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MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Strategic Systems Planning

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Strategic systems planning

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Advances in technology are creating a profusion of opportunities for increasing the value and cost-effectiveness of telecommunications, for example through the provision of new services for the customer and the use of more economical systems designs. But telecommunications is a complex and highly interactive process, and if the best use is to be made of the opportunities presented, a framework of definitions is required for the coordinated development of systems.

Following extensive studies of the definitions required, the Post Office and its principal suppliers are developing a family of standard switching and associated systems, collectively known as System X. Based upon digital, software and microelectronic technologies, System X is intended to increase the cost-effectiveness and evolutionary capabilities of the British network, with designs that are fully competitive on world markets. The definitions used for System X cover customer service and network interworking requirements, systems architecture, and a range of design standards and procedures. The arrangements enable vital interactions to take place between production and operational interests, and between the definition and design processes.

System X is part of an overall systems strategy that is being progressively created. It links System X with other developments, in terms both of service performance and technical standards. In all its aspects, strategic systems planning is expected to lead to the creation, in cost-effective ways, of basic capabilities providing hitherto unattainable opportunities for extending telecommunications services, increasingly in a global context. The continuing reconciliation of global needs and local aspirations in telecommunications represents perhaps the greatest challenge to strategic systems planners worldwide.

Introduction

Advances in technology are creating a profusion of opportunities for increasing the value and cost effectiveness of telecommunications. They provide abundant scope, and ample justification, for intensive Research and Development, aimed for example at the provision of new services for the customer, or the use of more economical systems designs. However, the resources required to explore the opportunities and to develop new services and systems are very substantial and any organization must be selective in the programme of studies and developments that it undertakes. Such is the complexity of telecommunications systems development that even a selective programme may be unmanageable unless the overall task is subdivided into projects of manageable size, that can be undertaken by reasonably independent teams, having the appropriate skills. But telecommunications is a highly interactive business – perhaps uniquely so – and if the best use is to be made of the opportunities presented, it is important that vital interactions be identified and taken into account in the projects that go forward.

In the Post Office, strategic systems planning refers to the process of identifying projects, and defining them in appropriate detail. The results are intended to provide a framework for the coordinated development of systems within which each project can be directed to best advantage. Strategic systems planning has many facets, including the customer services and facilities that should be catered for in new systems development, the systems concepts and technology to be used, network and systems architecture, and the detailed ways in which diverse elements of telecommunications networks interwork together to provide service. The process is much concerned with the evaluation of alternative courses and the timing of developments to ensure both that new service and operational capabilities are created and exploited in an effective sequence, and that advances in technology are used to best effect taking into account existing assets. However, strategic systems planning is also concerned with the development process itself, and the freedom that individual design teams can usefully have not only on service and technical issues but in such matters as the choice of components and the equipment, design and documentation practices that they use.

Strategic systems planning – the identification and appropriate definition of development projects – can thus have important consequences, not only in service, operational and technical terms, but in the way in which development is undertaken. It has been the subject of considerable study by the Post Office in recent years, much of it carried out jointly with the principal suppliers of telecommunications equipment in the U.K.: G.E.C. Telecommunications Ltd. (Coventry), Plessey Telecommunications Ltd. (Ilford), and Standard Telephones & Cables Ltd. (London). In reviewing some of the problems of strategic systems planning, this paper owes a great deal to the joint forums, notably of the Joint Telecommunications Systems Strategy Committee (J.T.S.S.C.) and the earlier Advisory Group on System Definitions (A.G.S.D.), for it is perhaps in these forums that the most systematic U.K. attack has been made.

A.G.S.D. STUDIES

A.G.S.D. was primarily concerned with two tasks. The first was basically technical: to advise the Post Office on the systems and subsystems that should be developed for the 1980s and beyond. The second was to advise on how best to reconcile innovation and competition in design with the standards necessary for interworking and effectiveness. In seeking answers to these questions, A.G.S.D. was able to involve numerous experts in the Post Office and Industry in a wide range of studies. Many of the resulting conclusions provide the basis for much current activity in the U.K., including, for example, the family of new switching and associated systems, collectively known as System X, now being developed in a collaborative relation with the main U.K. equipment suppliers. In view of their continuing relevance, the more important areas of A.G.S.D. study, and the principal conclusions reached, are summarized below. They are of course indicative of the problems faced by telecommunications organizations in many parts of the world.

Fundamental problem

In going about its task, A.G.S.D. was faced with a fundamental problem in telecommunications development, namely how to reconcile growth and change in telecommunications with the continuing need for compatibility and interworking between the diverse elements of telecommunications networks. New systems are invariably introduced into well established networks in which customers' apparatus, transmission links and exchange equipments all of various kinds and vintages cooperate together in well established ways which cannot easily be modified. In particular, the forms of signalling used, and the rigid way in which the signals are controlled and interpreted in much of the existing equipment, represent very considerable obstacles to change and the introduction of new services and facilities.

A.G.S.D. recognized that these inertias would become very much more significant if, as seemed likely, the competitive advantage of telecommunications over other forms of communication led to growing demands for new and more powerful services, including data and vision services. To cater for such demands on a national scale, it is necessary to create systems having high in-service flexibility and evolutionary potential, and to use them in ways which are not unduly constrained by what already exists.

System concepts

A range of system concepts promised the required evolutionary potential:

(*a*) General purpose switching arrangements which enable diverse types of line and signalling equipment to be interconnected, and progressively reconfigured as service and network interworking requirements change.

(*b*) Stored program control in which data-processing provides a general purpose and flexible solution to the problems of storing and manipulating the information and signals required to set up and supervise connections – and to manage the system; and at the same time enable the design problems of catering for a massive variety of different facilities, services and interworking arrangements to be rationalized and handled in the same disciplined way.

(*c*) Common channel signalling which provides the means of transmitting control and management data between installations in flexible, open-ended ways suited to an expanding range of services and facilities, and over paths no longer associated with the transmission channels that they control, leaving such channels free of signalling interfaces.

(*d*) Digital transmission which provides a general purpose transmission technique suitable for all services and a wide range of transmission media, and giving a performance that is virtually independent of distance.

(*e*) Integrated digital switching and transmission which enables both transmission and switching equipment to be time-shared over many telephone and data channels, without expensive interface equipment between them.

(*f*) Remote control, which enables some of the management and operational features of the network to be centralized.

(*g*) Concentrator working, which, with remote control, enables the benefits of stored program control and common channel signalling to be applied to small switching installations.

Microelectronics technology was of course expected to provide underlying economy of design, and it was recognized that although many of the system concepts could be exploited individually for specific service requirements and network rôles, an overall approach would be necessary if their full potential were to be realized. Such an overall approach would have its roots in the basic functions and sequences that are common to all services and facilities, strengthened by the deliberate separation of switching and transmission from signalling and control, that would allow each to evolve in its own way and at its own pace.

Network architecture

The approach seems likely to be more effective if new systems exploiting the evolutionary concepts can be introduced as an overlay used to extend the existing network, but having the minimum number and variety of interfaces with it and therefore virtually free of present interworking constraints. Such an overlay would lead to the establishment of a nationwide, high capability network by the earliest practicable date, and A.G.S.D. undertook numerous studies of, for example, call-routing strategies that would minimize the growth of traffic in the existing network and ensure that calls to and from customers' terminals connected to the overlay are routed within it whenever possible.

However, even with an overlay approach, the new systems will have to interwork directly with a considerable variety of exchange types – Strowger, crossbar and reed-electronic – that will still exist in the network in the 1980s and beyond. There is an even greater diversity of signalling systems that must be catered for – some 66 basic types, with variants; and quite inevitably a wide range of interworking configurations will be needed to meet local circumstances. In terms of, for example, technical make-up, telephone density and penetration, line-plant and accommodation capacity, the differences between one area of the country and another may be very significant and it is most unlikely that any pure approach to the implementation planning problem could be optimal. Overlay strategies themselves are complementary to other strategies for the growth and modernization of the overall network, and within both overlay and replacement strategies for modernization it will be desirable to make use of various planning options to be created in the course of development.

One important option concerns the evolution of an overlay network into a common services network, capable of sustaining an expanding range of services and facilities. The provision of separate, independent, nationwide networks for each new service would of course require substantial resources; perhaps these would be prohibitive in view of the high transmission, control and signalling costs required to interconnect few but widely dispersed customers. The best prospect of providing new services effectively is therefore likely to be through systems of high evolutionary potential, that maximize opportunities for the integration of basic telecommunications plant over different services – achieved, for example, by using common control and signalling equipments within the overlay, that are capable of routing a variety of connections for different services through switching and transmission paths of appropriate bandwidth.

Services and facilities

Of course the objective must not be to achieve some ultimate in technology, but to be cost-effective at all stages in meeting the changing, growing market for telecommunications services. However, the problems of forecasting demands even for established services and facilities are notoriously difficult, and beyond the immediate future it is not easy to be exact on when new services will be required, or the form that they should take. These uncertainties are more significant when the long timescales of telecommunications are considered, for new systems currently under development are unlikely to be in full production until the 1980s, or to dominate the network until the 1990s; and because of the continuing need for compatibility in telecommunications, they are likely to exert a continuing influence on service performance well into the early decades of the 2000s. And although considerable effort has gone into the identification and definition of possible new services that will be required in the earlier years, it is perhaps fortunate that the architecture of new systems can be considered and determined much more in terms of basic functions and sequences of operations, and of the need to create certain basic capabilities, rather than in terms of some highly specific facility schedule.

Systems architecture

The emphasis on basic functions and capabilities was carried into A.G.S.D's work on systems architecture, where the aim was to identify subdivisions of the total system that are functionally complete in themselves and therefore provided the basis for projects that could be undertaken by reasonably independent teams. It was recognized that many of the subsystems should be multi-purpose in order that they be used in various combinations and configurations to meet diverse planning and service requirements, and that interfaces between subsystems should provide convenient points for growth and adaptability. The studies indicated that while most of the subsystems are best described in terms of the telecommunications functions that they perform, it is better to define others in their own terms as utilities whose facilities can be used for other subsystems. The studies also showed that some of the subsystems are functionally transparent, defining only the general format in which information proper to other subsystems would be transmitted. On this basis, a range of subsystems was identified as follows:

(*a*) Terminal subsystems – telephones, coin-boxes, operator terminals, data terminals, video terminals, etc.

(*b*) Transmission subsystems – for local, junction, trunk and international networks, with analogue and digital variants.

(*c*) Switching subsystems – for subscribers' switching, route switching and junction switching, with analogue and digital variants.

(*d*) Processor subsystems – but regarded as utilities, that can be further subdivided into storage, processing, input–output and other subsystems.

(*e*) Message transmission subsystems – for common channel signalling including interprocessor and remote control signalling.

(*f*) Software subsystems – for call processing, call accounting, network management and maintenance, etc.

(*g*) Signal interworking subsystems – for interworking with existing systems and apparatus.

(*h*) Common service subsystems – power, tone generation, digital network synchronization etc.

(*i*) Connection and distribution frames.

Left to their own initiative, however, independent design teams may consciously or unconsciously draw their subsystem boundaries and define their interfaces in ways that are different and incompatible. The consequences may be serious, for even if essential interworking requirements are met – and this may be difficult – a great deal of operational flexibility may be lost and some service and planning options closed if a variety of basically incompatible systems designs are introduced into a network; each will place its own constraints on the way in which the overall network and service can evolve, and a complex of interactive developments may be needed to meet changing customer and operational requirements.

Levels of definition

The question therefore arises as to how best to place appropriate constraints on design teams. A.G.S.D's approach to this problem was to consider the various levels of detail at which subsystems could be defined. In principle, these can range from the almost purely functional to the use of hard, specific designs. Thus at one extreme, definitions would not mention technology or the system concepts to be used; they would merely identify major interfaces at natural network boundaries, for example between transmission and switching systems. Alternatively, and with increasing detail they could define:

(*a*) system technology, for example differentiating between analogue and digital operation;

(*b*) architectural features, for example covering the organization of switching subsystems, or the functions to be performed in hardware or software;

(*c*) internal interfaces, for example the electrical and other parameters defining the transfer of information between processors and switches;

(*d*) the standards and parameters to be used, in terms of, for example, components and design, documentation and equipment practices;

(*e*) the use of specific elements, such as specific switch designs, microprocessors or stores within a subsystem;

(*f*) and very specific definitions would say in effect, 'use this design of subsystem in all its detail'.

All of these definitions can, of course, be consistent with each other, and each may be appropriate at various stages in the overall design process; and clearly one would expect many fewer constraints to be appropriate at the research stage than in, for example, hard design for production or in the evolutionary development of established systems. But even in circumstances where the loosest form of definition seems appropriate, differences in the assumptions made at the functional level can have far reaching consequences, for example in terms of the capability of the overall network to evolve.

The development process

Consideration of the level of definition to be used as an input to systems development had important consequences for development in the U.K., for the study was undertaken at a time of intensive private venture activity by the companies, generally at the whole systems level, and when there was no clear machinery available to determine the definitions to be used. Concern at the possible consequences led on to a further study, of the overall development process from research through to the certification of designs for operational use. The study assessed the advantages and disadvantages of various approaches covering such matters as: the scope and level of definitions as a basis for advanced development; the degree of commitment to the definition and to the hard specification of designs for production; the degree of involvement of industry in the definition and specification process; and the design process itself, ranging from private venture to fully coordinated activity.

Various criteria were identified as important: service risk, the opportunities for innovation, the resources needed and the effective use of available resources. The important outcome of the study was the recognition of the interdependence that exists between the Post Office, its customers (the public), and the supply industry, and the many interests that they have in common. The study indicated that close interaction between the Post Office and the design teams of industry is essential to the objectives of all, including design effectiveness and the minimization of service risk; that the objectives of all can be prejudiced by a shortage of resources in the Post Office or industry, and, most importantly, that risks to all are reduced by the orderly flow of information between the Post Office and industry, so that production, service and operational interests may be taken into account and interact at all stages.

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Specification methods

Study of the development process said something about Post Office–industry relations in design. So did others: for example, A.G.S.D's work on specification methods showed that the specification of interface conditions in performance terms presents considerable difficulties, e.g. where idealized signals are distorted by the realities of the network, or before the availability of designs permits practical measurement. The problems can be particularly severe if new and untried interworking conditions and arrangements must be carried forward in parallel systems developments undertaken by separate teams, for example when new local and trunk exchange systems are being developed, with new forms of signalling between them. Maintenance, reliability and diagnostic requirements are similarly difficult to specify in performance terms, and it is even more difficult to ensure that statements of requirements are effective if the detailed technical implications – and cost consequences – cannot be known prior to design. The conclusion of these studies was that definition and design must be an iterative process that takes operational and economic consequences into account at all stages. This conclusion was in line with the lessons of some ten years' experience of the use of performance specifications in the 1960s and early 1970s, which demonstrated that their use, particularly in switching, can cause important interactions to be overlooked, and can lead to a proliferation of design variants.

Costs of design variation

These considerations led A.G.S.D. to undertake a study of the costs of design variation which showed that wherever a new or variant design is introduced, the Post Office incurs added overhead costs. Some 130 factors were identified, under seven main headings: development and evaluation, documentation, planning and procurement, training, maintenance, initial research and development, and direct operational costs. The study showed that the excess costs may depend upon many factors, including: the level of change (system, subsystem, rack, shelf or lower); the degree of change (new, major variation or minor variant); and the degree and rate of penetration of the variant into the network. The excess costs can be high, and they must be taken into account in assessing new designs at any level. They can outweigh the potential benefits of design change; and in particular, they can be so high that the development and introduction of a multiplicity of new systems, or of major system variants, cannot be justified. The study supported the general conclusion that in the switching area in particular, the use of performance specifications could not lead to a satisfactory situation.

Resources

The study also supported the conclusion that a much more coordinated approach to systems development was needed in the U.K., particularly towards a family of standard switching and associated systems having a common technological base, the repertoire of System X.

One final study set the seal on this conclusion, namely a study of the professional resources needed to develop such a family, for a range of local and trunk applications. It was assumed that effort would be essentially in two parts: the first, virtually independent of systems applications, concerned with basic systems planning, subsystems definition, processor development, and the establishment of common standards and practices, and the second, comprising the added effort to complete the development for each application. The results showed that a very substantial effort would be required, amounting to several hundreds of professional staff over several years, to develop the family once, without duplication and exploiting common practices, standards, subsystems and designs where appropriate.

Post Office–industry relation in systems design

These studies by A.G.S.D. provide much of the background to the relation that now exists between the Post Office and its principal suppliers in the design of switching and associated systems. The relation took time to establish because a number of very difficult commercial problems had to be resolved, concerned for example with the reconciliation of collaboration in development with competition in supply. Such problems are outside the scope of this paper, but the relation that has been developed enables the firms to collaborate with the Post Office in creating an overall strategy for the coordinated development of systems, and in the definition of switching and associated projects, notably for System X. In this work the aim is to establish a consensus view that takes into account the views and export interests of industry, but the Post Office has the right to take final decisions.

The result of this collaborative work is a programme of development projects that are undertaken individually by the companies through contracts let and funded by the Post Office. The contracts provide for the transfer of information under Post Office control as necessary both to provide for competitive supply of the resulting designs, and to enable each contractor to undertake its share of the programme effectively.

System X

Within the new relation, the Post Office and industry had no difficulty in agreeing that the most urgent and important task was the development of the family of new switching and associated systems, known as System X. Intensive joint preparatory work, carried out under the auspices of the Joint Telecommunications Systems Strategy Committee (J.T.S.S.C.), resulted in agreed bases for the development, which is now under way. In large measure it builds upon the work and findings of A.G.S.D. and the private venture activity of industry that paralleled the A.G.S.D. studies.

Thus System X is based upon digital, microelectronic and software technologies. It is highly modular in its architecture, to facilitate economic growth and evolution in terms of new services, facilities and technology. In addition, it exploits the principles of commonality whereby common components, units and subsystems can be used in a wide range of applications at home and abroad. It is a clear objective of the development to meet Post Office needs effectively, with designs that are fully competitive on world markets.

Applications and programme

The overall programme for System X provides for its development for a comprehensive range of applications, but highest priority is being given to the development of digital switching systems for junction tandem and trunk purposes, closely followed by a family of local exchanges required to meet the diverse situations that arise. The programme includes the development of System X for international, manual board and data services, and for the range of service, management and accounting centres that will be appropriate for the 1980s and beyond.

For the early applications, a two-stage design process is envisaged based upon models at manufacturer's premises closely followed by a testing stage on Post Office premises, in which it is expected that designs will be certified for production. With growing confidence and the progressive commitment of expenditure it is planned to build up production in the early 1980s for an expanding range of applications that exploit much of the basic designs proved in the early applications.

Systems architecture

The architecture to be used in the early applications has been defined and development is in progress, with separate design teams responsible for each application and the principal subsystems. These include:

(*a*) Processor Utility (PU), based upon G.E.C.'s Mark II BL processor, and providing powerful multi-processing facilities.

(*b*) Pre-Processor Utility (PPU), compatible with the PU, but used in applications where the full processing power of the PU is not required.

(*c*) Digital Switching Subsystem (DSS), based upon a time–space–time configuration to interconnect digital channels at standard C.C.I.T.T. interfaces with the switch.

(*d*) Analogue Line Termination Subsystem (ALTS), which converts the analogue signals carried on any of the circuits connected to the exchange into digital signals at the DSS interface.

(*e*) Signal Interworking Subsystem (SIS), required for interworking with existing exchange systems using the wide range of specialized signalling systems already in use in the U.K. Variants are required for local and digital exchanges, for voice-frequency and loop-disconnect signalling, and for digital and analogue circuits connected to the exchange.

(*f*) Message Transmission Subsystems (MTS), providing common channel signalling facilities, with error protection, and conforming with the emerging requirements of the new international system: C.C.I.T.T. Signalling System No. 7.

(*g*) Local Switching Subsystem (LSS), exploiting reed-relays in the subscriber switching stages, for use in a range of local exchange applications, covering different unit sizes and with options for concentrator working and remote control.

(*h*) Software subsystems, including specifically call processing, maintenance control, management statistics and overload control subsystems.

Standards and technology

Preparatory to the substantive development of System X, various standards were agreed to be necessary, for example to ensure that hardware units would be interchangeable from any manufacturing source, to rationalize design and design-proving problems, and to secure the benefits of scale in development, production and operations. In determining specific standards the aim has been to produce designs that are technologically advanced, cost effective and fully competitive on world markets, but inevitably in choosing particular standards fine judgments have had to be taken concerning the benefits and risks of using the most advanced, and therefore not fully proven, devices and technologies. Areas of standardization include:

(*a*) A standard form of mechanical construction known as Telecommunications Equipment Practice No. 1 (TEP 1), which creates an effective range of options in terms of dimensioning, cooling arrangements and maintenance access, and the specific options that will be used for System X, including printed wiring board standards.

(*b*) An approved list of components and devices, where possible conforming with widely accepted national and international standards; the list is by no means closed, and it includes conventional components, relays (where possible compatible with electronic components) and a range of semi-conductor devices including microprocessor and TTL integrated circuits.

(*c*) Circuit design rules, defining for example component de-rating factors, and interconnection rules and limits.

(*d*) Standard hardware interfaces including inter-shelf and inter-rack cabling standards.

(*e*) Software standards, including the use of a high-level programming language based on Coral.

(*f*) Power supplies and a standard range of d.c./d.c. converters.

Documentation and data base

The development is being undertaken by design teams at various locations, and care has to be taken to ensure that the need for common standards is widely understood and accepted, and that the defined standards are interpreted appropriately. This is just one aspect of a complex information-exchange and documentation process, on which collective development and the effective implementation of System X vitally depend, because a very great deal of design information, both hardware and software, must be exchanged between the design teams, and made available for planning, production and maintenance purposes. The information is not static, and over the years many thousands of unit, circuit and printed board designs will be generated in the development. The control of the information exchange and updating processes cannot be left to chance, and a coherent documentation scheme is being progressively developed, building upon earlier experience, that caters for a very wide variety of documents in a hierarchical structure with a common coding scheme. Paper, microfilm and magnetic tapes are being used in the exchange of information, but progressively a computerized data base is being developed and implemented.

Computer aided design and development

Computer facilities are of course becoming essential tools in support of complex systems development, and a variety of aids are being used in the System X development programme, some of which are made generally available to all the design teams via a data network having terminals at all the locations involved. The facilities provide for the simulation and testing of designs, both hardware and software, the simulation of the traffic performance of particular systems and subsystem configurations, the preparation of printed wiring board layouts, and of inter-unit and other wiring schedules. Closely coupled with the data base already referred to, the support facilities are expected to increase very substantially the productivity of the design teams, and the quality and cost-effectiveness of the resulting product.

Ideally, the facilities available to the design team would form a highly integrated and coherent set, but in the early stages of development of System X heavy reliance has had to be placed upon the somewhat divergent facilities already available to the Post Office and the participating firms. This divergence, which extends to present documentation and other practices, is perhaps an unfortunate consequence of the arms-length relation that has existed between the companies and between each company and the Post Office in recent years. The new relation now provides the opportunity for greater convergence, which it is vital to seize if the highly responsive development capability that will be needed to exploit future generations of technology effectively, and in meeting diverse needs at home and abroad, is to be created.

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Project control and evaluation

From what has been said, it will be seen that System X is a major development project. Some hundreds of professional staff are involved in the Post Office and industry, and will be involved for several years. The computer resource facilities involve expenditure of several millions of pounds, and scores of racks of model and test equipment will be required to validate the designs through to production. All told, development costs are likely to exceed £100 M. That cost is high, but it should be seen in the context of potential procurement programmes of some thousands of millions of pounds in the United Kingdom alone, and the prospect of a substantial export market.

However, such is the cost and value of the project that effective mechanisms for ensuring that progress, costs and value are in line with expectations are essential, and to that end various project control procedures have been developed during the preparatory phase. They build upon well tried methods for measuring progress against key dates, but with perhaps greater emphasis on the measurement and control of resource usage. Periodic reviews are made of out-turn performance against cost and operational targets, concerned with power and accommodation requirements for example. Very considerable importance is attached to the cost-effectiveness of the development as a whole, expressed in terms of the net present value of the development, taking into account the time value of money and the expected cash flows over many decades, including development costs and the whole-life costs of ownership of the equipment. The results of these evaluation studies to date, are encouraging, but as with many of the technical details of System X it would be premature to say more at this stage, bearing in mind the competitive aims of the project.

Export aspects

In the definition and assessment of System X and other developments, the Post Office must of course pay attention to whole-life costs and service performance, taking into account for example accommodation, power and maintenance costs, and in due course the benefits that may come from new customer services and facilities. In some quarters this has been thought to be at variance with industry's requirements for designs that have low initial costs, but of course most advanced administrations already attach considerable importance to whole-life cost-effectiveness, and there are signs that the international telecommunications forums may encourage its wider acceptance as the main criteria in the choice of systems in underdeveloped countries. In addition, of course, initial costs make a significant contribution to the whole-life cost of ownership. Indeed, in its own interests, the Post Office must ensure that its statements of requirements iterate with design, taking initial costs into account. The new relation with industry has enabled that to happen in the early phases of System X development, and the continuing appraisal of both specifications and designs should ensure that the most effective overall course is followed. This, coupled with the adaptability and modularity of so many of the elements of System X, gives grounds for growing confidence that the system will meet the operational needs and economic criteria of many markets overseas.

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Systems strategy

The foregoing résumé of the System X development is indicative of the variety of definitions that may be appropriate for a major systems development. It is perhaps an extreme example, for System X comprises a number of projects that are themselves highly interactive, requiring an unusually large number of definitions to be established and kept under review. All are considered necessary for the overall effectiveness of the project, and they are directed at two aspects in particular. The first is concerned with the service and network performance of the resulting product, and the second with securing the benefits of scale and design commonality in development, production and operation. In neither area can System X be considered in isolation.

Thus, in service and network terms System X must work with what already exists and be harmonized with other current developments that will change the service performance of the network and the interworking arrangements required. Many current developments increasingly require the network and the service to be looked at as a whole, for example integrated digital switching and transmission, the possibilities for common service networks, and the possibilities for new designs of local line plant capable of sustaining a wide variety of services (voice, data and visual). In terms of technology, standards and practices, System X already owes much to other developments, and will in its turn establish new standards, for example in regard to equipment practices, components, control procedures and computer support facilities, any and all of which may be expected to find valuable application outside System X. The increasing use of microelectronics and computer support facilities suggest an increasing trend for organizations to regard developments as a whole.

It is of course a main purpose of strategic systems planning to make appropriate use of these opportunities for integration and commonality. But in doing so, any temptation to over-define or over-rationalize must be resisted, for if carried into too much detail the definitions can blunt the motivation of design teams and lead to expensive delays while complex problems are being resolved, and perhaps relatively ineffective compromises reached. In creating the overall systems strategy, therefore, considerable care is needed to ensure that its component plans and definitions go into no more detail than is necessary for effective development, and that interested parties are appropriately committed. Crucial interactions must, however, be identified, and these vary considerably from project to project; the interactions that are important in the development of new transmission systems may be quite different from those required in switching. For example, in the former, conformity with international standards is of paramount importance, whereas the detailed requirements of switching systems may be much more influenced by local considerations including the historical make-up of the network.

The most complex definition problems probably arise in the service, facility and interworking conditions to be met in switching systems development, including such aspects as signalling, numbering schemes and the routing of calls through the network, fee registration, and the diverse administrative facilities required for the effective management of the system for the diversity of services. By way of illustration, it is expected that 700 documents will eventually be needed to define these aspects of the System X programme in its entirety. And many of these will also be used where appropriate, for the evolutionary development of established systems such as TXE2 and TXE4.

The past influences these definitions, but so must the future, and part of the overall strategy that is being created consists of scenarios as to how the future network – and the services – may be expected to evolve, taking into account, for example, the progressive introduction of digital transmission and its possible penetration into the local line plant, the newer forms of wide-band transmission such as waveguides and optical fibres, and the progressive development of new services such as Viewdata and packet-switching data services.

However, rather than being specific about the future in this paper, it is desired to stress that much current activity in strategic systems planning is concerned with increasing the cost-effectiveness and evolutionary potential of the network, and the removal, in ways that are fully cost-effective, of the technical and other constraints that make it difficult for telecommunications to reach its full potential. System X is intended as a major step in the removal of these constraints, and if one had to be specific, it is perhaps in the local line area that the major outstanding constraints may reside in the 1980s and thereafter.

Thus, in defining projects that are of relevance in the shorter term, for example in relation to exports and in reducing costs, strategic systems planning is also aimed at the creation of basic capabilities in telecommunications that provide hitherto unattainable opportunities for introducing new services and facilities. And in all of this, international considerations are of increasing importance. In particular, recognizing the growth and implications of global connections, it seems vital to ensure that the evolutionary capabilities of the world's national networks are kept broadly in step and that appropriate international standards are established not only for the technical interworking of national networks, but in the procedures whereby customers interact with the global system. There is a choice, it seems, between greater harmonization, coherence and convergence in the extension of the services provided to customers, and increasing confusion through an undue proliferation of customer procedures and interfaces. The choice represents a major challenge for the international forums in telecommunications, vitally affected by strategic systems planning in many parts of the world, not least in the United Kingdom.

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