the customer's internal business functions, such as procurement, planning and design, operations and customer support, internal marketing and administration.

At the heart of Syncordia's solution is an integrated approach to service level management. This approach allows the customer to monitor and control its international telecommunications services from a single platform—Concert™, BT's network management system.

Concert™ facilitates the integration of network management, customer support, and billing capability.

As an outsourcing partner, Syncordia acts in a consultancy role, by working with the customer to improve overall performance of the business. The consultant anticipates the customer's business requirements and recommends solutions that meet them through value-added application of communications technology. For example, a consultant may recognise that international travel costs could be cut substantially through judicious application of video conferencing.

Creation of Syncordia

History has shown the advantages of starting from scratch, relatively free of the structures and processes of the parent company, and so Syncordia was created against this background, with a new name, a new approach to the private telecommunication network needs of multinational companies, and a new entrepreneurial spirit.

Atlanta was chosen as its location, close to nearly half the world's top one thousand multinational corporations.

Syncordia has created a service level management approach that integrates all of its management functions—including customer support, network management, systems integration and consultancy—under a common scheme, which allows BT to provide multinational customers with seamless solutions that are consistently managed end-to-end. Syncordia's service level management includes:

- integrated network management systems

  —at the network control centres to manage the physical network

  —at the customer support centres to manage the customer interaction

  —on the customer's premises to manage the network services and related systems and equipment that combine to form the 'network';

- single-source support centres around the world offering personal help in five languages, seven days a week, 24 hours a day;

- integrated customised bills in any language, currency or format the customer requires.

Network management provides network visibility and control, enabling close supervision of performance and overall network quality. Customer support allows both Syncordia and its customers to anticipate the customer's future international telecommunications needs.

Network services are managed through network control centres located in Atlanta and London. Syncordia's network interconnects the 70 major manufacturing, industrial and financial centres of the world through numerous diverse-routed high-capacity digital links between locations. Syncordia's network management approach integrates control of the physical network with comprehensive customer service. The reliability of the network enables Syncordia to guarantee quality and reliability through service level agreements that are negotiated individually with customers.

Customer support centres are located in Atlanta and Paris offering service in five languages. These centres provide a single point of contact for all customer needs, including ordering, fault reporting and resolution, service status, performance reporting and customer assistance.

Integrated billing eliminates the need for the customer to execute complex algorithms to measure usage, reduces inaccuracy and risk, and provides a decision support mechanism for management.

What to Outsource

Senior information systems (IS) professionals are well aware of their options to outsource IS, and many have evaluated the appropriateness of various approaches. A multitude of arrangements is possible, differing in the degree of outsourcing or where in the organisation it occurs. These arrangements are typically driven by the customer's requirement to improve management of its costs, network complexity or growth. The outsourcing solution offered by Syncordia can vary widely, depending on which of these drivers applies to the customer.

For those who choose to outsource, it is often a matter of focusing on their core operations. Forward-thinking IS executives look to optimise resources by concentrating on what they do best. They apply their best management and technological assets to the core business by developing proprietary applications that have strategic value to the business. These IS executives do not limit their consideration to the data within the compu-

The administrative costs associated with the operation of a private network can be as high as 50% above the cost of the network itself.

ter centre, but also to its transport across the organisation and around the world. Whereas core functions are handled in-house, those components that are essential, but non-core, may be outsourced.

The decision process is conceptually straightforward—whether to outsource depends upon which alternative best meets the criteria that are set forth as critical. These criteria may include the level of service provided to IS users, cost, flexibility and the management of risk. In many cases, even when outsourcing systems operations cannot be justified by a comprehensive analysis, outsourcing only the international telecommunications function may still be warranted. In fact, 73% of multinationals in a recent survey have said they are willing to consider outsourcing all or part of their networks within the next two years.

Typically, up to 90% of a company's telecommunications needs are domestic, and most major multinational companies have networks in place and in-house telecommunications expertise to support them. Keeping abreast of technological, regulatory and marketplace conditions in only the domestic arena is enough of a challenge for today's telecommunications manager.

For most multinationals, the additional manpower it takes to monitor international developments represents an investment of questionable return. For example, the European telecommunications industry is governed by both European Community law and the national laws of its member states. The Asia Pacific has become a marketplace of great interest as well, with its own regulatory structures, and is characterised by its own competitive forces. Privatisation is spreading, blurring the service boundaries of international carriers.

Multinationals that manage their global telecommunications services in-house may suffer in two ways: either they expend a disproportionate amount of effort managing only a fraction of their telecommunications services, or they try to configure their global communications without the benefit of the same knowledge level they require for their domestic needs.

Key Criteria

Companies competing in the global marketplace have learned that profit margin, not cost, differentiates those that are successful from those that are dismantled. Tactics that maximise margins inevitably vary from industry to industry. In the silicon-chip industry, time-to-market is the key success factor for manufacturers. A lead time of only a few months marks the difference between the industry leader and the also-ran, yet the design cycle is virtually fixed. One entrepreneurial manufacturer reduced its time-to-market significantly by setting up design teams around the world. At the end of the working day in the UK, the design in its current state was transmitted to the United States; when that working day was over, it was sent to Singapore, and then returned to the UK. This illustrates that information technology may provide opportunities to increase value by managing margins instead of managing costs.

Different customers outsource to meet different goals. Multinationals may outsource to improve their ability to manage their global telecommunications. Outsourcing is an appropriate direction when significant international telecommunications costs cannot be measured by traditional means (network services or an in-house switch) and need to be applied to the department or product line that incurred them. Many organisations use outsourcing as a means to enter new markets at a moment's notice. In general, multinationals decide to outsource global telecommunications for several primary reasons: risk management, cost, flexibility, or service level.

Outsourcing will permit the customer to share risk in a partnership arrangement. The industry leader in any arena recognises the need to protect its own core business through comprehensive (and expensive) risk management. To the user of international telecommunications, the cost of providing the required risk management is difficult to justify; to the outsourcing partner, providing high-quality global telecommunications is the core business. Customers may enter into service-level agreements that are tailored to their individual needs, including penalties for missing service level targets. The amount of customisation is unlimited and extends to every aspect of the relationship. The arrangement between the customer and the provider is designed to benefit both partners by structuring the service, pricing and billing arrangements through incentive arrangements.

Not all outsourcing decisions are made on the basis of cost: there are many tangible and intangible factors that could support outsourcing. Multinational corporations must negotiate with telephone administrations in each country in which they have operations. These companies are compelled to maintain organisations to coordinate and manage their worldwide private networks, at a high unit cost for the quantity of international communications supported. The administrative costs associated with the operation of a private network can be as high as 50% above the cost of the network itself. Further, multinationals build private networks to support peak usage; the resulting networks are seldom utilised at more than 50%. For these companies, outsourcing provides a means to seek out additional capacity when high volume or high bandwidth is needed.

In summary, outsourcing can help central costs when the level of quality or reliability required cannot be provided without significant resource commitment or when service level standards differ by user department or by time period.

Benefits of Outsourcing

Outsourcing offers companies the flexibility to enter or leave international markets without making large investments in telecommunications infrastructure. In areas where demand is unknown or volatile, a variable cost arrangement protects the multinational company from either paying for unused capacity or being unable to meet demand. A spectrum of outsourcing arrangements enables the customer to own part of its network and buy services to manage peak usage levels, or to reach certain geographical markets. A virtual network can be established so that bandwidth is allocated based on demand. Or a multinational may choose to outsource to meet all of its global requirements, to avoid large capital outlays and the attendant support infrastructure.

Competition in the marketplace has driven companies to provide the highest quality possible. In service industries, telecommunications is often integral to service delivery. To achieve the required level of quality and reliability in-house, companies would have to build communications networks with enormous redundancy in lines, systems, and equipment. Outsourcing allows multinational companies to avoid large capital investments and ongoing expenditures in areas that are essential, but not core. Service level management allows the customer to tailor the quality of services to the needs of the business.

The decision to outsource is not a trivial one. Moving to an outsourcing solution generally requires a phased approach and could take several years to implement. Moving back from outsourcing to ownership and management is equally significant an effort. Thus, outsourcing represents a long-term partnership for both participants. The success of this strategic relationship rests upon the provider's ability to deliver value to the customer and adapt continually to the customer's changing business requirements.

Value cannot be defined strictly in terms of cost reduction. Providers need to go beyond committing to reduce or control service cost for the customer. The outsourcing solution must help customers increase their margins through a reduction to overall costs or an increase in revenues. It must provide strategic advantage or economic benefit.

Conclusion

The outsourcing decision is fundamental in the formulation of IS strategy. Those aspects of information technology that are essential, but non-core, become candidates for outsourcing. In many areas, outsourcing provides opportunities to maximise value in ways that would be cost prohibitive if conducted in-house.

Outsourcing is not the answer for all multinationals. But virtually every one should raise the question.

Biography

Gerald W. Thames
President and Chief Executive Officer, Syncordia Corporation

Gerald W. Thames is President and Chief Executive Officer of Syncordia Corporation, a wholly owned subsidiary of British Telecommunications plc that provides international outsourced network solutions to multinational corporations.

Bob Martin-Royle

The Evolution of BT's Internal Works Process —The WASP/Hornet System

This article explains the nature of the task facing BT in managing a multi-million pound annual capital investment programme. It traces the evolving scene which has led to the decision to standardise on a process supported by the WASP system for job control and Hornet for project control. The following four articles deal with the development of the internal works process, the WASP/Hornet product and describe in detail the computing and networking platform architecture.

Introduction

One of the major tasks facing any large telecommunications operating company is the process of growing and adapting its network to reflect customer demands and the new services available using new technology.

This represents a major annual capital investment which requires efficient and professional management. In BT, the network capital programme regularly approaches £2 billion per annum.

Ensuring that all the numerous and varied tasks which make up that programme are properly planned and executed in a timely and quality fashion has traditionally been carried out by the planning and works community. How these tasks are done and a new support tool are the subject of the following series of articles, but before discussing the characteristics of these tasks we need to make a small diversion to discuss terminology.

What's in a Name?

The expression *planning* is widely used in BT and can mean different things to different people. In the context of this and the following articles, we are dealing with planning relative to the network capital programmes as carried in the BT Worldwide Networks Zone.

A degree of standardisation now divides the planning activities into two main elements. The first is *tactical planning*, which is the process of deciding in the light of identified demands, say through a forecast, what needs to be done, when and where; for example, provide some additional exchange switching equipment, enhance the capacity at a transmission repeater station or perhaps cease some facility. The second stage to the planning process is where the details of what has to be done are worked out; for example, the site must be surveyed, the exact location of equipment determined, cable runs measured, the necessary stores identified and detailed specifications and cost estimates prepared for the job. The second planning stage attracts a variety of titles. In some places, it is termed *works planning*. Other popular variants are *detailed planning* and *implementation planning*. In other cases, the expression *planning* is simply used, which does sometimes cause some confusion.

At the risk of offending, this author will use the expression *works planning*. The authors of the following articles will no doubt be far more rigorous in their terminology!

Let us now deal with *works*—a well-established term surely which should not cause any problems? Most people will have heard the expression Clerk of Works relative to construction activities by a contractor.

Historically, people in the Zones (and before that Districts or Areas) have been divided between *construction* and *maintenance* duties. The construction people are those who either acted as Clerk of Works or, more importantly, carried out the hands-on tasks specified by the works *senior field planning managers need visibility across a wider and wider area with efficient support tools to enable them to plan, monitor control and execute their capital works programmes*

planners; for example, actually installing, commissioning, shifting or recovering the equipment.

The expression *construction* is, however, somewhat out of favour for two reasons. The first is that it is felt by some to be inappropriate relative to the advanced technology with which BT now deals. Popular alternatives are *implementation*, or *works execution*.

The second reason relates to organisation and human resource optimisation. There is a philosophy which says we should not divide the human resources on the basis of construction or maintenance duties, but rather on the basis of an individual's training, skills and availability to perform tasks. Thus individuals could be allocated tasks, on a daily basis say, of construction or maintenance on particular types of technology on which they had the correct training or have the right skill. This process has been named *work management* (work without an 's') and sometimes causes confusion with the longer established *works management* (works with an 's') process. The latter is the management of the implementation or execution of the plans specified by the works planners. It relates to the job to be done, although of course the availability of people to carry out the job is a vital ingredient.

The following four articles are not concerned with work management systems (work without an 's'), but with the process and support tools for works planning and works execution (works with an 's').

Jobs, Projects and Programmes

It will come as no surprise to learn that in any company the size of BT the number of jobs being undertaken at any one time is extremely large. As mentioned in one of the subsequent articles, a typical Zone database can contain 40 000 works records covering 2000 locations ranging across 250 classes of work. The jobs can range from major—for example, a large switching equipment installation—to minor—shifting a shelf of equipment. They all, however, form essential parts of a massive overall objective of ensuring that BT has the right services as required by the customer available at the right time and place.

This being so, it is obvious that many individual jobs have to be coordinated to deliver in a timely way a larger objective; that is, a *project*. For example, to open service on a new exchange requires more than simply installing switching equipment. Power plant will be needed together with transmission links to the rest of the network etc. Therefore, *project management* is an essential feature of the planning and works process.

In just the same way that many individual jobs interrelate to form a project, so many projects together form a *programme* of work. Programmes are the highest level of control activity in the process; they are generally related to specific periods of time—for example, one year or 5 years—and they form an essential basis for setting and monitoring the financial budgets for the capital investment of the company.

The Ever-Changing Scenario

In the non-existent ideal (and probably rather dull) world, the programmes, projects, and jobs could all be identified at the start of a year for the 12 months ahead and the management task would be a relatively simple one. Needless to say that is never the case. In a service industry such as telecommunications, the company must react swiftly to new or changed demands at any time. This is often called *injected works* and it affects the resource and timing plans of the previous programme. So rescheduling programmes, projects and jobs, testing various scenarios—the 'what happens if we do that' type of question are problems constantly facing the planning and works community.

Thinking on a Larger Scale

One final observation is that there is a trend in telecommunications to have to think on a larger and larger scale. Networks are increasingly national in concept and must be managed as such. Further the trend is to think in global terms for network services. All of this underlines the need to monitor and plan on a large scale while not losing the essential fine grain detail of individual jobs.

We see this trend reflected in organisational structure. Just over 10 years ago, BT had some 60 Telephone Areas. This reduced by the mid-1980s to just under 30 Districts. These were merged in 1990 into eight Zones plus London. So the senior field planning managers need visibility across a wider and wider area with efficient support tools to enable them to plan, monitor, control and execute their capital works programmes. So how has this task been done in the past and how will it be done in the future?

How did we Cope without Computers?

It is sometimes sobering to reflect that real-time on-line computing has only been with us, in any large scale way, just over a decade. Prior to that computers tended to offer help on a batch process basis, and before that, say the early-1960s, computers played a limited part in the general management processes.

Capital programme work was managed by a paper-based manual system. Generally, each Telephone Area had an office which acted as a *control* for its internal or external works tasks. These *works controls* operated mainly at the job level with limited use of project management and concentrated on the works planning and works execution function; that is, preparing estimates, ordering stores, setting completion dates and allocating jobs to the works execution teams. The works managers coordinated the carrying out of the *with the NATF and SSP studies, the stage was set for a major overhaul of both support systems and process in the planning and works areas*

tasks by their staff and reported on progress. Considering the lack of any computing support tools, it is to their credit that they generally delivered excellent results in an environment which we today would find impossible to accept so reliant have we become on computer support. Computers of course now allow us to cope faster with more tasks and so improve productivity.

As computing availability grew, moves were made to apply them to the internal and external works control tasks. The *internal works information system* (IWIS) and *management and control external* (MACE) became two widely used support tools for internal and external works controls respectively, and as personal computers became available, local initiatives led to a number of variants.

Evolving Systems

When, in the mid-1980s, National Networks was formed, it was decided to build on the proven IWIS system for managing its internal works retaining the best features of IWIS and adding extra ones. The system devised was called *works and stores programme* (WASP). The programme would run on an already available network of microcomputers (Altos) using the then relatively new UNIX operating system.

During the 1980s, various project management software packages were available—for example, Artemis, Hornet, Super Project Expert—and they began to find application in parts of BT.

BT however was becoming increasingly concerned about the variety and mix of the many different processes and support solutions in use for common tasks across the whole company. A variety of solutions each require back up to keep them in operation. This increased costs and limited data transfer etc. We all know of stories about non-compatible systems and the problem of sharing vital information.

Network Administration Task Force

In the late-1980s, a major study was carried out on how best to administer the evolving digital network. The Network Administration Task Force (NATF) reported in 1987 recommending common solutions for support systems based on the best practice currently available. It sometimes surprises people to learn that the NATF addressed the works control function as well as the maintenance, surveillance and operational functions but it did albeit briefly.

It was conceived in the report that network operations units (NOUs) would house the works controls as an integral part of the administration process, with one works control per NOU catchment area.

As an aside, it was the NATF that addressed the process of allocating tasks to people which it termed *work management* discussed earlier.

Strategic Systems Plan

Again in the late-1980s, a major survey was carried out of all the processes used by BT to carry out its business. This was termed the *Strategic Systems Plan* (SSP) and its report recommended a series of standardised high-level processes for the future programming, planning and execution of capital work in BT.

So, with the NATF and SSP studies, the stage was set for a major overhaul of both support systems and process in the planning and works areas.

Network Administration Implementation Programme

To roll out the NATF recommendations, the *Network Administration Implementation Programme* (NAIP) was established. One of its key tasks was to identify current best practice and establish this in all parts of the business. On the planning and works side, an early contender for study was the *internal works control* (IWC) support systems and associated process.

The Search for Current Best Practice

A working party was established in the late-1980s. Its first task was to find out what the users wanted and what currently available systems best met their needs.

The user needs were summarised as:

- a user friendly system;
- compatibility with other BT systems;
- direct data transfer for project management, stores ordering, resource information, labour and stores costs;
- on screen (paperless) works planning with 'what if' capabilities, and viewing of overall planning and works programmes;
- critical path analysis, electronic mail, automatic report production;
- performance monitoring; and
- full networking.

The working party found rather limited use of project control systems at that time but a variety of works control systems. IWIS had been adapted in some parts to MIWIS based on a microcomputer. Also individual solutions based on the Apple/MAC computer were in use, but in general IWIS (now rather dated) and WASP were the dominant systems in use.

The working party recognised that each system had its merits, but on balance WASP came closest to meeting user needs. This is not so surprising as WASP was derived from the proven IWIS.

Hornet was selected as the most appropriate project management package for the planning and works task (not as some wags claim so that

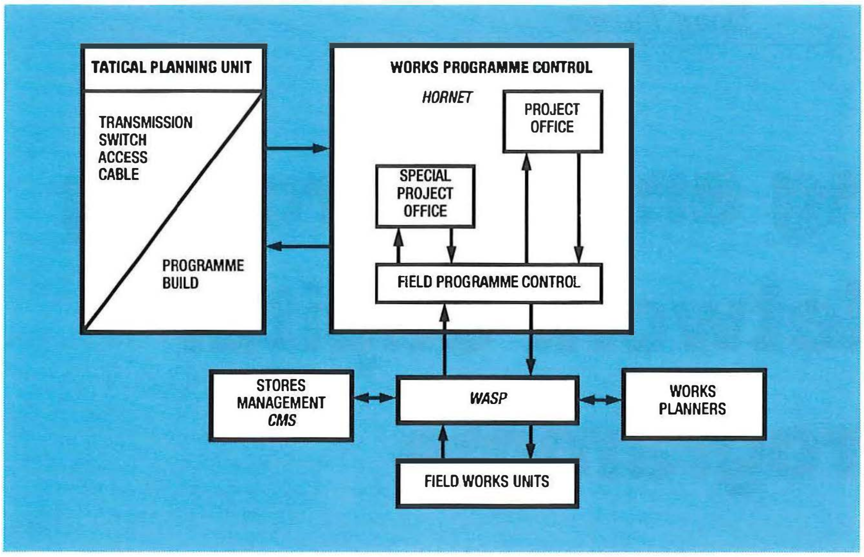


Figure 1—High-level template for the programme, project and job control process

we could generate a joke industry around the combination WASP/Hornet).

It is an interesting feature of modern life that people become very attached to their current processes and support tools—particularly if they themselves developed them. As is stated in a later article, there seems to be an unwritten rule for users that any new system is rarely seen to be as good as the one it replaces. Certainly, when the recommendation to standardise on WASP and Hornet was announced, it was not the end but the beginning of a long road to gaining company-wide acceptance. Existing systems were defended to the hilt and recently identified alternatives were nominated for study. This is no bad thing as it ensures that the decisions stand up to investigation. Eventually, however, WASP/Hornet has been generally accepted as best current practice, which does not rule out at some future date the introduction of something even better!

The WASP and Hornet systems would be interlinked with the consolidated management system (CMS) used by Logistics to manage stores to give an integrated project and job control support tool as requested by the users.

WASP/Hornet and Process

A formal business case to launch WASP/Hornet was accepted and an initial trial was successfully completed at Walsall network operations unit (NOU) in 1991 followed by a full trial at Leeds in 1992. The project was now broader than just the support tool. The whole end-to-end process for programme, project and job control needed addressing in the light of the SSP proposals. This study and the trials developed the high-level template proposals summarised in Figure 1.

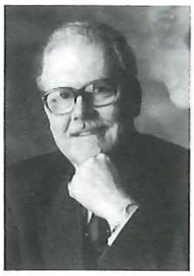
The roll-out of the WASP/Hornet system and associated standard process is now in full flow. The following articles deal with the various facets of this and I trust the reader will find them of interest and benefit.

The Future

So what of the future. Obvious spin-offs from WASP/Hornet are direct electronic links to the finance systems, which will aid capital expenditure tracking and interactive modelling to test the effect of various budget constraints on programmes and programme changes on capital expenditure. The use of WASP/Hornet for global platform projects is clearly attractive, and as users become more familiar with the product, enhancements will undoubtedly be developed.

WASP/Hornet applies to internal works. On the external works side, plans are in hand to update the MACE systems. The question which must be addressed is are there advantages in converging internal and external works controls onto a common platform system; if so what should that be and when should we do it? But these questions are for the future—for the present, WASP/Hornet is the stable internal product.

Biography



Bob Martin-Royle
BT Worldwide Networks

Bob Martin-Royle started his career in the City Area of London Telecommunications Region as a Youth-in-Training. After service in the Royal Air Force, where he specialised on radar, he returned to the (then) Post Office working on exchange construction. On promotion into the management grade, he worked first in the Training Department and then started a long association with microwave radio relay planning and works. This period saw the opening of the BT Telecom Tower, and the launch of colour TV in the UK. Also during this period, he held special responsibilities for radio engineering safety at the time of the introduction of the Health and Safety at Work Act; this stimulated his particular interest in safety issues which he still retains. In 1979, he became project manager for the introduction of optical-fibre cables and transmission systems into the network. With the advent of competition, he joined the National Networks team created in 1982 to accelerate the modernisation of the trunk network where he managed the works team in the Zones covering all switching and transmission responsibilities. His current responsibilities cover the overall management of the WASP/Hornet programme, emergency and restoration planning, and the planning of the interconnection of BT's network to competitors' networks as required by the regulator. He holds a Diploma in Electrical Engineering, is a Chartered Engineer, a Fellow of the IEE, Fellow of the British Institute of Management and an Affiliate of the Institution of Occupational Safety and Health.

Doug Turner

Monitoring and Controlling BT's Network Capital Programme

A review of the tools and techniques used by BT to schedule and control its capital works programme resulted in the launch of an improvement project known as WASP/Hornet. The project aims to introduce uniform practices and tools for works planning and execution and to integrate project management principles into the day-to-day activities. This article gives an overview of what the project aims to deliver.

Introduction

The primary business of BT Worldwide Networks consists of the delivery of a series of complex programmes made up of network projects. The work required to deliver these programmes comprises thousands of interrelated jobs. These jobs are collectively known as the *works programme* and in a typical Worldwide Networks Zone can contain up to 15 000 live jobs at any one time.

Efficient scheduling and control of these jobs to ensure that programmes and projects are delivered to their time, cost and quality requirements is the constant challenge posed to Worldwide Networks.

As explained in the introductory article[1], Worldwide Networks is continuing to meet this challenge through continuous improvement. The latest drive is to maximise the efficiency and coherent management of the works programme. To realise this, Worldwide Networks has taken best practice and current thinking on programme management to produce a uniform method of working supported by standard tools. The uniform working method is referred to as the *planning and programming process*.

The software tools chosen to support the process are WASP and Hornet. WASP (works and stores programme) is a menu driven data storage and retrieval system for job control, and Hornet.XK a proprietary project management package. The tools have been integrated to transfer data electronically and linked to the consolidated materials system (CMS), BT's stores management system.

The concepts of the tools and techniques are discussed below. Greater detail on specific elements can be found in the subsequent articles in this issue of the *Journal*.

WASP/Hornet Project

The Internal Works Process Improvement Project, or *WASP/Hornet* for short, has three main tasks: to determine, trial and implement BT best practice for the control and project management of network provision.

The benefits that the project aims to deliver are:

(*a*) efficiency improvements resulting through

- a single system, with development and support costs minimised;
- electronic data transfer;
- end-to-end project management;
- rationalisation, functional and geographic;
- 'what if' scenario modelling;

(*b*) improved management and control through

- structured work allocation;
- programmes built to match resource;
- consistent reports.

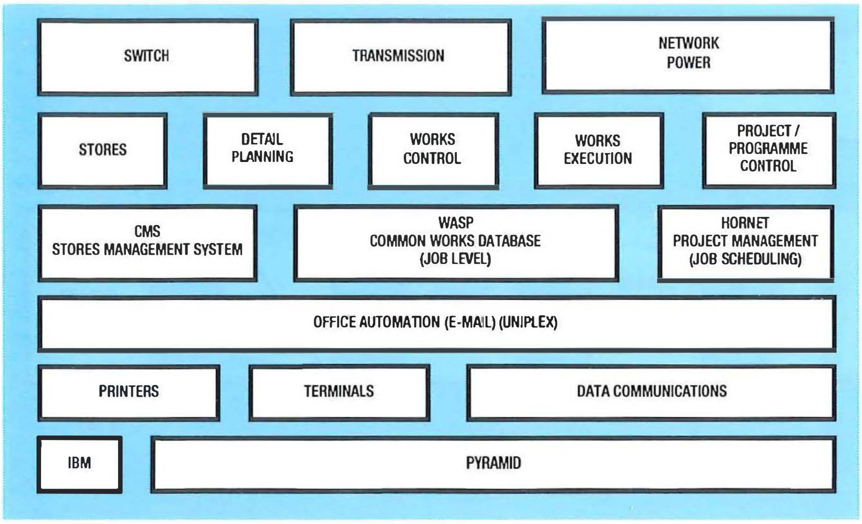


Figure 1—Project areas

The areas addressed by the project to achieve the benefits are illustrated in Figure 1. Implementation has involved several major sub-projects supported by a multi-discipline BT team and has included:

- the design and provision of a national data communications network of 2800 ports by BT Group Computing Services to accommodate 3300 additional users[2];
- the development of a major training programme for 4000 users by BT Training[3];
- production of a national process from the best practices of the Worldwide Networks organisation[4];
- a major upgrade to the computing platform that supports the process by Internal Systems Development[2];
- development of practice and procedures by Worldwide Networks that will allow the Zones to use a multi-access project management system;
- considerable software development to integrate WASP, CMS, and Hornet by Internal Systems Development and the Worldwide Networks WASP product team[2,3];
- the staging of a full pilot prior to national implementation[5] by Worldwide Networks North East.

Tools—WASP and Hornet[3]

To realise end-to-end management from programme to job level, two tools were chosen: one that supports the programme and project levels and produces a schedule of jobs, and another to track the execution of those jobs against the scheduled dates. Those tools are Hornet.XK and WASP respectively.

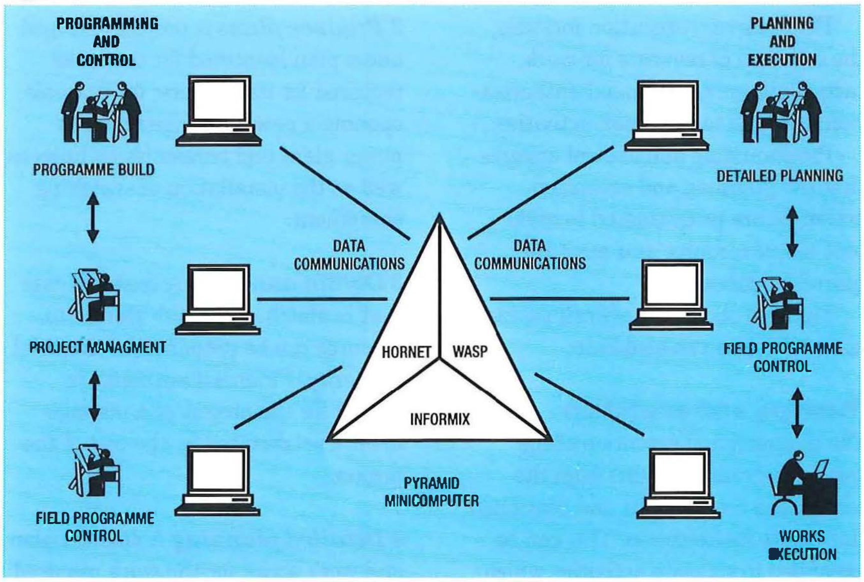
Working as an integrated system, they provide facilities to monitor, control, progress and review activities. As a result, the process can be tracked from start to finish to ensure overall control of network provision in Worldwide Networks (Figure 2).

The WASP/Hornet software run together on the UNIX operating system hosted on Pyramid minicomputers (see Figure 2).

WASP is a menu-driven information collection and distribution database for job control that allows for the management of all job information used by Worldwide Networks internal works. It was developed by BT using the concepts of the existing internal works information system (IWIS). It has been proven by Worldwide Networks and the previous Trunk organisation over 8 years but not linked to a project management system.

Hornet.XK is a commercial project management tool that has been tuned by the supplier and BT to meet BT requirements. It provides the facility to track progress, resource match and schedule across the entire Zone programme.

Figure 2—Hornet and WASP



Information Flow

Jobs are entered onto WASP from the projects contained in Hornet. WASP then allows for jobs to be planned in detail and for the work to be monitored. At various points in the process, updated information on jobs is automatically uploaded into Hornet. The WASP database is controlled by data entry on achievement by the various planning, control and works execution groups. All member groups have individual access. Information about the overall status of the programme can be provided through the Hornet reports structure.

Concept of the Planning and Programming Process

The process provides a framework for each Worldwide Networks Zone to

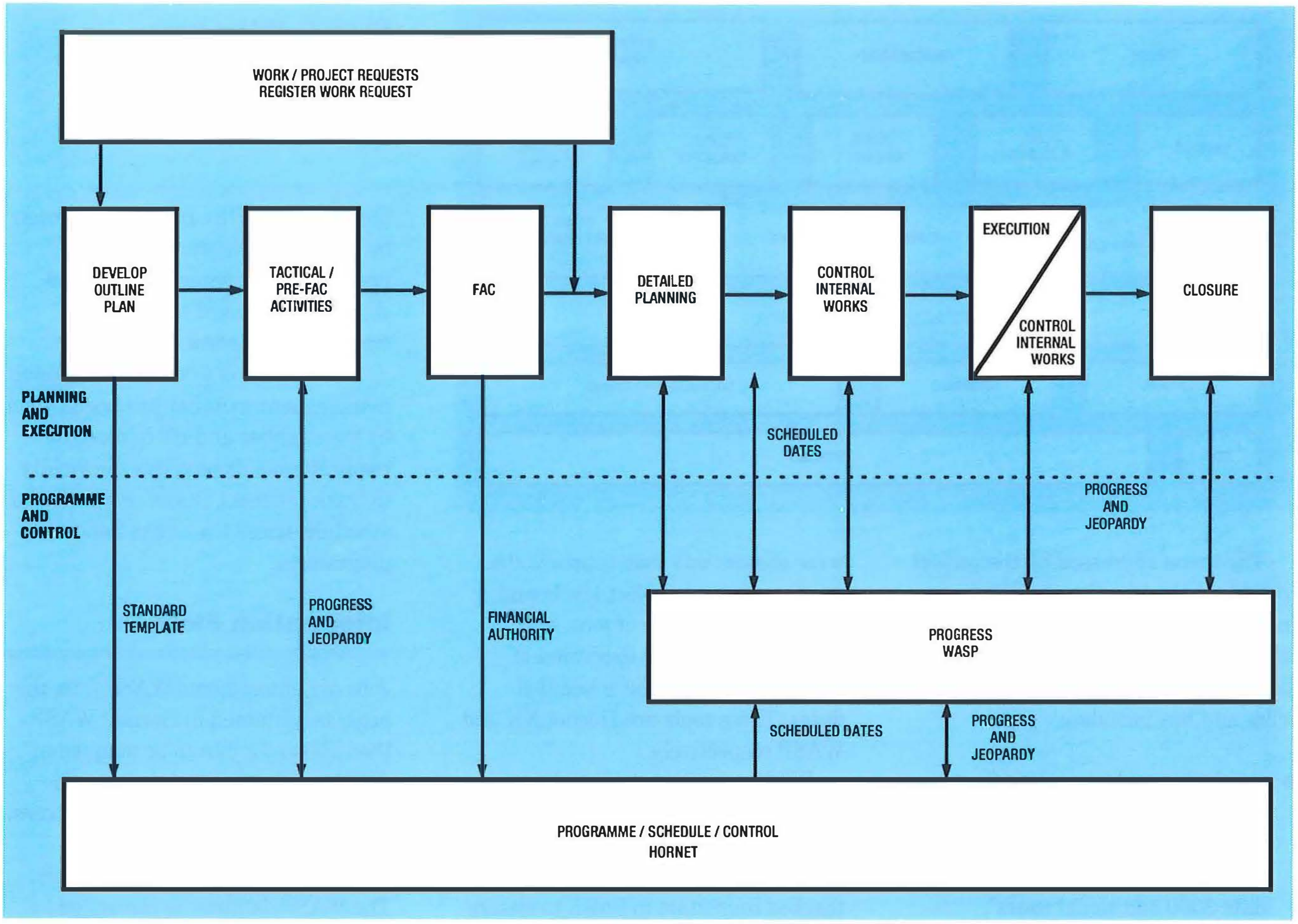


Figure 3—Planning and programming process

manage its programme of work from end to end; that is, from conception to delivery.

It was found easier during the early stages of definition to consider the process as two separate but interrelated components: the planning and execution activities—for example, installing a rack—and the programming and control of those activities—for example, when to install a rack.

Planning and execution includes the collation of requests for work, tactical planning, financial authorisation, through to execution activities.

Programming and control ensures that the planning and execution activities are programmed to make best use of resource and meet required by dates.

Figure 3 shows the overall process containing the two elements.

Planning and execution

The planning and execution of the works programme begins from the receipt of a requirement and continues through to its execution. This can be expanded to six main activities which can be programmed and tracked by using the WASP/Hornet system.

1 Register work requests Projects and injected work requests are received and logged onto Hornet; for example, providing an exchange extension. An assessment is made to ascertain if the request can be completed in the time requested and dates confirmed/negotiated.

2 Produce plans A project is scoped and a plan identified for the tasks required for its delivery; for example, opening a new exchange requires power plant and transmission links as well as the installation of switching equipment.

3 Obtain authority A business case that is matched through Hornet to resource can be prepared for financial authority. Financial authority is sought for the project at a management level dictated by the cost of the project.

4 Detailed planning A detailed plan and work script for the work required is produced including a cost estimate and specification and ordering of stores.

5 Control internal works This function monitors and controls the progress of jobs issued for the execution of the work, including stores progressing via the CMS database. It receives progress and jeopardy reports from the work execution function and initiates corrective action or escalation where a date is in jeopardy.

6 Execution A work file is received and executed in accordance with the field programme schedule of work. Job progress, jeopardy and completion are reported to the control internal works activity via WASP.

Programming and control

Programming and control of the planning and execution activities from the programme to the job level (see Figure 4) are supported by the WASP and Hornet tools for the main tasks of:

- tracking progress,

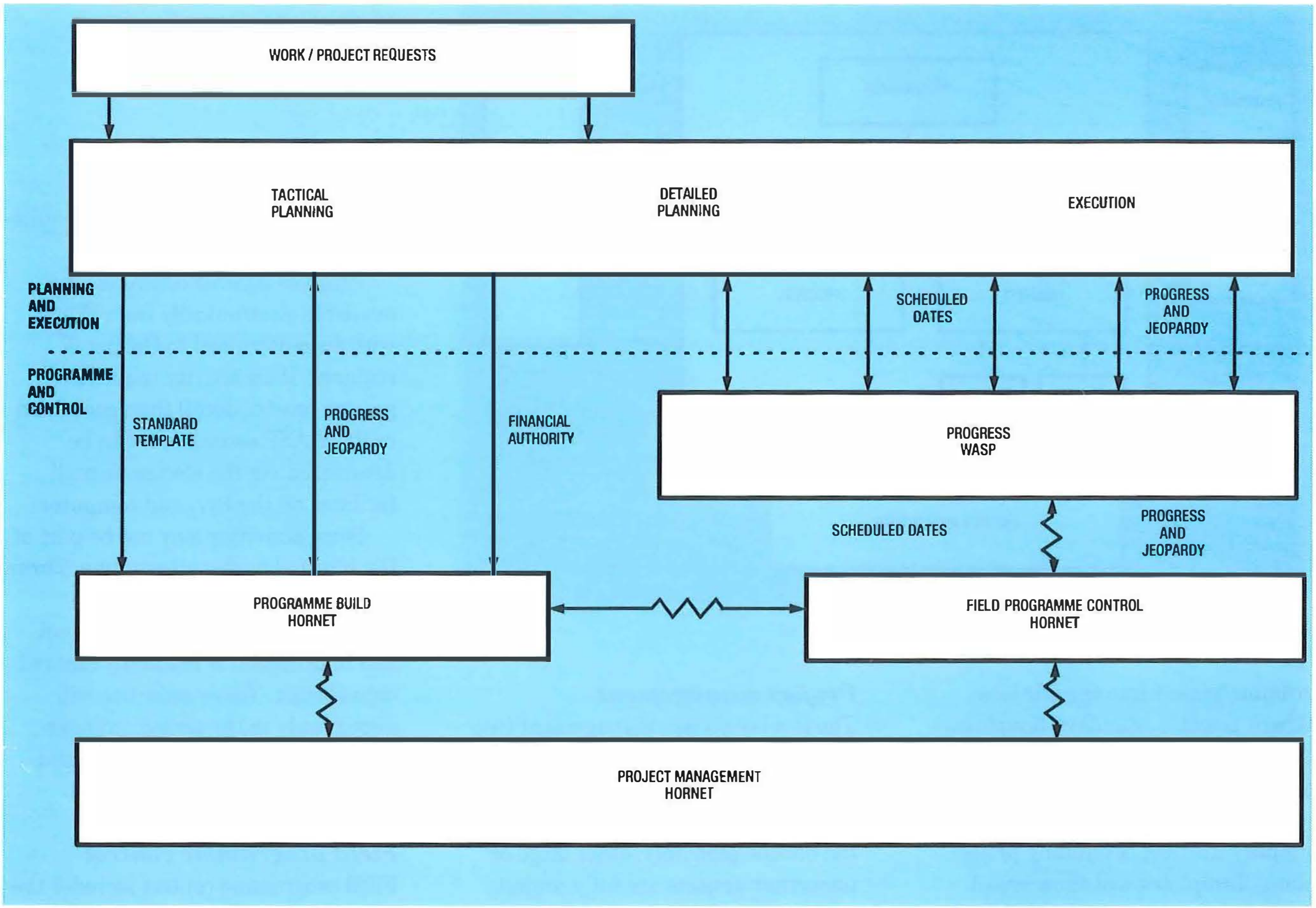


Figure 4—Programme and control component

- programming,
- scheduling,
- prioritisation, and
- resolving work difficulties.

WASP and Hornet can be used in more than one way to realise these requirements and a three-partition solution was chosen. The solution chosen enables a compromise between manual control, software ability and necessary management intervention. Full software scheduling of a live programme will not be carried out until those involved are fully confident that they understand what the system will do. The software tools will do exactly as asked, but it is necessary to understand exactly what is being asked of the system (rubbish in—rubbish out).

The chosen structure comprises three major partitions—programme build, field programme control and project management—which support their three respective components of the programming and control process. Two minor partitions for training and analysing 'what if' scenarios are also available (Figure 4).

The programme build partition contains data on all envisaged work and can be used to build up base data to enable the building of quality plans and budgets. The amount of detail held increases as the project or programme is developed.

The project management partition contains plans for projects at a greater level of detail than held on WASP. It is used for complex multi-discipline projects that may contain tasks/dependencies that are not part of the works programme; for example, cable and duct work for a new exchange.

The field programme control partition contains all authorised work; this is matched to field skills, disposition and capability to produce detailed programmes (schedule of work) for the field execution groups.

Programme build

The programme build component of the process (see Figure 5) monitors and controls the development of a programme or project through to obtaining financial authority.

The programme for a Zone will contain data ranging from outline plans several years ahead to detailed jobs for the current year, with greatest detail for live work.

The Zone programme, comprising national and local programmes for up to 5 years ahead, is scheduled and resource matched at a macro level. Programmes and projects are entered into Hornet to provide a picture of work requirements for the Zone, and business priorities are applied to assist scheduling.

Programme build receives project plans and outline programmes of work from customers and tactical planners for new work. For work in hand, it receives progress and jeopardy information from tactical planners, and takes action to ensure that programmes and projects remain on target.

Outline plans for forthcoming programmes are constructed that identify the main activities, dependencies, resource requirements and approximate costs. They are entered into Hornet as key milestones for the work areas that are required to be undertaken to develop the pro-

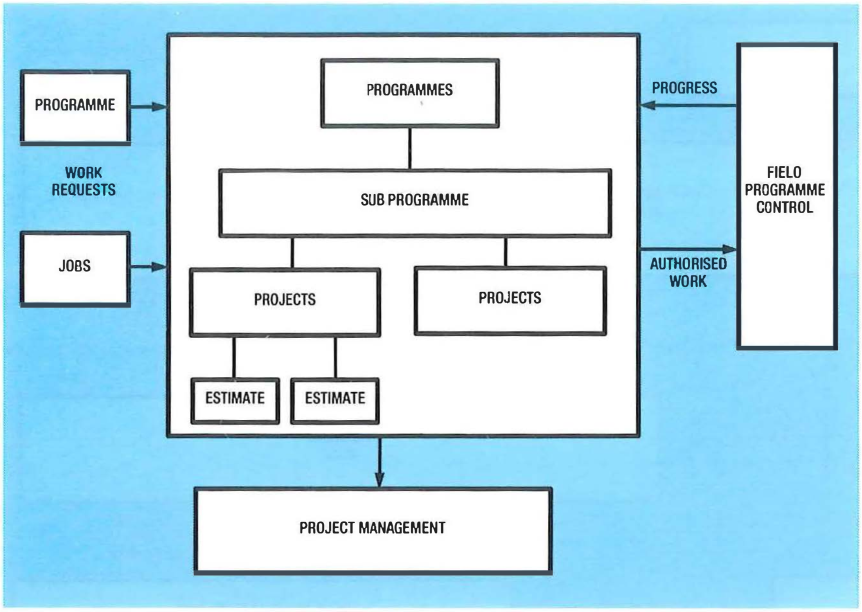


Figure 5—Programme build

gramme/project into specific jobs. Where possible, standard templates are used to develop the programme/ project plan held on Hornet.

Standard templates help to simplify the task of building project plans. Templates will show broad activities required; for example, produce business case, predicted resource requirements (derived from historic synthetics), resource type required, approximate timescales and costs.

The partially defined projects will be passed from programme build at financial authorisation to either the project management or field programme control functions.

Project management

The level of project management (see Figure 6) depends on the complexity of the project. Some projects will be managed at the job level contained in the outline plan only; other large or important projects are fully project managed to increase achievement in time, cost and quality.

Projects requiring project management are passed from programme build just prior to financial authorisation and developed into a suitably detailed project plan, again by using standard templates where available.

They will then be managed against the plan through to delivery as specified in the Client Requirements Definition (CRD) and Project Requirements Definition (PRD).

Progress against estimates is available electronically from WASP with auto-download to Hornet if required. If an activity requires a greater level of detail than contained in the WASP estimate, it can be progressed via the electronic mail facilities on the Pyramid computers.

Some activities may not be part of the internal works programme. These do not appear on WASP but are progressed by project management and information is manually entered onto Hornet. These activities will appear only in the project management partition of the database and not the field programme control.

Field programme control

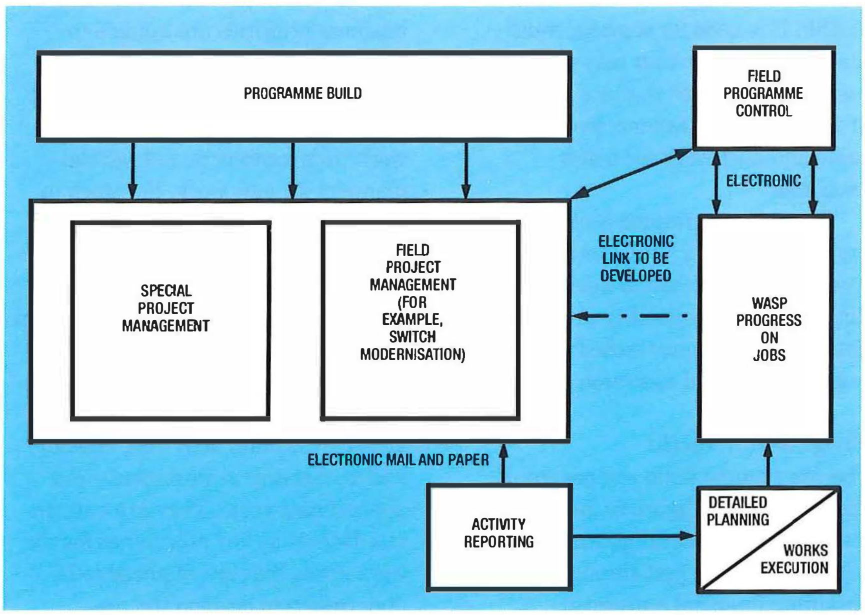
Field programme control includes the detailed scheduling and resource matching of work requests once the work is more precisely scoped at field level with agreed parameters set by programme build that achieve customer dates (Figure 7).

The increased level of control by programme build ensures that the issue of specific jobs can then be generated in a timely fashion consistent with the overall requirements of the programme.

The major activities are as follows:

- Authorised plans are received from programme build (electronically) and/or project management detailing specific work requirements.
- The resource allocation for execute works is revised after detailed planning has been completed and rescheduled if required.
- Any dependencies not already identified by programme build between projects, estimates and activities are recorded on Hornet.
- Short-term predicted resource availability and commitment are received from the detailed planners and work execution functions.

Figure 6—Project management



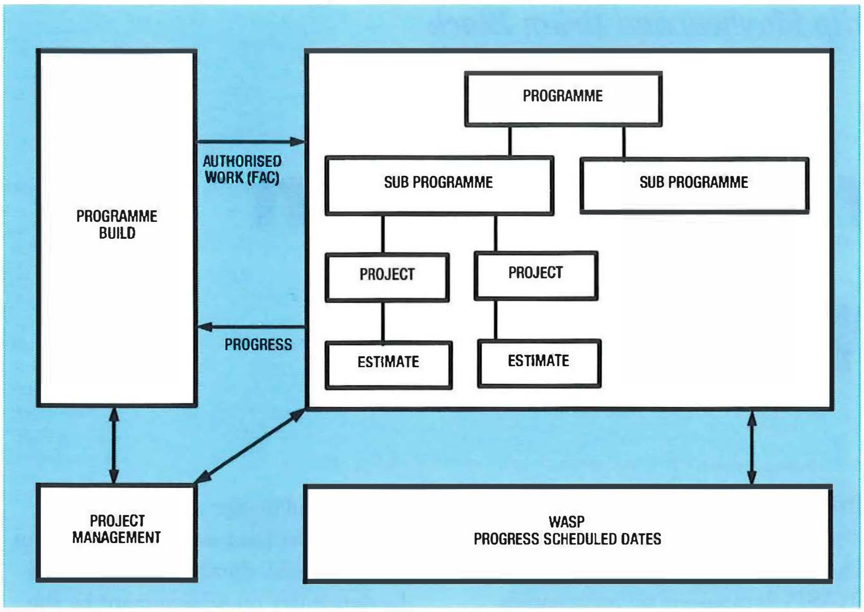


Figure 7—Field programme control

- Detailed planning and works manpower is allocated to projects, activities and estimates taking account of priorities, availability, geographical location and skill (transmission/switch/power). The resource required can be compared to that available using resource profiles available from Hornet.

- Scheduled dates are passed electronically from Hornet to WASP.

- Progress information is received from WASP. Where jeopardies are reported, the process takes corrective action, including rescheduling, to ensure that customer dates are met. Rescheduling takes place on Hornet and date changes are fed back automatically to WASP. Electronic time scheduling takes place outside normal hours and involves an electronic uplift of data from WASP to Hornet, an auto-schedule of work and then an auto-download of date changes to WASP.

- A schedule of work is issued showing all activities required to be done, dates and resource allocation. This can be produced for each management level as required.

Future

The WASP/Hornet project provides a common standard upon which work will continue to exploit the full potential of the tools in the areas of financial tracking, performance monitoring, and the management of national projects.

The drive for continuous improvement will continue so that those planning the future network can progress and resource their plans with the greatest possible accuracy.

Acknowledgements

The author wishes to acknowledge the work of the national and local Zone cross-divisional project teams in bringing the project to its current status.

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Biography

Doug Turner
BT Worldwide Networks

Doug Turner is the national project manager for WASP/Hornet. He joined the then British Post Office in 1973 as a Trainee Technician Apprentice in Newcastle Area and subsequently worked as a technician on transmission maintenance and construction. In 1982, he gained an honours degree in Electrical and Electronic Engineering. Upon graduation he was appointed an Assistant Executive Engineer in the then National Networks Headquarters responsible for the development of working practices for installing optical-fibre cables in the trunk network. In 1987, he became an Executive Engineer planning the growth of the trunk transmission network in London, and in 1989 working in the core transmission major fixed capital programme office. In 1990, he was promoted to his current project management role. He is a Chartered Engineer, has a post-graduate diploma in management studies and is a member of both the IEE and BIM.

Philip Mayhew and Brian Black

Network Provision Support System

This article provides readers with an overview of the design, implementation and use of the tools—the works and stores programme (WASP) database and the Hornet.XK project management package—used by people in the programming, control (including project management) and execution environment of BT Worldwide Networks.

Introduction

The works and stores programme (WASP) database is an information collection and distribution database used in the programming, control and execution environment of BT Worldwide Networks for planning, controlling, monitoring, progressing and reviewing all estimates (BT internal construction work packages).

Product Concept

The initial concept of the database is based on the older internal works and planning systems. This helped to facilitate the transfer of information from the older systems to WASP.

A whole-systems approach to the database design was adopted. The role of all groups involved in estimate preparation, progressing and execution was examined and a database structure was designed to accommodate all the appropriate users. By making maximum use of networking facilities, the responsibility for entering data was assigned to the appropriate operational groups, thereby minimising paper transfer of information and reducing clerical demand on all the functions involved. The functional data flows are illustrated in Figure 1.

To continue the whole-systems concept, the designers of the new database also included control of materials, as well as control of estimate and works details, on the one database. From this, WASP was born.

The database has been designed to meet existing requirements; however, the systems employed retain considerable flexibility and are capable of accommodating changes in procedure, process and design around the database without loss of existing data.

The WASP database is controlled by date entry on achievement by the various planning, control and works groups. All members of the groups involved should have individual access. The entry of these achievement dates changes the job status. This gives all users an easy and quick guide to the progress of work.

The information contained on each Zone WASP database and the Uniplex word-processing package, part of a complete office automation system resident on the same hardware platform, are available as separate menu options on one terminal. This gives the individual user access to features such as electronic mail, Telex, Telecom Gold, spreadsheet and other databases. Users can not only carry out all of the planning and works functions required but also communicate electronically with other users on the hardware platform.

WASP makes use of these facilities by producing a comprehensive suite of reminder reports automatically generated by the database and electronically mailed to the appropriate user. All estimates are allocated to individual planning and works groups, each group being identified by a unique organisational unit code (OUC). Linked to the OUC is an environment file, the duties file; environment files are explained in greater detail later. This file contains the computer login name of the intended electronic mail recipient.

The recipient of any such mail can view, store in the word processor, or print, either locally on draft printers or on a local pool printer (typically a BT standard laser printer serving on average ten users).

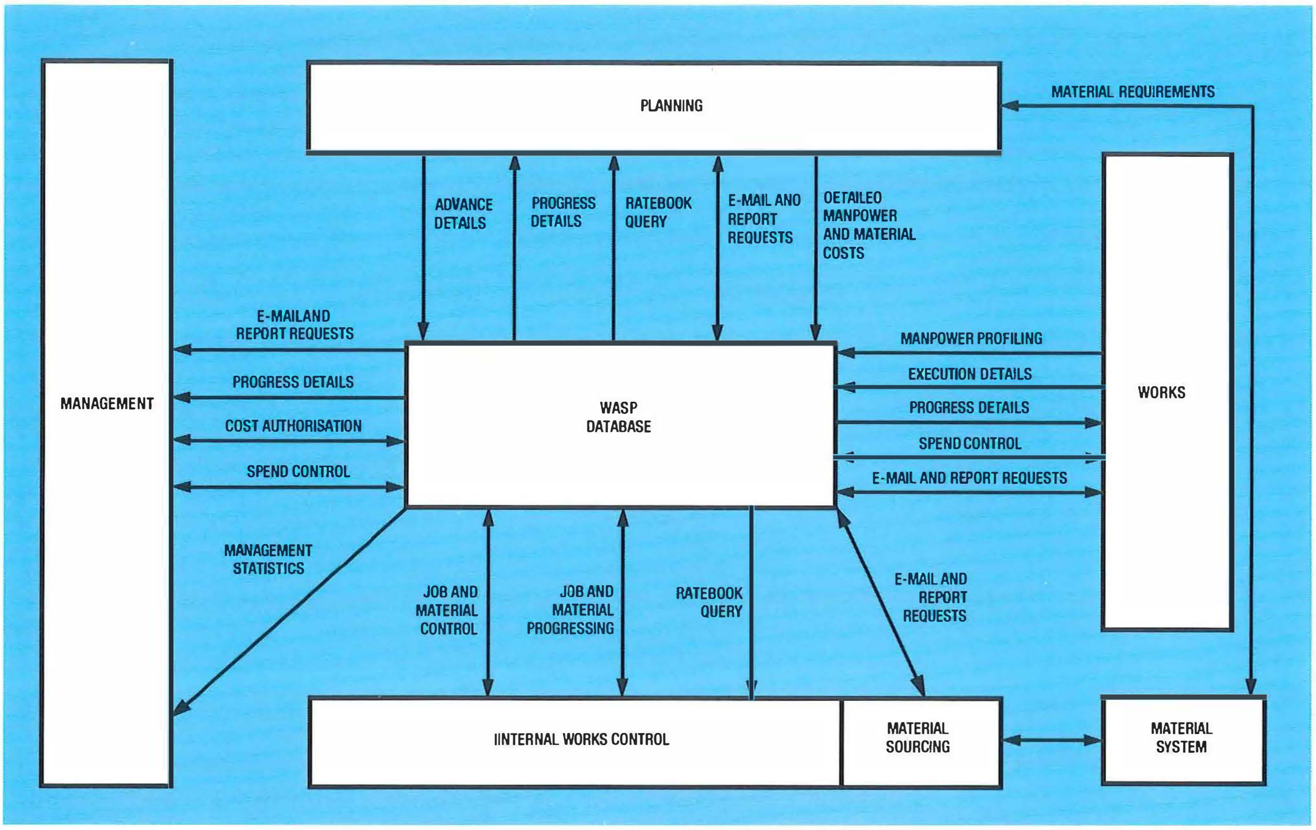


Figure 1—Functional data flows for WASP

A powerful query facility exists on WASP so that all users given access to the system can not only access a comprehensive range of standard national, and locally written, reports (available for view, store or printing), but also examine any individual estimate in detail or query any series, or ranges, of estimates. For example, in seconds, managers can find out from their terminals how many estimates are live with any or all of their people, and can subsequently examine each in turn on the screen if they wish. Each estimate record is displayed in turn, controlled by the user with a single keystroke.

The on-screen query facility allows any user to enter search strings, including wild cards and number ranges, in any field or combination of fields. Examples of WASP screens are given in Figure 2.

The instances of erroneous data entry by WASP users are minimised by the inclusion of comprehensive verification elements within the WASP software. Some of these elements are hard coded within the application language, such as logical date sequences. Other elements are covered by the extensive use of environment files which have the effect of disallowing data entries should they not match the valid predetermined values. These values include national and local (Worldwide Networks Zone) standard entries. For instance, in the CLASS file only finance-approved classes of work are valid entries.

WASP database structure

Figure 3 outlines the database structure chosen by the designers as being the most appropriate for the needs of all the application users. The ESTIMATE file is the WASP master file. The STORES, WORKS, PROGRAMME, estimate jeopardy and progression report file (A770), LOCATION and MANPOWER are all detail files. The DEPOTS, RATEBOOK, SUPPLY, MONTHS, STOCKED, DUTIES, INDICES and CLASS files are all look-up environment files.

The ESTIMATE file contains the unique job information. Each record contains a serial field which is the unique WASP job number; this field is used as the join field on subsidiary, otherwise known as *detail*, files. The ESTIMATE file details include fields for Directorate, Zone, control area, location, class of work, planners and works duties' OUCs. All these fields have look-up links to the relevant environment file and only allow validated data input.

Other data fields include title; description of work; target and actual dates (dates have to be input in the correct logical sequence), predicted, estimated, basic and planned (calculated by multiplying each input basic hour with a correct factor, entered by the class of work link); manhour costs (calculated by the manhour rate entered by the class of work link) and total spent manhours, predicted; and planned total material costs. The database calculates and displays, instantly, the total cost of each estimate (material plus manhour plus other miscellaneous costs, including contract, both local and national).

The STORES file, a detail file from the estimate file, contains all the detailed stores information, including ratebook code (look-up link to the material ratebook file); material item description (filled in by the look-up link on item code field); order; received and issued quantities; ordered, received and issued dates; and requisition numbers. This file contains links to stores delivery addresses, ratebook file and order quantities on a many-to-many relationship. The STORES file has a many-to-one relationship with the ESTIMATE file, the inter-file link being the unique WASP job number.

```
Query Next Previous Add Update Remove File Screen Current Master Detail
Output Bye                                      **1: estimate file**
*******************************************************************************
*Use Master/Detail * UPDATE ESTIMATE DETAILS - Planning Stage - Screen 1 V4.27
===============================================================================
wasp_no   d'rate zone ctrl_area locn_code  B_end      cow    est     ck wks_order
[0       ][    ] [  ] [    ]    [         ][          ][     ][     ][ ][      ]
location                extn/sch type cat  B_locat              [     ] np_number
[                    ] [      ] [ ]  [  ][                     ]  [          ]
title                   originator    orig_mark      priority          status
[                    ] [          ] [       ]      [  ]              [  ]
proj_no                           subproj_no           prgm_no          sub_prgm_no
[         ]                       [    ]               [    ]           [0    ]
planning     plg_start plan_by   orig_plan_by  pred_plg_hrs              orig_targ
[          ][00/00/00][00/00/00][00/00/00]    [0      ]                 [0     ]
works        start     orig_rqd_by agrd_rqd_by pred_mhrs pred_stores   new_targ
[          ][00/00/00][00/00/00]  [00/00/00]  [0     ]  [$0.00      ] [0     ]
related_job_nos                    remarks
[     ][      ][       ]           [                                         ]
[     ][      ][       ]           [                                         ]
prj_man  Project_no Network_no  Plan_act_no Wks_act_no Plg_res_no Sto_res_no
details  [    ]     [         ] [         ] [         ][    ]     [    ]
```

```
Query Next Previous Add Update Remove File Screen Current Master Detail
Output Bye                                      **1: estimate file**
*******************************************************************************
[0       ]         UPDATE ESTIMATE DETAILS  - Planning Stage   Screen 2  V4.27
===============================================================================
planned basic hours direct labour
re         rc         lc         ep         tr         sm         el         misc
[0.0     ] [0.0     ] [0.0     ] [0.0     ] [0.0     ] [0.0     ] [0.0     ] [0.0     ]
===============================================================================
planned basic hours contract supervision
sc         at                                                      prev_bhrs
[0.0     ] [0.0     ]                                               0
============================Estimate Summary===================================
bhrs       mebf     mhrs         rate         cost           lab_cost
dl         0.00     x 0.0    =[0.0       ]@ $0.00     = $0.00       }
cs         0.00     x 0.0    =[0.0       ]@ $0.00     = $0.00       } [$0.00      ]
unforeseen                        [0         ]
===============================================================================
basichrs  manhours  stores_pvde stores_rec  loc_purch  loc_cont    total_cost
[0      ] [0      ] [$0.00     ] [$0.00     ] [$0.00    ] [$0.00     ] [$0.00      ]
===============================================================================
plg_started[00/00/00] plg_spent_hrs[0  ] planned[00/00/00] for_auth[00/00/00]
```

```
Query Next Previous Add Update Remove File Screen Current Master Detail
Output Bye                                    **2: stores file**
*******************************************************************************
UPDATE ESTIMATE DETAILS  - Planning Stage   Screen 3  V4.27
* use Add to input          planned stores items          wasp_no  [0       ]
===============================================================================
item_code item_description                       unit_cost       quantity
[      ]                                           $0.00          [0      ]
[                                      ][$0.00     ] Unit of Issue is
                                                     Undefined
===============================================================================
source_code                                                  source_notes
[      ]                                                     [                  ]

unit of issue
code    lead_time  sda_code      item_status               item_total
[0    ] 0        [0 ]       [       ]    [  ]                   [$0.00       ]

0.00

===============================================================================
```

Figure 2—Sample WASP screens

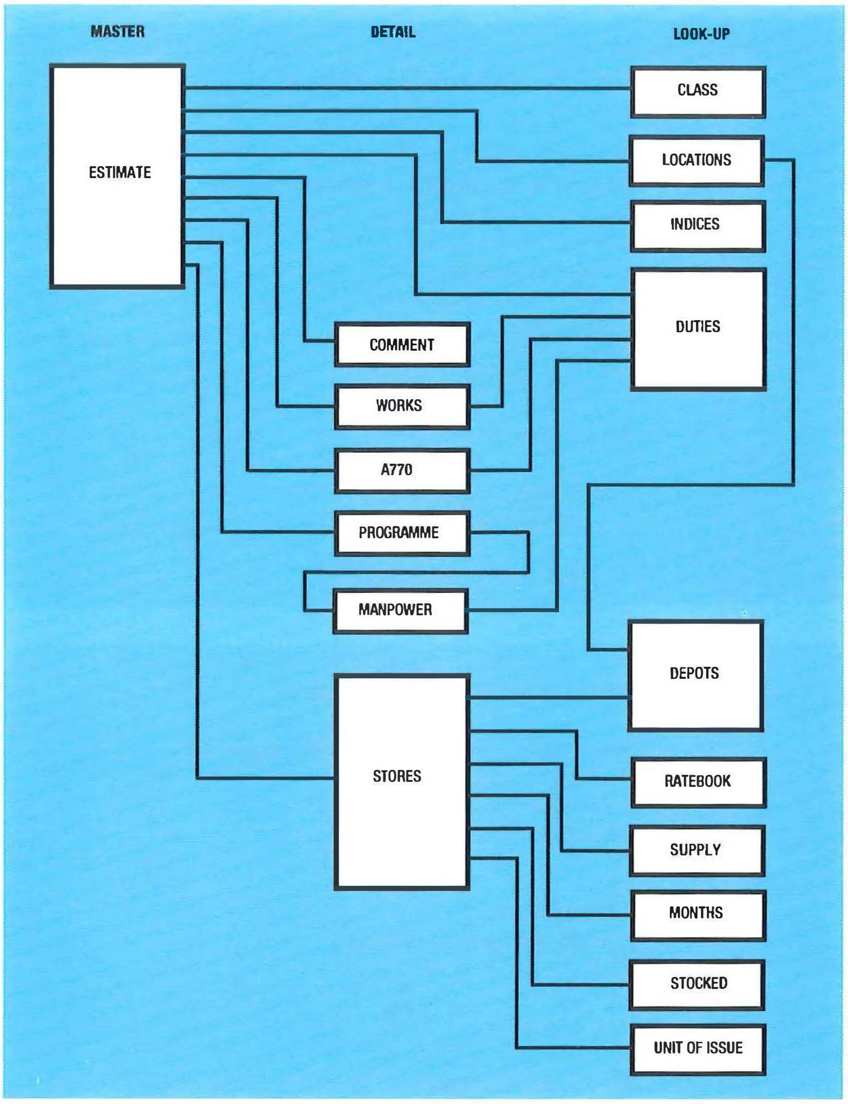


Figure 3—WASP database structure

The WORKS file, detail from the ESTIMATE file, contains the amount of spent works time. This includes the time spent each week. Although this is the time period currently adopted by the works groups, time spent on estimates can be entered in any time period; for example, daily, weekly or monthly. Each entry also records the date of spend, the name of person who spent time and the OUC of the works group (checked against the duties environment file, a many-to-many relationship). The WORKS file has a many-to-one relationship with the ESTIMATE file.

To help ensure that standard information is entered, an environment file structure was built. These files contain, for example, class of work, locations, duties and sub-Districts, stores delivery addresses, materials ratebook and materials minimum order quantities.

All these files, except for DUTIES which has a many-to-one relationship, have a one-to-one relationship with the main files. Each ESTIMATE record relates to a number of records in various detail files. For example, each ESTIMATE work package has a unique record in the master file. This relates to a number of records in the STORES file, each one representing a separate stores item.

Environment files are look-up files that contain general information which can relate to more than one master or detail record. For example, the CLASS file contains one record for each valid class of work and holds related information such as manhour rates. Only classes of work that are held in this file, and are therefore valid, are allowed to be entered on the ESTIMATE screen.

The remaining WASP files are now described:

LOCATION Environment file for ESTIMATE containing engineering locations and identified by location code.

PROGRAMME Extension detail file for ESTIMATE containing a programmed spread of manhours for each job over specified monthly time-slots within a three-year period.

MANPOWER Detail file for ESTIMATE containing total monthly manpower availability for each works group over a three-year period.

A770 Detail file of the ESTIMATE containing A770 records that can be produced by the electronic A770 mechanism. The file contains text regarding the progress, including jeopardy reports, of the estimate during the report period; the report period; and percentage completions.

DEPOTS Environment file for LOCATION and STORES containing stores depot identities and addresses.

RATEBOOK Look-up file from the STORES file containing materials department stores items identified by item code. The material item description, unit off issue and section code.

SUPPLY Environment file for the STORES file, containing authorised source of supply codes, and descriptions.

MONTHS Environment file containing accounting period code and the accounting period end dates.

STOCKED Look-up file on the STORES file, listing all surplus stores items and equipment that have been in the works order stores for more than a preset variable time period.

DUTIES Environment file for the ESTIMATE, WORKS, PROGRAMME and A770 files, containing authorised OUCs, users system account name and account code.

INDICES Look-up file for the ESTIMATE file, superseded by the CLASS file. Now used for identifying the region and control areas.

CLASS Environment file for the ESTIMATE file, containing authorised classes of work, monthly stores balances, indirect and direct manhour rates and a preset manpower multiplication factor.

UNIT OF ISSUE This environment file translates the unit of issue code into words for the STORES file.

COMMENT Detail file from the ESTIMATE file to enable programme control function to input detailed comment regarding the estimate.

Figure 4—Standard planners' menus

```
WASP PLANNING MENU 1 (V4.4)

1.Input Estimate Details
2.Update Estimate Details
3.Estimate Progress (View Only)
4.Rate Book Query
5.REPORTS MENU
6.WASP PLANNING MENU 2
7.CMS MENU
8.WORD PROCESSING MENU
9.LOCAL FACILITIES

* = Log Off

ESC = (Main Menu)
-   = (Last Menu)

[ ] Select An Option
```

```
WASP PLANNING MENU 2 (V4.4)

1.QA DIRECT LABOUR (FORMS) MENU
2.Summary (A832)
3.Stores List
4.Initial A770 Reports
5.
6.
7.TNSR MENU
8.WORD PROCESSING MENU
9.

* = Log Off

ESC = (Main Menu)
-   = (Last Menu)

[ ] Select An Option
```

Menu structure

The WASP menu structure has been implemented nationally and a standard has been developed called the *national standard WASP* (NSW) menu structure. The national product group is responsible for the NSW menu structure, which is installed on all the BT Worldwide Networks Zone Pyramid machines.

Once the WASP option has been selected from the main menu, the resultant WASP menu presented to the user is the menu that is functionally required. For example, a planner receives a planning menu and a works person receives a works menu. To retain the flexibility of approach required, the responsibility for allocating menus to the end user rests with each Zone applications manager. This approach ensures that each Zone user has the appropriate menu for his/her functionality.

The menu system itself is simple to operate, having a single-key stroke operation. The user is given a choice of options, clearly labelled with short descriptions. Such as Uniplex, WASP and so on. A single press of the appropriate menu option number, 1 to 9, inclusive, takes the user to a further menu displaying 9, or less, further numbered options. Figure 4 shows a standard planners' menu.

The menus also allow the user to flick between some main menus with a single key stroke, the '-' key. The user can leave, or log off, the system from any menu with a single keystroke, the '*' key.

WASP Implementation

Part of the WASP/Hornet project included migration from all the myriad other works and planning systems in Worldwide Networks to WASP.

The internal works information system (IWIS), being the database with the largest user base—23 BT District databases and 300–400 users—and being resident on a mainframe computer, presented the biggest migration challenge.

Modern software tools perform analogous tasks considerably more efficiently than older equivalent software. When viewed in isolation this may seem to make data migration from one computer system to another a simple task.

An additional complication of systems migration is the need to take account of the proclivity of computer system users. To overcome the aversion of the end users to all new systems it is necessary to adequately train all new users. The IWIS-to-WASP migration project was no exception to this. The training given to users is described in greater detail later in this article.

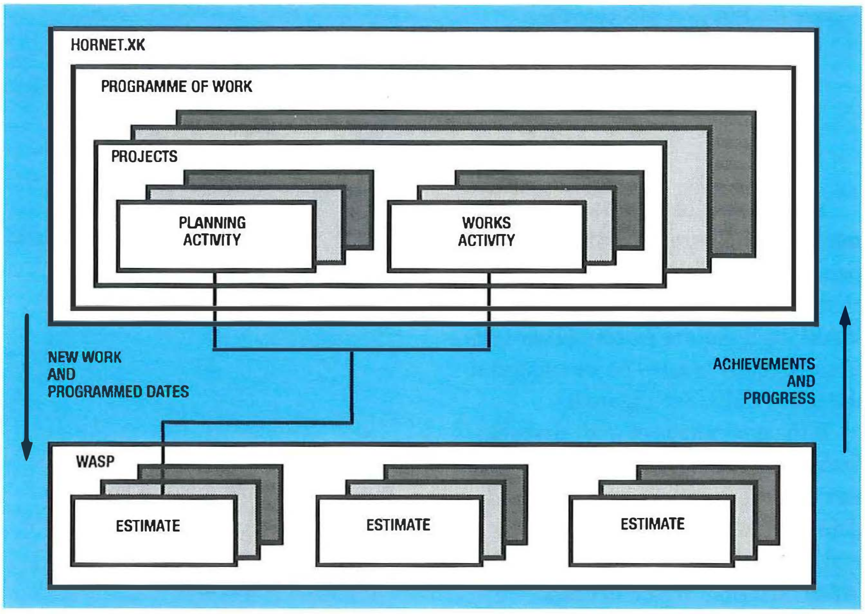
The actual transfer of data was achieved by a combination of special transfer software on the new host, and good project management techniques.

The project plan identified the IWIS databases that were to be transferred, then constructed a programme which would enable the transfer of these IWIS databases in a project managed way.

The occasional failure of the IWIS data download on the programmed day made it necessary to compress the follow-on activities in order to keep to the programme. However, on 15 May 1992 the IWIS–WASP migration project plan was successfully completed. All planning, control and works groups within Worldwide Networks now have access to WASP.

Phase two of the WASP/Hornet project is identified on the project plan as implementation and will give wider access to all individual planners, and works people. Phase two

Figure 5—WASP-Hornet.XK interface



will also use the latest BT standard communications and peripherals.

Hornet Implementation

Contained within the Network Administration Implementation Programme (NAIP) strategy was a proposal that WASP should be interfaced with a project management system.

The implementation of the strategy, part of the WASP/Hornet project, will give project and programme managers the appropriate tools to manage, for individual projects to the whole programme of work, all resources, time, money, materials and manpower. The introduction of project management tools and techniques will allow the flexible planning, allocation and implementation of work packages, thereby giving BT Worldwide Networks the ability to respond to all changes in customer requirements.

After trials conducted within the pilot network operations unit, in Walsall, and further volumetric trials in the North East Zone of Worldwide Networks, implementation of the project management package, Hornet.XK, commenced and will be completed by April 1993.

Interfaces

Several initiatives have taken place to incorporate the nationally recognised best practice standard systems for each functional area; for example, materials supply (consolidated materials system (CMS)). This has meant that appropriate interfaces are required between each system.

The interface between WASP and the project management package Hornet.XK was seen as appropriate for an electronic interface. This need not be the case for all interfaces.

WASP-Hornet.XK

The electronic interface between WASP and Hornet.XK has been designed to transfer programmed and target data from Hornet to WASP and progress data from WASP to Hornet.XK. See Figure 5.

The data transferred from Hornet includes limited estimate details, such as standard building location codes (1141 codes); planning and works OUCs; plan start, plan by, work start and work end dates. The interface also transfers the predicted planning resource, works resource and stores resource.

This information is used by the electronic interface, where appropriate, to create jobs on WASP. The interface software automatically informs the relevant planning and works groups by electronic mail that new estimates have been added to their programme of work.

The interface checks the network and activity codes against the project to ensure that only unique estimates are added to WASP. If an activity matches estimate details already in WASP, the interface does not add a new estimate. The interface software updates the existing estimate with the relevant data. This updated estimate information is also sent automatically by electronic mail to the relevant works and planning groups.

When actual progress is made on any estimates, the appropriate details are added to the Zone WASP database as it happens. For instance, if a planner enters the planning started date on an estimate, or if a works manager enters the works started date, this data is picked up by the interface software and loaded into the corresponding activity on Hornet.XK. The interface also feeds planning ended and work ended dates, and the estimated percentage work done for each estimate into the appropriate activity details on Hornet.XK.

The interface is controlled by the field programme control function. Data is transferred between the two systems by the interface on request by this group. The interface gives the field programme control group the option of project, or the complete programme of work, transfer.

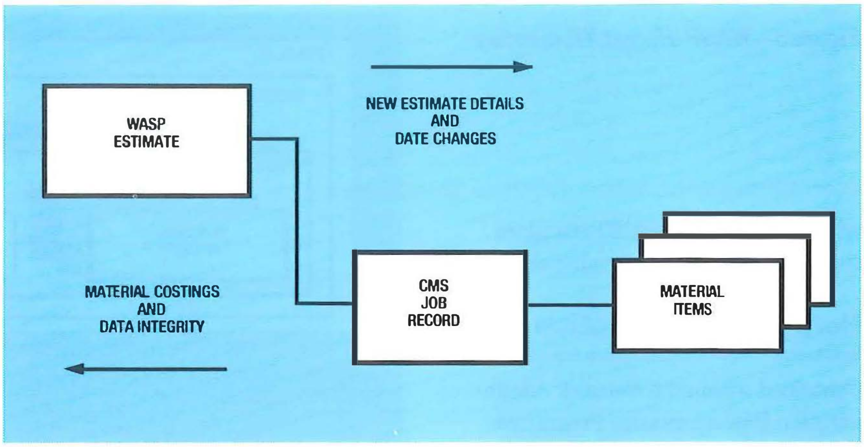
This facility operates in both directions. A future enhancement of the interface could be to transfer automatically progress data from WASP to Hornet.XK as it happens.

This ensures that the programme of all work—in progress, pre-financial authorisation, or just broad brush project details 5–6 years out—can be accessed by the system users. This gives all users the latest, and widest, picture of progress in resource commitment, work allocation and the like.

WASP-CMS

The WASP–CMS interface will be electronic. This interface operates between two different computer environments, WASP being resident on the Unix-based Pyramid hardware platform, and the material database, CMS, being hosted on an IBM mainframe. The data transfer protocol used is the file transfer protocol (FTP), over a closed-user-group BT X.25 network. Further details of the transfer protocols, network types and structures, machine hardware and so on, used by the systems and tools described in this article can be found in Reference 1.

Figure 6—WASP–CMS interface



The purpose of the interface is to maintain concurrence of the independent system dates. This means that estimates on Hornet.XK and WASP that require material items are automatically created on the material database CMS. See Figure 6.

If the programme of work changes, for instance customer dates are brought forward, then the appropriate estimate date information flows, electronically and automatically, from Hornet.XK to WASP and from WASP to CMS.

Other interfaces

Several initiatives on interfaces are in the feasibility stage, including an interface to the finance systems for the automatic transfer of dates and costs, and the allocation of estimate numbers.

This interface will allow functional groups, such as the fixed asset group, to gain information electronically. For instance, as soon as equipment is installed and working in an exchange, the ready-for-service date is entered on WASP, and this information is transferred to the finance systems immediately.

Further interfaces include links to network growth forecasting systems such as EXPRES.

Training

Training was identified early as an important activity in the overall project plan, and because of the magnitude of the training activity professional trainers were consulted. Training has been provided under four headings:

Training the new WASP user

Introducing the features and benefits of any product to new or prospective users and providing them with support through the important early learning curve should always be high on the list of priorities. The design team included members from the WASP national product group and professionals from the course design group at BT's training college in Stone. The team have designed a standalone self-teach package 'WASP—An Introduction For New Users'. This course is available through the normal BT training department channels.

The training package, or *controlled field tuition package* to give it its technical name, is based on a look-alike version of a real WASP database which enables the absolute beginner very quickly to become acquainted with the overall concepts and structure of the product and its many tools. Students are provided with a workbook, which is divided into three modules:

Module 1 Training Introduction
Module 2 WASP - The Basics
Module 3:
- 3a Planning
- 3b Internal Works Control
- 3c Works

The first two modules provide essential training to all prospective users while the third module focuses on the specialisation of detailed planning, internal works control and works execution.

During phase one of the WASP/Hornet project, 800 people received this kind of training within their own working environments. Phase two of the project will involve 2500 people being trained in this manner.

Hornet training

The supplier of the project management system Hornet.XK has designed courses which are commercially available. Some 50 people will attend this course.

BT has designed a beginners' course to be rolled out to most of the project management tool users. This course will reflect the usage that BT will make of the tool. It will be run at eight sites, one in each Zone, and will be given by lecturers from BT's training college at Stone. Four hundred people will be tutored in the use of this tool.

The product supplier has also designed an expert users' course. This course will be attended by 50 BT people at the supplier's site.

Product statistics

There are eight Zone Pyramid machines, each resident in network administration computer centres (NACCs) located throughout Worldwide Networks. Each Pyramid machine has on average 400 users.

Each WASP database contains, on average, some 15 500 estimates, 40 000 works records, 60 000 ratebook items, 250 classes of work, 2000 locations, and 500 duties.

The project management, Hornet.XK, database areas contain between 20 000 and 40 000 records, within approximately 600 networks, with an average of 500 resources.

The size of each data area is approximately 40 megabytes.

The individual data storage area taken by the WASP software is 12 megabytes.

Informix training

The supplier of the on-line product has designed several courses suitable for all types of users. To date, the only course used by the project is the database administrators' course. Twenty people have attended this course at the supplier's site.

Process training (culture change)

Because the project envelops such a wide range of skill families and has introduced considerable change into those areas, it is a requirement of the project to involve everyone, not just users of the computer tools. To this end, an objective field-led course has been designed by the training activity team.

This course will be given by trained managers in each Zone, and in this manner will be cascaded to all people involved in the project. The aim of the course is to introduce a cultural change to all 4000 people involved in the project.

Training conclusions

By the end of the project, nearly 4000 people within BT, from all the functional areas involved, will have been trained. Four types of course delivery have been chosen on the advice of the professional course designers. These courses, both in content and type, have been specifically tailored to meet the delivery time and economic requirements of the project.

Conclusion

The tools, and the techniques required to use them, will enable BT Worldwide Networks to respond positively to customer requirements. The implementation and use nationally of modern database engines and other products will allow the easy, and quick, production of standard national, and Zone, reports and management statistics, giving all management levels up-to-date and accurate information to enable the efficient use of available resource.

The ease of use of these products, together with the training offered, will allow people new to the systems to gain quickly the expertise required to operate the tool effectively. The implementation of national standard tools will give senior managers the ability to modify the process and tools to suit business needs.

References

1 Crocker, I. Computing Platform for BT's WASP/Hornet Project. *Br. Telecommun. Eng.*, Oct. 1992, **11** (this issue).

Biographies

Philip Mayhew
BT Worldwide Networks

Philip Mayhew joined the then British Post Office in 1973 as a Trainee Technician (Apprentice) in the Colchester Telephone Area having worked for Plessey Telecommunications Ltd and Standard Telephones and Cables Ltd. In 1976, he joined the exchange maintenance division, and after two years he moved to exchange construction duties. In 1984, he became a member of the team that developed and constructed the working procedures within the National Networks East Region, including the setting up of the internal works controls and Altos computer support group. When, in 1988, he was promoted to the management and professional grades, he managed the day-to-day running of the WASP product, designing and implementing changes to the WASP product and designing, writing and releasing national policy instructions for the internal works process. He was also involved in NAIP, representing the national WASP/IWC support group. In 1991, when the WASP/Hornet project was given approval for national roll-out, he was given responsibilities for the design and implementation, including project managing works packages, of interfaces with WASP. He has also been involved in the development and implementation of project management tools and techniques in Worldwide Networks.

Brian Black
BT Worldwide Networks

Brian Black joined the then British Post Office in the London Centre Telephone Area as a Trainee Technician (Apprentice) in 1966. In 1969, he joined the Strowger trunk exchange maintenance division. From 1975–1984, he had periods of substituting for management and professional grades in the trunk exchange maintenance group and the Centre Area training office. In 1984, Brian assisted in the development and construction of the working procedures, within the National Networks London Region, including the setting up of the London Region internal works control. In 1985, he was promoted to the managerial and professional grade responsible for the London Region internal works control and Altos computer system administration. In 1987, he moved to the National Networks Central Office to manage the day-to-day running of the WASP product, designing and implementing changes to the WASP product and designing, writing and releasing national policy instructions for the internal works process. In 1991, when the WASP/Hornet project was given approval for national roll-out, he was given responsibility for the customer-facing role of the WASP product, dealing with day-to-day issues with representatives of the end user. He was the project manager for the migration of all IWIS databases to WASP and the WASP controlled field tuition pack for the WASP/Hornet project.

Ken Sutcliffe and Andy Baume

Improving the Works Programming and Control Process—A Zonal Perspective

The development of tools, practices and procedures to support 'best practice' in the field of works planning and execution is the basis of a major project in BT Worldwide Networks. This article describes the work carried out within the North East Zone in support of the project and discusses the benefits that are expected. Finally, the authors suggest aspects of works planning and execution that could benefit from future development.

Introduction

BT has long sought a method of improving the efficiency and effectiveness of works planning and execution. Several initiatives have successfully automated component parts of the process, but the sheer scale of the diversity and complexity of BT's major work programmes has made a seamless integration difficult to contemplate.

These programmes are often subject to significant swings in content and priority as BT rebalances its resources to satisfy the demands of its stake holders. Assessing the implications of the change proposals and reflecting these changes accurately throughout the works programme have long been among the more difficult tasks a Zone has had to perform. The introduction of new practices and procedures supported by Hornet.XK (a commercial project management system), WASP (works and stores programme) and the consolidated materials system (CMS) (the BT stores management system) integrated through automated interfaces offers a breakthrough in the way in which the works programmes can be managed in future.

This article seeks to explain these developments from a zonal perspective and illustrates how the project has benefited from local involvement and initiative. Also explained is the way the project has been managed through trial status, and views are expressed on possible avenues for follow-up development.

Background

The North East Zone (NEZ) was formed from three Districts through the Sovereign reorganisation of 1991. With this change came the formation of BT Worldwide Networks, a consolidation of District and National Network people, and a new organisational template for the way in which work would be managed more effectively. The introduction of this new structure provided increased management focus and the opportunity to recognise and standardise operations based on recognised best practice.

After the reorganisation, considerable variations in the way work programmes were being managed became apparent; effective Zone-wide control could only be brought about by radical standardisation of support systems. In line with the national Internal Works Process Improvement Project (IWPIP), WASP was recognised as best practice. Plans were established to extend the existing penetration of WASP access by consolidating the hosting of all transmission and switch programmes onto the network administration computer centre (NACC) sited Pyramid computer by October 1991.

Coincident with this, the NEZ was supporting the IWPIP and joined in directorate-wide meetings to promote its development. It was apparent that the Zone had a significant lead in the penetration of PC-based Hornet and WASP. To supplement the Walsall functional trial, NEZ was selected to give the Hornet.XK tool a volume trial

The major problem that the Zone faced was in maintaining consistency between works programme and project driven requirements, which was exacerbated by changing tactical demands

which would be a prerequisite to national acceptance. The scope of the project was extended to encompass programme build at the tactical level. The NEZ joined a project team comprising experts recruited from throughout Worldwide Networks. Preparations for the national trial then commenced.

Opportunity for Improvement

As explained earlier, the creation of the NEZ offered the opportunity to functionally organise responsibilities and streamline the planning process to match the template which had been devised. A works and planning programme office was established with the aim of obtaining effective control of programmes across the Zone. Works programme office interfaces are illustrated in Figure 1. Before Sovereign, these functions had resided independently within detailed planning units where it was impractical to exercise effective overall control of an operation the size of a Zone.

Supporting the works programme stream was a dedicated project office, capable of driving through the delivery of critical projects across many functional interfaces.
The major problem that the Zone faced was in maintaining consistency between works programme and project driven requirements, which was exacerbated by changing tactical demands. Defined simply, a works programme is a stream of work which is designed to deliver the required milestones within the constraints of field resource, disposition and capability. Projects would normally comprise of many dependent activities which may be included in work contained in a works programme.

Effective control of the works programming and control process was hampered by manual and inflexible planning interfaces and much time had to be spent gathering data to provide for even the simplest 'what if' analysis. One particular area of difficulty was relating and tracking project activities with works and planners programmes so that progress on projects could be effectively tracked. A concept known as *project related planning* was developed as a way of overcoming this shortcoming and this will be explained in detail later in this article. Another key drawback of the Zone system concerned work scheduling. Rescheduling of works programmes was extremely labour intensive; in fact anything other than fine tuning the build programme was clearly impractical with the tools that existed.

Therefore, against this backdrop it was foreseen that significant improvement could be expected from a project management tool if it was able to interact with the works programme data hosted on WASP. Figure 2 gives a simple illustration of this. The national project team developed this concept of project/works programme interaction and specified the interface requirements in the form of a statement of requirements against which the Hornet.XK product could be tailored and judged for effectiveness as part of the volume trial.

Figure 1—Programme relationships

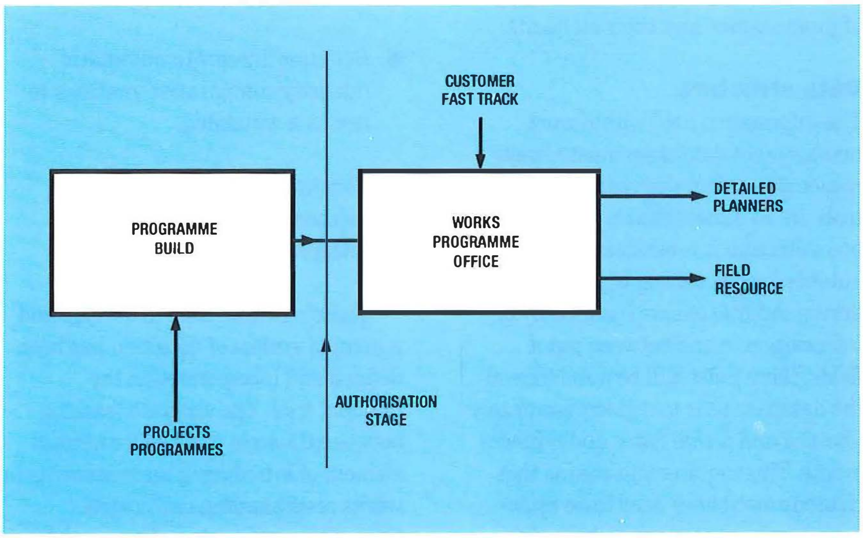
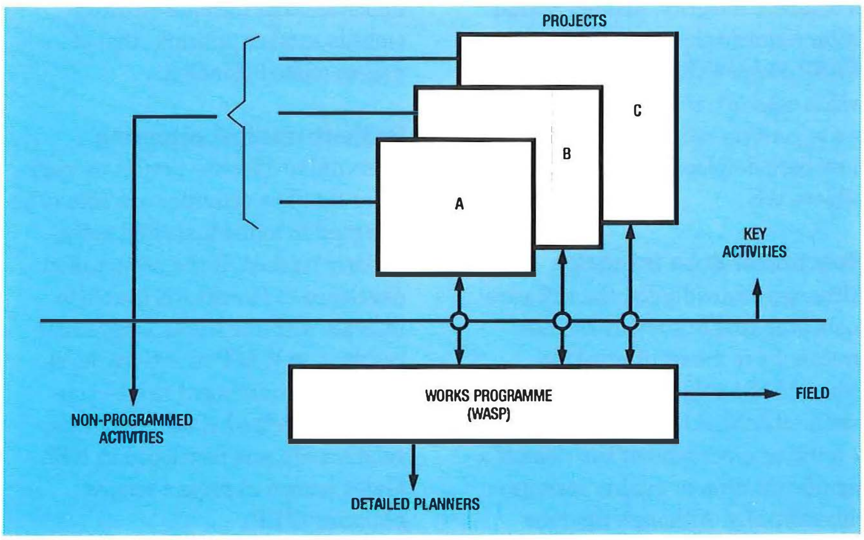


Figure 2—Project / works programme relationship



Key benefits of project-related planning are standardised planning, effective project tracking (financial and milestone) and simplified project budgeting

Zonal Data Structure

As discussed, the structured interaction between a project management system, the works programming database and the material ordering system was seen to offer considerable scope for improving zonal planning and works operations. By supporting this with a defined set of practices and procedures mapped against a standard planning process, the tools should be able to yield major improvements in the way projects and works programmes are managed. However, an essential prerequisite to the efficient application of the tools in a busy Zone is a reliable data structure that accurately represents the status of programmes and their elements.

Data structure

The information held within work management databases must always reasonably reflect the 'real world' if the tools are to be dependable in day-to-day use. Although it is essential that automatic data vetting is performed during input to ensure consistency of information in and between input fields, there must still be a reliance on the database user to register accurately planned and actual dates and achievements. This requirement means that rigorous disciplines need to be established and enforced throughout the zonal planning and works environment, supported by effective database administration. This is only one aspect of database integrity. Another critical factor concerns the relationship of the WASP, Hornet.XK and CMS tools, which need to track accurately if they are to perform satisfactorily. Proposals have been developed in an attempt to achieve this.

Relational data integrity

Although, individually, the software tools proposed to support the new process have inherent integrity expected of a relational database, when interfaced together and used in a working environment the risks of a significant drop in quality increase substantially. Although rigorous testing and input data vets can help to contain the risk, the new tools will operate in a complex and dynamic environment where unforeseen problems are bound to be uncovered. This is particularly critical in situations such as WASP/Hornet.XK where separate archives are used to backup each tool independently. To minimise the danger of a serious loss of information, which will be extremely difficult to restore effectively, while keeping cross-database relationships intact, a three-point plan is proposed:

- *Prevention* Rigorously define and structure all interfaces. Test under static and transient conditions.
- *Detection* Integrate automatic integrity comparative routines to use as a watchdog.
- *Correction* Define restoration method to restore any loss in integrity detected.

These will take time to develop and a manual system of detection has been defined and incorporated in the national trial. The accurate tracking between the tools will be an essential element of introducing improvements in works programming and control through resource scheduling (a sophisticated assignment feature of Hornet.XK) and automatic achievement reporting against projects. To support these, it is important that the data structure embeds another principle, that of project-related planning.

Project-related planning

It is vital to effective project management that key activities are able to be assigned to individuals and subsequently tracked. If the project plan developed in Hornet.XK is able to interact with the works programme resident on WASP at activity level, then this requirement can be supported. A method of attaining this relationship was developed in NEZ and is known as *project-related planning* (PRP).

The concept of PRP was devised as a simple means of linking project activities with programmed estimates by the use of work packages and tasks. The principles of PRP were developed in support of exchange modernisation but can be adapted to suit any project. Key benefits of project-related planning are standardised planning, effective project tracking (financial and milestone) and simplified project budgeting.

Figure 3 shows how PRP actually works in NEZ. Estimates are structured as a group of defined work packages that contain the tasks necessary to deliver that package. The estimates reflect the aggregated durations of the underlying activities which ensures they can be accurately programmed. The relationship which exists between the project plan and the estimate is described in the works instruction. Estimates defined in this way are also used as templates in NEZ for the creation of new projects on Hornet.XK, and linked with WASP.

The basic objectives of the trial will now be described.

Trial Objectives

The trial objectives have been developed and refined by the national project team. It is not the intention of this article to give a detailed account of the content of the trial but a brief statement of key objectives is given below:

- to ensure that the performance of Hornet.XK meets benchmarks;
- to demonstrate that Hornet.XK provides the functionality and performance necessary to meet requirements for programme build, work programming and project management;
- to establish the level of concurrent usage of Hornet.XK;
- to review the functionality of the WASP/Hornet interface in view of

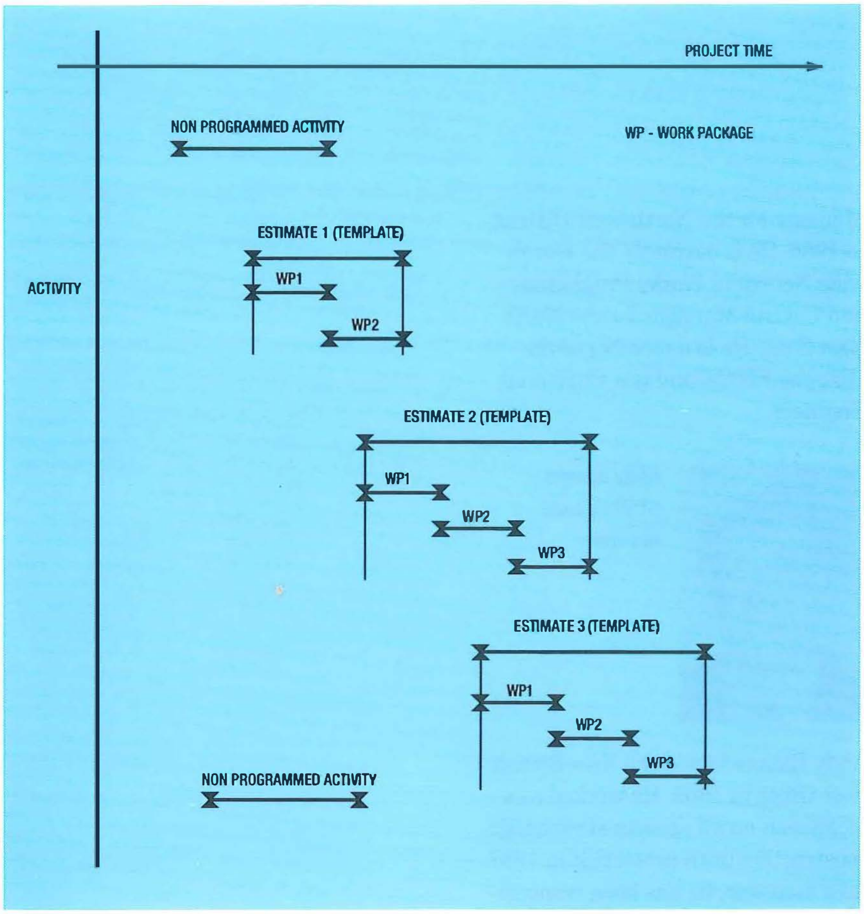


Figure 3—Typical project plan based on project-related planning

the increased span of usage within the Zone;

- to produce documented practices and procedures capable of supporting the introduction of the tool nationally; and
- to consider any enhancements and developments for the tools that would further streamline the planning process.

Trial Management

A detailed project plan was developed (using Hornet PC-based software) to detail the preparations required before the trial could start. A team of key players (including a representative from the supplier of Hornet) worked to deliver this plan. Some of the key achievements are depicted below:

- 42 users trained to use Hornet.XK;
- input given into the development of the national process;
- data structures were defined;
- data-build procedures were developed;
- reporting requirements were identified;
- communications platform was integrated;
- development of tools and interfaces was specified;
- benchmark tests were determined for trial; and
- staff associations and Zone managers were briefed.

To support the trial itself, a management plan was produced which assigned clear ownership of activities and accountability for decision making. Also documentation to quality management system (QMS) standards was produced, with the key procedures in the form of deployment flow charts. It is worth describing the latter initiative in more detail as this gives an example of the considerable amount of teamwork which has been a major feature of this project from its beginning.

Documentation

Documentation was recognised as an essential ingredient of both the preparation and management aspects of the trial. However, it was also appreciated that procedural information would need to be presented simply if it was to be effective, and the technique of deployment flow charting was determined to be an effective vehicle for this purpose. The procedures that needed to be developed had to support the national process and, because the development of the national process was influenced by the major players in works programming and control within the UK, it was readily accepted by the national project team. To carry out this significant task, North East, North West and Scotland planning unit representatives supported by QMS facilitators agreed to work together as focused teams to agree and develop the trial operational procedures within the boundaries of the national process. This is typical of the approach that has been adopted throughout the project to identify and adopt best practice.

Early Trial Experiences

The trial team have had the many ups and downs expected of a pathfinding project. One of the major difficulties experienced was due to the fact that a live WASP database had to be maintained and managed to a higher degree of integrity than had been foreseen. Data fields which did not materially affect WASP-based programme management were found to corrupt the Hornet data build and these had to be retrospectively cleaned. Problems with consistency between WASP and Hornet calendars and dates were typical of other difficulties which are still being encountered and overcome through the hard work and commitment of the project and support teams. The trial has now reached the benchmark testing phase. The team is optimistic of a successful outcome.

The Way Forward

The integration of Hornet.XK and WASP will continue to be refined if the trial is successful. The WASP/CMS interface is under development and this will provide improved tracking between planning and materials provision. The NEZ is determined to continue to build on the gains towards improving the efficiency and quality of services it provides to its customers. Establishing fully the concept of project-related planning with feedback to project plans and introducing resource scheduling rather than time scheduling offer opportunities for improving the service provided to the works programme customers. Beyond this, it is envisaged that the works planning and execution process could be made even more effective still with an improved work assignment and management system supported by the development of electronic estimating and tasking. Perhaps a 'son of WASP/Hornet.XK'?

Acknowledgements

The authors are pleased to be able to record the excellent achievements of Doug Turner, Les Slater and the national trial project team who have brought this project near to a successful conclusion.

Biographies

Ken Sutcliffe
BT Worldwide Networks

Ken Sutcliffe joined the then British Post Office at Leeds in 1968 as an apprentice on exchange maintenance. Gaining promotion to Assistant Executive Engineer in the North East Service Division, he subsequently moved to Newcastle Telephone Area in 1982 as Executive Engineer in charge of a mixed maintenance load. He established the North East District Support Group in 1985 and became the Network Planning Manager for the North East District in 1986. He is currently the Worldwide Networks Works Programme and Control Manager for the North East Zone. He is a member of the IEE, the FITCE and is a Chartered Engineer.

Andy Baume
BT Worldwide Networks

Andy Baume joined the then British Post Office in 1969. He worked as a technician on all aspects of exchange construction until promotion in 1987. As a manager, he has been responsible for the project management of many and varied network projects, most being related to exchange modernisation. These responsibilities continued with the formation of the North East Zone. He became involved in the WASP/Hornet trial in 1991, and subsequently project managed the trial preparation. He is now the North East Zone implementation manager for the Internal Works Process Improvement Project. He was the author of the original paper on project-related planning and is now responsible for further development of the theory within the North East Zone.

Ian Crocker

Computing Platform for BT's WASP/Hornet Project

The WASP/Hornet project, being rolled out to 4000 users in BT Worldwide Networks, is providing a means of managing the BT network capital works programme. The underlying computer network is the largest Unix network in BT. After a brief history of the network, this article describes the hardware, software, communications networks, support arrangements and the future of the system.

Introduction

With the formation of internal works controls in BT National Networks (BT regional trunk network construction) in 1983, there arose a need for a computer system to control this work. Each BT region was provided with a local area network (LAN) of Altos microcomputers. These computers provided word processing (Uniplex 3.0) and database facilities (Informix 3.3). The word processing was used for writing specifications and the database was used to support the internal works controls. This database, known as WASP (works and stores programme), was based on the internal works information system (IWIS), but with a stores component. The WASP system allowed the internal works controls to plan, progress and monitor the construction work on the trunk telephone network.

For a complete description of the WASP/Hornet process and programs, see the accompanying articles in this issue of the *Journal*[1-4].

By 1988, this network consisted of 97 Altos microcomputers, distributed through 10 regional offices and supporting 1000 users. The Altos machines were based on Intel 8086 and 80286 processors running Xenix and used a proprietary LAN to link the machines in each office.

By 1988, it became apparent that the Altos network was nearing the end of its useful life. The reasons for this were primarily that the machines and the network that connected them had no more capacity for growth. Pyramid Technology won the contract to replace the machines, and the LAN of microcomputers in each office was replaced by one Pyramid 9000 series minicomputer per region. These minicomputers were sited in network

Figure 1—Geographical position of Pyramid MIServers

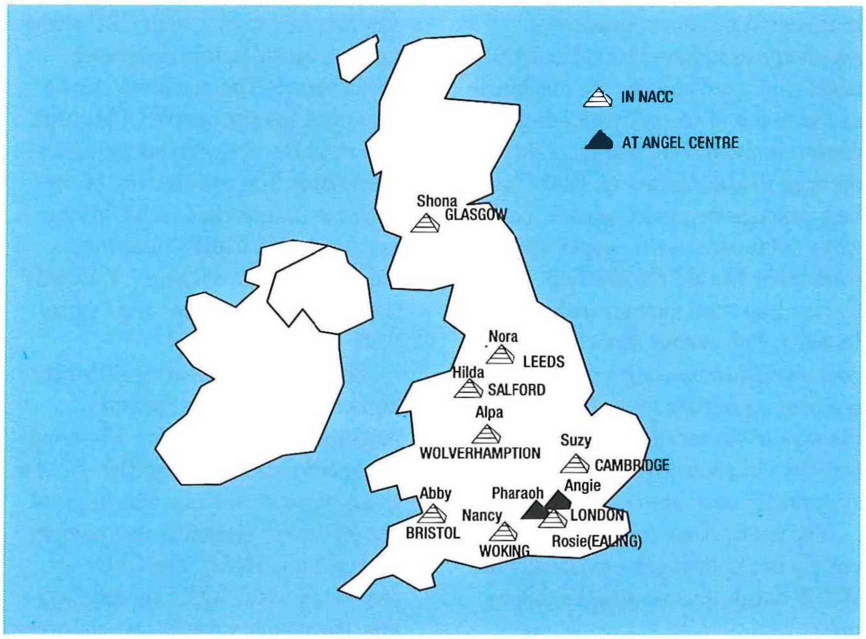
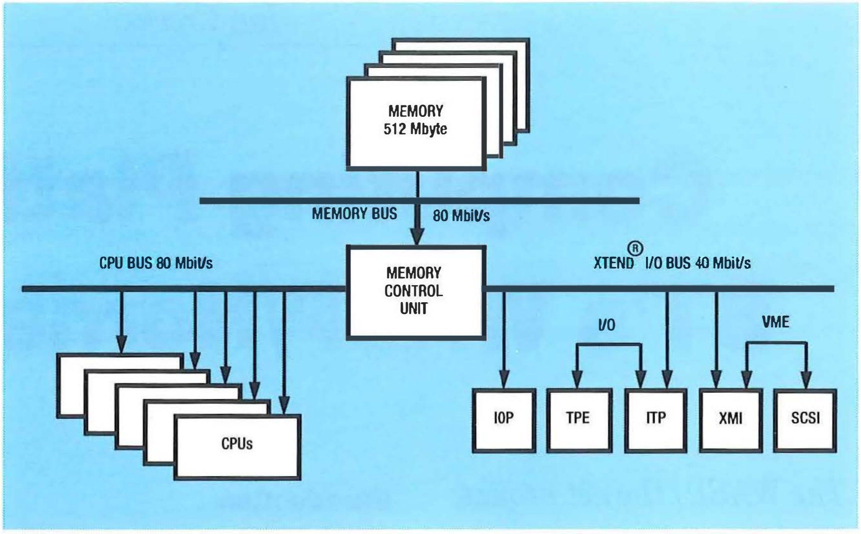


Figure 2—Mainframe architecture



administration computer centres (NACCs), except for the development machine and the head office machine, which were both located in an office environment (see Figure 1). The roll-out of these machines was arranged to cause minimum disruption to the works controls, and therefore took some two years to complete.

As the users were no longer collocated with the machines, it was necessary to provide a communications network to provide access to the machines. As the BT internal computer networking strategy (TNET) could not support Unix connectivity at that point in time, a statistical multiplexer solution was chosen. The move from the Altos Xenix machines to the Pyramid Unix machines was straightforward. The reasons for this were that there is little difference between Xenix and Unix, and that the major applications were running on the same packages (Uniplex and Informix). The Pyramid machine used Uniplex 6.0 and Informix 3.3. The opportunity was taken to rationalise the software present on the old machines and to enforce nationwide standards.

By 1991, the number of users of the machines had grown to 2000. At this time, the 9000-series machines were upgraded to MIServer T-series machines, which are described later in this article. This upgrade was necessary to support the extra 2000 users that would access the machines as the result of the network administration improvement project (NAIP) decision to standardise on WASP as best practice for works control. These extra 2000 users were people who had worked for the old BT Districts, which by now had been merged with the Regions. This meant that there were now myriad computing systems performing similar roles. NAIP had the task of standardising on best practices in procedures and computer systems for each area of work.

The network currently supports a variety of applications—primarily the WASP database, but also the following:

- national databases (used by the whole country),
- local databases (peculiar to one or two zones),
- electronic information systems,
- national electronic mail, and
- office automation facilities such as general word processing and spreadsheets.

Hardware

The Pyramid MIServer T-Series machines are based on a multiple RISC (reduced instruction set computer) CPU architecture, each CPU having 1 Mbyte of both data cache and instruction cache memory (see Figure 2). This means that programs with large working-set 'footprints', such as large database engines, can enjoy a high CPU cache hit rate which, in turn, increases performance. The machines can be expanded to take twelve CPU cards. The machine uses symmetric multiprocessing. The architecture of the machine is such that each CPU can execute 14 VAX MIPs (a de facto industry standard where 1 VAX MIP is the processing power of a Digital VAX 11/780 computer).

This MIPs rating is significantly higher than previous Pyramid machines, the reasons for this being advanced technology and the use of a three-bus architecture. The heart of the MIServer system is the memory control unit (MCU). The CPUs are connected to the MCU via the CPU bus, the memory boards are connected to the MCU via the memory bus and the input/output (I/O) subsystem is connected to the MCU via the XTEND bus. The memory and CPU buses both run at 80 Mbit/s and the XTEND bus runs at 40 Mbit/s. A typical I/O transaction would consist of the CPU building an IOCB (I/O control block) in memory and telling the I/O device to start processing, with the I/O device liaising with the peripheral to achieve the I/O and, finally, the I/O device interrupting the CPU to inform it of the completion of the I/O request. Each IOCB may contain more than one I/O transaction request.

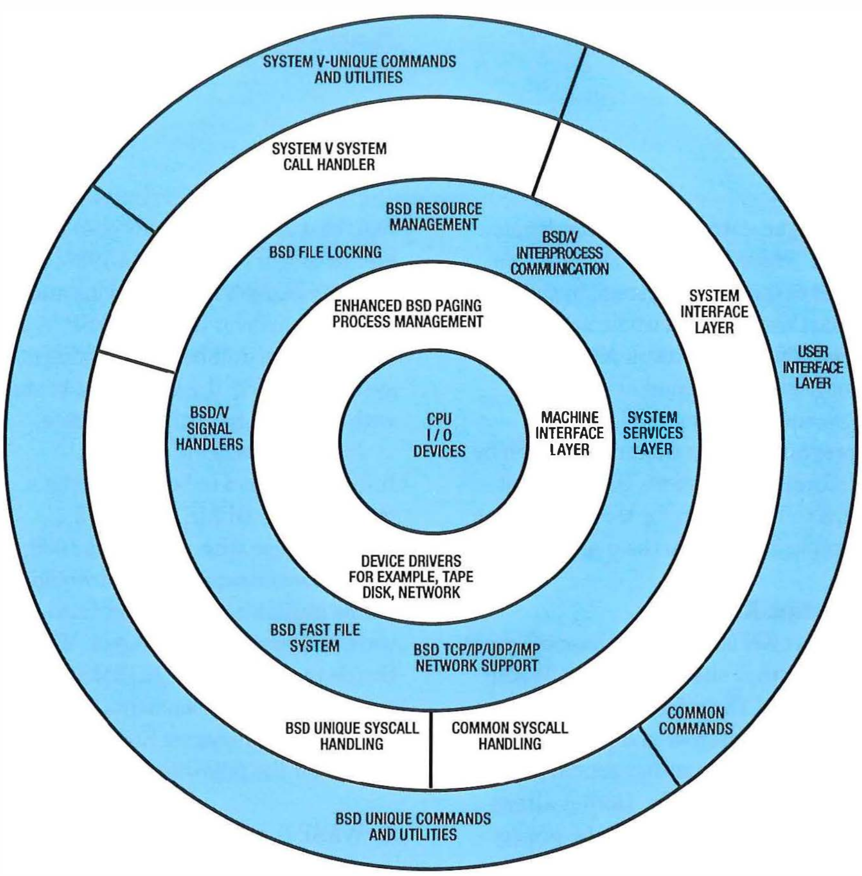
High throughput I/O is achieved through the use of intelligent I/O processors (IOPs), which are used for the connection of disks (1·7 GByte) and Ethernet cards. Each IOP has four slots for disks, mirror disking being performed between pairs of disks, served by different IOPs. In addition to the disks, each IOP supports a single Ethernet connection (10 Mbit/s), a single tape drive interface (½ inch) and a single printer interface.

Terminal I/O is provided by intelligent terminal processors (ITPs), each of which can support 16 terminal connections. Since the ITP contains a processor, it is able to take some of the I/O processing (such as canonical processing) away from the main CPUs.

Tape drives and Ethernet connections are handled by TPEs (tape, printer, Ethernet).

Other I/O operations are performed by using an XTEND mapper interface (XMI) which connects the XTEND bus to other proprietary

Figure 3—Structure of OSx operating system



buses such as the SCSI (Small Computer System Interface—a de facto standard bus for small computers). X.25 and SNA (IBM proprietary networking standard) communications are achieved by using intelligent synchronous communications (ISC) cards attached to the XMI, which can be configured to handle either protocol.

The machines range in size from six disks, six CPUs and 128 Mbytes of memory (680 users, 170 concurrent) to two disks, two CPUs and 64 Mbytes of memory (220 users, 55 concurrent).

Software

Operating system

The Pyramid MIServers run the Pyramid OSx operating system. OSx is a dual-port operating system, which means that it has ports of two different operating systems running concurrently. The two systems are AT&T System V and Berkeley BSD (Berkeley Software Distribution) Unix. Pyramid was the first company to release a dual-port operating system, in 1984 (see Figure 3).

System V and BSD Unix differ in the facilities that they provide. For instance, System V offers shared memory and semaphores, while BSD has a more robust, faster file system and integrated network support.

At the machine interface, the operating system is almost exclusively BSD. This is because BSD is faster and more flexible. A dual-port operating system is really defined at the system call interface level, and it is here that OSx provides different methods of access to the operating system.

OSx uses the concept of a 'universe' to distinguish between System V and BSD. A user may work exclusively in one universe or may mix the two. It is even possible to mix commands from both universes on one command pipeline.

Conditional symbolic links are used to allow the two universes to coexist. A conditional symbolic link is much the same as a normal symbolic link, except that the resolution of the link depends on the universe in which the process resides. Many system directories exist twice, once containing System V commands and once containing BSD commands. When a user tries to run a command, for instance /bin/ls, the binary that is executed depends on the resolution of the symbolic link /bin. Hence, a user in the System V universe runs a different binary to a user in the BSD universe. The same principle applies to the compilation of programs. Different libraries of system calls are available to the program, when it is compiled, depending on the universe in which it is compiled.

Once a program is compiled, it can be run in either universe. This allows the development tools of one universe to be used to produce an application that is targeted for the other universe.

The Pyramid machines are operated as far as possible in the System V universe. However, it is often necessary to use some of the BSD features; for example, the networking commands. Later in this article, when TNET integration is discussed, it will be seen how useful the dual port operating system has been.

OSx conforms to the US Department of Defence C2 security standards. The use of the C2 features is optional, although Worldwide Networks uses most of the options that are available.

Uniplex

The office automation system used on the Pyramids is Uniplex v6. The choice of Uniplex was made mainly for historical reasons. The earlier Altos systems had used Uniplex version 3, thus the users had many thousands of documents already created before the move to Pyramid. Conversion of documents from Uniplex 3 to Uniplex 6 was straightforward. Other OA systems were considered, but Uniplex was the most popular product at the time with a market share of 65% in Europe and 40% worldwide.

The zonal machines currently have the Uniplex base system and the Advanced Office System (AOS). The base system provides word processing, electronic spreadsheet and database. The spreadsheet offers all the usual facilities and Lotus 123 file format compatibility. The database part of the system is not supplied to the regional systems as the end users are not allowed to create or modify database systems.

The Advanced Office System provides an electronic organiser, time manager, card index and electronic mail. These items are not used as a part of the WASP system, but all apart from the electronic mail are available for the users. Electronic mail on the Pyramid network is provided by using the Unix mail programs with a front end written by Information Systems Development (ISD). The reason for this is to keep a simple interface to the mail system.

Hornet.XK

Hornet.XK is the project management system that sits on top of the WASP database. The relationship between WASP and Hornet is discussed in more detail in another article in this *Journal*. Essentially, Hornet allows the jobs held in WASP to be project managed effectively. There is an electronic interface between Hornet and WASP written by ISD.

Hornet.XK was developed from the PC product Hornet 5000i and is fully compatible with that product. XK is the Unix version of Hornet and is intended to run on a wide variety of hardware platforms of differing size and power. For this reason, it is based on industry-standard Structured Query Language (SQL) database engines. Hornet.XK can operate with Informix SQL, Oracle and Ingres. On the Pyramid, the Informix SQL system is used.

The major features of Hornet that make it particularly suitable for the WASP project are its capacity and flexibility. Hornet is not constrained by the usual limits imposed by other software systems. The limiting factor is the size and the power of the computer on which it runs. The product can also be completely redefined from the standard system. All menus, screens and reports are user definable.

Informix

When the WASP database was ported from the Altos network to the Pyramid network, the decision was made to continue to use Informix version 3.3. Informix 3.3 is a relational database system, although it is not SQL based. It was already obsolete and no longer supported in 1989, but, owing to budgetary restrictions and lack of manpower to port WASP to a more modern database management system (DBMS), it was decided to stay with this version until a later date.

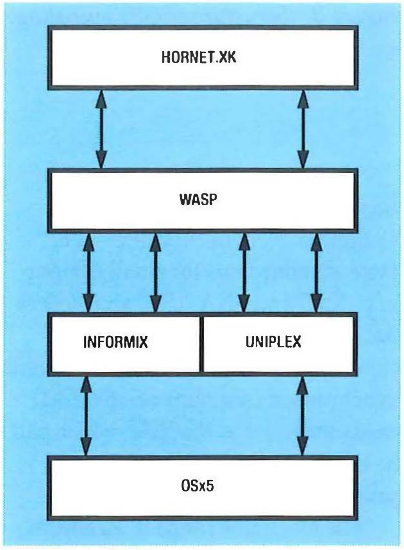
In 1991, it was decided that Informix 3.3 had to be replaced by a more modern DBMS. Version 3.3 could not cope with dates past 1999, was no longer supported and would not be available on any later hardware platforms from Pyramid. While Oracle is the strategic RDBMS for all open platform developments within the company, Informix SQL was chosen for the following reasons:

- WASP is an existing product and not a new development,
- easy upgrade path from Informix 3.3,
- flexible licensing arrangement,
- Informix SQL already being used by the Hornet product,
- price.

The Informix SQL package has four parts: On-Line, ISQL, 4GL and ESQL.

On-Line is the database engine. It is the interface to the database files through which the user processes communicate. High performance is delivered through the use of raw disk partitions, shared memory and multiprocessor features. A raw disk partition bypasses the Unix file system. This means that data is written directly to and read from the physical disk by the database engine. This results in optimum use of the disk for maximum efficiency. Shared memory is used by Informix to cache data from the database. This is effectively the same function as the Unix buffer cache, but once again it is optimised for database access. Among the parallel processing features is a parallel sort. On-Line carries out multiple sorts in memory and the data is then merged.

Figure 4—System hierarchy



Data integrity is ensured through On-Line's own mirroring of raw partitions, the on-line archiving of databases and transaction logging.

ISQL provides an ANSI (American National Standards Institute) standard SQL interface, a report writer, a schema editor, a form builder and a menu builder.

Informix 4GL is a fourth-generation language and development environment. For large items of work, 4GL is the fastest method of development. However, for smaller items, and perhaps end-user use, SQL is better. When WASP was ported from Informix 3.3 to Informix SQL in September 1992, most of the work was carried out in 4GL by the ISD team.

Informix ESQL is the interface to SQL for third-generation languages. This package will be used for the rewrite of the WASP interfaces during the port from version 3.3 to On-Line. C programs with embedded SQL will be used to interface between WASP and Hornet, and WASP and the consolidated materials system (CMS). These programs are currently written in C, but use a non-SQL interface to the version 3.3 data files. The use of embedded SQL will make these programs smaller and simpler.

Figure 4 illustrates the relationship between the systems software on the Pyramids.

Networks

Statistical multiplexer network

As already mentioned, a statistical multiplexer network was installed when the Altos machines were replaced by Pyramid minicomputers. This link was needed to connect the user sites to the NACC. A typical region has two Datelmux 5500/SOFT multiplexers, one at the NACC and one at the main user office. Smaller offices are served by 5100 series multiplexers.

To ensure that the equipment was functioning correctly after installation, some test software was used that had been produced for benchmarking machines while tendering for the Altos replacement. Two small Unix machines were used to simulate up to 80 users on the network. Forty V.24 ports from each machine were cabled to the terminal ports on the multiplexer. The computers then simulated normal user activity, such as log on, word processing, shell commands and so on. Reports were produced showing the response time of the multiplexer. The tests would be left running for several days. This period was usually long enough to uncover any problems with the multiplexer. When the multiplexer could operate normally for 48 hours, it was considered ready for service.

TNET

In 1989, the NAIP decision to roll out WASP as the best works control package meant that the communications strategy for connection to Pyramid had to be reviewed. All the existing users were connected by using the 5500 multiplexer networks and these were not suitable for the extra 2000 users who needed access to the system. The solution was to modify TNET to be able to communicate with the Unix hosts. TNET is a proprietary DECNET network that has been customised by BT to suit its needs—primarily for access to VAX/VMS and IBM mainframe systems.

Because TNET was already based on DECNET, and because BT did not want to mix protocols on its networks, the first solution that was tried was a product that implemented a DECNET protocol stack in the Pyramid host. This allowed the Pyramid to use the DECNET protocol. This solution was aborted because of performance problems. Another problem with this solution was that with a DECNET stack being implemented in each Unix host, every new host on the network would require a licensed copy of the networking software. It was decided at this point that TCP/IP networking would be investigated as this is a standard feature on most Unix implementations. This would also be more economical in the longer term, as once TNET was equipped with the necessary software, any number of Unix hosts could be connected to the network at no extra cost.

The solution chosen for Unix connectivity is a package called TCP_ware. TCP_ware software resides within the TNET network and implements a TCP/IP protocol stack in the network.

Terminal access to a Unix host is straightforward. The NAM sets up a TELNET (terminal emulation) session to the desired host. There were few problems encountered with this part of the work. Most effort was spent customising the terminal drivers on the Pyramid to drive the terminal emulation used by TNET.

Printing, as ever, proved to be more difficult. Two solutions can be used to physically transport a print from the Pyramid to a TNET network management control port (NMCP): BSD remote printing or an ISD developed solution using file transfer protocol (FTP). By using BSD printing, prints are spooled by the local machine and, if the destination printer is remote, the request is passed to a program running on the remote machine. As already mentioned, the Pyramids are operated as far as possible in the Unix System V universe. This means that all the applications on the machines use the System V printing mechanism. As System V offers more flexible printing, and to avoid having to rewrite the interface between the applications and the printer spooler, the Berkeley spooler is run beneath the System V spooler, passing all TNET prints to it. Hence a print is passed from the application to the System V spooler. Here the job is formatted before being passed to the Berkeley spooler. The Berkeley spooler then passes the job on to the TNET NMCP.

The FTP solution was tried merely because it had already been set up for another network (token ring—discussed in the next section). Here the System V spooler takes the formatted output that would normally be sent to the printer and uses the file transfer program FTP to send the file to the NMCP. The advantage of this method is that there is only one printing system to administer. The disadvantage is that the use of this solution requires more programming work on the Pyramid host and is not standard.

With both of these solutions, a print can be sent directly to a TNET printer queue or to the TNET parser. The print contains a header that specifies the name of the TNET printer that the print should be sent to. This is a little more flexible.

Token ring

A Worldwide Networks site in Wales was chosen as a pilot for a token ring network late in 1991. This was done to explore alternative networking solutions to those already being used by TNET, and to lessen dependence on one supplier. The Pyramid machine serving this site is located in Bristol. The Pyramid has an Ethernet and attached to this Ethernet is a token ring to Ethernet bridge. This is then connected to a token ring network in Wales via a 256 kbit/s link. The token ring network is populated with PS/2 model 35s running DOS and PS/2 model 70s running OS/2. The PS/2 35s are used as intelligent workstations allowing access to multiple hosts simultaneously and the PS/2 70s are used as print and file servers.

Terminal emulation is provided by a TCP/IP package that runs on each machine on the token ring. As with TNET, these machines use TELNET to speak to the host.

Printing is provided by using the FTP solution described in the section

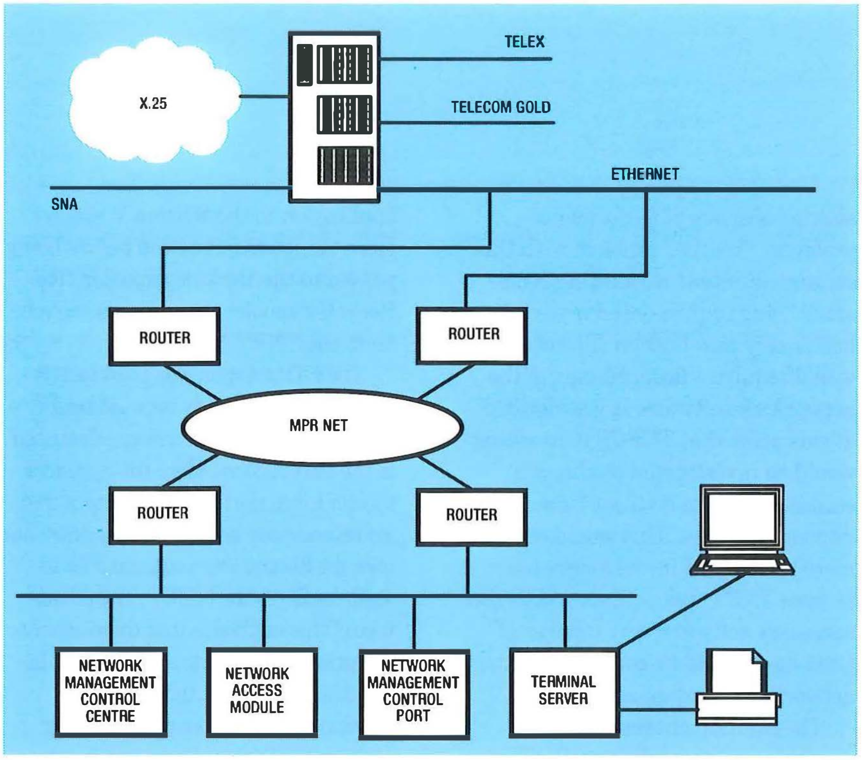


Figure 5—Pyramid communications

on TNET connectivity. However, on the token ring, the print is not given to a parser (as none exist), but sent straight to a port on the printer server. The Pyramid contains a lookup table that specifies the printer server and port to use for each logical printer. Software on the printer server redirects the print to a local port or to a LAN-based printer.

The token ring network is only suitable for sites containing several users as it does not offer a solution for sites with one or two users.

X.25 network

All the Pyramid machines are connected to the Packet Switch-Stream (PSS) network via 9600 baud links (although there are plans to upgrade this to 48 kbaud). The most basic command available to the user is PAD (X.25 terminal access), which sets up a terminal session on a remote machine. This gives the ISD support team the ability to maintain and fix problems on a live machine by logging in directly from the development machine.

So that standard Berkeley networking commands can be used over the PSS network, the Pyramid incorporates a package, called *XI*, which allows the TCP/IP protocol to send packets over X.25 connections. The machine maintains tables that map internet addresses onto PSS addresses so that both the X.25 and XI subsystems address the same machine when given a machine name.

The full suite of Berkeley commands can thus be used (for example, RLOGIN—remote login, PING—network test, FTP—file transfer) over the local Ethernet and the wide area X.25 network (although the performance over each is somewhat different).

Network security is achieved by the use of a closed user group (CUG). Of the ten systems, eight are configured in such a way that they can only make calls to and receive calls from other machines in the CUG. The head office machine is allowed, in addition to this, to make calls outside the CUG (but not receive them), and the development machine is allowed to make and receive calls from anywhere. Security is enhanced on the development machine by demanding that the system administrator registers the addresses of calling DTEs in a file and demanding that a remote user supplies an extra 'dialup' password before being allowed to log in.

Other communications links

Each Pyramid machine has an SNA connection. The Pyramid simulates a cluster controller and attached 3270 terminals. This facility is little used and will become less important once TNET is available to all users.

Each system also has a Telex package that can send and receive Telex messages, and a connection to Telecom Gold.

Figure 5 shows a typical communications network attached to a zonal machine.

Support

The system administrators for the Pyramid computers are Worldwide Networks staff. Each zone usually has three staff to support the machine. This team provides day-to-day support, addition and deletion of users, performance monitoring and so on. The system administrator is also responsible for the operation of the statistical multiplexer network as these are owned by Worldwide Networks.

The machines are supported by a group within BT's Information Systems Development Directorate, providing the following functions:

- fault clearance,
- capacity planning and monitoring,
- application development,
- systems development,
- communications development and support,
- technical support,
- hardware upgrades, and
- evaluations.

Figure 6 shows the hierarchy of support arrangements for each zone.

Future

The Pyramid computer systems are easy to upgrade by the addition of more CPUs, memory and disks. As most of the zonal systems have only two CPUs, this means that the existing machines have a sound future. When it becomes necessary to replace the machines, Pyramid has a more powerful machine available. Of course, because of the relative ease of

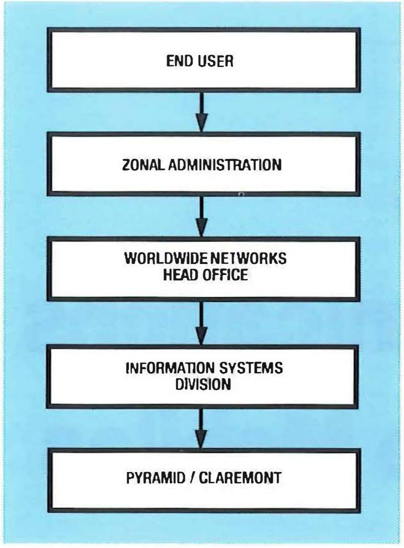


Figure 6—Support arrangement

porting Unix applications, the future upgrade path does not have to rely on one manufacturer.

Communications technology is continually evolving. At present TNET only supports dumb terminals. The trend is towards intelligent workstations with graphical user interfaces. There is already a need for a high resolution graphics capability. Hence there is bound to be development in this area.

The other area in which work will be carried out later in 1992 is connection of the Pyramid network to BOAT (office automation within BT). BOAT has already opted for Unix machines running Openmail as part of its portfolio. Openmail uses Uniplex and so it can be seen that the Pyramid is a suitable candidate for easy integration to the BOAT network, giving an extra 4000 users BOAT access.

Conclusion

This article has given an overview of the computing platform and tools that support the WASP/HORNET project.

The system has evolved from one of the first, and certainly the largest, Unix networks in BT. The transition from Altos to Pyramid hardware showed the advantages of open systems.

The current network has plenty of scope for expansion and will be capable of serving the customer's needs for the foreseeable future.

Acknowledgement

The author would like to thank his colleagues for their help in producing and refining this article.

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Biography

Ian Crocker
BT Development and Procurement

Ian Crocker graduated from Kingston Polytechnic with an honours degree in Computer Science. He joined BT in 1987. He has spent the last five years working with Information Systems Division. Initially, he joined as an analyst/programmer. He now heads a team that is primarily responsible for communications for the WASP project.

Glossary

ANSI American National Standards Institute
BOAT Office automation system in BT
BSD Berkely Software Distribution
DBMS Database management system
CUG Closed user group
FTP File transfer protocol
I/O Input/output
IDP Input/output processor
IOCB Input/output control block
ISC Intelligent synchronous communications
ISD Information Systems Division
ITP Intelligent terminal processors
IWIS Internal works information system
LAN Local area network
MCU Memory control unit
NACC Network administration computer centre
NAIP Network administration improvement project
NMCP Network management control port
PSS Packet SwitchStream
SQL Structured Query Language
WASP Works and stores program
XMI XTEND mapper interface

Trevor Warry and John Hawkes

INMARSAT-C Satellite Data Communications for Land and Maritime Mobiles

Owners of ships, boats, trucks, buses, trains, etc. now have an economic and convenient means of communicating messages and data with their vehicles anywhere in the world. This has been brought about by the advent of the INMARSAT-C satellite communications system. This system and its implementation at BT's Goonhilly Satellite Earth Station are described in this article.

Introduction

The advent of the INMARSAT-C system is causing a revolution in mobile communications. Now owners of small ships, boats, trucks, buses, trains, etc. have an economic means of transmitting data to and from their vehicles. BT is offering two services to customers using INMARSAT-C: *C-Sat* and *C-Club*.

C-Sat offers the basic messaging service using the Telex network. C-Club offers enhanced facilities as well as access via the telephone and data networks. These services are available on a worldwide basis from BT's satellite earth station at Goonhilly and via cooperating earth stations in Norway and Singapore.

INMARSAT-C builds on the success over the last 10 years of the INMARSAT-A maritime satellite communications system[1, 2]. It offers easy to use store-and-forward messaging facilities. The INMARSAT-C mobile terminal equipment is small and inexpensive with an omnidirectional antenna, unlike INMARSAT-A which requires a 1 m diameter stabilised and tracking antenna. Figure 1 shows an INMARSAT-C land mobile earth station installation.

INMARSAT[3] provides satellites and defines the system parameters for maritime and land mobile communications. It has divided the earth surface into four areas, called *ocean regions*, each served by a satellite located in the geostationary orbit.

Figure 1—INMARSAT-C land mobile installation

This gives global coverage except for the polar regions where geostationary satellites are below the horizon. In addition to its 'A' and 'C' systems, INMARSAT also operates an aeronautical system[4], and will shortly start operating its 'B' and 'M' systems.

INMARSAT-C offers store-and-forward messaging services between fixed terminals, operated by terrestrial customers, and maritime and land mobile terminals, called *mobile earth stations* (MESs). The services offered are:

- terrestrial customer to MES messages;
- MES to terrestrial customer messages;
- MES to MES messages;
- distress messages from ship borne MESs;
- polling of individual or groups of MESs by a terrestrial customer;
- automatic data reports from MESs to terrestrial customers;
- broadcasting a message from a terrestrial customer to groups of MESs; this is known as *enhanced group call* (EGC).

INMARSAT-C System Infrastructure

The INMARSAT-C system infrastructure comprises primarily three entities: the *land earth station* (LES), *mobile earth station* (MES) and *network coordination station* (NCS).

The LES is the gateway between the MESs and terrestrial networks. Each ocean region is served by many LESs, which are owned and operated by competing service providers. All MESs in the region are free to choose the LES through which they wish to send their messages.

The system has been designed to make the MES as portable and low cost as possible. To meet this objective, omnidirectional antennas are used to avoid the need to track the location of the satellite; typical implementations are helical antennas about 280 mm high enclosed in conical radomes.

Each ocean region is served by one NCS, which provides the following functions:

- the allocation of shared resources within the region;
- broadcasting information to MESs relating to the LESs in that region;
- broadcasting poll commands and EGC messages to MESs;
- announcing shore-originated calls to MESs; and
- maintaining a global MES registration database.

The NCSs are owned by INMARSAT but operated on their behalf by a selected service provider in each region. Goonhilly operates the NCSs for the Atlantic Ocean East and West regions. INMARSAT also manages the global network from a network control centre (NCC) located at its headquarters in London. The NCC has links to each NCS which are used to monitor system performance, to download information about new MESs, and to change network configuration information.

Mobile terminal list

Each MES is required to log into an ocean region before it can send or receive any traffic. This is achieved by the MES transmitting a login packet to the NCS in that region. That NCS then updates its own database and relays the information to all other NCSs around the world. All NCSs relay the information to all LESs in their respective regions. The LES database is then used to decide whether or not to accept a call to a particular MES.

The login protocol is also used to ensure that MESs know what LESs are currently working in that region, the frequencies on which they operate and the services which they provide. The configuration is broadcast, by the NCS, to MESs in packets, known as *network update packets,* which include a version number. When an MES logs into the region, it indicates, to the NCS, the current network version held in its memory. The NCS then includes updated network configuration data in the login acknowledgment packet if the version held by the MES is no longer valid.

All MESs are required to pass a set of commissioning tests before they are permitted to enter the network. These tests are conducted fully automatically without the need for any manual intervention at either the NCS or LES. New MESs are added to the NCS database by the NCC with the MES in an uncommissioned state. That information is then distributed in the same manner as log-on information. When a new MES first attempts to log-on to an ocean region, the NCS automatically forces that MES to perform a series of performance tests through a particular LES.

Terrestrial Customer to Mobile Terminal Services

The LES supports a range of services that can be accessed through either the public switched Telex network, public switched telephone network (PSTN) or packet switched data network as depicted in Figure 2. For billing and customer authentication reasons, these services are divided into those available to the general public and those available to registered customers.

Public access

This form of access is only allowed from the Telex network. Customers of the worldwide Telex network can send single address messages to MESs by dialling the country code for the ocean region in which that MES is located followed by the MES number. The call is then established through the international Telex network to an LES that serves the called ocean region.

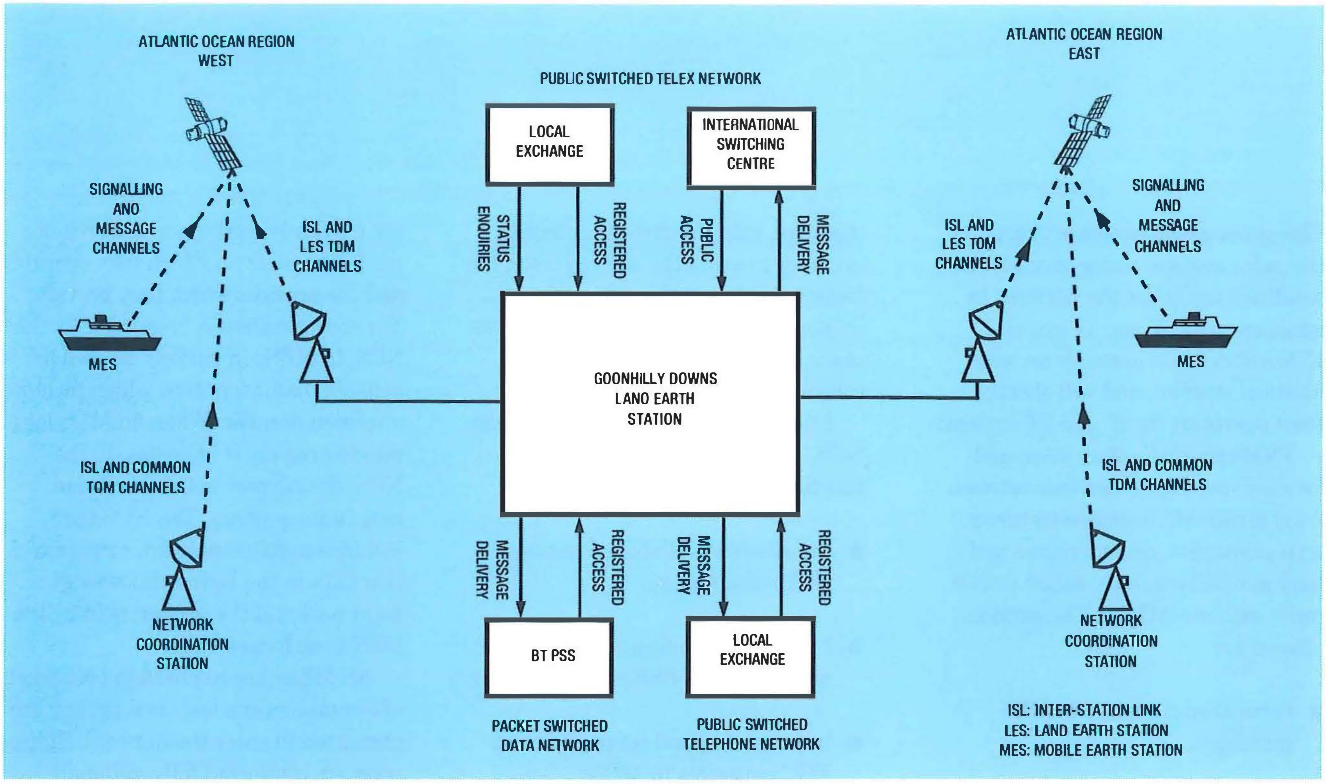


Figure 2—The service access points of the land earth station at Goonhilly

That LES then checks that the MES is logged into that region before accepting the message. The procedures for such access have been agreed internationally and are defined in CCITT Recommendations F.127 and U.208[5, 6].

Registered access

This form of access is available only to customers who have previously entered into an agreement to use the enhanced services described below. Customers first dial their nominated LES and, when connected, enter their user name and personal identification number (PIN). Having gained access to the LES, the customer can then select the required service from one of the following:

Multi-address messages

Instead of just one MES, registered customers can specify up to 20 MESs for each message entered. The LES then attempts to deliver the message to each of the MESs a number of times at predefined intervals until the calls are accepted. The customer can also specify the time that delivery of the messages should start as well as limit the time during which the message delivery will be attempted.

Enhanced group call (EGC)

This is a broadcast facility which encompasses a number of different services grouped into two types called *Fleetnet* and *Safetynet*. Fleetnet services are used by authorised commercial information providers, including fleet owners and operators, to enable them to broadcast to groups of MESs. Safetynet services are restricted to customers that have been authorised by the International Maritime Organisation (IMO), under the global maritime distress and safety system (GMDSS), to distribute maritime safety information (MSI) to MESs. The messages can be addressed to either predefined groups of MESs, all MESs in a geographical area, or an individual MES. At the time of message input, the customer selects the number of times, and interval, that the EGC message should be broadcast. Safetynet customers also have the capability to set the priority of the message to either routine, urgent, safety or distress.

Polling and data reporting

Customers can issue poll commands to a group of MESs to elicit information from them in the form of preformatted reports, known as *data reports*. MESs have group addresses downloaded into them from LESs known as *data network identities* (DNIDs). The poll can then be addressed to the whole DNID group, an individual member of the group or all members of the group within a geographical area. On receiving the data reports, the LES either forwards them directly to the terrestrial customer or into a file held at the LES for that customer. This file can then be either retrieved by the shore-based customer or automatically delivered at intervals defined by that customer. Poll commands are also available which enable the customer to establish regular reports from MESs at a required interval. MESs may also initiate data reports, without having received a further poll command, to the LES through which the DNID was downloaded.

Mobile Terminal to Terrestrial Customer Services

The services available to mobile terminal customers are as follows:

Multi-address messages

MESs can send a message to a maximum of 20 different addresses on any network connected to the called LES, but all the addresses have to be on the same terrestrial network.

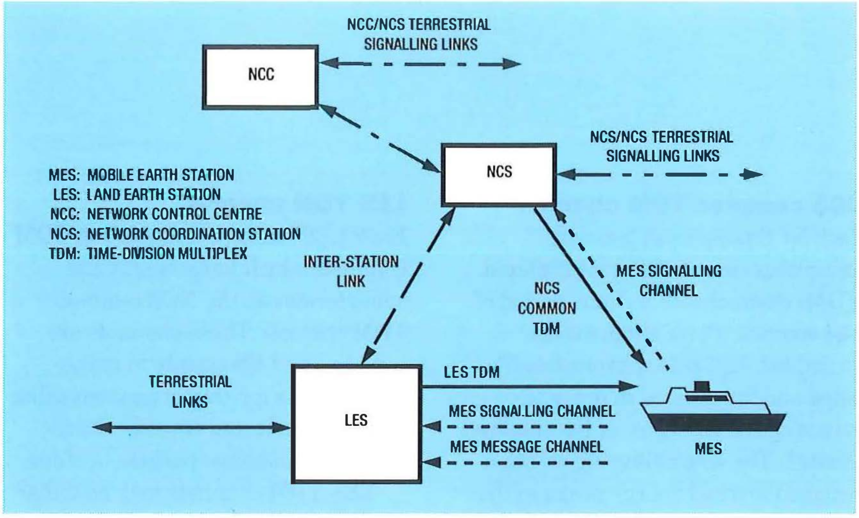


Figure 3—Communication channels in the INMARSAT-C system

Short-code addressing
The system also supports short-code addressing for value-added services supported through the LES. Typical value-added services supported by the LES at Goonhilly are phone text, providing a facility for customers to deposit their message at a bureau, which then calls the destination by phone and reads the message to the recipient; and Telex letters, where messages addressed to this service are forwarded to the addressee by post. A number of special services are also available through short-code access which the customers may use in case of difficulty such as medical advice, medical assistance and technical assistance.

Data reporting
This service is linked to the polling service as described above. MESs may also address a message to the LES by using a DNID number. This message will then be treated as a data report and either delivered to the called customer or stored in his/her DNID file.

Distress priority messages
Distress priority messages are also available to maritime MESs which are automatically routed to the nearest maritime rescue coordination centre (MRCC), which is Falmouth Coast Guard in the case of Goonhilly. These messages are automatically routed to an alternative address, in addition to a fast retry scheme, if the delivery attempt fails. Distress priority messages also raise alarms in the LES indicating the progress of the message.

Maritime distress alerting
Maritime MESs can initiate a short, coded, message on a signalling channel known as a *distress alert*. The LES decodes the message and then forwards it to the MRCC in the same way as a distress message. The alert provides information such as the course, speed, location and nature of distress and is used for safety of life at sea purposes. As this service is intended for emergency situations at sea, land mobile terminals do not support this service.

Land mobile alerting
This provides a service similar to maritime distress alerting, for use by land mobile customers, but with some important differences. These alerts do not have distress priority, over the satellite, for two main reasons. Firstly, to avoid this service jeopardising the efficiency of the maritime distress alerts and secondly because there is no internationally recognised definition of distress in a land mobile environment. Each fleet operator will require the alerts to be routed to its own emergency coordination centre. To meet this requirement, the decoded messages are delivered to an address held in the LES database for each MES.

General Services

The following services are available to all customers:

Delivery notification
If the LES is unable to deliver a message to an address, it automatically returns a non-delivery notification (NDN) to the originator of the message giving the reason. The address used for the NDN is derived from the originating Telex answerback for unregistered customers, an internal database for registered customers, or the originating MES number. Customers can also request, on a per-message basis, confirmation that the message has been delivered to the addressee.

Status enquiries
The LES maintains status information for all messages for 72 hours which can be accessed by the message originators. Public access customers access the LES via a special Telex route dedicated for this purpose, whereas registered access customers can use the service through their normal access point. MES customers are restricted to requesting the status of one message at a time, but terrestrial customers can also request the status of all messages within a given date/time range or a message reference number range.

Communication Channels

The INMARSAT-C system has several different communication channels as shown in Figure 3. The structure and use of each of those channels are described below.

Inter-station links (ISLs)
Each LES communicates with the NCS serving that region via a satellite channel employing differentially encoded binary phase-shift keying (BPSK) modulation at 1200 bit/s. The link layer protocol used over these channels is CCITT X.25. Various signalling packets of fixed format but variable length are exchanged over these links. Each packet has a header describing the packet type, length and priority followed by the information and ended with a cyclic redundancy checksum. The four NCSs are also fully interconnected via terrestrial X.25 links, running at 9600 bit/s, which are used to distribute MES registration information.

NCS common TDM channel

Each NCS radiates at least one continuous time-division multiplexed (TDM) channel with a frame period of 8·64 seconds. These channels are scrambled, half-rate convolutionally coded and interleaved in order to maximise the efficiency of the satellite channel. The scrambling algorithm is designed to avoid energy peaks in the radio-frequency spectrum radiated to the satellite, the convolutional code provides forward error correction and the interleaving spreads the data in time to reduce errors that could arise due to fades in the signal arising from multipath effects. Unfiltered BPSK modulation at a rate of 1200 bit/s is employed.

At the start of each frame there is a bulletin board packet which indicates the type of channel (for example, NCS, LES, standby NCS), its current operational state and any associated signalling channel frequencies. The bulletin board has to include the type of channel as all TDM channels in the system have an identical format. Immediately after the bulletin board there are signalling channel descriptor packets which give information on the state of all of the signalling channel slots associated with that TDM channel. The remainder of the frame is then used for information packets which have the same format as the packets used over the ISL.

The NCS common TDM channel is used to communicate to all MESs when they are idle. All terrestrial originated call announcements, EGC messages and poll commands are broadcast on the common TDM channel having first been received from an LES on the ISL. The NCS also transmits system information on this channel such as network update packets which inform the MESs which LESs are in the region, the frequencies on which they operate and the services supported. Currently, the NCSs only radiate a single common TDM channel but the protocols allow for the case when more than one channel is required.

LES TDM channel

Each LES radiates a number of TDM channels which have exactly the same format as the NCS common TDM channel. These channels are used by the LES mainly to make assignments for ship originated calls, clear channels and transfer shore-originated message packets to ships.

LES TDM channels may be either permanently assigned to each LES, or demand assigned by the NCS upon request from the LES. The system is currently working with one TDM permanently assigned to each LES.

MES signalling channel

Every LES and NCS TDM channel has a number of MES signalling channels associated with it. These channels operate in a combination of slotted alloha and reserved access mode. The LES informs the MES of the state of each slot as either reserved, burst received or burst not received through the slot state marker packets on the TDM channel. There are 28 slots synchronised to the start of the TDM frame and each slot contains a fixed format packet with 12 bytes of information in it. The data is scrambled, half-rate convolutionally encoded and unfiltered BPSK modulated at 1200 bit/s. These channels are not interleaved and in order to maximise the channel capacity these bursts do not have the preamble used by the message channel to aid acquisition.

These channels are mainly used by the MESs to initiate calls, log into an ocean region, send distress and land mobile alerts, respond to announcements and send data reports. Data reports may be up to three packets long, containing up to 32 bytes of user data, which are transmitted in the same slot position in successive frames. Due to the satellite and processing delay successive frames may be two or three TDM frames apart depending on the location of the LES and the slot in the frame.

MES message channel

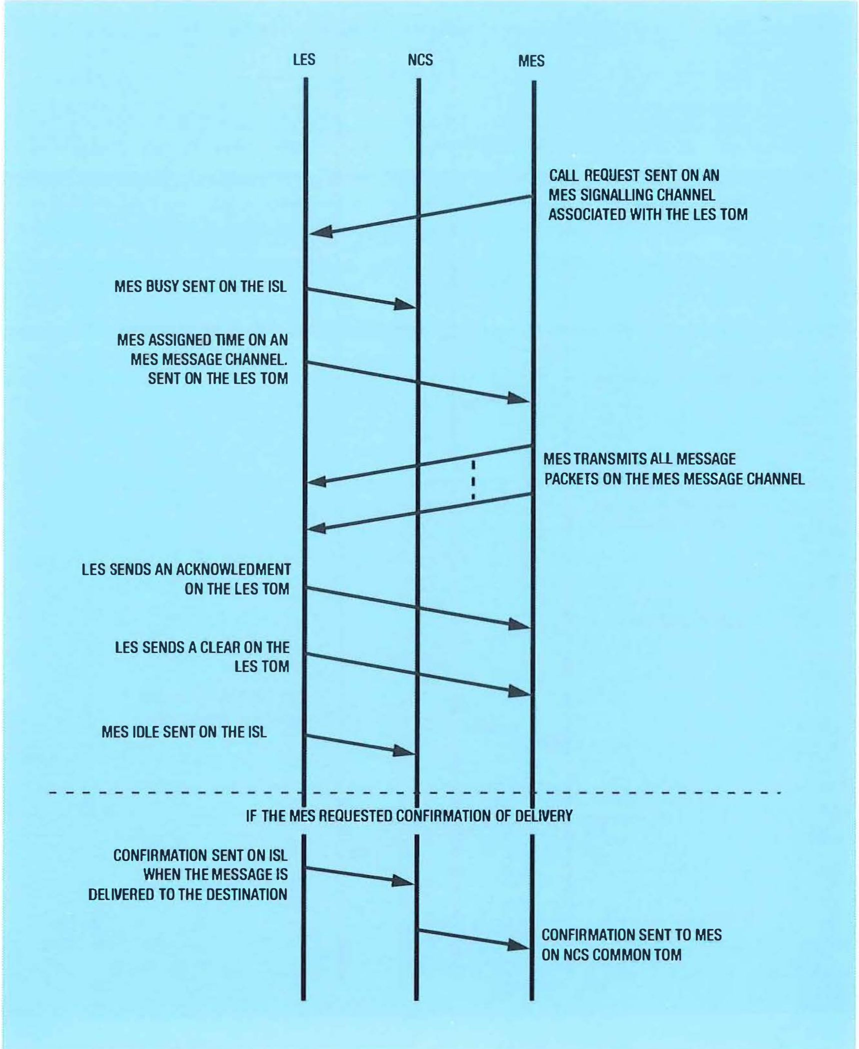
These channels are associated with LES TDM channels, but not NCS common TDM channels, and are used by the MES to transfer messages to an LES. The channels are operated in a quasi-TDM mode with the use of the channel allocated to MESs on a demand assigned basis by the LES. This is achieved by the LES assigning to the MES a frequency, the transmission start time and a TDM frame length. The MES then transmits the entire message to the LES starting at the assigned time with the message data contained in a number of frames. Each frame is further subdivided into 1 to 5 packets each containing 127 bytes of information. As in the case of TDM channels, these channels are scrambled, half-rate convolutionally encoded, interleaved and unfiltered BPSK modulated at a rate of 1200 bit/s. The interleave block is variable and the same size as the frame. A 192 bit preamble is added to the transmission to aid carrier and clock recovery at the LES.

Mobile Terminal to Terrestrial Customer Message Transfer

The transactions that take place over the satellite in order to transfer a message from an MES to the LES are depicted in Figure 4.

When the MES has formatted a message in its memory, the MES operator selects the LES through which the call should be made. The MES tunes to the LES TDM, decodes the bulletin board to ensure that the required service is supported and transmits an assignment request in a free slot on an MES signalling channel associated with that LES TDM carrier. The request states, inter alia, the network to which the call is directed, the destination country and the size of the message. If the LES accepts the call, it assigns the MES the required time on one of its associated MES message channels and informs the NCS that the MES is busy. The MES tunes to the assigned MES message channel and then transmits the entire message commencing at the time allocated by

Figure 4—MES to LES message transfer



the LES. Each message packet is checked for errors via a cyclic redundancy checksum at the end of the packet. Any packets received in error are requested to be transmitted again. When all packets have been received error free, the LES transmits a clear packet to the MES followed, after a delay, by an MES idle message to the NCS. The delay is to allow the MES time to tune back to the common TDM channel.

The full network address(es) is contained in header information in the message. This header is also used to indicate the alphabet (ITA2, IA5 or data) used for the message, as well as to request confirmation of delivery for the message. If the MES had requested a delivery confirmation, the LES will send a confirmation packet to the MES after the message has been successfully delivered to the terrestrial customer. The confirmation packet is transmitted to the NCS via the ISL which then relays the packet to the MES on the common TDM channel.

The message delivery procedures to the terrestrial networks vary depending on the network used. Essentially, the LES sets up a call in the same way as a terrestrial customer would make a normal call. The LES then sends header information indicating the identity of the LES followed by the message reference number, the MES number which originated the message and the date and time. The LES then transmits the message and clears the call.

Terrestrial Customer to Mobile Terminal Message Transfer

The procedures for sending a message to the LES depend on the terrestrial network used to access the LES and whether or not the customer has registered with that LES. The registered access method of sending a message has not been subject to international agreement and is LES dependent. Public access has been defined so that it looks very similar to a normal Telex call, except that after the initial answerback exchange, the LES returns a short header followed by a go-ahead prompt. This article concentrates on the transactions that take place over the satellite as depicted in Figure 5.

When the LES has received a complete message for transmission, it sends an MES status request and announcement packet to the NCS via the ISL. If the MES is idle, the NCS then relays the announcement to the called MES, via the common TDM channel, and returns the MES status to the LES, via the ISL. The announcement informs the MES, inter alia, which LES is making the call and the TDM channel on which the message will be transmitted. The MES tunes to the assigned TDM channel, selects a free slot on an associated MES signalling channel and transmits an assignment response to the LES. On receipt of the assignment response, the LES transmits an MES busy packet to the NCS, via the ISL, and the message packets to the MES, via the TDM channel. Upon completion of the transmission of message packet transmission, the LES requests the MES to acknowledge correct receipt of those packets. Packets received in error are retransmitted. When the complete message has been correctly received, the LES transmits a clear packet to the MES on the TDM channel followed, after a delay, by an MES idle message to the NCS.

Land Earth Station

The LES comprises a complete satellite earth terminal which transmits and receives signals to the satellite at SHF frequencies and interfaces the terrestrial networks at baseband. The radio-frequency equipment and antenna system are fairly typical of satellite earth stations; the equipment utilised for access to the Atlantic Ocean Region West has previously been described in an earlier article[1]. The remainder of the LES is contained within a subsystem known

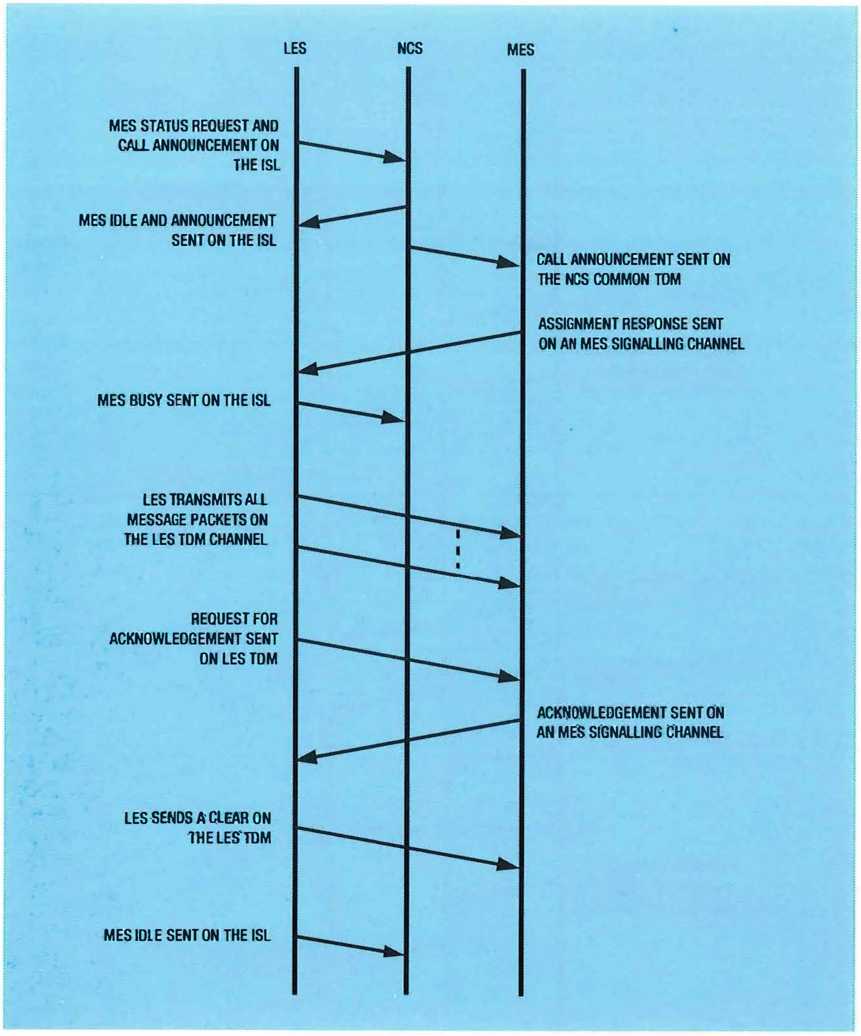


Figure 5—LES to MES message transfer

as the *access control and signalling equipment* (ACSE). A photograph of the ACSE is shown in Figure 6.

The ACSE has been implemented as a central computer controlling two front-end processor (FEP) groups via a duplicated Ethernet LAN as shown in Figure 7. The central computer is a fault tolerant system running with a mirrored disc pair known as the *host*. The other two computing groups are the satellite channel unit group and terrestrial interface group. The FEPs are based around the manufacturer's own CPU card, which is common to all units; this simplifies the design and aids maintenance of the equipment.

The host computer controls call set up, supervises the system and performs the message handling and call data functions of the ACSE. It also gathers the statistics for the system and automatically generates a variety of reports relating to system performance, message throughput and call failure reasons. The FEPs perform the interface to various external connections of the ACSE and present the information to the host in a consistent manner. They also perform all of the low level protocols required for each circuit type.

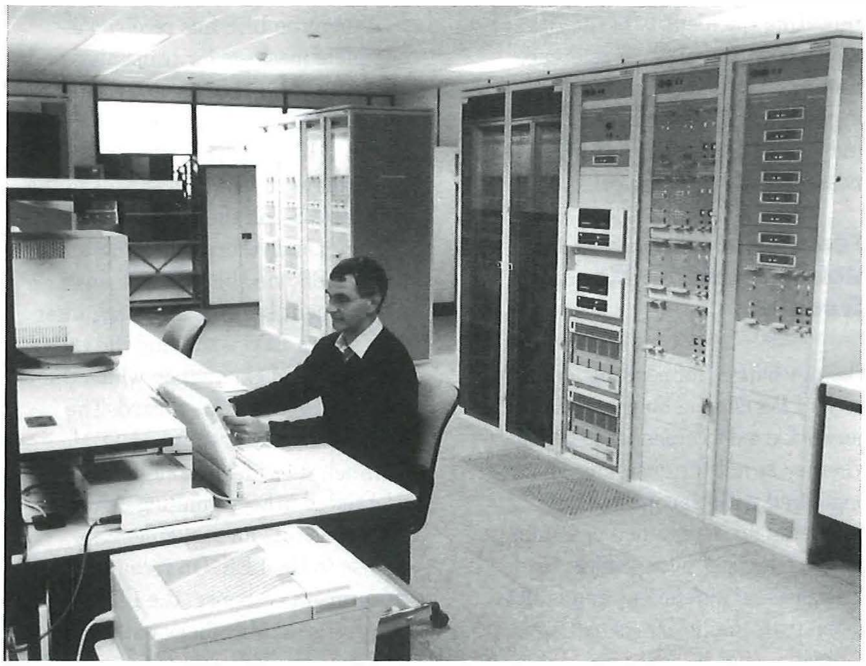
There are duplicated tape servers which control open reel magnetic tape drives which are used to generate billing tapes, data archive tapes and INMARSAT call data record tapes. The INMARSAT tapes are required to present them with information on satellite usage for accounting and statistical purposes.

The operational staff control the ACSE from one of two identical workstations connected to the LAN. One is located with the equipment and the second at a central control area where all of the satellite mobile systems are monitored and controlled outside of normal working hours. The operator's interface has been designed around a menu driven system with copious on-line help facilities.

Inherent in the ACSE design are a number of trace functions which can be set to help debug the system. These can be used to monitor information transfer between the various processes in the system. Each of the FEPs also has front panel connectors where it is possible to connect a dumb terminal to monitor the activity and status of that device as well as initiate test calls.

Two MESs have also been provided at Goonhilly, one in each ocean region, in order to allow the operational staff to test the system. They are both

Figure 6—Access control and signalling equipment



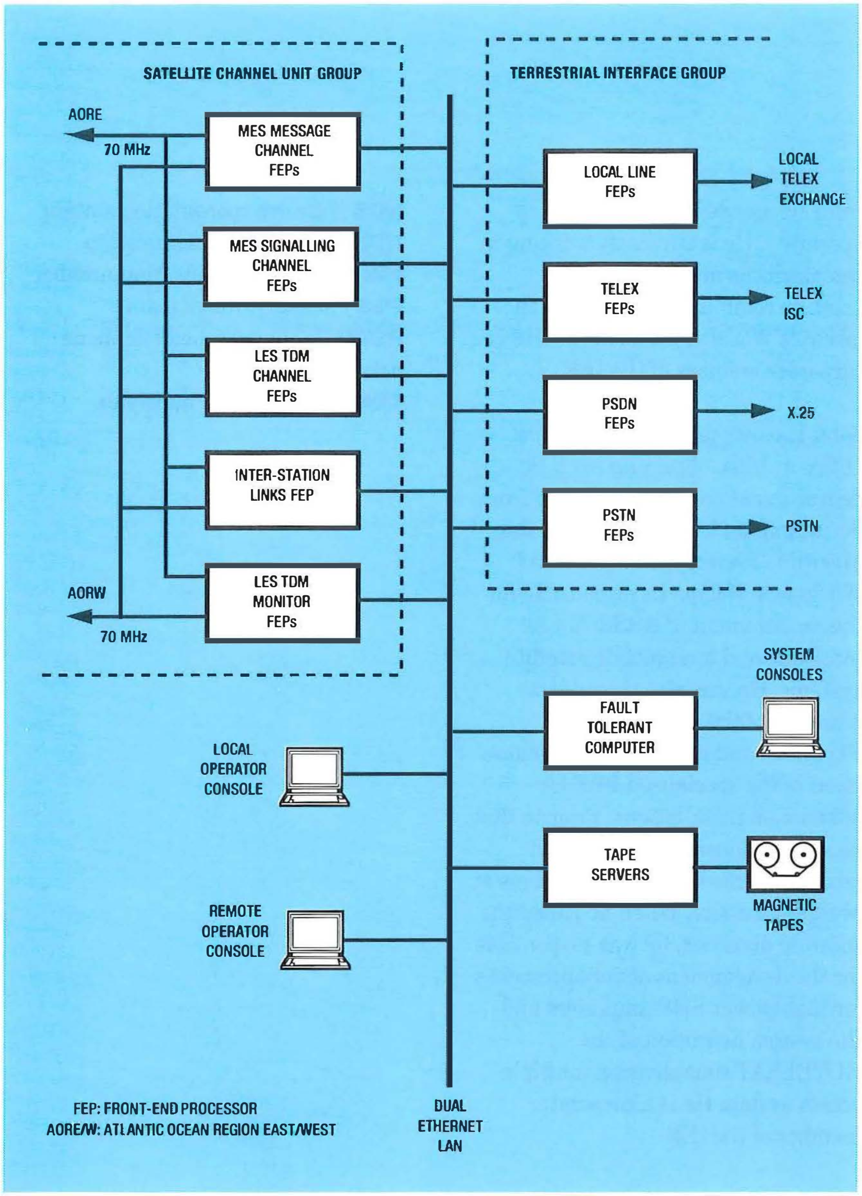


Figure 7—ACSE block diagram

standard terminals with their antennas located on the roof of the ACSE building. The MESs are also capable of some special test functions which facilitate the monitoring of signalling packets over the satellite as well as generating special packets.

Terrestrial access interfaces

Public access for message transfer is routed to the LES via international Telex trunks. This is because the bills for these calls are generated in the originating country so the call must be routed to a country code with a tariff which reflects the use of the satellite circuits.

Registered access to the LES is via local exchange lines from either the Telex, packet switched or telephone networks. This is because the bill for use of the satellite circuits is sent directly to the customer by the LES service provider. The PSTN interface supports either V.22 or V.22*bis* modems working at either 1200 or 2400 bit/s.

Messages for the packet switched network are all delivered via Packet SwitchStream (PSS) exchanges at Reading and Bristol. As there is no guaranteed error checking for calls delivered to the PSTN, the messages may be either delivered directly to the customer or deposited in a mailbox at the choice of the customer.

A special route from the local Telex exchange is reserved for public access customers to gain access to the LES for status enquiries without occupying the circuits for registered customers.

Future Trends

Currently, over 4000 MESs are in operation worldwide, about two thirds being maritime terminals. These MESs generate some 200 000 messages per month. The rate of growth of MESs is about 50 per month, and the traffic is doubling in a year. Ultimately, INMARSAT expects to have up to 500 000 MESs in the system.

Several enhancements are being considered for the INMARSAT-C system and the LES, including the following:

- A CCITT X.400 interface is planned for the LES at Goonhilly, which will support the interchange of messages directly with electronic mail systems.
- Although INMARSAT-C has been implemented purely for messages, INMARSAT has built into its system specification the capability of adding half- and full-duplex circuits in the future. These would enable real time communication between terminals with the penalty of keeping a satellite channel open for the whole call duration.
- INMARSAT is also considering the feasibility of adapting the system for use with aircraft.
- Encryption and data compression facilities are being planned to enhance security and increase the transmission efficiency.

The INMARSAT-C system is now firmly established in the maritime and land mobile market, with 13 LESs in operation and 35 models of MES approved by INMARSAT. It is proving to be popular with customers and profitable for manufacturers and operators. As time progresses, the applications for this system will proliferate, and the sight of an INMARSAT-C antenna on a lorry or boat will become ever more common.

Acknowledgements

The authors wish to express their thanks to INMARSAT for permission to publish the photograph in Figure 1.

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Biographies

Trevor Warry joined the then Post Office in 1980 as an Assistant Executive Engineer having gained a B.Sc. honours degree in Physics at London University Imperial College. He initially worked on the provision of the equipment to support the INMARSAT-A maritime mobile system at Goonhilly. He then developed the software for a specialised telephone branch exchange for use in communications with offshore oil platforms. In 1986, he worked on the early stages of the provision of BT's Skyphone system. From late-1987, he was the project manager for the provision of the INMARSAT-C ACSE from system definition through to operation. He is currently working in the maritime and land mobile satellite communication provision group of Worldwide Networks. He is a corporate member of the IEE.

John Hawkes joined the then Post Office in 1964, obtaining his B.Sc. degree in electronic engineering from Southampton University. He is the Maritime Projects Manager in BT Worldwide Networks responsible for the procurement of ACSEs for all maritime and land mobile satellite systems. He was also the project manager of the early stages of Skyphone and the software development of the specialised PBX for offshore oil installations. Prior to that he was responsible for the direct labour and clerk of works functions at Madley SES site. When he joined the satellite divisions, he was responsible for the development of enhancements for high-power SHF amplifiers and the system definition of the EUTELSAT time-division multiple-access system He is a corporate member of the IEE.

Glossary

ACSE Access control and signalling equipment
BPSK Binary phase shift keying
DNID Data network identity
EGC Enhanced group call
FEP Front-end processor
GMDSS Global maritime distress and safety system
IMO International maritime organisation
IA5 International Alphabet No. 5
ISC International switching centre
ISL Inter-station link
ITA2 International Telegraph Alphabet No. 2
LAN Local area network
LES Land earth station
MES Mobile earth station
MRCC Maritime rescue coordination centre
MSI Maritime safety information
NCC Network control centre
NCS Network coordination station
NDN Non-delivery notification
PIN Personal identification number
PSS Packet SwitchStream
PSTN Public switched telephone network
TDM Time-division multiplex

Edward A. Kessler

Improving Facsimile Performance for International Networks

This article outlines the important characteristics of facsimile transmission, discusses the factors which limit performance, and describes how new transmission techniques being introduced in the international network can result in both the improved use of transmission capacity and improved performance.

Introduction

Transmission of still pictures and photographs through the telephone network is something which has a long history, though early techniques[1] tended to be slow and cumbersome. The stage was reached in the late-1960s, where several companies had independently developed machines which were capable of giving quality which was limited primarily by the precision of the mechanical scanning process, and by the permissible transmission time, given that the means then available for image transmission would have required about six minutes for transmission of each page. However, in the early-1970s, the rapid advances in modem technology provided the opportunity for extensive standardisation of facsimile procedures and transmission formats to permit interworking between machines made by different manufacturers. This resulted in the definition by the CCITT of three different sets of facilities and transmission parameters for PSTN facsimile, known as *Group 1*, *Group 2* and *Group 3*. Group 3 is the most recently defined[2,3], the most widely used, and has the most comprehensive features for use on ordinary analogue networks. Group 4 facsimile provides even better features, but requires an integrated services digital network (ISDN) connection to do so.

The development of the facsimile service provides a good example of the advantages of standardisation, both to the potential user, and to manufacturers and telecommunications organisations. Users have benefited from facsimile's development from curiosity, through ubiquity to necessity: few indeed are the businesses which are not accessible by facsimile. Manufacturers have been active in the standards fora and have benefited from this in terms of greatly increased sales volumes. Growth in the domestic sector seems set to follow the fall in equipment prices which has resulted from this. In consequence, telecommunications organisations have benefited from increased call revenues. All of these benefits are directly attributable to good standardisation work, which has inspired confidence in the manufacturers.

On some international routes, it is known that over 20% of traffic is now facsimile. It therefore makes commercial sense for manufacturers and telecommunications organisations alike to do their utmost to ensure that users experience as few problems as possible, both in the interactions between facsimile machines, and in the interactions of the machines with other devices in the telephone network.

Facsimile Terminal Equipment

Most facsimile machines in use around the world are Group 3 machines, which use the exchange of 300 bit/s signals to convey the procedural messages (such as the facilities that each machine has available), and unidirectional signals at up to 9·6 kbit/s to convey the 'video' (in other words, the page content) information. The 300 bit/s messages

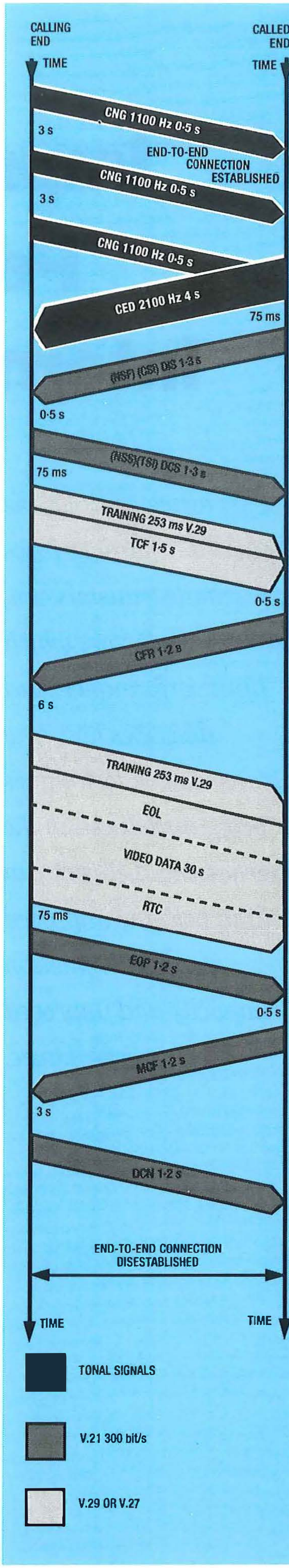


Figure 1—A message sequence chart for a single-page facsimile call

use the modulation scheme specified in CCITT Recommendation V.21[4] (upper channel only), whereas the video information is usually transmitted by using either the modulation schemes derived from CCITT Recommendation V.29[5], or V.27 *ter*[6]. In the start-up phase, facsimile machines use 1100 Hz calling tone (CNG), and 2100 Hz echo-control disabling tone.

In addition to the modulation and demodulation circuitry, facsimile machines usually incorporate some form of page-scanning mechanism, a processor to control the progress of the transmission, an image processor to apply data compression to transmitted images and decompression to received images, an image printer for reproduction of received images, and some form of display for indicating the machine status and any error messages. All but the cheapest machines usually also incorporate a keypad for dialling the distant machine, without having to plug a separate telephone into a socket on the machine.

There is an increasing tendency towards integration of facsimile functions within other types of equipment. For example, facsimile modem cards are now widely available and may be fitted into the expansion slots of personal computers. This has had the important consequence of making available to computer users a cheap means of image transmission without the quality degradation associated with scanning an intermediate image on paper; file conversion utilities permit popular word processing and drawing packages to produce facsimile images for transmission. A further consequence has been the use of special communications software with the facsimile card for computer-to-computer file transfer, rather than transfer of images.

Facsimile Transmission Format

A typical single-page facsimile call would have the sequence of signals shown in Figure 1. (The timings shown in Figure 1 are typical of those actually used by many facsimile machines and illustrate some deviations from those laid down in the standards.)

Initially, the facsimile machine instigating the call goes to the OFF HOOK state, and on receiving dial tone, sends the required multi-frequency or loop-disconnect digits to set up the path through the telephone network (PSTN) to the distant facsimile machine. The calling facsimile machine then starts sending the CNG signal which consists of 0·5 s bursts of 1100 Hz tone punctuated by 3·0 s pauses. When the connection has been set up, and the called machine has had sufficient time to recognise the presence of the CNG signal, it responds with a long (2·6 to 4 s) burst of 2100 Hz *echo control disabling* (CED) tone. On international calls, this ensures that any echo-control devices present in either direction of transmission will be disabled until there is a pause in both directions of transmission of more than 100 ms. If digital circuit multiplication equipment (DCME) is in use, then at this stage it will identify the call as a voiceband data call, and will allocate a channel which provides the improved signal-to-quantisation distortion and freedom from clipping which such calls require[7]. At this stage, the calling and the called machines are ready to commence a handshaking procedure in order to agree the facilities and transmission options to be used.

Before the echo control can be re-enabled, the called machine commences the handshaking procedure by sending a 300 bit/s *digital identification signal* (DIS), which indicates the facilities which it has available. Within the same burst of data it may also send a *non-standard facilities* (NSF) message, which enables a superset of facilities to be used if both calling and called machine have the same manufacturer, and *called subscriber identification* (CSI) which contains the telephone number of the called machine (provided that the machine's operator has entered it).

There is then a pause of approximately 0·5 s, during which, on an international call, any echo-control devices in the circuit will be re-enabled, but the voiceband data state previously applied by any DCME present is maintained.

The calling machine responds with the *digital command signal* (DCS), confirming which of the facilities indicated in the DIS message will be used. Within this burst of data, a *non-standard facilities setup* (NSS) response to the NSF message may be sent if the machines are capable of interworking with a superset of facilities. The *transmitting subscriber identification* (TSI) may also be sent if the telephone number of the calling machine has been stored.

At this stage, all necessary decisions have been taken by both machines, with the important exception of the choice of video modulation and rate. This choice is made by attempting to transfer information at the highest available rate that both machines support, and then, if performance is not adequate, stepping down to a lower rate which the circuit is capable of supporting.

It is particularly important that this phase of the call is protected against initial clipping by echo-control devices to enable advantage to be taken of the full information transfer rate of the circuit. Manufacturers vary in their approach to this, some preferring to rely on careful choice of intervals between signals, whereas others prefer to use guard tones.

The calling machine commences by sending a known pattern of bits that can be used by the called machine to select the optimum adjustment of its adaptive equaliser. This is referred to as the *training sequence*. It is followed by a *training check frame* (TCF), which is correlated with a sequence in the called machine and used to give an initial indication of whether the error performance is acceptable at that data rate. If it is acceptable, the called machine responds after about 0·5 s with a *confirmation to receive* (CFR) message. If performance is unacceptable, the called machine may respond with *failure to train* (FTT), which after it has been received a predetermined number of times, may result in call failure.

Precise actions will depend upon the calling and called machine characteristics, and how many attempts have been made. Generally, the first data rate attempted is 9·6 kbit/s, with fall-back rates being 7·2 kbit/s, 4·8 kbit/s, and 2·4 kbit/s.

After a few hundred milliseconds' pause to allow for paper handling, the calling machine repeats the training sequence for the bit rate finally agreed, but instead of transmitting TCF immediately afterwards, transmits an *end of line* (EOL) character to indicate the start of page information, then the encoded video information. Various data reduction techniques are used to ensure that maximum advantage is gained from long runs of consecutive black or white picture elements within a single line or between adjacent scan lines. Each scan line is terminated by an EOL character, so that synchronisation is not lost in the presence of errors, and the effect is localised to one particular area of the page. When the end of the page is reached, the calling machine marks the end of the video by sending a *return to control* (RTC) message, which consists of six successive EOL characters. (This explanation assumes that error correction mode is not used.)

This is followed from the calling end within 55 to 95 ms by an *end of procedures* (EOP) message in the case of a single-page transmission or a *multipage signal* (MPS), if there is another page to follow. After about 0·5 s, the called machine acknowledges the receipt of either message with a *message confirmation* (MCF) signal. If there are no more pages, the calling machine responds with a *disconnect* message (DCN) and returns to the ON HOOK state. During this last phase of the call, echo control, if present, would have been enabled; this is acceptable because the 300 bit/s message exchange is well protected against clipping. It is also quite robust to adaptive differential pulse-code modulation (ADPCM) encoding. However, the pauses in transmission are not sufficiently long for the voiceband data state to expire in any DCME used in the connection. This is done deliberately, in order to protect the more fragile high-speed signals—the training and video—from the possibility of corruption.

Optional Facsimile Features

Manufacturers are able to choose from among the facilities specified by the CCITT. However, for leading-edge products, for example those providing superfine resolution or colour, they are able to make use of the NSF/NSS exchange of messages to set up communication with those machines (generally from the same manufacturer) which are compatible.

Some CCITT specified facilities which are of interest include error-correction mode (which divides the video information into 64 kbit blocks of 256 byte frames, each of which is subject to error checking and retransmission procedures), polling mode (for which the called machine transmits the page data) and higher transmission speeds[8].

Factors Affecting Facsimile Quality and Performance

There are three ways in which facsimile calls may be affected in traversing the network:

- one or more of the procedural signals may be so badly mutilated that premature call termination occurs;
- it may be impossible to train at the first bit rate attempted, so that the call falls back to a slower rate; or
- training may be successful, but the received pages may contain errors.

Corruption of procedural messages may occur due to noise or crosstalk in the local or trunk network (or indeed in the customer's premises—proximity of fluorescent light cabling or dimmer switches is often a cause). In the international network, this problem may occur due to misoperation of echo-control devices or gross overload of DCME[7].

Retraining to a lower bit rate for the video information may occur due to the fact that a better signal-to-noise ratio is required for acceptable demodulation of high-speed signals. The V.29 modulation method for 9·6 and 7·2 kbit/s transmission uses a combination of amplitude and phase modulation in order to transmit at a baud rate of only 2400 symbols/s. A single phase and amplitude state (or the change from one state to another) must therefore represent several bits, four in the case of the V.29 9·6 kbit/s modulation. The phase/amplitude states diagram for a particular type of modulation is referred to as the *constellation*. The constellation for V.29 modulation is shown in Figure 2.

Since, in practice, the permissible phase and amplitude changes between states are limited, it follows that for high data rates, the states of the constellation must be closely packed. A consequence is that higher data rates are more vulnerable, both to amplitude and phase noise, and to other effects such as channel-filter ringing non-linearity. Impairment of signal-to-noise ratio could occur at any point in the connection, and the effects are not necessarily strictly additive. The result is that the constellation at the receiving machine would not have clearly defined points for each phase/amplitude state (see Figure 3).

When the density of points in the constellation is so high that they can no longer be individually resolved at the receiving machine with a given set of channel impairments, the use of a lower data rate will sometimes cure the problem.

Errors in the images on the received pages have a similar cause to errors in the training phase of the transmission, but the degradation is not sufficiently severe (or sufficiently frequent) to have an adverse effect on training. Facsimile machines which use error-correction mode will give significantly better image quality under these conditions, but will have longer transmission times because of the retransmission of errored frames.

Reduction of Degradation Effects for International Calls

Facsimile traffic presents the operators of international networks with two problems:

- how to maintain quality on long international connections; and
- how to keep per-circuit costs for facsimile calls down to the same level as for voice calls, where DCMEs are used to reduce capacity requirements.

Fortunately, the same answer can be given to both questions—the

Figure 2—The amplitude and phase states diagram (constellation) for a V.29 modem at 9·6 kbit/s

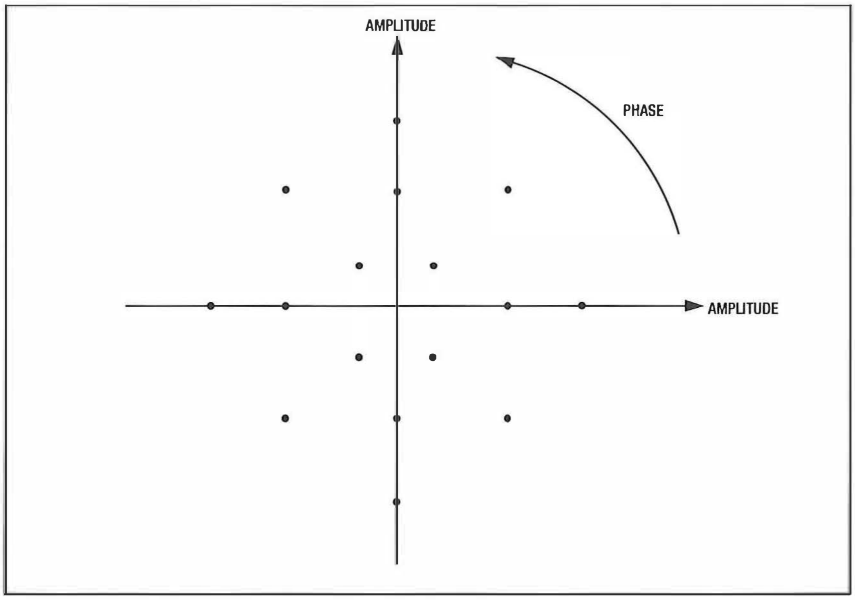
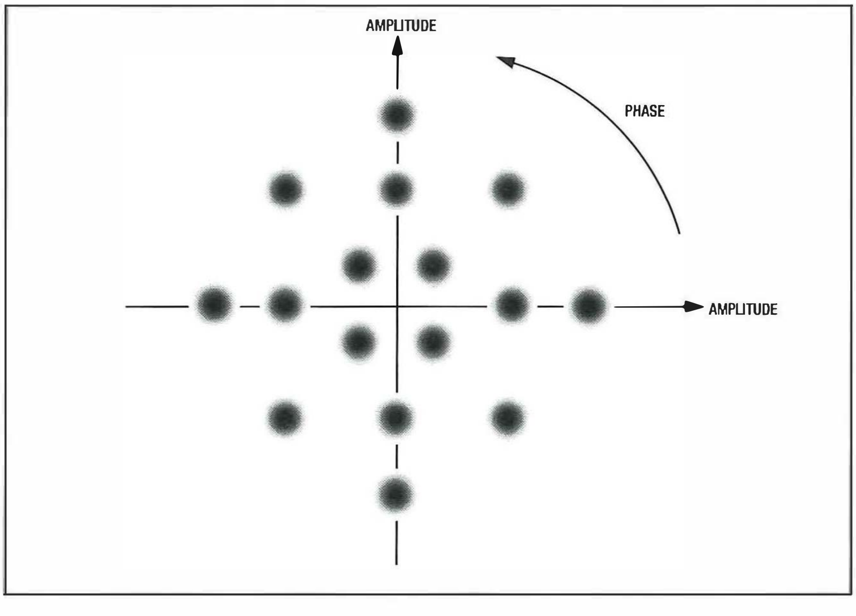


Figure 3—Effects of circuit degradations on the V.29 constellation



facsimile data is demodulated to baseband for transmission in digital form at its basic data rate through the international network. This technique is referred to as *facsimile compression*, and its use in association with DCMEs is being standardised by the CCITT[9]. (This is not to be confused with *facsimile image compression* as defined in CCITT Recommendation T.4.) The location of the facsimile compression equipment in an international connection is shown in Figure 4.

Facsimile compression provides the following advantages:

- It isolates the impairments of the two local loops; the facsimile signal is regenerated, so that impairments do not accumulate.

- Performance in the presence of echo-control devices may be improved, because the presence of facsimile compression at the 4-wire point eliminates far-end echo[10].

- The digital path between the two facsimile compression devices can be provided with forward-error correction (FEC), thereby eliminating another possible source of degradation.

- Incorporation of facsimile compression in DCME eliminates the reduction in DCME gain[7] which otherwise occurs due to the high activity factor of facsimile calls.

- Degradations which might occur due to tandem operation of ADPCM (when switched transit calls are carried by DCMEs) are unlikely to be a problem.

Structure of a Facsimile Compression Equipment Module

The block diagram of the facsimile compression module associated with a DCME is shown in Figure 5. It comprises the following:

- a demodulator/analysis block, which demodulates the modulated signals, and may analyse and classify them according to waveform;

- a front-end delay buffer, which provides time for signal analysis and validation;

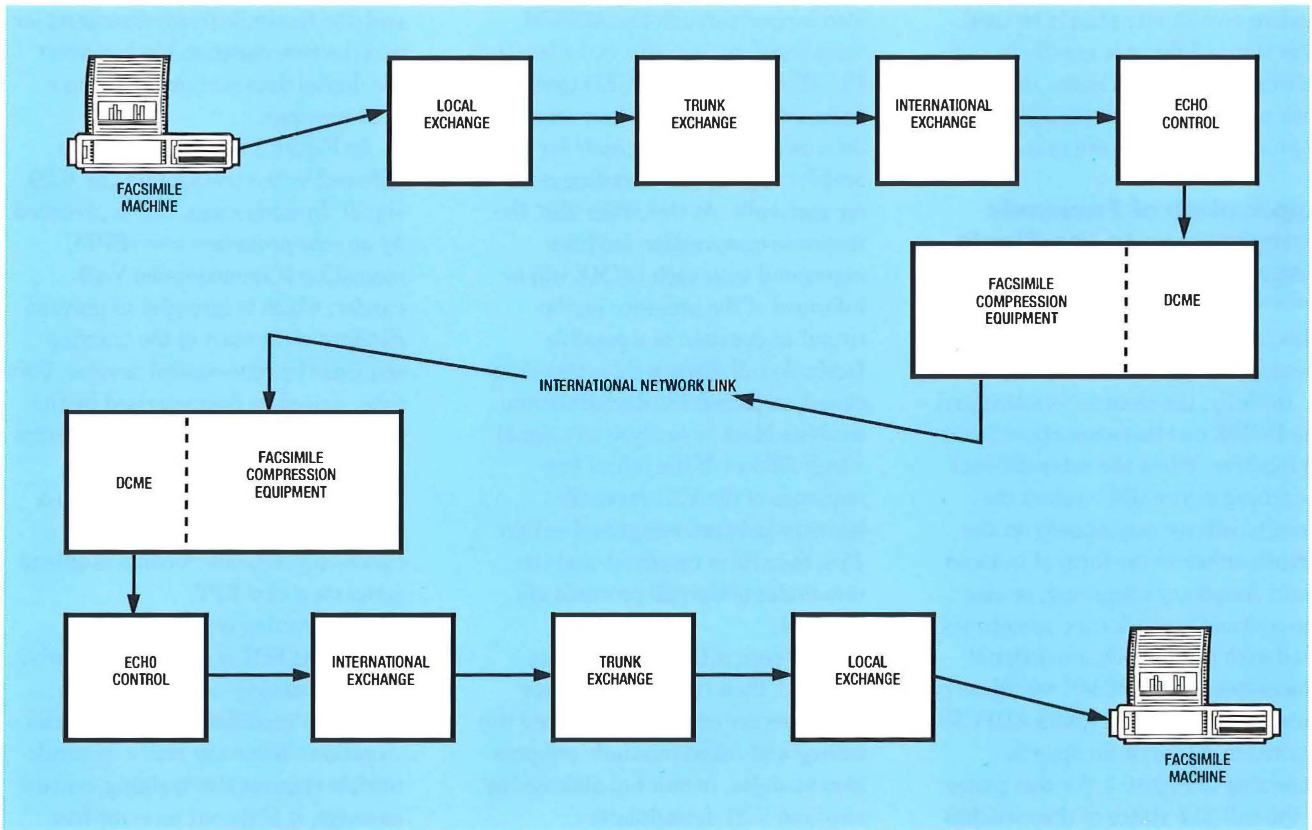
- facsimile frame assembler and disassembler blocks, which format the digital information for transmission on the link between the facsimile compression modules;

- a remodulator block, which regenerates the voiceband signal for retransmission to the receiving facsimile machine; and

- a facsimile module controller, which oversees the operation of each block and interacts with the DCME.

Two different approaches to facsimile compression are possible:

Figure 4—Location of facsimile compression equipment in an international connection



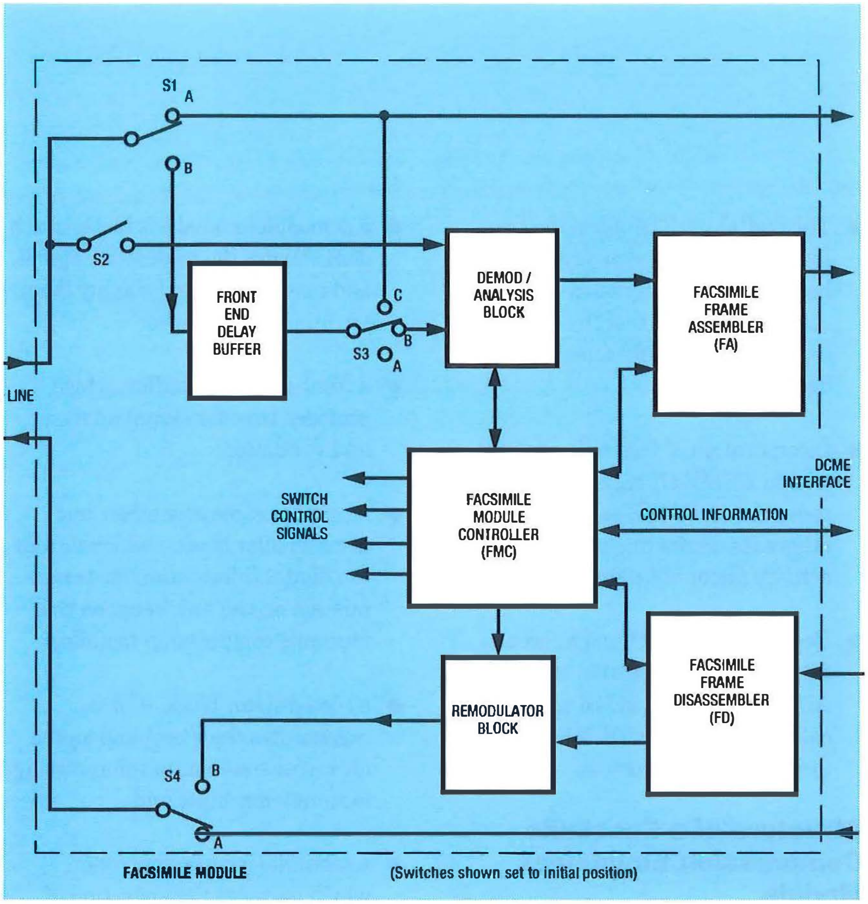


Figure 5—Structure of a facsimile compression equipment module

either the protocol exchanges can be demodulated and used to determine the progress of the call, so that the correct high-speed signals may be selected, or the signal waveforms may be analysed in order to determine without prior knowledge which modem and bit rate should be used. This subtle difference results in some differences in the decisions reached at each phase of the call, though the two approaches can be made to interwork.

Application of Facsimile Compression to the Single-Page Facsimile Call

This example assumes the use of protocol analysis.

Initially, the channel is silent and the DCME has therefore classified it as inactive. When the international switching centre (ISC) seizes the circuit, activity may appear on the circuit, either in the form of in-band multi-frequency signalling, or else the continuity check tone sometimes used with common-channel signalling systems. The DCME would carry these by using the 32 kbit/s ADPCM algorithm intended for speech. Referring to Figure 5, for this phase of the call, the states of the switches are: S1 = A, S2 = open, S3 = B and S4 = A, for each facsimile module.

After the completion of dialling, the calling facsimile machine starts sending CNG, as shown in Figure 1, and eventually receives CED in response. Both of these signals are also carried through the ADPCM voice encoding initially, but when the DCME recognises the CED tone, it reclassifies it as an active voiceband data call, so that the remainder of the activity is given the encoding reserved for such calls. At this stage also, the facsimile compression modules associated with each DCME will be informed of the presence on the circuit in question of a possible facsimile call. Switch S2 is therefore closed, to permit the demodulation/analysis block to analyse any signal which follows. If the initial flag sequence of the V.21 facsimile handshake is not recognised within 15 s, then S2 is reopened, and the remainder of the call proceeds via ADPCM.

However, if the V.21 flags are detected, then resource allocation messages are exchanged between the calling and called facsimile compression modules, in order to allocate the required V.21 demodulators, remodulators and the digital transmission capacity between the DCMEs. If the resource allocation is confirmed, then the call can be set up through the demodulated path, during the pause which follows the DIS message (the DIS message itself is carried by the ADPCM path). Once this is complete, both facsimile compression modules are set to the facsimile mode by setting switches S1, S3 and S4 to position B.

When the calling-end demodulator/analysis block recognises a V.21 signal, it allocates a V.21 demodulator. The front-end delay buffer provides additional recognition time to prevent inappropriate demodulator allocation; for example, when certain fault conditions result in a signal of unanticipated bit rate occurring. The facsimile module controller sends control messages to the distant facsimile module controller, to cause the allocation of a V.21 remodulator. The facsimile frame assembler, meanwhile, formats the demodulated data stream for transmission via the digital channel between the DCMEs. At the called end, the facsimile frame disassembler and the remodulation block convert the digital data stream back into a V.21 message.

As Figure 1 illustrates, DCS is followed by the training for the V.29 signal. In some cases, this is preceded by an *echo protection tone* (EPT), consisting of unmodulated V.29 carrier, which is intended to prevent clipping of the start of the training sequence by echo-control devices. This tone, if used, is characterised by the calling-end facsimile module in terms of frequency, duration and level. These characteristics are put into a control message, from which the called-end facsimile module is able to generate a new EPT.

The training sequence which follows the EPT is handled similarly, but the 'training' control message content is 'modulation', 'bit rate' and 'duration'. When the called facsimile module receives the 'training' control message, it plays out an error-free training message; any impairments present on the original are not passed on.

The training sequence is followed by transmission of the TCF message through the demodulation-remodulation path, using the high-speed demodulator and remodulator.

On receipt of the TCF message, the called facsimile machine may send CFR, which is handled by the V.21 demodulation-remodulation path. It is at this stage that initial agreement is reached on the speed of transmission for the page data, since the CFR message is carried end-to-end to indicate that a particular bit-rate selection was successful.

The training sequence is then repeated, as a precursor to the page data, and is again handled by transmission of a control message and the generation of a new training sequence at the called facsimile module. The page data which follows is handled by the high-speed demodulation-remodulation path. When the end of the page is reached, the EOP message is sent through the V.21 demodulation-remodulation path. This is acknowledged by an MCF message, also through the V.21 demodulation-remodulation path, from the called facsimile machine.

The calling facsimile machine then sends a DCN message, which also passes through the V.21 demodulation-remodulation path. The calling-end facsimile module recognises the DCN message as the end of the call, and closes the demodulation path, by sending a control message to the called-end facsimile module. Both facsimile modules then deallocate their resources, and reset S1, S2, S3 and S4 to their initial positions, so that any subsequent activity is handled by the DCME using an appropriate ADPCM path.

Facsimile compression performance

Early results obtained in field trials of proprietary facsimile compression equipment show that many of the theoretical advantages can be realised in practice, particularly if the option of using FEC on the digital channel(s) between the facsimile modules is used. A comparison[11] between the performance of data-optimised ADPCM, 64 kbit/s clear channel, facsimile compression without FEC and facsimile compression with FEC showed that in overall performance terms, when the digital bearer system error performance is poor, facsimile compression with FEC offers a significant reduction in the number of errored scan lines and a significant improvement in transmission speed (that is, number of pages at maximum bit rate). In most respects, even without FEC, the overall performance was similar to a 64 kbit/s clear channel, and in some instances considerably better.

Conclusion

Facsimile compression offers great promise for improving facsimile quality and transmission rate. New facsimile machines using modulation schemes currently under development may offer bit rates greater than 19·2 kbit/s through the PSTN[12]. DCME with facsimile compression provides the means for the network to keep in step with improvements to terminal equipment through lower transmission costs and improved quality.

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Glossary

ADPCM Adaptive differential pulse-code modulation
CCITT International Telephone and Telegraph Consultative Committee

CED Echo control disabling
CFR Confirmation to receive
CNG Calling tone
CSI Called subscriber identification
DCN Disconnect
DCME Digital circuit multiplication equipment
DCS Digital command signal
DIS Digital information signal
EOL End of line
EOP End of procedure
EPT Echo protection tone
FEC Forward error correction
FTT Failure to train
MCF Message confirmation
MPS Multipage signal
NSF Non-standard facilities
NSS Non-standard facilities setup
PSTN Public switched telephone network
RTC Return to control
RTN Retrain negative
RTP Retrain positive
TCF Training check frame
TSI Transmitting subscriber identification

Biography

Edward Kessler
BT Worldwide Networks

Edward Kessler joined the External Telecommunications Executive of The Post Office in 1975, after obtaining a B.Sc. in Applied Physics at the University of Sussex. He worked first on the introduction of digital switching systems, and later on research and development coordination and network optimisation. He then spent some years working on measurements and theoretical analysis of interference effects in satellite communications. His involvement in DCMEs dates from this period, when he played a part in setting the functional requirements for equipment to be used in the INTELSAT and EUTELSAT systems. Since then his work within International Networks has become progressively more network rather than systems orientated, particularly as regards transmission quality.

Roger Hodges and Sue Barclay

Development and Testing of DCME Systems

Digital circuit multiplication equipment (DCME) requires extensive testing before it is introduced into the network. This article describes BT test and evaluation activities from the earliest stages of a DCME development project until the successful completion of an international field trial, including testing at the manufacturer's premises and in a controlled environment at a BT operational site. The test programme covers the basic functions of a DCME, operation and maintenance issues within BT, and compatibility with the international transmission network.

Introduction

Digital circuit multiplication equipment (DCME) is now widely used throughout the international network. It enables telecommunications companies to get the best possible advantage from their available transmission capacity, by multiplying the number of circuits which can be carried on a 2 Mbit/s bearer. Whereas 30 channels can be transmitted on a 2 Mbit/s line using standard pulse-code modulation (PCM) techniques, DCME typically allows up to four times as many channels to be fitted onto the same 2 Mbit/s line, without noticeable degradation in the quality of service.

This is achieved by making use of the combination of digital speech interpolation (DSI) and adaptive differential pulse-code modulation (ADPCM). The DSI process detects speech activity on the input circuits, and reassigns the available transmission capacity from silent channels to active channels, as necessary. ADPCM provides a more efficient way of encoding speech and voice band data, typically using four bits per sample for speech, in place of the eight used by standard PCM. Speech, fax and data can be routed through the DCME, but each must be handled in a different way. For further details about the technology of DCME, see E. A. Kessler's previous article in the *Journal*[1].

In practice, DCMEs are normally arranged in clusters, consisting of either seven or eight main DCMEs (dependent on DCME type), a stand-by DCME, a switching matrix and a controller. This arrangement improves the reliability of the system, since the stand-by is able to take over the traffic on one of the main DCMEs in the event of a failure. The whole cluster is considered as a system, and all the elements of it have to be addressed in an evaluation programme. A typical cluster, as installed in the international transmission centre, is shown in Figure 1.

Inevitably, DCMEs are complex systems, and there are many different ways in which they could fail. Careful testing is required, at various stages of development, to ensure that they are fit to be introduced into the network.

This article is intended to give an overview of the range of test and evaluation activities which are typically performed by the development manager, before a DCME goes into service.

Preliminary Phases of Development

BT's practice is not to design and manufacture its own transmission equipment for use in the network, but to procure equipment from external manufacturers. For new technologies, particularly those which are not yet in use anywhere else in the world, it is necessary to work with the manufacturer throughout the development process, constantly providing feedback on design decisions, clarifying requirements, and testing to find out whether the equipment really can provide the functionality and quality of service for which it was procured.

Specification and design

Once BT is committed to a particular manufacturer, the BT development

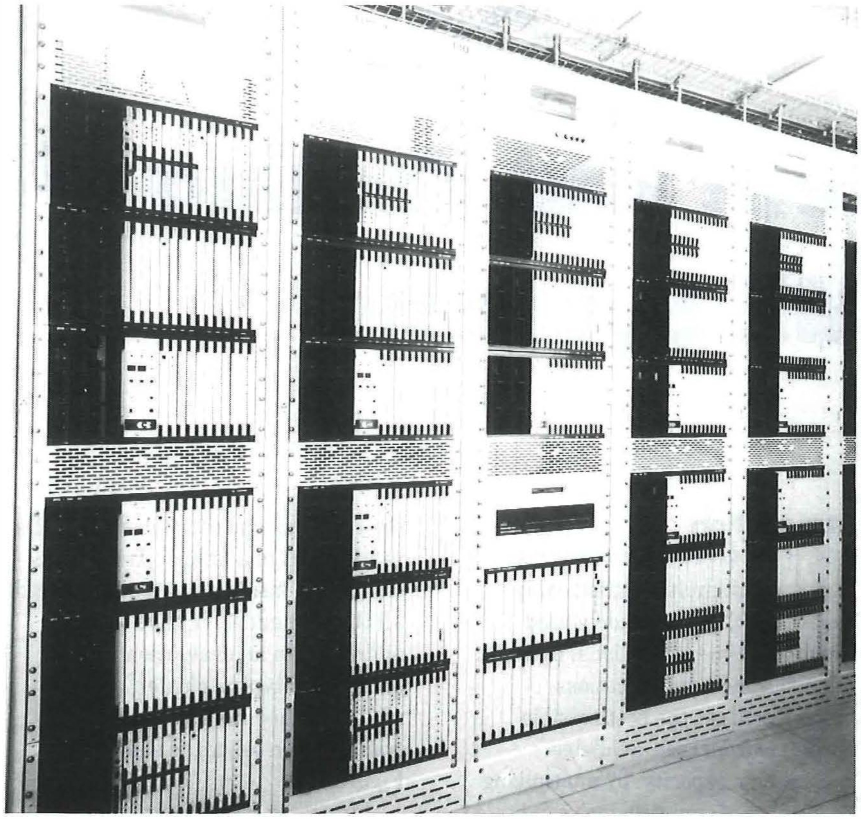


Figure 1—An operational DCME cluster

manager becomes involved in the discussion of design issues. Even when a comprehensive specification has been produced, it is important to discuss the details of the implementation with the manufacturer, to ensure that the company fully understands the implications of the functional requirements, and has the level of technical and manufacturing competence necessary to meet the design objectives. This stage is also useful in generating innovative solutions to problems, as a result of the close interaction between customer and supplier.

Quality assurance

Quality assurance is a vital function throughout any development project, from the earliest stages of design through to the release of the final production equipment. BT, as the prospective customer, is concerned to see that sound quality assurance procedures exist in the company supplying the goods, and that every precaution is taken to ensure that the equipment delivered is of a high quality.

BT's quality assurance experts are brought in to conduct an audit of the supplier's control procedures, potentially including both questionnaires and physical inspections. Both software and hardware quality are evaluated.

Design assessment

The first DCMEs to become available were proprietary designs, built to BT's generic specifications, but providing the required functions in their own way. Each manufacturer's implementation is therefore highly individual, and unable to interwork with that of any other manufacturer. The purpose of the design assessment for this type of equipment is primarily to evaluate the validity of the manufacturer's approach in implementing the required functions.

More recently, INTELSAT (International Telecommunications Satellite Organisation) and EUTELSAT (European Telecommunications Satellite Organisation) have issued detailed specifications for DCME[2,3], which aim to ensure sufficient commonality between different manufacturer's implementations to permit interworking. A superset of these specifications has been standardised[4] by the CCITT. In the future, different manufacturers' implementations of these specifications will require exhaustive testing of protocols and functions to ensure that they are fully compliant with the specification, and therefore compatible with each other.

Once the manufacturer's design proposals have been assessed against the specification, and the issues of reliability and network compatibility have also been considered, the next stage is to obtain either a prototype or production equipment for testing.

Prototype Testing

A preliminary test of most of the basic functions of the equipment can be conducted on prototype equipment, if available. This is a valuable part of the process, since feedback at this stage can still result in real changes to the final design of the equipment. It is therefore appropriate to conduct tests on electromagnetic compatibility and materials at this stage, since significant hardware changes may be required.

EMC testing

The issue of electromagnetic compatibility (EMC) is of great importance for all electrical equipment, given the fact that the European directive on EMC becomes mandatory in 1996. This has had the benefit of increasing suppliers' awareness of EMC issues, and has provided a common set of requirements and test methods which can be used by all the potential users of telecommunications equipment. However, even apart from this legislative pressure, EMC has always been important: BT cannot accept into a transmission centre any equipment which is likely either to cause interference to other equipment, or to be susceptible to interference from other equipment. In the past, extensive testing against BT's internal specifications for EMC was usually required. However, now that equivalent European standards exist for EMC, it is increasingly realistic to expect equipment to be tested, even by overseas contractors, before it is offered to BT. Despite this, it will still often be necessary to conduct some further tests, to examine the precise nature of the electromagnetic emissions and susceptibility of the equipment[5].

Safety

An important aspect of testing any equipment is a safety assessment, which can broadly be split into two areas, hardware and electrical. A hardware safety audit includes checking for things like exposed sharp edges and heavy removable units which are not conveniently accessible. The build of the equipment and rack units is also evaluated at this point.

An electrical safety audit looks at issues such as the earthing standards applied, the power supply (which should normally meet an internationally recognised standard), and the accessibility of high voltages. Although not immediately obvious, the accessibility of high voltages must be checked even when the equipment is powered from the station 48 V supply, since most modern DC-to-DC converters use switch-mode power supplies, which are capable of generating high transient voltages when switching.

BT is committed to ensuring that the equipment it purchases and installs is as safe as possible. Therefore, to ensure that all BT's DCMEs meet the safety standards currently in force, safety experts are requested to perform a safety evaluation before the equipment is put into service. The outcome of the evaluation is then acted on by BT or the supplier as appropriate.

Flammability

Some of the materials used in the construction of telecommunications equipment are potentially flammable plastics. Where the manufacturer is not able to supply adequate information on the chemical composition of these materials, a sample is sent for analysis by BT flammability experts.

The sample is burnt in the presence of various concentrations of oxygen, and the level at which it is able to support combustion (the oxygen index) is compared to the limits specified in a BT standard. The oxygen index required varies according to the way in which the material is actually used—labels can have a lower oxygen index than printed wiring board sockets, for instance, because there is a lower risk of ignition.

Acceptance Testing

Occasionally, during a DCME project, it is necessary to perform acceptance testing at the manufacturer's premises or in the factory. Since none of the DCME manufacturers are UK based, BT has only limited access during development and production. Nonetheless, to ensure that a strong contractual position is maintained, visits must be made at certain key points in the development process. It is easier to stop a DCME leaving a factory, than to send it back if it fails to meet requirements. Acceptance test visits are only made following the manufacturer's assurance that the equipment is working and ready for test, and when this assurance is backed up by the production of the manufacturer's own test results. Acceptance testing falls into two distinct categories, qualification acceptance testing and factory acceptance testing.

Qualification acceptance testing

During the development of a DCME, there are certain key milestones, such as the construction of a pre-production DCME terminal, at which it is necessary to 'qualify' the design of the equipment. This entails detailed testing, to demonstrate that the equipment meets the exact requirements of the specification. For example, a key function of the DCME is speech detection. The performance of the circuitry and software which implement this function is measured at this stage.

Included in the qualification of the equipment is an evaluation of the hardware and software quality, and the processes used by the manufacturer to ensure that standards are controlled and maintained. Evaluation includes an examination of the quality of workmanship of printed wiring boards, and a check that the firmware mounted on the circuit boards is correctly labelled. The manufacturer is asked to describe how changes to hardware and software are controlled, and to demonstrate this as appropriate. This function is strictly speaking quality assurance, and, where possible, is normally performed by a representative from BT's Quality Assurance Division. However, it is not practically possible for BT Quality Assurance to attend every qualification test visit, and, if necessary, a spot check is performed by the development manager, to verify that standards have not slipped, and that any recommendations by BT's Quality Assurance Division from its last visit have been implemented.

Factory acceptance testing

Once a DCME has been put into production and has passed a qualification test, it is not usually necessary to repeat the full set of qualification tests for future orders of equipment built to the same specification. It is necessary, however, for BT to be satisfied that the equipment it is about to purchase is in correct working order. It is therefore necessary to perform a factory acceptance test, which consists of a subset of the qualification tests, and is aimed at verifying the correct operation and functionality of the DCME. The rationale behind this is that it is less time-consuming, and therefore less costly to the business, but still ensures that BT's interests are met.

Network Testing

The DCME is not simply a 'dumb' piece of transmission equipment which provides a transparent transmission medium between international exchanges. It performs complex signal analysis and processing, dynamic circuit switching in real time, and has to recognise the difference between speech, data and signalling without degrading network performance. Further, it must be able to respond to transmission failures and interruptions in a controlled manner, and not introduce additional problems into the network.

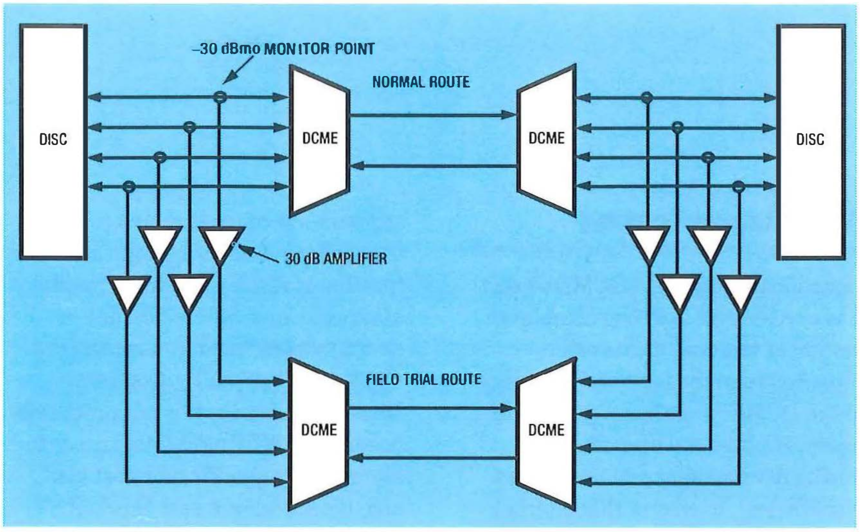


Figure 2—Point-to-point monitored live traffic

Throughout the development of a DCME, consideration must be given to the network environment in which the equipment will be used. The design of the DCME must be evaluated and tested against all conceivable network conditions. For example, CCITT C6 and C7 signalling systems use a 2000 Hz continuity check tone at the start of a new call. The DCME must discriminate this tone from the 2100 Hz echo suppressor disabling tone generated by modems and facsimile machines.

Field trial

When certain major development milestones are reached, it is useful to perform a field trial. The main purpose of a field trial is to expose the equipment to a real operational environment, and test any specific features of the equipment which may be influenced by the network. For instance, the fax demodulation feature discussed below involves such complex processes that only a field trial can properly reveal some of the problems, and they cannot be reproduced in a factory environment.

Prerequisites

A field trial requires considerable resources, in terms of both people and facilities, and therefore the DCME to be tested must first have been thoroughly tested by both the manufacturer and BT. Any problems must be identified, corrected and tested before the field trial; once the trial has begun, it is not easy to make changes to the equipment, since any change may invalidate previous testing. On occasions, a problem found during a field trial may be so serious that a change must be made in order to complete the trial, but this is always seen as a last resort.

International coordination

In most cases, DCME field trials are performed over international satellite or cable facilities. This requires considerable coordination with the other participants to set up the facilities required, such as satellite or submarine cable circuits (typically 2 Mbit/s) and terrestrial facilities to route the circuit to the international repeater station. However during the past 5 years, BT has established very good working relationships with other major communications providers such as AT&T, DBP and KDD, and there is a high degree of co-operation for DCME testing. Where possible, economies can be made by sharing test information and occasionally the responsibility for conducting tests in the trial.

Traffic tests

A vital stage of any DCME field trial is to subject the system to real traffic. In the first instance, monitored traffic is used (see Figure 2). The purpose of this is to assess the effect that real signals will have on the DCME, and to see whether it processes them correctly. The virtue of using monitored traffic is that it does not affect BT's customers, or BT's quality of service.

Only when the DCME has successfully passed all previous stages of the field trial testing is live traffic connected to it. Before the traffic is connected to the DCME, its normal performance is measured by using fax call analysers and the statistics generated by the digital international switching centre (DISC). This performance information is compared with that obtained when the traffic is connected to the DCME under test. Simple listening tests are also performed, to ensure that customers are not having any difficulties communicating through the DCME.

Detailed Tests

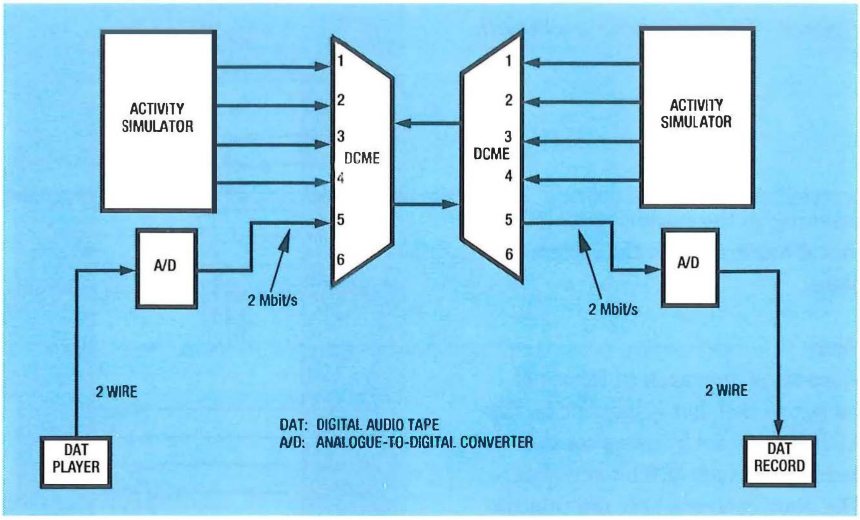
In all the above phases of a full evaluation programme, a series of detailed tests must be performed. The purpose of testing is to find and eliminate as many faults as possible, before the equipment goes into service. While it would, in theory, be possible to work around certain faults, on the understanding that the operators would be properly warned of the problems, it is all too easy for information of this kind to be lost, once the original development team is dissolved. The consequences of this are an increase in the cost of maintenance, and a reduction in the quality of service offered by the system. It is therefore far more effective to invest extra time and effort at the development stage, when it is still possible to have problems resolved by the manufacturer.

Some of the tests typically performed in an evaluation of a DCME system are described below.

Transmission interface

The first stage in a detailed test programme is to ensure that the 2 Mbit/s interface to the transmission network is fully acceptable. This interface is tested to ensure that it meets the jitter, pulse-shape and pulse-amplitude characteristics defined by the CCITT and in BT's own specifications. In addition, the alarm strategy of the DCME must be tested, to ensure that it provides the correct indications to the network, in the event of a fault. Synchronisation is another important issue; the DCME must be able to derive correctly its clock source from the transmission network, if necessary.

Figure 3—Subjective speech testing



Alarms

DCME alarms can be divided into two categories; transmission alarms and equipment alarms. Transmission alarms are generated in response to 2 Mbit/s trunk and bearer conditions, such as signal loss and alarm indication signal. This testing is more involved than for multiplex equipment, because the DCME is effectively the reverse of a multiplexer; it interleaves the capacity of 8 Mbit/s (4 × 2 Mbit/s trunks) onto a 2 Mbit/s bearer. To add further complication, the DCME has time-slot interchange facilities, and therefore the transfer of the correct alarm condition to the correct trunk channel also has to be tested.

Equipment alarms relate to the operation of the DCME itself. Some DCMEs have sophisticated self diagnostic facilities, which constantly test the operation of the DCME. In the event of a fault being detected, the DCME may either switch in its own internal stand-by circuits and raise an alarm to the operator, or send a message to the cluster controller to initiate a changeover.

Synchronisation

Within the BT national network all 2 Mbit/s are synchronised to a national clock with an accuracy of 1 in 10^{11} as specified in CCITT recommendation G.811[6]. However, problems can occur when working to another country which also has a synchronous 2 Mbit/s network, operating from its own national standard. Naturally, there will be very slight differences in the 2 Mbit/s clock frequencies of the two countries. This situation is known as *plesiochronous working*.

To overcome the effects of any difference in clock frequencies, all DCME 2 Mbit/s interfaces have plesiochronous buffers. When a buffer either fills or empties, the DCME performs a controlled slip in which it either skips or repeats a 2 Mbit/s frame.

The user can select the source for the DCME's synchronisation: from a trunk, the bearer, or an external 2 MHz source. It is also possible to select the source to be used in the event of a failure of the main source.

Tests have to be performed to check that the DCME correctly synchronises from a given source, and that changeover to and from the reserve source occurs in a controlled manner. One method is to set up a 64 kbit/s unrestricted data channel, as described below, and to measure for errors on a pseudo-random binary signal.

Basic DCME functions

Once the equipment's interface to the transmission network has been proved, the next major task is to prove the DCME's basic functions: its handling of speech, fax and data. The DCME has to distinguish between these types of activity on each incoming circuit, and process them appropriately.

Speech

Speech is subject to both DSI and ADPCM processing, as described above. The main concerns of the development manager when testing for correct speech processing are that speech quality is acceptable, and that speech is correctly mapped through the system, so that it arrives in the correct time-slot at the distant end.

Speech quality is evaluated by playing a digital audio tape recording of various speech bursts in one of the time-slots of a 2 Mbit/s trunk input. This is processed by the DCME, and recorded at the distant end. A typical test configuration is shown in Figure 3. The process is repeated under a range of different conditions, with varying activity generated on the other input channels by test equipment. A full description of subjective speech testing and some of the speech performance problems encountered is planned for a future issue of the *Journal*.

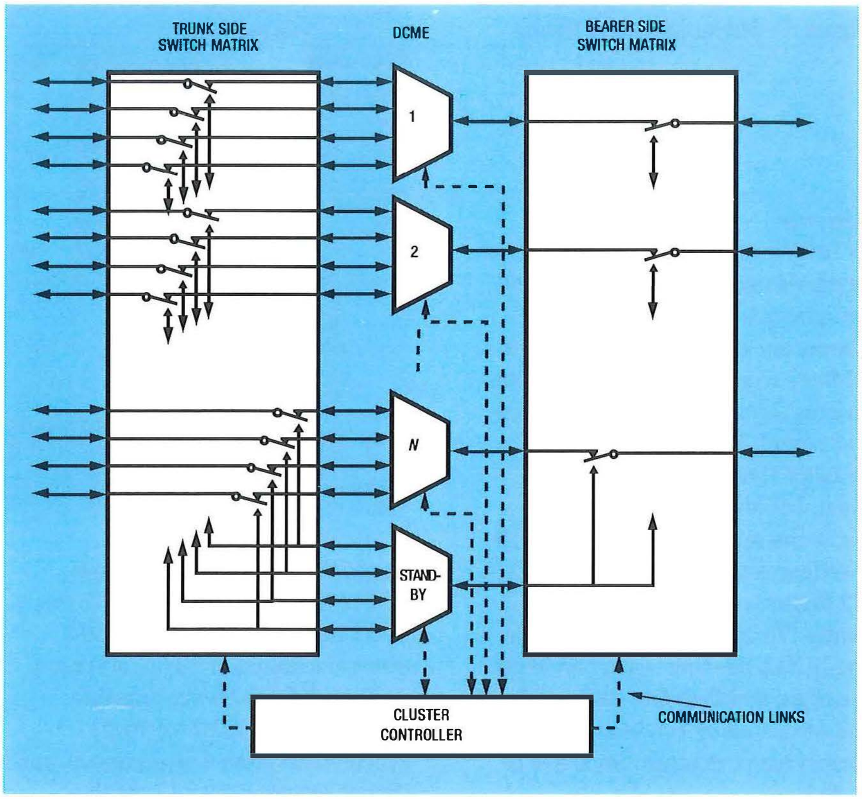
The DATs recorded at the distant end are evaluated, and an index of the perceived quality of the speech will be obtained for each sample, under each set of conditions.

As the activity increases on the DCME input trunks, the bit stealing process begins to take effect, so that the average number of bits per sample falls below 4. To ensure that speech is not degraded beyond acceptable limits, it is possible to define a threshold, such as 3·7 bits per sample, at which the DCME outputs a dynamic load control (DLC) indication. This indication is interpreted by the DISC as an overload, and no further calls are assigned to the DCME. The DLC condition is not removed until the average bits per sample rises above a different, higher threshold, such as 3·9 bits per sample.

This function is tested by applying an increasing load with test equipment until the equipment reports that the average bit rate has decreased to the DLC ON threshold. DLC is activated either by a relay, or by signalling to the switch according to the protocol defined in CCITT recommendation Q.50[7].

Finally, if speech is processed correctly, and to an acceptable quality, it is necessary to test that it is actually mapped to the corresponding channel at the distant end. This can be done by applying a tone to each of the input time-slots in turn, and

Figure 4—Cluster switching schematic



listening on the outputs to make sure that it has arrived in the correct place.

Fax

Voice-band data such as fax is not subject to DSI, but is handled by the ADPCM process by using special techniques, such as 5 bit encoding. The main concerns here are that the fax transmission should be successfully completed, and that the image arriving at the distant end should be of an acceptable quality. This is tested by sending a number of multipage faxes through the DCME, under different conditions of load and bearer error rate.

If faxes are not being successfully completed, one of the possible reasons for this could be that the hangover time is not long enough. This is the amount of time for which bearer capacity remains assigned to the channel containing the fax call, before it can be released for reassignment to activity on another channel. This time must be long enough to hold the bearer assignment between the end of one page and the start of the next.

The subjective quality of fax transmission is evaluated by counting the number of errors in each page of the faxes sent. A special test page, defined by the CCITT[8], is normally used for this purpose, since it contains images of various kinds, and is designed to make the loss or retransmission of a line very obvious.

64 kbit/s digital data

A DCME has the capability to provide a 64 kbit/s digital data path (a clear channel), which bypasses the DSI and ADPCM processes. A clear channel can either be preassigned or demand assigned, depending on the way in which it will be used. In the preassigned case, a specified trunk channel is given a fixed 64 kbit/s digital path through the DCME. This may be used for CCITT No. 7 signalling channels and international private leased circuits (IPLCs), for example. Demand assignment allows the DISC to request 64 kbit/s unrestricted facilities dynamically for a particular trunk channel, using the CCITT Q.50 protocol. This can be used for ISDN services.

One of the main factors in evaluation of data transmission is error performance. The error rate on the output trunks should always be the same as that applied to the bearer; if no additional errors are inserted on the bearer path, a pseudo-random binary signal should be transmitted through the system from end to end, with a zero bit error rate. The DCME itself should be error free.

To ensure that demand assignment of 64 kbit/s clear channels is correctly implemented, the full CCITT Q.50 protocol is also tested. This protocol uses spare bits in time-slot 16 for signalling between the DCME and the DISC.

Cluster operation

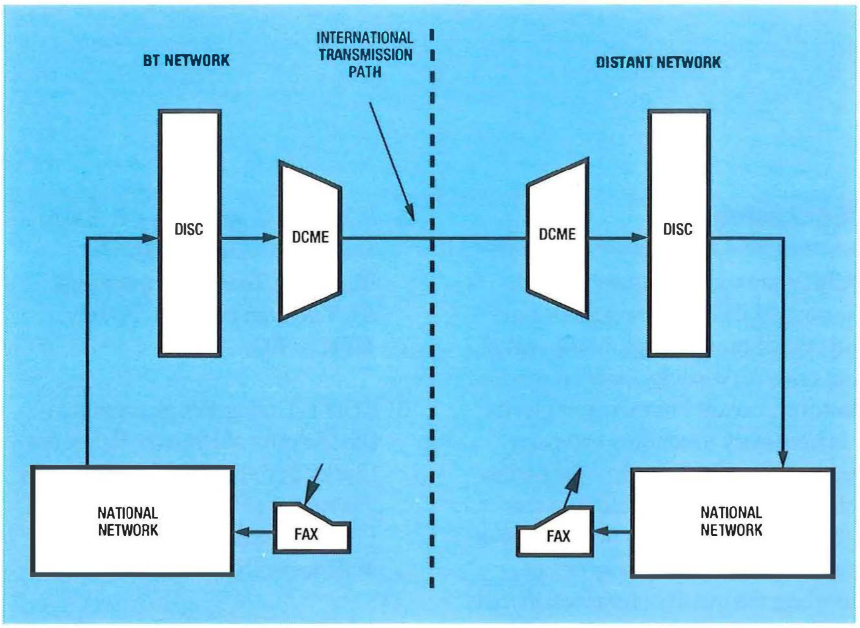
The testing of the correct operation of a DCME cluster is an extremely important part of the test programme. As shown in the cluster schematic in Figure 4, the cluster controller communicates with the switch matrices, to switch the trunk and bearer connections from a main DCME to the stand-by, in the event of a failure.

This switching or changeover operation is performed automatically when a DCME fault is detected. Prior to changeover, the stand-by DCME is loaded with the configuration of the faulty DCME, so that the interruption to traffic is kept to a minimum. Typically the interruption to traffic may vary between tens of milliseconds to a maximum of 90 seconds, dependant on the nature of the DCME failure, and the type of DCME. Once a DCME has been substituted by the stand-by, a manual changeover must be made to restore the cluster to normal operation.

The changeover feature is extensively tested to ensure that certain strict criteria for automatic changeover are met. An automatic changeover must only occur when a DCME detects a fault which is not due to problems or conditions external to the DCME, and when the stand-by DCME is available and shows no fault conditions. It is essential that false changeovers do not occur, in order to prevent interruption to traffic, and the consequent reduction in the quality of service.

When a changeover occurs, the stand-by DCME must be checked to ensure that it has correctly assumed the same configuration as the DCME for which it has been substituted. Any corruption in the transfer of configuration between the DCMEs could

Figure 5—Facsimile tests



have serious consequences for the international traffic it is handling.

User interface

Another important consideration, given that the equipment is functionally correct, is that it should be usable. Equipment as complex as a DCME cannot normally be operated from the front panel, and all the existing DCME systems incorporate a computer-based control system, usually known as an *operation and maintenance controller* (OMC). From this terminal, the user can send commands to the cluster, and receive information about the status and performance of each DCME.

At an early stage of any test programme, the user interface of the OMC is evaluated. The purpose of this is to ensure that the needs of the user have been adequately taken into consideration, in terms of both usability and functionality. Any shortcomings are fed back to the manufacturer, so that they can be corrected. This is taken very seriously, since the people operating the equipment in an international transmission centre will have to be familiar with a number of different systems, produced by different manufacturers, and with completely different user interfaces. The interface should support the user's interaction with the system, to make it as easy as possible to learn and to use.

The interface will be evaluated for consistency and reliability, with particular regard for the adequacy and accuracy of the information provided on the screen and printer. There should also be adequate protection against invalid inputs, and the system should always keep the user fully informed about the status of any operation. During testing, the weaknesses of the software are fully explored: it should not be possible to crash the OMC under any circumstances, or to perform traffic-affecting operations on the cluster without some warning as to their consequences. The question uppermost in the mind of the development manager during this phase is 'What happens if ...'.

In the future, there will be an increasing pressure for OMCs to offer a standard set of features, and standard interfaces to network management systems. The CCITT is beginning to address this issue in its work on the telecommunications management network (TMN).

New Features

Fax compression

The development of facsimile compression has posed many new problems. Because of the complex nature of fax transmissions, and given that the DCME analyses the signal to determine whether it can apply compression techniques[9], the only way to test fax compression is to use real fax signals. The problem is that, while it is easy to connect a fax machine or fax analysis equipment to the DCME, only one call at a time is being made. In theory, a DCME could be expected to handle up to 180 simultaneous fax calls. In practice, the number is more likely to be 40–60 calls, but even so, it is still not possible to generate this number of calls by using the fax testers available to BT.

Furthermore, the simulation of a real network environment presents a significant problem. While signal impairments such as noise, errors, delay and attenuation can be added to the fax signal, it is not possible to simulate the complex interactions of the DISC, signalling systems and echo control.

To prove that fax compression will work in the international network, a field trial must always be performed. A typical field trial test configuration is shown in Figure 5. Special routing codes are set up in the BT national network and in the international switch, to route calls from a predetermined location to the DCME under test.

Multidestination working

DCMEs to the CCITT G.763 and INTELSAT IESS-501 specifications are currently under development. These DCMEs are able to work in both multidestination and multiclique modes, as well as the more standard point-to-point mode. In multidestination mode, the DCME can operate to a maximum of four destinations: the traffic for each destination can be sent over any of the available time-slots on the bearer. Multiclique mode divides the bearer into two pools of time-slots, with a fixed boundary between them. One of the pools must be dedicated to a single destination, but the other can work in multidestination mode, with traffic for up to three destinations assigned to any of the time-slots in the pool.

The testing of these modes of operation is still evolving. The issues to be considered include alarm transfer, channel assignment and subjective performance. The situation is further complicated by the need to test that DCMEs from all the vendors are mutually compatible (a problem that does not occur with proprietary systems).

Conclusion

DCMEs are complex systems, with the potential of providing their users with significant savings on the cost of transmission capacity, once in service. However, because of their complexity, it is necessary to conduct extensive tests, often including a full field trial, before they are introduced into the network. An evaluation programme of this nature is the only way of safeguarding the quality of service offered to BT's customers and ensuring that the DCME can be operated and maintained in an efficient and cost-effective way. It also enables feedback to be given to the manufacturers of these systems at a time when it is still possible to achieve significant changes.

BT's current level of DCME expertise, and the experience accumulated over several years and several different systems, means that while BT is at the forefront of new technology for DCME, there is also the best possible chance that the innovative features will be successfully implemented, and that BT's objectives for quality, reliability and maintainability will also be achieved.

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Biographies

Roger Hodges joined BT International in 1972 as an apprentice. In 1977, he joined BT Research Laboratories as a technician working on high-speed digital transmission research. He moved to Mormond Hill Troposcatter Radio Station in 1980, where he worked on the maintenance of radio and FDM transmission equipment. In 1986, he joined the Central Engineering group of BTI, involved in addressing the impact of new digital technologies on the international network. Two years later, he moved on to the Technology and Development division of BTI, working on DCME development. He is now responsible for coordinating technical aspects of all DCME development within BT.

Sue Barclay joined the Technology and Development division of BTI in 1987, and has been involved in DCME projects since 1991. Her special interest within the DCME development team is software quality, and the evaluation of the user interface. She is responsible for the field trial of the first multidestination DCME, which will run from July to November, 1992. She has a BA degree in Physics and Latin, from the University of Keele.

Glossary

ADPCM Adaptive differential pulse-code modulation
CCITT International Telegraph and Telephone Consultative Committee
DAT Digital audio tape
DCME Digital circuit multiplication equipment
DISC Digital international switching centre
DLC Dynamic load control
DSI Digital speech interpolation
EMC Electromagnetic compatibility
EUTELSAT European Telecommunications Satellite Organisation
INTELSAT International Telecommunications Satellite Organisation
IPLC International private leased circuit
OMC Operations and maintenance controller
PCM Pulse-code modulation
TMN Telecommunications management network

Ron Haslam and Chris Johnson

ISDN Service and Applications Support in the UK

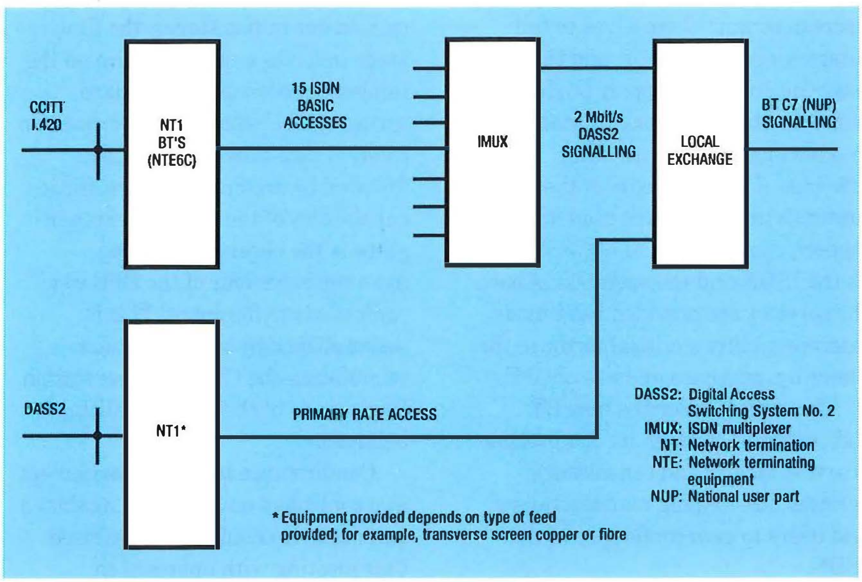
Full interworking and interoperability of customer premises equipment (CPE) worldwide are essential for the successful operation of an international integrated services digital network (ISDN), to which BT is committed. This article discusses the steps that are being taken to achieve standardisation and full compatibility, including in particular the important role of the BT ISDN Service and Applications Laboratory, which was set up for the purpose.

Introduction

The term *integrated services digital network* (ISDN) was first coined in the 1970s, and the first set of standards for the ISDN appeared in the CCITT 1984 Red Book. Since that time, most major world telecommunications operators have implemented various ISDN trials or pilot schemes before proceeding to offer a full ISDN service. In 1985, BT became the first telecommunications company in the world to offer a commercial ISDN service, known as the *integrated digital access* (IDA) service. This provided both a single-line and a multi-line service to the customer. The single-line service supported two traffic channels, one at 64 kbit/s and one at 8 kbit/s for data/voice access, and an 8 kbit/s signalling channel. Access was over the existing twisted copper pair from the customer's premises to the integrated digital network (IDN). The multi-line service supports 30 × 64 kbit/s user channels with one 64 kbit/s channel for signalling and another for frame synchronisation. The introduction of the IDA service and similar trials contributed to the work on standards, while at the same time highlighting the need for common ISDN standards. Activity on standards has continued in Europe in the European Telecommunications Standards Institute (ETSI) and in the CCITT with the publication of detailed recommendations in the CCITT 1988 Blue Book. Public network operators, like BT, are now moving from their trial/pilot ISDNs to a service based upon these 1988 recommendations.

In January 1991, BT introduced its basic-rate ISDN service, called *ISDN2*, based on the recommended delivery of two 64 kbit/s user channels and one 16 kbit/s signalling channel. The implementation is shown in Figure 1. The ISDN2 service supports the full CCITT I.420[1] interface at the

Figure 1—BT's ISDN implementaion



For ISDN to be a success, it requires a community of users, each user having one or more terminals that interwork with other users' terminals

customers' premises, which in Europe is the regulatory interface between the public telecommunications operator and the liberalised customer premises equipment (CPE). It is the maturity of this standard that is now encouraging the development of harmonised terminal equipment throughout the world. Harmonised terminals that interwork not only nationally but internationally will create a worldwide ISDN network of interworking terminals. As a signatory to the European Memorandum of Understanding (MoU) for the provision of ISDN, BT is in full support of both harmonised basic- and primary-rate access, and is totally committed to a pan-European and international ISDN. However, the primary-rate interface, launched as the ISDN30 service in 1988, is still based on the IDA standard and is not expected to comply fully with the international standard until 1993.

For ISDN to be a success, it requires a community of users, each user having one or more terminals that interwork with other users' terminals. A crucial factor in making ISDN a success therefore lies in the availability of required terminal equipment working to the agreed standards covering both signalling protocols and applications. Experience has shown that early implementations of ISDN have suffered from the reluctance of manufacturers and users to commit themselves to full international standards, and they have continued to support products based on standards lacking stability and harmonisation with other offerings. The complexity of the protocols and interfaces used for a modern communication network such as the ISDN and the openness of how the services are provided have made interoperability a critical factor in the planning, purchase and use of CPE.

This article describes how BT Laboratories, through its comprehensive test facility and consultancy services, are helping manufacturers and users to gain confidence in the ISDN.

ISDN CPE Testing

The development of the ISDN requires a new range of terminals to be produced which will be compatible, not only in physical access, but also in the comprehensive range of services and signalling protocols that the network provides. This means that terminals must support not only the basic access protocols but also bearer services, lower-layer compatibility (LLC) and higher-layer compatibility (HLC) coding, teleservice profiles and supplementary services.

In the UK, terminals are required to be submitted for an approvals test before being connected to the network. This approval testing is designed to ensure that the terminal is 'safe' for connection to the network. In order to ensure that terminals are able to interwork with both the network and other terminals on the network, adequate testing must take place before the terminal is put on the market. There are two main areas of CPE testing: verification of conformance to interface standards, and interoperability testing.

Conformance

Conformance testing is the process by which it is determined whether an implementation of a standard complies with its specification, and performs the behaviours mandated in the standard. Conformance testing is carried out in two stages: the first stage involves a questionnaire on the implementation of the standard, known as the *protocol implementation conformance statements* (PICS), followed by an analysis of the static capabilities of the CPE. The second stage is the observation of the dynamic behaviour of the CPE in a controlled environment. This is accomplished by test equipment stimulating the CPE and observation being made of the CPE's resulting behaviour.

Conformance testing is carried out in a controlled environment against a test suite. It should be emphasised that meeting with approval on conformance testing does not give any guarantees that the CPE will interwork either with the network or with other terminals. Conformance testing will only give confidence that the CPE was implemented as specified by the standard. The dynamic behaviour of the ISDN protocols is very complex, and to perform adequate testing on every aspect of the standard would be out of the question both in resources and timescale.

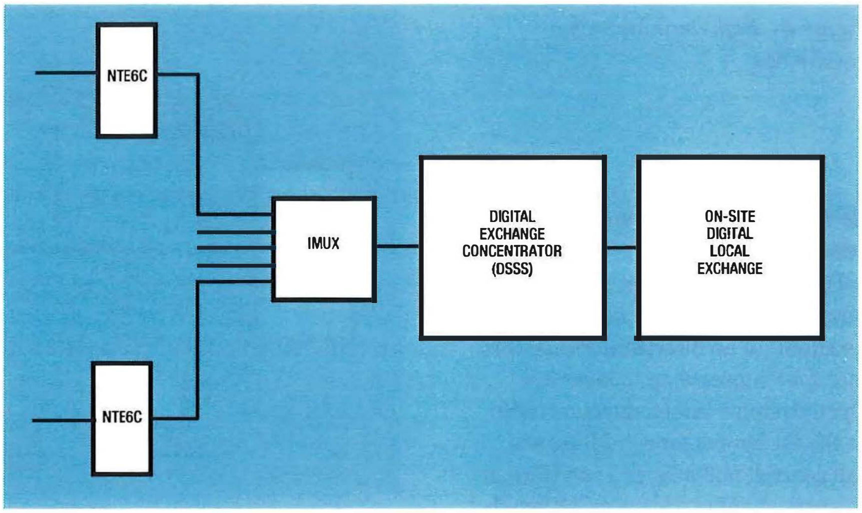
It could be argued that conformance testing should be the responsibility of the manufacturer, to ensure that his product conforms to a standard. It would be difficult to argue the case for each manufacturer ensuring that his product interworks with the plethora of other manufacturers' products over the international IDN, across varying networks and routes, and in a variety of combinations. In any event, it is in the interests of the network provider to have some knowledge in this area.

Interoperability

Many factors influence the behaviour of CPE in the 'real world' and, therefore, the successful operation and interoperability of CPE; for example, delays in power-up of the network interface, or the loading of other terminals on the same access point. Interoperability testing is not just connecting two terminals together and seeing if they will work, but it is an exhaustive examination of all the possible combinations of types of terminals, working in different scenarios with each other, across varying networks both national and international. Test suites need to be written for each type of CPE to cover all possible combinations of CPE, applications, and networks. The terminals under test are connected to the 'real' network and tested against those scenarios.

Interoperability testing reflects the real world of the user, providing confidence to the manufacturer that his equipment works to itself and to similar manufacturers' products. It also gives confidence to the network

Figure 2—BT Laboratories' captive network



provider that the network is performing to requirements, but, most importantly, it provides confidence to the user that the CPE bought will perform the tasks for which it was intended. The key to interoperability is international standards. For the interchange of information between personal computers (PCs) over an ISDN, this relates to the *applications programming interface* (API) which defines the interface between the applications and the PC. For a file transfer application to be successful between two different vendors' computers with ISDN interfaces, the file transfer applications must use the same API, or different APIs but which have a common interpretation of the data they are handling. More importantly, they must use a common protocol profile to support the application within the B-channel, otherwise one terminal will encode the users' data in one form which will be unrecognisable by the other terminal, resulting in garbled user data.

BT's ISDN Service and Applications Laboratory

Prior to the launch of BT's ISDN2 service, it was recognised that for CPE manufacturers to invest in the development of ISDN CPE with an emerging complex interface standard, little test equipment and limited prior knowledge of ISDN, some assistance had to be provided. The assistance from BT came in the form of a free test and advice service to manufacturers. This was provided by means of an ISDN Service and Applications Laboratory (ISAL). The laboratory has a small captive ISDN network, shown in Figure 2, that can be used for testing prototype terminals without fear of interfering with BT's customer service. In addition, access is provided to a large number of BT's basic-rate and primary-rate ISDN lines, PSTN lines, the packet switched service, local area networks (LANs), the pilot IDA service (IDA is still providing service to some customers), and via these to international services. ISAL has many types of testers available (including protocol analysers, bit error rate testers, layer 1, layer 2, and layer 3 testers for a range of interfaces including I.420, X.21, V.24, and V.35, some of which can be seen in the photograph in Figure 3).

The ISAL has over the years had to acquire a wide range of CPE not just from the UK but from all corners of the world. BT's technical experts in ISDN are available to offer assistance where it is needed, and suppliers' visits to ISAL are treated with confidentiality. Suppliers are invited and encouraged to bring their terminals to the ISAL for testing against the network. Basic electrical safety testing is performed initially, followed by detailed evaluation of the signalling protocol in conjunction with the BT network requirement for basic call set-up and clear down. Results monitored on a protocol analyser are compared with a set of reference call results and differences highlighted. Further end-to-end testing and the support of applications can then be evaluated over national and international networks, and problems identified can be flagged to the supplier who can modify his equipment accordingly. This test service helps suppliers to gain the confidence that their ISDN terminals are ready for submission to the UK approvals process, although, as already mentioned, the purposes of the two tests are somewhat different.

The laboratory has continued to expand, and as well as providing manufacturers with CPE test support, it has now grown to provide full interoperability testing between different manufacturers' equipment in order to support its customers. Over the years, the number and expertise of the staff have grown, and this has now provided a core of excellence within BT where knowledge gained from years of working with many forms of ISDN CPE and networks is recognised worldwide. The laboratory is sited within BT Laboratories, Martlesham Heath, Ipswich, which offers the additional benefits of the support of experts in all forms of telecommunications and the availability of specialised test equipment when needed.

Figure 3—ISDN testers

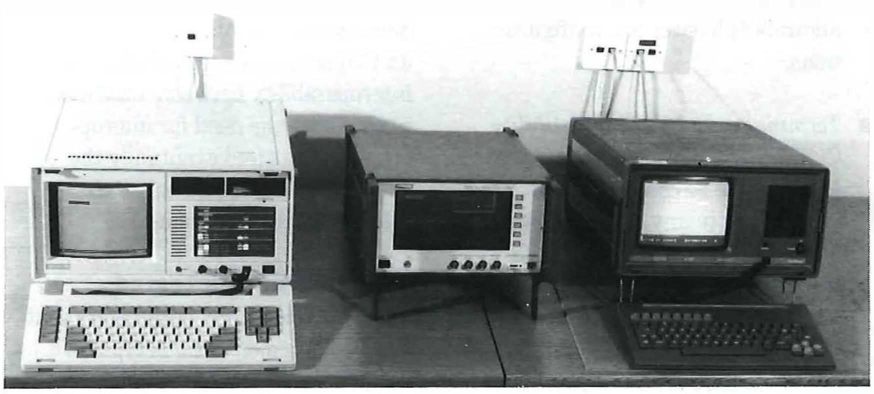
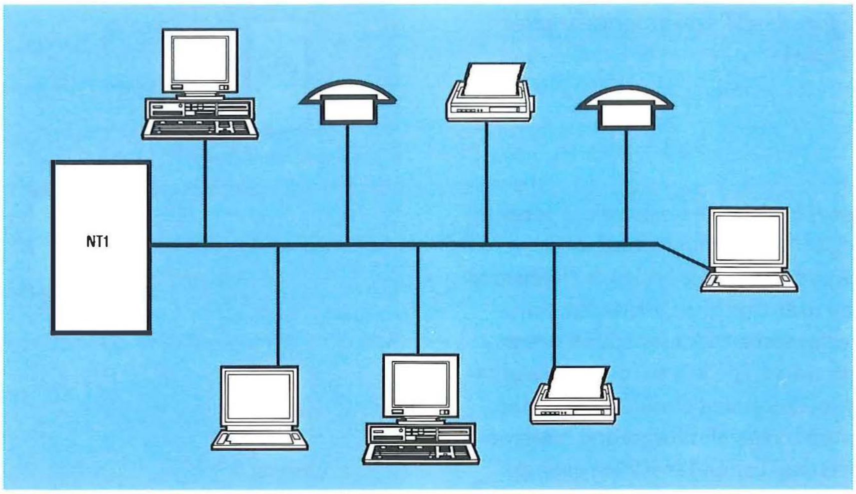


Figure 4—Eight terminals on a passive bus



CPE/network interworking tests

ISDN provides the user with a physical interface into which to plug a terminal. In architectural terms, this interface supports up to layer 3 of Open Systems Interconnection (OSI) in the D-channel for signalling and call control, and a layer 1 interface in the user channel. However, although the ISDN is an international standard, there are many optional fields within the standard. In practice, national implementations of CCITT I.420, for instance, do differ either in the services supported or in the manner in which services are encoded and transferred by the protocol, creating difficulties for the international interworking of CPE. In many cases, there can be a mismatch between the services supported by the network and those features supported by the terminal. The network not supporting a service used by the terminal can result in the call being rejected by the network.

In the ISAL, equipment is tested for interworking on the network between similar terminal types and between different vendors' terminals supporting common applications. Products are also tested for their compatibility with other terminals when physically connected to the same ISDN basic-rate interface on the passive bus. The testing is divided into three classes of matrices:

- *Physical bus configurations / basic call control*
  This involves testing the basic call establishment and release of ISDN equipment over the different allowable physical bus configurations.

- *Terminal equipment compatibility*
  CCITT I.420 allows for up to eight terminals to be connected to a passive bus in any combination as shown in Figure 4. The purpose of the tests is to evaluate different CPE and combinations of CPE on the interface for a range of different network services; for example, bearer services, MSN, sub-addressing, HLC etc.

- *Interworking of CPE and applications*
  These tests evaluate successful call establishment and support of end-to-end user data transfer between terminals either over an ISDN or over a physical connection comprising different networks, but including the ISDN. Within the scope of CCITT definitions, *interworking* means working between terminals using or requiring different network services.

Interoperability testing

Interoperability implies call connection and successful user data transfer between different vendors' terminals, even different types of terminals, but all supporting common applications. For example, different implementations of OSI file transfer, access and management (FTAM) on different vendors' hardware should allow successful file transfer if both implementations are written to the same OSI standard. However, because they may differ in the way data is handled this will not necessarily be true. Just because an application has been developed and conformance tested to an OSI standard does not guarantee interoperability between implementations; hence the need for interoperability tests and eventually the need for accredited global interoperability test houses.

CPE parameters tested

Tests of typical CPE parameters that are performed on various types of equipment are now discussed.

ISDN terminal adapters (TAs)

All the supported features of the TA are tested, particularly those associated with its user interface, such as physical interfaces; speeds supported; asynchronous or synchronous modes of working; and rate adaptation methods. Also checked is the encoding of the information into the CCITT Q.931 signalling protocol as information elements within the call set-up message, covering aspects such as bearer capability; baud rate; synchronous/asynchronous mode; and rate adaptation.

This type of testing is necessary as part of the CPE/network tests to ensure that the device is compatible with the UK implementation and hence will work on the UK ISDN. End-to-end interoperability tests will then be performed between the vendor's own product and between different vendors' products.

Further testing will cover the evaluation of users' applications. Some TAs can support ISDN HLC or teleservices and supplementary services. The supported features will then be tested by making calls utilising these features and checking that the TA does implement these features in the manner expected.

Personal computer (PC) ISDN adapter cards

For a vendor's PC card, CPE network testing is again performed to check on the encoding of user signalling into the CCITT Q.931 call set-up messages to ensure compatibility with the network. Beyond this, most of the testing concerns the end-to-end testing of the PC card's supported application. This is generally performed at the user level, since it is difficult to observe the internal software of the PC. This type of testing includes checking all the supported features of the application from the user's perspective; that is, selecting options from the application's user interface and then checking that they work in the manner expected.

Currently, most PC applications available are proprietary implementations using their own protocol profile. Hence interoperability between different vendors' products is not generally possible, and testing and use must be restricted to like systems.

Other interesting aspects which can be evaluated are the PC card application programming interface (API) for its features such as hardware platform independence; operating system independence; access to ISDN features (for example, supplementary services); multitasking capabilities; and support for different types of applications (for example, voice, data and multi-media).

Group 4 fax

For group 4 (G4) fax machines the testing is really limited to the CPE network and Q.931 implementation, together with interworking tests. For interworking, the important issues concern the appropriate selection of protocol profiles (for example, T.70 or T.90), and any enhanced features implemented by the vendor above the G4 standard (for example, higher resolution scanning algorithms).

G4 fax machines can have either a CCITT I.420 interface or an X.21 interface which can access ISDN via a TA. Successful interworking of G4 fax requires more than just call establishment: it also requires that the higher-layer functions supported by the terminal for selection of teleservice profile and transfer of user data be configured correctly and consistently at each end.

LAN interconnect

Tests cover the end-to-end interoperability between similar LAN environments interconnected over ISDN through bridges or routers. This testing includes CPE network testing and the encoding of the ISDN CCITT signalling, but it additionally now covers aspects such as routing, addressing and security features; for example, the ability to map LAN addresses into ISDN directory numbers and use of calling line identification (CLI).

Common Faults in Prototype CPE

It would be difficult to list all the common faults seen in prototype CPE; some of the more regular ones are discussed here.

Most problems are due to the interpretation and implementation of CCITT Q.931 and BTNR191, particularly with information elements and their (sometimes) optional parameters. Implementations are sometimes inconsistent between different vendors' products, leading to interworking problems. Additionally, terminals developed for other national implementations will differ from those required for UK ISDN working, and the problems encountered are in modifying their existing implementations to that required for the UK. Imported terminals on test have shown that manufacturers have difficulty with the national differences in the implementation of ISDN.

Examples seen during testing in ISAL have been problems with German terminals imported into the UK having HLC information stored. For connection to the German 1TR6 network, it has been essential that HLC information existed in the terminal, but BT's network does not require this information. Therefore, German terminals have required modification before connection to BT's network.

Some terminals require the receipt of a set-up acknowledge message in layer 3. This is a requirement of BT's network, but it is not supplied by all ISDN networks. Within the UK, some manufacturers are opting for CCITT T.70 G4 fax protocols, others T.90. The BT network supports both T.70 and T.90 protocols, whereas the French ISDN only supports the T.90 protocol. This causes problems of interworking between the UK and France. Problems also exist in communicating between the UK and the USA. This is due to many 64 kbit/s terminals in the UK not supporting 56 kbit/s. Even within the USA many of the trunks are still 56 kbit/s, so that users are never sure whether their connection will end up as 56 kbit/s or 64 kbit/s. Requesting 64 kbit/s in the call set-up cannot guarantee bearer capability and the connection may not be compatible with the far end.

For PC cards, many of the faults relate to the limitations of the API, in not allowing the application access to sufficient D-channel information, resulting in non-meaningful error messages or poor support and use of ISDN services. Also with PC cards, robustness and reliability seem to be problematical. Experience has shown that applications can fail almost without reason. This is probably due to their nature, which is almost that of development prototypes rather than mature and stable commercial products.

The most difficult problem for application developers is the lack of standardised protocol profiles for use on ISDN to transfer application data, together with internationally standardised and supported APIs.

The most common fault found in prototype ISDN TAs has resulted from a lack of understanding of the X.21 interface by TA manufacturers. A regular problem has been with the definition of the term 'TA leased line mode for X.21 TAs'. Traditionally, the meaning of leased line has been the provision of a fixed point-to-point circuit, whereas the term *leased line* in TA terminology refers to the immediate dial-up of a stored number. Confusion has caused problems with implementation.

Owing to the complexity of the mapping of X.21 onto CCITT I.420, *There can be little doubt as to the importance of interoperability testing. It is regarded by many as the most important step any ISDN provider can take to ensure confidence in implementation.*

many manufacturers have attempted to take short cuts with switched X.21—shortcuts which have proved to be impractical when tried on the open network.

Issues Impacting on Complete CPE Interoperability

Several issues still need to be addressed in order to obtain complete and guaranteed international interworking and interoperability between customers. Some of these are discussed below.

End-to-end architectural issues

The architecture of the ISDN is not completely specified in OSI terms. This leads to suppliers, and sometimes users, having to complete the architecture in order to utilise the ISDN to support an application. Suppliers have, up until now, implemented their own architecture to support their applications by way of implementing protocol profiles for use in the bearer channel to transfer the application data. In many cases, the protocols used are proprietary implementations and are not even de facto industry standards.

The user has little choice, therefore, in the protocols used to support his application, and indeed is limited to procuring 'like systems', which is the only way to guarantee interworking and interoperability.

The application programming interface (API)

International standard APIs must be standardised and supported by terminal manufacturers and application developers to provide users with an open systems environment over ISDN.

Without an international standard for APIs, it is difficult to test applications for conformance to a common standard. Applications can only be evaluated from their user interface for aspects such as use of features, use of ISDN supplementary services, user friendliness, robustness etc. Without comprehensive software test suites, applications can only be evaluated from the user's perspective. This is unlikely to be technically comprehensive or sufficiently rigorous to determine the correctness of the applications. Some applications are developed to proprietary or emerging de facto APIs for use with ISDN. Such applications can be compared and evaluated against the command set and message sequences for these APIs. However, until international standards are produced, test suites will need to be developed for each proprietary API, and software conformance tests for ISDN applications are unlikely to be developed.

Once an API is defined and accepted as an international standard, conformance test software can be developed, and it will be possible to perform rigorous and reproducible interoperability tests for ISDN applications.

The number of national variants

As stated earlier, one of the challenges facing any CPE manufacturer is the number of international variants of ISDN. To sell a product into the five main ISDN markets—France, Germany, Japan, UK and USA—requires at least six different versions of the D-channel protocol stack (including two separate versions for the main USA switches, the AT&T 5ESS switch and the Northern Telecom DMS 100). This is obviously a resource-absorbing exercise and will include, within Europe, type approval by subjection to a set of exacting network access tests which will have variations for each country. Changing the product to meet one country's type approval may result in failure to meet another's type approval.

The variation in feature and supplementary services with the latest implementations of ISDN in each country is different, some are supported in one country, others are not.

Conclusions

The ISDN has been the natural progression path for the telecommunications operator. It has grown from a need to modernise the voice network by providing digital connection from one end user to another. This modernisation has made possible the offer of two digital channels each offering a 64 kbit/s path for data, voice, or video, with a separate 16 kbit/s channel for call control. The sheer complexity of this achievement has meant that strict standards needed to be drawn up, standards that must eventually be agreed between all participating providers, manufacturers and users to ensure uniformity and interoperability of the service.

Even though the main digital routes in many countries are in place, the ISDN has a limited availability of service. It is little wonder that, internationally, countries are at different stages of implementation. For any country, the ISDN is an extremely expensive network to provide nationwide, and therefore needs to be put in place gradually in a series of phases and implementations. To rush too far ahead before standards are set can add much additional expense in retrofit charges.

The number and variation of implementations by the network providers have been reflected in the shortage and high cost of ISDN terminals. The lack of a common API has meant that users are reluctant to invest in an ISDN terminal that may not be compatible with terminals owned by their business partners or by overseas companies with whom they do business.

The only practical way to overcome these problems is by interoperability testing, recognising where international interworking can take place, what problems exist, how to overcome those problems in the short term, and the identification of which items of CPE and applications interwork. There can be little doubt as to the importance of interoperability testing. It is regarded by many as the most important step any ISDN provider can take to ensure confidence in implementation. It is an excellent way of showing what ISDN can achieve nationally and internationally, but, more importantly, it can give users confidence in knowing the limits of the current worldwide ISDN offering.

It is for this reason that BT has established the ISDN Services and Applications Laboratory at Martlesham Heath. Ideally, what is now needed is for national interoperability laboratories to work together, identifying ISDN products, testing for product interoperability worldwide, and sharing any knowledge gained on an open forum.

References

1 CCITT Recommendation I.420: Integrated Services Digital Network (ISDN) Overall Network Aspects and Functions, ISDN User-Network Interfaces. CCITT Blue Book 1988 Vol. III — Fascicle III.8.

Biographies

Ron Haslam
BT Development and Procurement

Ron Haslam joined BT in 1961 after working with the Royal Air Force on coding and cypher equipment. He worked in various areas of BT including Telex, modems and TV outside broadcast. In 1976, he gained a B.Sc. degree in Physics, followed by an M.Sc. in Physical Measurement Techniques and Implementation. He transferred to BT Laboratories in 1981 working on analogue line circuit design and, later, the development of fibre networks. Since then, he has headed groups involved with ISDN development and support. He is, at present, in the Digital Services Division at BT Laboratories, and is the Technical Group Leader in the ISDN Support Group involved with helping manufacturers to reach the approval stage with their developments in ISDN terminal apparatus and applications.

Chris Johnson
BT Development and Procurement

Chris Johnson graduated in 1976 and joined STC Transmission Systems where he worked for three years. He then joined BT Laboratories working on the design of digital line cards for digital local exchanges and the Monarch PABX. He then moved into the field of LANs and MANs working on LAN/WAN interworking and collaborative European projects for performance management of MANs. He currently works in the ISDN Support Group within the Digital Services Division on the evaluation of applications for the ISDN.

Glossary

API Applications programming interface
BTNR BT network requirement
CPE Customer premises equipment
ETSI European Telecommunications Standards Institute
FTAM File transfer, access and management
IDA Integrated digital access
IDN Integrated digital network
IMUX: ISDN multiplexer
ISAL ISDN Service and Applications Laboratory
ISDN Integrated services digital network
HLC Higher-layer compatibility
LAN Local area network
LLC Lower-layer compatibility
MAN Metropolitan area network
MSN Multiple subscriber number
NT: Network termination
NTE: Network terminating equipment
OSI Open Systems Interconnection
PC Personal computer
PICS Protocol implementation conformance statements
PSTN Public switched telephone network
TA Terminal adapter
WAN Wide area network

Dick Landau

Exchange Transfer: Challenge and Innovation

The process of transferring customers from an analogue telephone exchange to a new System X or AXE10 local switch within BT's digital network is a complex task. This article describes how recent exchange transfer initiatives, centred on the main distribution frame, have led to reduced fault rates, lower costs and improved customer satisfaction.

Introduction

Although BT has a digital trunk network[1], some 45 per cent (June 1991) of customers are still connected to analogue local exchanges that await replacement as part of the ongoing modernisation programme.

A key modernisation milestone was met in June 1991 by which date half of BT's local exchanges had been replaced with digital switches. During 1992, another milestone was reached—the remaining London customers that were still connected to Strowger and crossbar exchanges were transferred to new digital switches.

The exchanges to be modernised vary in size, from 1000 lines or less to over 30 000 lines. Virtually all customers are connected to these exchanges via the twisted copper pairs that make up BT's access network. These pairs terminate on the main distribution frame (MDF) of the exchange.

The MDF

The MDF is the interface between the access network and the telephone exchange equipment in a traditional copper pair metallic environment[2]. The conventional MDF remains basically unchanged since its 1893 original design. The access network copper pairs are terminated on the *line* side, and the exchange equipment terminated on the opposite *exchange* side, the connection between the two being made with a twisted-pair semi-permanent *jumper*. (See Figure 1).

The MDF and Modernisation

The exchange transfer is a complex task and the activities are centred on the MDF. The changeover should be transparent, the customers' perception being only of improved facilities and services that modernisation brings. The main steps are:

- MDF record verification—checking the records of jumpers between customers' copper pairs and the exchange equipment and correcting where necessary.
- Bulk pre-jumpering—between the new digital switch appearance on the MDF exchange side and the line side copper pairs.
- MDF jumper verification—testing the new jumpers for accuracy and continuity.
- The physical MDF transfer or 'cut-over'. The customer is disconnected from the old (losing) exchange and connected to the new digital switch.

Figure 1—Customer's connection, showing the MDF

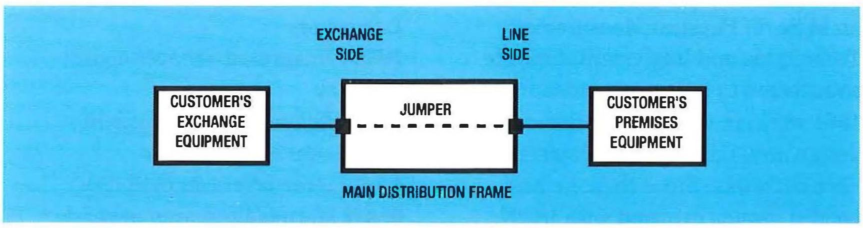
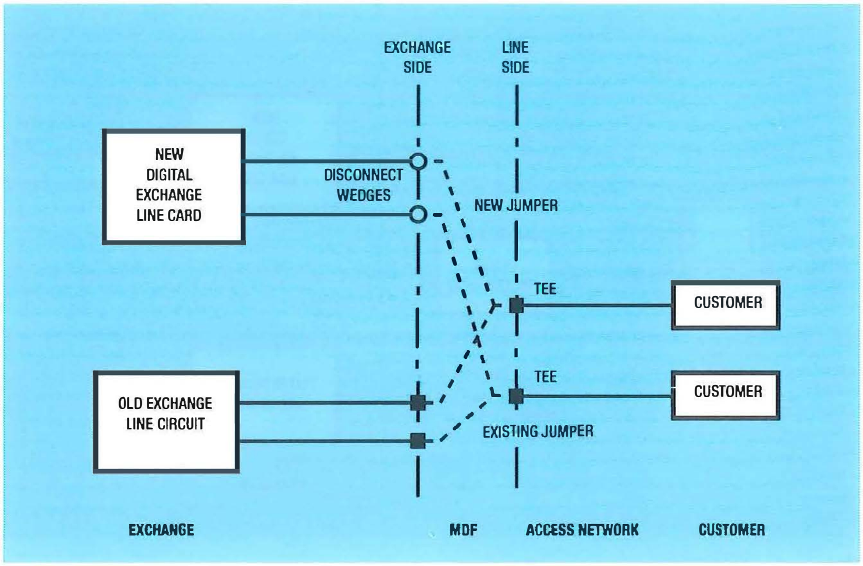


Figure 2—MDF transfer connections, showing two customers



A data build process precedes the MDF and transfer activities. The process includes, as a prerequisite to the build itself, cleansing of the customer data so that the new switch data aligns with the analogue exchange that it is replacing. This includes MDF record verification.

The data build process itself is outside the scope of this article[3]. However the MDF transfer activities are inextricably linked to the data build and it is this linked process that permits the necessary MDF bulk pre-jumpering of all customers' pairs (line side to new exchange side) to take place.

The Exchange Transfer Challenge

The size of BT's impending transfer programme and the problems that would arise as a result were recognised in the early-1980s. This challenge included:

- An approximate 10 million line transfer programme (1980–1990).
- Use of methodology that was little changed from that used for transferring manual exchanges to automatic: tapping-out and pulling MDF jumpers for verification, plus the need to ring every customer—both pre and post transfer.
- Slow testing procedures that allowed only one test of the new jumpering and took little account of the jumper activity (known as *churn*) that takes place as customers' lines are provided and ceased in the period up to transfer.

The improvements, and areas highlighted for improvement, that resulted from a study at that time included the following:

- There was a need to exploit BT's most valuable resource—its people and their ideas.
- Computerised MDF allocations and jumpering schedules were introduced—a software tool known as *INTRANS* (*INternal TRANSfer*). This developed into the frame record system (FRS), and the current product is the frame allocation and recording system (FARS).
- A range of hand-held manual testers for record verification, jumper verification and internal call-through testing (to test without involving the customer) was introduced. These are the 300 series testers such as the Tester 325A Record Verification Tester.
- MDF frame management and new MDF hardware were introduced[4].
- The need to bring the new switch into revenue earning service, as soon as possible after acceptance from the supplier, was recognised. The period between acceptance and being brought into service is known as the *C period*, and it is the time when BT's pre-transfer testing activities take place.

INTEST (Tester 397A)

Although the hand-held testers that were introduced, together with the other benefits, offered improvement, the pre-transfer testing was still basically a manual process which relied on paper records. Such methods become slower and more unwieldy as the number of exchange connections increases and are virtually unmanagable on the very large exchange transfers.

Works people in Colchester Telephone Area (now part of World-wide Networks Northern Home Counties Zone) looked at the possibility of automating both the record verification and jumper verification testing functions.

This work culminated in the *INternal TESTing system* (INTEST). INTEST was computer driven, by a small business computer (SBC) with CP/M operating system, and it offered a fully automated solution.

Verification of the new jumpering using INTEST posed a problem to the design team since the new switch must be isolated from the old exchange, even though both sets of jumpers come together (teed) at the MDF line side copper pair. Isolation is normally achieved by inserting 'disconnect' wedges into the MDF test jacks of the new switch; thus disconnecting the line. (See Figure 2).

The novel solution, which allowed INTEST to be used, consisted of replacing the normal disconnect wedge with one having a capacitor in each leg. In this way the new switch was effectively isolated (from a DC point of view), but INTEST could check the jumpering by passing an AC tone from the old exchange, the tee and the capacitive wedge, back via the new switch to a tone detector (See Figure 3). Typically 300 lines per hour can be automatically tested by INTEST in this mode.

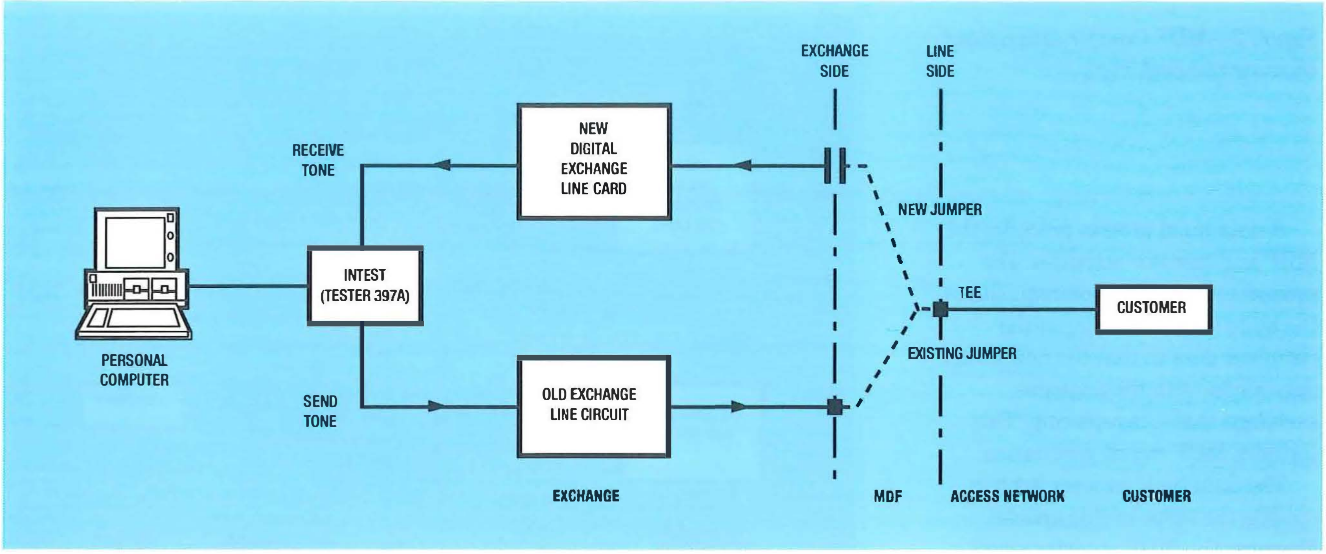


Figure 3—INTEST jumper verification

INTEST offers many other transfer related tests and facilities. Ongoing development has resulted in INTEST being driven by a personal computer with the MS-DOS operating system, the production of software to cater for all types of transfer including digital to digital, plus an *Intest For Frame MANagers program* (IFFMAN). The current version of IFFMAN (IFFMAN4) can be used to verify the frame records of any type of analogue or digital exchange.

Jumper Installation Fast Form (JIFF)

In order that the exchange transfer can take place, the MDF is pre-jumpered in readiness. However the large amount of work to carry out the necessary bulk jumpering is disruptive to the normal day-to-day frame activities.

The *jumper installation fast form* (JIFF) system was devised in Thameswey District (now part of Worldwide Networks Northern Home Counties Zone). With JIFF, 'forms' of up to 200 jumpers are made up on a template jig. This jig can be remote from the MDF, in a different building if necessary and possibly in a centralised 'factory' environment. Printed labels are produced using the FARS. These give the termination details and are attached to both ends of the jumpers.

The bulk jumper forms are then transported to the MDF where they are placed on the jumper bed and terminated. This can be performed out of normal working hours if necessary to avoid disruption.

JIFF contributes to reducing the C period, particularly on large jobs where bulk jumpering using traditional methods takes a long time. The amount of jumper reworking necessary, due to churn, is also reduced because completion of the bulk jumpering can be accurately timed.

Other advantages of the JIFF system are:

- elimination of customer affecting faults on the MDF caused by bulk provision, including jumper chafing, burning and breaking;
- frame management, in respect of time sharing by the different groups that require access to the MDF;
- the number of people used for the bulk jumpering can be increased. Once the JIFF jumpers have been laid in, a complete MDF vertical or line side block can be terminated without the operator needing to move.

MDF Cut-over Arrangements

The traditional way

Customers on the exchange to be transferred should receive uninterrupted service in the period up to transfer, yet be transferred to the digital switch, with minimum disruption. In order to carry out the transfer, it has been common practice for many years to fit each MDF pair with a transfer plug and wedge on the old MDF exchange side.

Figure 4—Transfer using plugs and wedges

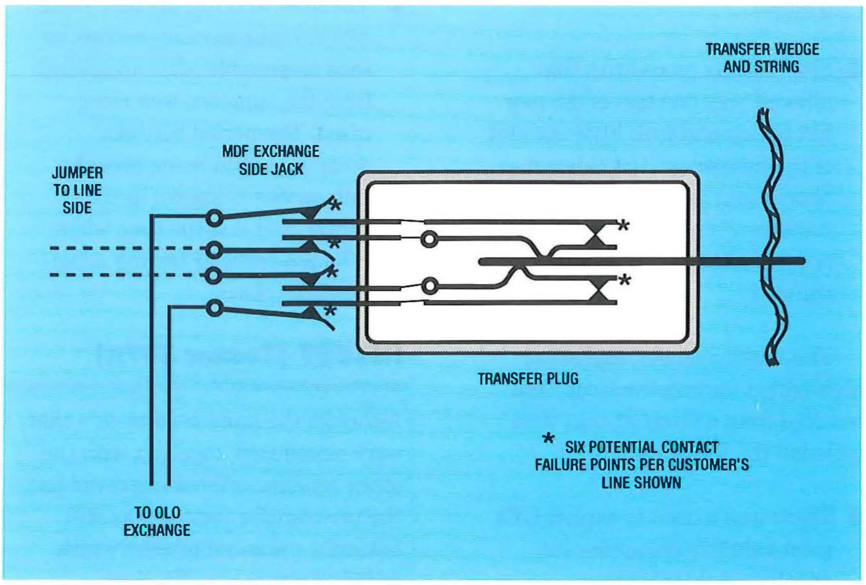
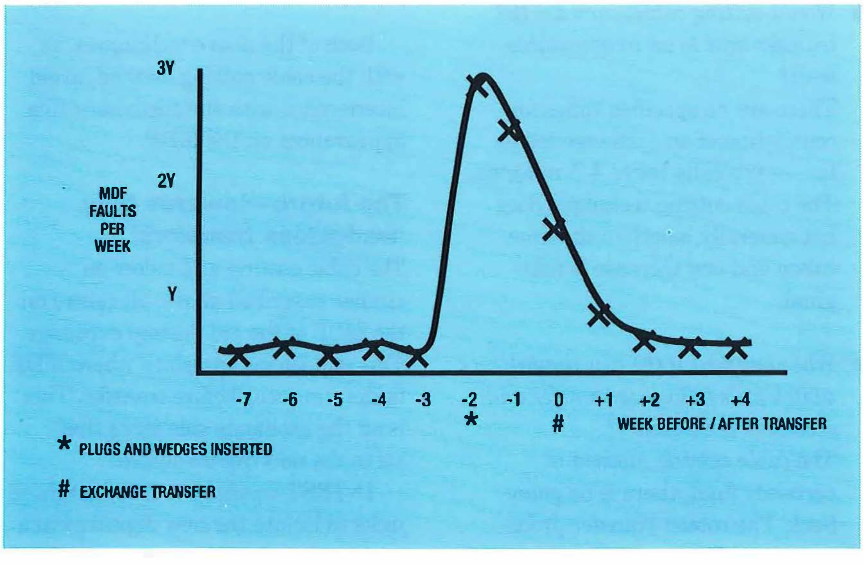


Figure 5—Exchange transfer—removing INTEST wedges on the MDF

Transfer plugs and wedges vary. Their precise pattern depends upon the type and vintage of the MDF hardware. However, they all perform the same function: when the plug, with its associated wedge fitted, is inserted in the MDF exchange side, continuity is maintained and the customer is connected through to his line equipment on the analogue unit. The wedges have holes and it is customary for them to be 'strung-up' so that a gentle pull on the string removes all of the wedges on an MDF vertical. Removal of the wedges opens contact springs and the connection to the old exchange is disconnected. (See Figure 4).

The next step is to perform a similar function on the new digital unit where the INTEST wedges are strung-up (see Figure 5). Removal of the INTEST wedges connects a metallic path between the customer and his exchange line card equipment. The old MDF jumpers are then recovered and the MDF transfer is complete.

Figure 6—Typical fault pattern when transfer plugs and wedges are used



Is the traditional method best?—Another successful transfer?

A quality improvement project (QIP) carried out by London Network Operations (now Worldwide Networks London) questioned the use of transfer plugs and wedges on the old exchange MDF.

The study stated that, by tradition, the quality of an exchange transfer was based on fault reports received *after* the transfer. However the introduction of INTEST had reduced the post-transfer faults to a low level; the major fault area was now in the pre-transfer period.

Specifically, no measure was made of the number of faults that were directly attributable to the plugging up of the old MDF *before* transfer. It was also suggested that the whole transfer scenario required a radical culture change as well as a possible change of methodology. Such a change would avoid the acceptance, prevalent in all disciplines (for example, works, fault reception and maintenance people), that a high number of customer-affecting MDF faults was to be expected in the period leading up to transfer.

Figure 6 shows a typical fault pattern, as revealed by the QIP, when transfer plugs and wedges are used. (Numerical values indicating faults/week have been deliberately omitted as the graph is not intended to typify any type or size of exchange.)

A number of recommendations arose from the QIP. These centred on overcoming deficiencies in the methods of fault analysis and targets.

The QIP, however, led to a follow-on study, namely how to overcome the high fault rate that was inherent in the design of the transfer plugs and wedges used on the MDF. When plugs and wedges are used, there are six potential electrical contact failure points on each customers line. These are shown in Figure 4.

A historical note

Transfer plugs and wedges, although in existence, were not generally used when exchanges were converted from manual to automatic working. We can only speculate as to whether fault liability was the reason. However it was probably not a consideration: the MDF exchange side furniture in use at that time had a low packing density and was of a generous size. It permitted a simpler method—'wedge shaped strips of hardwood are provided at the old exchange so that, at the time of the transfer, the subscribers can be disconnected from the old exchange equipment by the insertion of these wedges into the test springs. The hardwood strips are made of sufficient length to disconnect 20 lines per strip'[5].

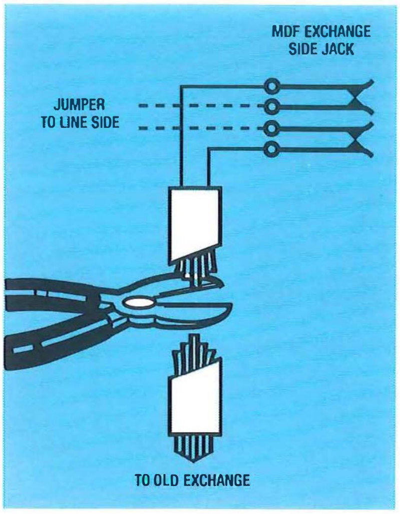
To wedge or not to wedge?

The LNO follow-on study attempted to find an alternative to the use of transfer wedges because:

- the general level of customer faults caused by the digital modernisation programme had reduced steadily; and
- this general fault reduction, coupled with changed criteria for measuring transfer success, highlighted the MDF—in particular wedging operations—as the remaining primary source of customer-affecting faults.

The study concluded, after a controlled trial on a 5000 line strowger exchange transfer, that the method to be adopted should be to cut the cables that are connected to the old MDF exchange side. This being literally a 'cut-over' as shown in Figure 7.

Figure 7—Transfer using cable cutting method



Exchange transfer by cutting cables

Cutting the cables to the MDF appeared to be a simple operation, but a number of questions had to be addressed before national adoption:

- *Were the cables physically accessible?*
  At the trial site, the cables could be accessed above the MDF by the required number of people. This is true at most locations.
- *Would an unacceptable level of faults be caused by short circuits at the cut ends?*
  Contrary to popular belief, faults are not generated by cutting cables provided the cable shears are in good condition.
- *Would cutting 'live' cables cause problems?*
  In general it was felt that cutting cables carrying customer line circuit battery conditions (–50 V and earth) was not good practice. The majority of the line circuit batteries are therefore disconnected by using preference keys. The remaining few circuits that cannot be disconnected amount typically to one per cable and can therefore be discounted.
- *Would cutting cables increase the transfer time to an unacceptable level?*
  There are no specified times for completion of an exchange transfer—it typically takes 4–5 minutes. The cable cutting technique does not generally lengthen the time taken and any increase is marginal.
- *What happens if the new digital switch fails following transfer and reversion is necessary?*
  The cable cutting method is certainly final; there is no going back. The robust transfer procedures currently in place, coupled with more resilient digital switch hardware, mean that exchange transfer is now a very controlled process; reversion to the old exchange is not a consideration. The required procedures, including check lists and sign-offs for each activity, are contained in controlling documentation—the *Digital Exchange Transfer Compendium*.

Later enhancements

The cable cutting technique can be used on all types of old (losing) exchange. However, other alternative methods have since been devised and have application typically where space above the MDF is restricted:

- For electronic exchanges (TXE2 and TXE4), the slide-in units—the customers' 'A' switch or line unit—can be removed.
- For crossbar (TXK3) exchanges, the stringing up and removal of links (cavaliers) can effect transfer.

Both of the above techniques, as with the cable cutting method, avoid interference with the customers' line appearances on the MDF.

The future—towards fully 'wedgeless transfers'

The cable cutting and follow-on studies described above, all centre on the MDF of the old (losing) exchange. This still leaves one place where MDF faults can occur before transfer. This is on the exchange side jacks that serve the new digital switch.

INTEST wedges are fitted on these jacks to isolate the new digital switch from both the old exchange and the customer.

100-way test jacks are currently fitted on conventional MDFs when a new System X or AXE10 switch is installed. The increased packing density and miniaturisation of the jacks has resulted in problems, particularly when they are fitted with the front administered INTEST wedges. Also any interference such as that caused by jumpering activities (for example, re-jumpering to deal with the churn) can be fault inducing.

Because of the problems, trials are taking place to see if a full 'wedgeless transfer' is viable. This has stemmed from an idea that originated in Worldwide Networks Wales and the West Zone.

It is suggested that instead of using a conventional INTEST wedge, use is made of a position at the side of the jack intended to house protector modules. (The protector modules give protection against lightning and AC mains line contact). This position offers a more robust connection—for an INTEST capacitive plug—sited away from the vulnerable contact spring area at the front of the jack. The capacitive plugs will be removed and replaced with protector modules before the transfer takes place.

Conclusion

The service that customers receive depends on the quality of the main distribution frame. The MDF becomes the focal point when an exchange is being modernised and any weaknesses and limitations are soon exposed.

The huge modernisation programme embarked on by BT has shown a number of areas for improvement in the MDF and exchange transfer arena. These have been enthusiastically investigated and innovatively solved by initiatives from BT people.

Many of these initiatives are currently in use. When put together, they will form a portfolio of best practices to be adopted for exchange transfer.

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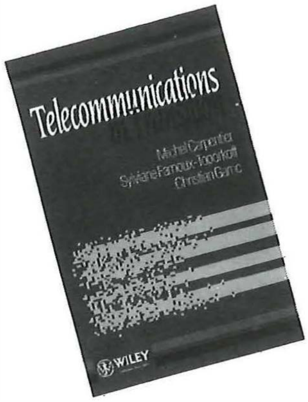
Biography

Dick Landau
BT Worldwide Networks

Dick Landau has responsibility for exchange transfers within the works policy team in Worldwide Networks. He joined London South West area as an apprentice in 1963. After working on director exchange maintenance, he transferred as a technical officer to Service Division in headquarters in 1971 where he was part of the STD special investigation team. This work included quality of service investigations on the local, trunk and the trunk transit networks plus a field trial of miniaturised SSAC9 equipment. On promotion to a level 1 manager in 1973, he initially had responsibility for maintenance of trunk switching and signalling equipment. He followed this with a period dealing with the installation and maintenance of measurement and analysis centre (MAC) access equipment before transferring to the digital works group in 1985 from where his present responsibility evolved. Dick is interested in the history of telecommunications and is a member of the Telecom Heritage Group.



Telecommunications in Transition

Michel Carpentier, Sylviane Farnoux-Toporkoff, and Christian Garric

The global telecommunications business is unquestionably in the midst of a major transformation. Government-owned monopolies are increasingly being replaced by privately owned companies and competition is being introduced. Basic telephony, Telex and private services carried over analogue copper networks are gradually being usurped by intelligent digital networks carrying a vast selection of high-speed high-quality services.

The enormous advances in technology in recent years have undoubtedly enabled these services to be offered, but it is the changes in regulatory frameworks and the initiatives of international bodies such as the Federal Communications Commission in America and the European Commission this side of the Atlantic that have provided the catalyst for this transformation. Technology alone would not have had the opportunity to make such a rapid impact.

Telecommunications in Transition takes the reader on a guided tour of the history of global telecommunications regulation and examines how technology advances, commercial pressures and government initiatives have forced this transformation through at such a pace.

The history of American telecommunications is summarised, providing the reader with the background to the 1983 deregulation and break up of AT&T. The seven resulting Regional Bell Operating Companies and AT&T, and their progress in a competitive market, are assessed and views on the future of the North American services and equipment market put forward.

Attention is then turned to Europe. The European Commission has produced several reports, including the Green Paper of 1987, each of which is analysed and its major recommendations summarised. The changing regulatory environment in each of the EC countries is described, the UK often being singled out as pioneering in its attempts to encourage competition and in the privatisation of the national telecommunications organisation.

It is not until the last few pages of the book that the reader is offered some of the staunchly pro-European opinions of the authors. The general direction of European standardisation is whole heartedly supported, but a few major concerns are also aired.

Harmonised regulation and standardisation, high investment in research and development and the development of a trans-European network infrastructure are encouraged:

'If liberalisation is necessary for the development of new trans-European services it is appropriate to avoid the inevitable malfunctioning which would ensue from the absence of harmonised regulation. Examples of effects to be avoided include the provision of services incompatible with the use of different equipment or network standards; tariff wars that would jeopardise the viability of networks and infrastructures; or a disorderly choice of frequencies, ruling out trans-European mobile communications services.'

A concern raised in the book is the ever-increasing presence of the Americans and Japanese in Europe (particularly in the equipment market) compared with the failure by European companies, with a few notable exceptions, to gain a significant presence in overseas markets.

The economic pressure on America to reduce its trade deficit acts as a further hindrance to European penetration of Japanese and American markets. This pressure results, it is argued, in an increase in disguised American protectionism, American industry being given priority in any opening in the Japanese market (Motorola is cited as an example) and a movement to relocate Japanese industry to the US with a re-exportation to Europe.

Telecommunications in Transition suggests that the European approach to this situation should not be a return to a protectionist system, but an aggressive attempt by European players to assert themselves on the global and European scenes. This should be achieved by seeking growth in all forms: internal growth, buy-ins to joint ventures, acquisitions and partnerships. This strategy should be pursued even if there is no apparent short-term return.

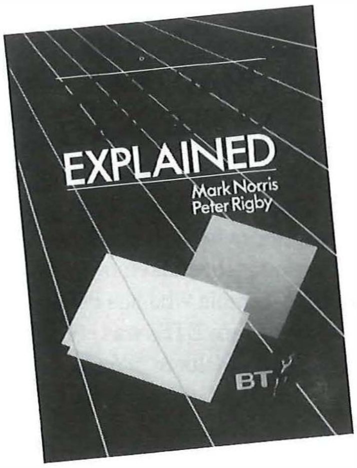
The telecommunications revolution is only just beginning. *Telecommunications in Transition* argues convincingly that the European Community's strategic and regulatory frameworks offer the ideal environment for the prosperity of European telecommunications organisations.

Telecommunications in Transition will be of particular interest to those with an interest in telecommunication regulation globally. Good use of tables and diagrams make this heavy-going topic easier to digest. It is in the conclusions at the end of each chapter and in the final chapter that the real value in reading this book is found. The arguments offered are thought provoking and well constructed. This book should be one of the sources read by all those seeking a well-balanced view of the continuing telecommunications revolution.

Published by John Wiley & Sons.
£19·95. xvi+176 pp.
ISBN 0-471-93190-X.

Reviewed by Rob Houghton

Note: The books reviewed here have been added to the IBTE Library. Library forms are available from Local-Centre Secretaries for IBTE Members.



Software Engineering Explained

Mark Norris and Peter Rigby

In the 1960s, it was recognised that the greatest impact of technology lay in the software control of the telephone exchange. Therein was the chance to provide flexibility in customer and management services. However, the software utopia proved elusive. Initial estimates of code size were too small by orders of magnitude. The problems of writing, testing and maintaining the software were wildly underestimated. So severe were the problems that in the 1980s even the suggestion of a small change in the software was an anathema. This experience was not confined to exchange software; mainframe operating systems and applications too were threatened by unexpected reliability problems. Real-time systems controlling medical equipment, chemical plants and vehicles could fail with dangerous consequences.

From chaos had to come order. From about 1975 onwards, a whole series of more or less successful strategies were developed for handling software and after 17 years the subject is maturing as 'software engineering', the subject of this book.

A single solution to the problem has not yet emerged. The wide range of applications and equipment on which these can be run may mean that the single solution may never be possible. Anyway, the level of maturity of the topic is still such that a range of strategies can be recommended.

This book offers a readable overview of the situation as it is today, covering the needs of the software engineer and the range of solutions with their strengths and weaknesses. For those on the periphery, such as managers and users of software, it gives an insight into the ways things are done. To those with their heads down analysing, coding and testing, it offers a broad view of the world in which they work.

The book covers the whole range of software development from identifying systems requirements, through design to testing. It is most commendable that the usually ignored subject of maintenance is covered at length; after all most of us experience software during this phase of its life cycle. Throughout, the authors have the refreshing ability to recognise that the whole process is driven by real people with all their strengths and weaknesses. In a book of this size it is clearly not possible for techniques to be set out in detail but the book offers many references and contains a useful bibliography. Whether you need a primer on the subject or just want to put your experience into context, this is for you.

Published by John Wiley & Sons.
£19·95 xii + 208 pp.
ISBN 0-471-92950-6

Reviewed by John Griffiths

Phone Wars—The Story of Mercury Communications

Keith Bradley

Phone Wars is a very readable account of the birth, development and management of Mercury Communications. From the beginnings during the 1980s, it describes the Government's vision to allow competition in telecommunications at a time of public indifference and uncertainty as to the provider of an alternative network.

The book gives an account of the entrenched position taken by BT management and unions leading to decisions taken in the law courts.

It offers an insight into the decision-making process when forming a new company where the market is unclear and yet requires high initial capital investment. Mercury was able to provide basic digital technology at a time when BT was only beginning to modernise its analogue network.

The management issues are of particular interest when compared with those of BT during the early-1990s. The average age of Mercury employees is below 30 years, recruited with specific technical skills. A flat management structure ensured low overhead costs and enabled rapid internal communication. As a non-unionised company, emphasis was placed on having structured personal appraisal, remuneration scheme and effective career development.

The introduction of quality management systems was seen as vital to the success of the company. There are interesting comparisons with BT quality systems.

Phone Wars is not only compulsive reading but the concepts described may well assist with the formulation of strategic business decisions within other telecommunications companies.

Published by Century Business.
£16·99. xix+251 pp.
ISBN 0-7126-9826-4

Reviewed by Geoff Fell

Note: The books reviewed here have been added to the IBTE Library. Library forms are available from Local-Centre Secretaries for IBTE Members.

Euro-Network Deal

BT, France Telecom, Deutsche Bundespost Telekom, Telefonica of Spain and ASST/STET of Italy have joined forces to develop a new managed European network infrastructure. Known as the *Global European Network* (GEN), it will be based on optical-fibre technology and digital switching systems and will provide telecommunications services beginning in 1993.

Another aim of the project is to reduce the provisioning time for international private circuits, and allow each network operator to speed up network configuration. Should network failure occur, reserved capacity will be used for circuit restoration. The network will be managed from centres in the UK and France.

BT is keen to emphasise that the GEN will not overlap with its Syncordia project. While Syncordia concentrates on service provision, the GEN is intended to provide the infrastructure for other services to be offered on the top.

Fibre First for Mercury

Northern Telecom Ltd reports an initial contract from Mercury Communications Ltd, in which Mercury will be the first carrier to use 2·5 Gbit/s optical-fibre equipment in a UK network. Northern Telecom's S/DMS TransportNode 16L supports the new synchronous digital hierarchy network architecture, which enables carriers to offer high-speed services such as multimedia and dial-up videoconferencing; the synchronous equipment will quadruple the capacity of the existing installed fibre network, providing capacity for 30 720 voice channels.

Olympic Benefit for Telefonica

Telefonica's president, Candido Valazquex, estimates that international revenue for Telefonica as a result of the Barcelona Olympics will amount to 3000 million pt. Catalonia was due to receive the benefit of investment in 1994 and 1998, but this was brought forward because of the Games.

Although Madrid and Catalonia head the field in Spain for their advanced telecommunications, (there are 45 telephones for every 100 citizens), over the last ten years, other areas of Spain have shown greater growth.

In this period, telephone installations in regions such as Extremadure, the Canary Islands, Andalusia and Castilla-La Mancha have doubled. The satellite communications centre in Granada del Penedes, just outside Barcelona, boasts five ground stations and spent its time transmitting the Games TV signals with a capacity of up to 31 permanent channels. It is now being used as an international telephony, telegraphy and data centre, as well as to receive and transmit TV signals through the European EUTELSAT satellites and the INTELSAT world satellite.

BR-Chunnel Link-Up

British Rail Telecommunications Ltd has signed with Eurotunnel plc to lease a wayleave to lay telecommunications cables through the channel tunnel.

It has also ordered an international trunk exchange from GPT Communications Systems Ltd to link its UK network to that of French national railway operator Société Nationale des Chemins de Fer in Paris as part of plans to launch an international leased line telecommunciations service at the end of next year.

The company says that the kit is to be used to service existing customer needs and is not particularly linked to its pending applications for a UK public telecommunications operator's licence. The company is using two 2 Mbit/s links and says that a new agreement will be needed with Eurotunnel before the link could be used for switched service. It further says to expect an announcement around October concerning the commercial partnership that will open the way to the PTO licence.

New TA Chairman for ETSI

The Technical Assembly (TA) of the European Telecommunications Standards Institute (ETSI) has a new Chairman. Mr Peter Hamelberg (53), Director of Standards and International Affairs for PTT Telecom in the Netherlands, has taken over from Stephen Temple who has been chairman since ETSI was created in 1988. Mr Hamelberg, a former FITCE president, has been with the PTT since 1966, and has worked on transmission technology, telegraphy, and data communications as well as residential and business communications. He will serve as chairman for two years.

Cellnet Profit Boost

Cellnet has reported interim pre-tax profits to 31 March of £57M up 90% from last year, on turnover up 20% at £197M. Cellnet yielded interim profits to the group of £22·8M before interest and tax.

The profit which Cellnet contributed to Securior grew a substantial 88·4% on last year's figure of £12·1M and reflects the improved rate of net subscriber connections and the development of Cellnet's Callback messaging facility. Cellnet claims to have taken over 50% of new market growth in the last 18 months, although Vodafone Group plc claims around 56% of the 1·2 million subscriber mobile telephone duopoly with Cellnet.

Securicor Cellular Services, the cellular retailing company, and Securicor Datatrak, the other businesses operating alongside Cellnet in Securicor's Communications section, also produced improved results; final pre-tax profits for all three were £27·6M.

World News

***CIS*:** Siemens AG, Munich, Bavaria, reports an order worth about $22M to set up a nationwide data network in Russia. The order covers data networks to be installed in all major cities before 1996 and it was awarded by a joint venture between Moscow's telephone company MGTS and Iner EVM.

***Czechoslovakia*:** The Ministries of Transport and Communications in Czechoslovakia were abolished at the end of September. The decision was taken after a meeting between Antonin Baudys, Federal Deputy Premier; Karel Dyba, Czech Minister of the Economy; and Roman Hofbauer, Slovak Minister of Transport and Telecommunications. After abolition, a residual structure attached to the Federal Government will deal with essential issues and start work on the transfer of powers to the republics.

***Denmark-Russia*:** The STC Submarine Systems arm of Northern Telecom Ltd has now begun the laying of the underwater optical-fibre telecommunications link into Russia from Denmark. When the project is completed, the link will offer a basic capacity of 16 000 circuits for voice, data and video. Last September, Telecom Denmark and GB Great Northern Telegraph Co. awarded Northern Telecom the $65M contract to link Denmark with Russia by a cable under the Baltic.

***Germany*:** Deutsche Bundespost Telekom is to cut its workforce of 255 000 by 12 900 by 1995. The move is part of a job reduction programme aimed at cutting 31 400 across the three Deutsche Bundespost divisions, Telekom, Postdienst and Postbank. It is hoped that the bulk of reductions will come from natural wastage.

***Hong Kong*:** The SmartCom consortium, including McCaw Cellular Communications, Sun Hung Kai Properties, paging company ABC Communications (Holdings) and Town Kahn (owned by China's Ministry of Post and Telecommunications) has won the licence to operate Hong Kong's fourth cellular network. The group is expected to invest more than $1 billion in the service during its start-up phase.

SmartCom has committed itself to cheaper call charges, and says that network coverage will service all road and rail tunnels including the entire Mass Transit Railway system. It plans to launch the service by the middle of January 1993.

***Hungary*:** Salomon Brothers has been chosen as privatisation advisor for MATAV, the Hungarian telecommunications company. Other bidders were Credit Suisse First Boston, Daiwa-MKB, Kleinwort Benson, Merrill Lynch and NM Rothschild. SPA, the company's sole owner, had previously picked NM Rothschild as its advisor, and the two will now work side-by-side.

***Japan*:** AT&T's newest cable ship, the *Global Sentinel*, has completed its maiden voyage and laid TPC-4, the first transpacific optical-fibre cable to directly connect the US and Canada with Japan. Customer service in the £373M system is planned for November.

***New Zealand*:** Telecom Corporation has raised telephone rental charges by 67%. The company says that it currently loses around US $16M a year on residential services and that the increase would 'not quite cover' the loss.

***Northern Ireland*:** Mercury Communications has installed an optical-fibre cable linking the UK mainland to Peel in the Isle of Man as part of its plan to connect Northern Ireland into its telephone network. Peel on the west coast and Port Grenaugh on the east are the landing points for the Blackpool-Ballywalter cable.

***Portugal*:** BT has announced that its Global Network Services is now available in Portugal. With local partner Comnexo, the data network service arm of Compta, BT has installed an initial node in Lisbon, with further nodes planned for Porto and Faro early in 1993.

***Sweden*:** The Communications Ministry has released a set of preliminary proposals outlining the future of Swedish Telecom (Televerket). As expected, the entire Televerket group will be incorporated into a limited company at the beginning of 1993, but there is no privatisation timetable yet. Communications Minister Mats Odell said that the privatisation process could be completed more quickly than some of the observers expected. It is unlikely though that the telephone company will be split into its constituent operating units.

***USA*:** AT&T has reported the beginning of customer service on the TAT-10 transatlantic optical-fibre cable, just five months after TAT-9 began service: the $300M system is the first direct optical-fibre route between the US, Germany and the Netherlands, and connects Green Hill, Rhode Island, with Norden, Germany, and Alkmaar, Netherlands. Service between Germany and the Netherlands is scheduled to start this autumn. A third cable system, TAT-11, is targeted for service next year to connect the US, the UK and France.

AT&T is to dedicate its 900-555 exchange for companies offering business-to-business, pay-per-call database services. Bell Communications Research, which manages the national telephone numbering plan, has assigned exclusive use of numbers in the 900-555 exchange to AT&T.

Bellcore is also researching the possibilities of using solar energy to power telecommunications services over optical-fibre cable. Computer-simulated tests it has run are claimed to show that its system can generate enough electricity to sustain daily telephone use by four average US households, representing up to 120 watts on a sunny day.

London Sets the Pace for European Telecommunications

On 28 July 1992, London's telephone network became one of the most advanced of all European capitals when BT replaced the last remaining old-style electromechanical exchange in the region. Two local school children switched on the new digital equipment at the Stapleford exchange, near Abridge, Essex, and made the first call on the new system to Mike Bett, BT's Deputy Chairman, at the BT Tower.

Over the past seven years, BT has spent £17 billion upgrading its entire UK network. Nearly £2·5 billion of that investment has provided BT's 4·5 million London customers with the most advanced telecommunications system of any European capital.

With the conversion at Stapleford, all the 534 exchanges in London and the area within the M25 will use modern technology. Of these, 70% are the latest in digital technology and the rest are modern electronic exchanges that have been enhanced to operate on the digital network.

The international switching capability is world class with all switching units being digital and a number having advanced features.

The London modernisation programme has been completed six months ahead of schedule and on budget and makes it the only European capital to have replaced all its electromechanical exchanges with modern digital or electronic ones.

This maintains London's prime position as a centre for telecommunications excellence as customers can enjoy all the benefits of one of the world's most advanced telecommunications networks, including faster call set up, clearer lines, and the option of itemised billing.

Tom Denniss, Director Operations London, who has spearheaded the modernisation drive during the past two years, attributed the success to BT people working together as a team to coordinate the complex programme, and professionalism in project management.

He said: 'Two new organisations were established pre-Sovereign—London Network Operations and London Network Planning—to accelerate the modernisation of a network which over the years had grown into one of the largest and most complex serving a metropolitan conurbation. And they also had to plan and execute the London Code Change as a sideshow.'

'The fact that the objectives have been achieved within their time, cost and quality targets speaks volumes for the dedication and hard work of staff.'

To plan the new London network, BT set up a team of 200 skilled engineering designers, which expanded to about 300 at the peak of the work. They created a new simplified backbone network for London—a grid of high-speed, high-capacity optical-fibre cables linking 10 key centres. The new system is designed to cope with future growth and enables BT to re-route lines if one route fails.

A 3000-strong workforce was mobilised to speed up the huge task of replacing London's creaking electromechanical telephone exchanges—some more than 40 years old—with modern high-speed computer-controlled equipment.

BT Research and Development Awards

Two outstanding technologists, Mike Carr and Richard Nicol, working at BT Laboratories, Martlesham Heath, have been awarded BT's prestigious Martlesham Medal for their pioneering work on digital video—work which has played a major part in enabling video by telephone and opened the way to the convergence of video with computing and telecommunications.

Presenting the awards, Iain Vallance, Chairman of BT, said: 'I have no doubt that video by telephone is going to be the next step change in worldwide communications. Just as we have seen computing and telephony converge to yield all kinds of exciting new benefits, we are now seeing video coming in to join them in a digital trio of enormous potential. Mike Carr and Richard Nicol have been instrumental in opening up these new horizons.'

Reflecting increased emphasis on commercial objectives, BT has this year struck a new medal to be awarded yearly in recognition of outstanding achievements in developing technologies that advance the company's business objectives.

Iain Vallance said: 'If the Martlesham Medal is about achievements in research, the BT Gold Medal has been introduced to recognise the equally important arena of development; that is to say the exploitation of technological progress to address specific business objectives.'

The BT Gold Medal was presented to BT director of information systems development Barry Cook and two of his senior colleagues, Linda Hancock and Dave Quinn. The awards are in recognition of their decisive contributions to the development of computerised support systems that now underpin all BT's day-to-day service for 26 million customers.

The systems, known as *CSS*, are ranked among the most powerful of their kind in the world and are helping BT to maintain competitive advantage in an increasingly tough market.

'CSS has the potential to offer every customer-service operator virtually instant access to all kinds of data, on any one of our customers, from anywhere in the country,' said Mr Vallance. 'It is giving us a real competitive advantage by enabling a speed of response to customers that seemed quite unrealistic just a few years ago.'

'The sustained development work that has gone into CSS has been a key factor in the development of BT itself into a quality company offering world-class service to millions of customers.'

BT Helps Major Banks Cut Down Plastic Fraud with GNS Cardway

Two major banks have teamed up with BT in an effort to combat the increasing level of card fraud, which last year cost the banking industry £165 million. BT has offered both banks reduced prices for GNS Cardway—its new credit card validation and authorisation service. Barclays Merchant Services and National Westminster will use GNS Cardway to carry their growing number of card transaction authorisations. Cardway will link thousands of retail point-of-sale terminals to the Barclays and National Westminster computers via an 0800 number and BT's Global Network Services (GNS) data network.

It is expected that the two banks will use the service to carry hundreds of transactions each year. Retailers and card holders will benefit from the increased speed and efficiency and reduced costs of the new network.

GNS Cardway is the latest example of BT's commitment to serve the retail sector. Over recent years, BT has provided a number of managed networks for major retailers such as Sainsbury's, Dixons and Rumbelows. The lower prices for the Cardway service have enabled the banks to bring the benefits of managed networking to the smaller retailer.

Some 40 000 terminals will be connected to the network next year and this number is expected to rise sharply in the future.

The GNS Cardway connection will ensure faster turnaround of data for the benefit of retailers and credit card holders. It will help reduce the incidence of fraud and its resulting costs which are inevitably passed on to the shopping public.

BT's Highland Operators Lead the Way on Teleworking

The freedom and efficiency of working from your own home, while enjoying all the benefits and none of the drawbacks of full-time employment, has come a step closer with the launch of a unique BT experiment.

Since 1 July, 10 volunteer directory assistance operators from Inverness have been working in the comfort of their own homes—offering the same first-class service to callers to 192, but still enjoying all the benefits of working as a team with one another and their colleagues back at the centre.

The purpose of the experiment is to investigate the technical, managerial and social aspects of teleworking, so that systems can be developed to satisfy the increasing demand for alternative ways of working.

The volunteers have specially adapted terminals installed in their homes, giving them all the on-line facilities they used to have in the centre. To counter any feelings of isolation, they are also linked by videophones. This gives them direct contact with their supervisor and, during breaks, allows them to chat to each other or catch up with the office gossip through another videophone installed in the centre's rest room.

The past decade has seen an explosion of new technology. BT's mission is to give everyone that benefit. BT is demonstrating in this highly practical way just how advanced teleworking now is and pointing the way for other companies in Britain and around the world.

BT has estimated that by 1995 more than two million Britons could be working from home for at least three days a week. This experiment is unique. Nowhere in the world has anyone ever used electronic mail and videophones in this way.

The Inverness experiment will run for 12 months and be closely monitored. But over that year the teleworking operators can look forward to travelling to work by telephone, avoiding the daily cost and drudgery of commuting while enjoying the life in one of the UK's most scenic areas.

In-Flight Fax

A technical breakthrough by engineers at BT Laboratories has paved the way for commercial facsimile services on board in-flight aircraft. A full commercial service could be introduced worldwide by 1993. The service should enable documents to be sent to and from aircraft at any point during flight to any destination in the world.

The contract for an in-flight facsimile and circuit mode data service was put out to international tender by INMARSAT. BT offered the 'unique' solution of upgrading the existing voice codec design, used for Skyphone, to recognise the tones of facsimile machines as well as the human voice.

The BT technology does not require additional hardware in the avionics rack and hence does not add weight to reduce the efficiency of the aircraft.

The voice codec developed by BT engineers for Skyphone takes speech and throws away most of the redundant sounds before sending the information as streams of data between the passenger on the aircraft and the recipient on the ground. These streams of data are turned back into recognisable speech at BT's ground earth station at Goonhilly Downs in Cornwall.

The codec was designed to 'compress' the voice by a factor of almost seven to keep the cost of satellite telephone calls as low as possible. The result was that the codec was unable to recognise or handle facsimile message tones.

BT's tender-winning modification opens the door to a whole range of services based on the ability to pass data and encrypted transmission as well as voice and facsimile down the same channel. End-to-end encryption of both voice and data services is now a very real possibility.

BT Makes Lower-Cost Colour Remote Surveillance A Reality

Colour remote surveillance over any distance can now take place at a fraction of the cost of existing comparable methods.

By using videophone technology, in the form of the new RS3300 videocodec, BT is giving remote surveillance users the chance to see much more than has been possible with slow-scan systems. The codec allows moving pictures to be transmitted on a digital telephone line by transmitting only the parts of the picture which move.

The £5000 RS3300 codec can be connected to a camera and BT's dial-up integrated services digital network (ISDN). From any distance, and in colour, it allows the speed and flow of traffic to be monitored as well as the surveillance of property for security reasons. Until now, quality pictures of this sort have typically only been available for at least double the cost.

BT is still marketing products for users that require very high-quality pictures, but many applications lend themselves to dial-up colour surveillance. For example, surveillance of a site that already has burglar alarms need not always be continuous. It is only when an alarm goes off that pictures are required. Also, because the new system has no constraints on distance, a central control room could be used to monitor the scene in a group of bank lobbies, or railway station car parks—often many miles apart.

The RS3300 video codec system digitises and compresses pictures for transmission over 64 kbit/s digital circuits or the ISDN. The system can be connected either to an X.21 interface 64 kbit/s leased wire, or via a terminal adaptor to one B-channel of an ISDN line. The system, which is CCITT H.261 compatible, can be configured to enable full 64 kbit/s vision or audio, or a combination of 48 kbit/s vision and 16 kbit/s audio in either direction of transmission. The audio paths can be used for speech or, by using the appropriate interface equipment, for remote control data.

The system accepts both colour and monochrome video signals. At 64 kbit/s, the picture has a refresh rate of up to 15 frames per second. The RS3300 is housed in a 1U high unit designed for mounting in a 19 inch rack. When the system is connected via the ISDN, the inclusion of an autodialler in conjunction with a suitable terminal adaptor provides easy selection and dialling of pre-stored numbers.

BT and IBM Keep Pledge of Multimedia Openness

BT Visual and Broadcast Services and IBM have kept their promise to publish application programming interfaces (APIs) for their forthcoming PC-based videotelephone and desktop interworking products.

The two companies announced in April that they are producing PC-based products which bring together the technologies of the telephone, TV and personal computer. The PC card and associated software will allow users to see and speak to each other via moving image windows; share the contents of any of the PC's windows; and transmit data between PCs.

The products will work over BT's integrated services digital network (ISDN) and will be available early next year.

API information has been sent to major industry players to enable them to produce compatible products including applications software and even video answering machines.

BTVBS Portfolio and Business Development Manager Graham Mills said: 'We have received a large number of requests for information from around the world since April. It is apparent that there is significant global interest from users, independent software vendors, PBX manufacturers, OEMs and telecommunications companies. They all recognise the importance of converging as fast as possible upon a common set of open standards for interoperability.

'Where there are international standards already established,' Mills continued, 'Such as H.261 for videocoding, we have used them in the development of this product. Where there are no standards, we are publishing the interfaces so that people can adopt the same APIs'.

IBM's Networking Strategy Manager Chris Frost said: 'It is intended that, over time, the system will converge with IBM's person-to-person /2 product which provides users with the ability to share information over LAN and wide area network architectures as well as ISDN.

'We are releasing this information to enable interested parties to understand and comment on the APIs with a view to enabling them to begin the planning and high-level design of their applications.'

BT Marine Places Eureka Order

BT Marine of Southampton has placed a seven-figure contract with Soil Machine Dynamics Ltd. (SMD) of Northumberland for supply of the Eureka post-lay burial system.

The Eureka system will be capable of post-lay burying all types of cables and small pipes to a burial depth of 1 m, and can work in water depths of up to 1000 m.

The system comes with its own dedicated handling and control system, and can be operated off any of the BT Marine cableships or construction vessels. It is also suitable for deployment off a wide range of ships of opportunity.

Eureka is a valuable addition to BT Marine's array of ploughs and submersibles and reconfirms BT Marine's commitment to applying new technology in the field of cable burial.

Eureka offers an unrivalled capability for post-lay burial operations worldwide, using advanced water jet cutting technology which has been extensively championed and researched by BT Marine in recent years.

SMD will design and build all the major equipment including the vehicle itself, the 'A' frame handling system and umbilical winch. Eureka is scheduled to be ready for service in summer 1993.

Motorola and BT to Bring Next Generation of Multimedia Communications to the Desktop

Motorola and BT Visual and Broadcast Services have announced plans to develop technology which will bring users the next generation of multimedia communications products.

Throughout the partnership, BT and Motorola will share their respective expertise in videoconferencing and semiconductor manufacturing with the mutual goal of improving the quality and reducing the cost of videoconferencing technology which currently relies upon devices called *videocodecs*. Videocodecs are needed to compress the digitised television or video pictures for transmission over digital circuits.

Motorola will integrate BT's standards-based video coding technology into a personal computer multimedia communications chip set capable of simultaneously processing real-time video, still image and data. Multimedia communications is a merging of television, facsimile and computer with audio and video capabilities into a single desktop multimedia communications terminal.

Motorola will manufacture and market the chip set to key business partners worldwide. BT will incorporate the chip set into future video communications products such as slot-in PC cards. Commercial availability is targeted for 1994.

This is a significant milestone not only for BT and Motorola but for the industry as a whole. Motorola's advanced semiconductor technology, coupled with BT's expertise in videocodecs, will enable all the technology available in today's videoconferencing equipment to be put into a single chip set which can be placed virtually in any desktop personal computer.

BT Offers Direct Paging Input from PCs

Customers of BT's paging service are being offered the facility to input paging messages direct from their PCs.

A new software package being made available by BT allows not only direct input, but also group call messaging, message printing, pager number storage and a host of other facilities.

The new service makes the sending of messages easier, quicker and cheaper—by eliminating the need to call the paging operator bureau.

Direct PC input offers companies a faster service, with added confidentiality, and greater convenience. Companies, whether small or large, that have invested in PCs and in pagers can now combine the two technologies to maximise the benefit of their investment.

IBTE Local-Centre Programmes 1992–93

Further details can be obtained from Local-Centre Secretaries, see p. 236.

East Anglia Centre

24 November 1992: *A Current Topic* by Bruce Bond, Group Director, Products & Services. To be held at Aylesbury ATE, from 14.00–16.00 hours.

13 January 1993: *BT Money Talks* by Robert Millington, Barclays de Zoete Wedd. To be held at Assembly House, Theatre Street, Norwich, from 14.00-16.00 hours.

10 February 1993: *A Current Topic* by Hugh Mothersile, ex General Manager BT/WWN. To be held at St Peters House, St Peters Street, Colchester, from 14.00-16.00 hours.

17 March 1993: *Tunnelvision* by Paul Faulkener, BT Cordialle. To be held at St Peters House, St Peters Street, Colchester, from 14.00-16.00 hours.

Lancs & Cumbria Centre

All lectures will be held at the Harris Conference Centre, 253 Garstang Road, Preston, from 14.00–15.45 hours, coffee from 13.30.

3 November 1992: *Cipher—The Next Step* by Andy Robinson.

1 December 1992: *The World of Network Management* by Steve Heap.

5 January 1993: *Developments in Private Services* by John Bateman, Network Platform & Technical Futures Manager.

2 February 1993: *Finance in the New BT—Can we Afford it?* by Mike Wood.

2 March 1993: *The Local Access Network* by Peter Lisle.

Liverpool Centre

18 November 1992: *National Account Management* by Debbie Wardle, BT National Account Manager Manchester. To be held at Bradford Hotel, Tithebarn Street, Liverpool, commencing at 12.45 hours. Buffet available from noon.

20 January 1993: *The World of Private Services* by Mike Langston, General Manager, BT Customer Network Organisation. Venue to be decided.

11 February 1993: Prestige lecture with Manchester Centre. *European Leadership* by Mike Bett, BT Deputy Chairman. To be held at UMIST Weston Conference Suite, Manchester, from 13.30-15.15 hours. Admission by ticket only.

17 March 1993: *The Mersey Tunnels* by J. R. Gillard, General Manager, Mersey Tunnels, Liverpool. To be held at Bradford Hotel, Tithebarn Street, Liverpool, commencing at 12.45 hours. Buffet available from noon.

21 April 1993: Presentation by BT Laboratories, Martlesham. Further details to be announced later.

London Centre

All lectures, unless otherwise stated, will be held at the Assembly Rooms, Fleet Building, 40 Shoe Lane, London EC4V 3DD commencing at 12.30 hours. Buffet lunch at noon.

10 November 1992: *Developments in the Private Services Field & Achievements by the Private Services Organisation* by John Bateman, Network Platform & Technical Futures Manager.

5 December 1992: Christmas Family Lecture. *Widget Wonderland—The Art of Predicting the Science & Technology of Tomorrow* by television presenter Kate Bellingham. To be held at the Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, at 11.00 hours and 14.30 hours. Refreshments available 30 minutes before each session. Admission strictly by ticket. Free tickets can be obtained by writing to: 1992 IBTE Christmas Family Lecture, PP 1103, Camelford House, 87 Albert Embankment, London SE1 7TS stating your preferred session and enclosing a self-addressed envelope to your office address.

27 January 1993: *Payphones—Yesterday, Today & Tomorrow* by Patricia Vaz, Director BT Payphones.

10 March 1993: *Chaos in Communications* by Dr. David Leakey, ex BT Group Technical Advisor.

28 April 1993: *A Review of Network Access Strategy* by Keith Oakley.

Manchester Centre

17 November 1992: *Tomorrow's Access Network* by John Peacock and Tim Finegan, BTRL. To be held at UMIST Staff House, Room 4/5, commencing at 12.30 hours.

9 December 1992: *Single European Market* by Prof. Kenneth Dyson, Head of European Studies, Bradford University. To be held at UMIST Staff House, Room 4/5, commencing at 12.30 hours.

19 January 1993: *Glimpse of the Future* by Dr. Peter Cochrane, Systems Research BTRL. To be held at UMIST Staff House, Room 4/5 commencing at 12.30 hours.

11 February 1993: Prestige lecture with Liverpool Centre. *European Leadership* by Mike Bett, BT Deputy Chairman. To be held at UMIST Weston Conference Suite from 13.30–15.15 hours. Admission by ticket only.

30 March 1993: *Safety Management* by Ken Clark, BT Chief Safety Officer. To be held at RB/UMIST, Theatre F14, commencing at 12.30 hours.

North Downs Centre

All lectures are to be held at the Boxley House Hotel, Boxley, Maidstone, commencing at 13.30 hours. Buffet available from 12.45 hours.

17 November 1992: *Oftel's Relationship with BT*. Robin Seaman, Government Relations Department.

13 January 1993: *How Safe is Nuclear Power*. Presenter from Nuclear Electric's "Let's Talk" service to be announced.

17 February 1993: *The Nuisance Call Bureau* by Paul Hamilton, BT Manager in charge of NCB at Canterbury.

16 March 1993: *Tunnel Vision—Communications and the Channel Tunnel Project* by Jerry Lyne, Manager from Cordiale Group.

13 April 1993: *Private Network Business in BT* by John Bateman, Network Platform and Technical Facilities Manager.

Severnside Centre

All lectures will be held in the 6th Floor Conference Room, Mercury House, Bond Street, Bristol commencing at 14.15 hours.

4 November 1992: *The Evolving World of Data Communictions* by Mr J. Atkins, BT Laboratories, Ipswich.

3 February 1993: *Network Traffic Management in BT* by Mr R Garrison, Traffic Management Team.

3 March 1993: *The Cable Challenge* by Mr L Baddeley, PC Marketing Manager Wales and West.

7 April 1993: *ISDN* by Mr D Mansell, ISDN 30 Project Manager.

South Downs Centre

All lectures will take place at the Lecture Theatre, Worthing Central Library, Richmond Road, Worthing, and commence at 12.45 hours. Buffet lunch from noon.

10 November 1992: *The Cable TV Threat and BT's Response* by Norman Westlake, Forecasting and Business Planning Manager.

8 December 1992: A talk by John Ziemniak, Director Policy, Planning and Performance.

12 January 1993: *What the Papers Say—A talk on Managing Media Perception* by Andrew White, BT Public Relations.

9 February 1993: *Private Services* by John Bateman, Network Platform and Technical Futures Manager.

9 March 1993: *Syncordia. A Global Strategy* by Dick Lechmere, Syncordia Operations and Planning Manager.

Staffordshire Centre

All meetings are to take place at the BT Training College, Stone.

9 November 1992: *FeatureNet* by Mark Bullock, FeatureNet Marketing Manager, commencing at 13.45 hours.

7 December 1992: A Joint IBTE/IEE meeting. *Solitons* by Professor N J Doran, University of Aston, commencing at 18.15 hours. Refreshments available from 17.30 hours.

18 January 1993: *The Intelligent Network—the Wider Aspects* by Trevor Wyatt, IN Features Manager, commencing at 13.45 hours.

15 February 1993: *BT Finance—Who Does What* by Tom Leitch, Senior Management Accountant, PC Midlands, commencing at 13.45 hours.

15 March 1993: *A Worldwide Opportunity* by John Butler, Director, Policy and Planning, BT Products and Services. Commences at 13.45 hours.

Thames Valley Centre

24 November 1992: A Prestige lecture by Bruce Bond, Director, BT Products and Services. To be held at the Aylesbury Conference Centre, commencing at 12.30 hours.

13 January 1993: *Fast Provision of Service* by Cliff Watts, Frame Manager, WN Northern Home Counties Zone. To be held at the Sports and Social Club, Aldershot, commencing at 12.00 hours.

17 February 1993: *Personal Computing Services* by Dawn Mills, Group Computing Services, Northern Home

Counties. To be held in the Board-room, Telecom House, Reading, commencing at 12.00 hours.

17 March 1993: *Communications for British Aerospace Farnborough*, presenter to be advised. To be held at the Sports and Social Club, Aldershot, commencing at 12.00 hours.

14 April 1993: *Facility Management / Global Services* by Gary Matcham, Quality Manager, Global Customer Services. To be held in the Board-room, Telecom House, Reading, commencing at 12.00 hours.

West Midland Centre

10 November 1992: Joint IBTE/IEE 1992 Faraday Lectures. *Seventh Sense* by British Gas. To be held at the Birmingham Town Hall. Sessions commence at 13.30, 15.30 and 19.00 hours.

11 November 1992: *Finance—Who Does What* by Mr T Leitch, Financial Control Unit, Leicester. To be held in the Ground Floor Conference Room, UG 35, Berkley House, 245 Broad Street, Birmingham, commencing at 14.00 hours.

West of Scotland Centre

10 November 1992: *Generic Speech Systems* by Kevin Rose, Generic Speech Systems. To be held at the Strathclyde Institute, 229 George Street, Glasgow, commencing at 12.30 hours.

9 December 1992: *A Customer's Perspective*. Presenter to be announced. To be held at the Strathclyde Institute, 229 George Street, Glasgow, commencing at 12.30 hours.

13 January 1993: *Polish Experience* by Forbes Hamilton, Field Operations Manager (North). To be held at the Buchanan Suite, Royal Glasgow Concert Hall, commencing at 12.30 hours.

10 February 1993: *High Fliers*. Presenter to be announced. To be held at the Buchanan Suite, Royal Glasgow Concert Hall, commencing at 12.30 hours.

17 March 1993: *BT's Finances—Myths and Realities* by Barry Romeril, BT Finance Director. To be held in Lecture Theatre 1, Herriot Watt University, Riccarton. Time to be announced.

Yorks and Lincs Centre

Except where otherwise stated all meetings will be held at the Congreve Room, West Yorkshire Playhouse, Quarry Hill Mount, Leeds, commencing at 13.00 hours.

26 November 1992: *BT—Sleeping Giant, Ugly Ducking, Misunderstood, Out of Touch.... Or What?—An External Viewpoint* by Michael Harrison, Managing Director, Harrison Smith Associates.

14 December 1992: *Business Process Management* by David Beattie, Process Management Strategy Manager, PC Business Processes.

21 January 1993: *A Glimpse of the Future* by Dr Peter Cochrane, Manager Systems Research Division, BT Laboratories.

February 1993: To be announced.

March 1993: To be announced.

21 April 1993: *The Role of Operator Service in BT* by David Beattie, Head of Operations Support, Operator Services.

notes and comments

Contributions to the Journal

Contributions of articles to the *Journal* are always welcome. Anyone who feels that he or she could contribute an article (either short or long) on a telecommunications engineering- or business-related topic is invited to contact the Managing Editor at the address given below. Guidance notes for authors are available and these will be sent on request.

Field contributions

The Board of Editors is particularly keen to increase the number of field contributions published in the *Journal*. For example, novel engineering solutions to field problems could form the basis of very interesting short articles. Items of this nature would be very welcome, and potential authors are encouraged to contact the Managing Editor (see below).

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BRITISH TELECOMMUNICATIONS ENGINEERING ISSN 0262-401X

Published in April, July, October and January by *British Telecommunications Engineering Journal*, 2–12 Gresham Street, London, EC2V 7AG. (Formerly *The Post Office Electrical Engineers' Journal* Vols. 1–74: April 1908–January 1982.)

Printed in Great Britain by Unwin Brothers Limited, The Gresham Press, Old Woking, Surrey, GU22 9LH.

Subscriptions and Back Numbers
Price: Single copy—companies, universities, libraries and other bodies £5·00 (£5·75 including postage UK, £7·00 including postage overseas); private individuals (paid by personal cheque) £3·50 (£4·25 including postage UK, £5·50 including postage overseas). Annual subscriptions (including postage)—companies etc. £23 UK, £28 overseas; private individuals (paid by personal cheque) £17 UK, £22 overseas.

Overseas customers can pay by sterling drafts drawn on London banks or by sterling Eurocheques.

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Associate Section Zone Committee Contacts

The following is a list of Associate Section Zone contact points to whom enquiries about the Associate Section should be directed.

Zone Committee	*Contact*	*Telephone No.*
London	Peter Stevens	071–829 4541
Midland	John Sansom	0604 230635
North East	Tim Toulson	0742 708037
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Northern Ireland	Brian Walker	0232 232565
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